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Evidence-Based Apps? A Review of Mental Health Mobile Applications in a Psychotherapy Context

Joyce H. L. Lui, David K. Marcus, and Christopher T. Barry
Washington State University

mHealth denotes the use of mobile devices within a health care context. One type of mHealth that has gained increased popularity is the use of mobile applications (apps). Despite a plethora of apps that are commercially available, the efficacy or effectiveness of these apps is largely unknown. This article reviews the literature on the use of mental health mobile apps in a psychotherapy context. The review focuses on the efficacy or effectiveness and common features of mental health apps. At present, there is insufficient empirical support for any 1 particular app to be considered evidence-based. A number of methodological concerns among treatment outcome studies further complicate conclusions regarding efficacy and effectiveness. Nonetheless, preliminary results are promising and warrant further research. Apps included in this review were generally extensions of empirically supported treatments, primarily grounded in cognitive–behavioral therapy. Implications and clinical issues for practitioners are discussed. Given the current state of the research, clinicians may wish to consider cautiously incorporating apps as an adjunct to treatment or recommending apps to clients, but much is unknown including the possibility that in some circumstances, particular apps may prove to be iatrogenic for some clients.

Keywords: apps, mHealth, mental health treatment, psychotherapy, effectiveness

The use of mobile technology in health care has been termed *mHealth* (Donker et al., 2013; Luxton, McCann, Bush, Mishkind, & Reger, 2011), which broadly includes the use of mobile devices such as smartphones, tablets, personal digital assistants, and more recently, wearable devices. Many scholars have articulated the potential advantage of mHealth to overcome barriers associated with cost, transportation, lack of therapists, lack of insurance, or a long waitlist for services (Ben-Zeev et al., 2014; Dulin, Gonzalez, & Campbell, 2014; Heffner, Vilardaga, Mercer, Kientz, & Bricker, 2015; Luxton, Hansen, & Stanfill, 2014; Roepke et al., 2015). Other promises of mHealth include less stigma and more privacy, as individuals can access services at any location without attending a treatment facility, clinic, or office (Miner et al., 2016; Watts et al., 2013). Some proponents of mHealth argue that because mobile technology is convenient and portable, interventions can be delivered in the moment of need in any location and time, such as during high-risk or triggering situations, or times of significant distress (Ahmedani, Crotty, Abdulhak, & Ondersma, 2015; Ben-Zeev et al., 2014; Enock, Hofmann, & McNally, 2014; Gonzales & Dulin, 2015; Luxton et al., 2011). Furthermore, when mHealth is used as an adjunct to traditional therapy, it has the potential to increase homework compliance and generalization of therapeutic skills outside of sessions (Ahmedani et al., 2015; Ben-Zeev et al., 2014; Enock et al., 2014; Luxton et al., 2011; Newman, Przeworski, Consoli, & Taylor, 2014; Witkiewitz et al., 2014). Finally, mHealth may also promote early identification and early intervention, as well as offer brief services to those who may have less severe or subthreshold symptoms (Ahmedani et al., 2015). Most of these purported advantages primarily pertain to the use of video services via a mobile platform rather than newer technologies, such as location trackers, augmented reality, or biofeedback sensors or other physiological monitoring (Luxton et al., 2011).

One particular type of mHealth that has attracted increased attention in recent years is the use of mobile apps. The current review focuses on such *apps*, defined as discrete and independent software that run on a mobile device (Heffner et al., 2015; Sherwin-Smith & Pritchard-Jones, 2012). This definition encompasses apps on devices such as smartphones, tablets, personal digital assistants, and iPods, among others. Mobile apps are of particular interest because they may have additional benefits beyond accessing websites and text messaging that may make them a particularly valuable platform for dissemination of interventions.

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Joyce H. L. Lui received her MA in clinical psychology from The University of Southern Mississippi. She is currently a graduate student in the doctoral clinical psychology program at Washington State University. Her research focuses on correlates and outcomes of psychopathic traits in youth, such as social-emotional processing, social perception, and externalizing behaviors. She is also interested in examining effective treatment strategies for youth with psychopathic traits.

David K. Marcus received his PhD in clinical psychology from Clark University. He is currently a professor and department chair at the Department of Psychology at Washington State University. His research has examined treatment equivalence (i.e., the dodo bird effect), specific factors in psychotherapy, and the therapeutic alliance.

Christopher T. Barry received his PhD in clinical psychology from the University of Alabama. He is currently an associate professor in the Department of Psychology at Washington State University. His research focuses on the relation between adolescent self-perception (e.g., narcissism, self-esteem) with behavioral and social adjustment, as well as intrapersonal risk factors (e.g., CU traits) for child and adolescent behavioral problems.

Correspondence concerning this article should be addressed to Joyce H. L. Lui, Psychology Department, Washington State University, Johnson Tower 233, Pullman, WA 99164-4820. E-mail: joyce.lui@wsu.edu

For example, apps can be personalized (Gustafson et al., 2014), are visually engaging, user-friendly, and self-paced, have multimedia capabilities, can track progress anytime and anywhere, and often also include features to share content via social media (Bricker et al., 2014; Luxton et al., 2011). Furthermore, apps used in a clinical context can aid symptom assessment, provide psychoeducation, track treatment progress, provide real-time intervention and communication, and can take advantage of game technologies, global positioning system (GPS), and connectivity to external devices such as biofeedback sensors (Luxton et al., 2011). Such features likely help enhance engagement, motivation, and adherence, which may lead to better clinical outcomes.

However, the use of mobile apps for clinical purposes is not without its challenges. A primary concern is risks involving privacy and confidentiality. Data gathered from apps can be accessed by unauthorized individuals through digital theft or physical loss of the phone (Luxton et al., 2011; Prentice & Dobson, 2014). Apps may also have inadequate data protection (i.e., lack of encryption) or may not fully inform users as to what information is automatically gathered and returned to software developers (Luxton et al., 2011; Prentice & Dobson, 2014). Some apps have embedded advertisements (particularly if the app is free), and personal information may be distributed to marketers and advertisers (Giota & Kleftaras, 2014). Apps that have the functionality to connect to social media may involve an additional risk, as data (e.g., phone number, demographic information, name, etc.) may be shared with such social networking sites without the knowledge of the user, or users may later regret sharing this information. Despite these security risks and other challenges of mHealth (cf. Luxton et al., 2011), the development and dissemination of mental health apps continue to proliferate and outpace both research and regulatory policies.

Smartphone ownership is increasing, with 68% of adult Americans owning a smartphone (Pew Research Center, 2015a). Rates of smartphone use are high within ethnic minority and low-income populations: 68% of African Americans, 64% of Hispanic, and 52% of individuals with an annual income below $32,000 have a smartphone (Pew Research Center, 2015a). Thus, this platform cuts across demographic boundaries and can reach traditionally underserved populations (e.g., <10% of Black or Hispanic individuals utilize mental health services, and <23% of individuals with low incomes; SAMHSA, 2015). Such high rates of technology use provide for the widespread dissemination of interventions. Indeed, smartphones serve as an access point for health conditions for as many as 62% of owners (Pew Research Center, 2015b). Currently, a plethora of mobile apps exist for mental health issues. A search of "mental health app" on iTunes yielded 100 apps for users of Apple devices (e.g., Optimism, Mindshift, Recovery Record), and a search on Google Play yielded 248 apps for users of Android devices (e.g., Talkspace, PTSD Coach, SAM). The number of apps increases considerably when one expands the search parameters to mental health related behaviors such as sleep, stress, and relaxation.

Yet there is a lack of evidence or rigorous evaluations for these apps. Existing reviews on mental health apps specifically and mHealth more generally have addressed important topics including current trends in the use of mobile technology in clinical psychology (Clough & Casey, 2015; Torous & Powell, 2015), features of mental health apps for specific clinical problems (Luxton, June, & Chalker, 2015; Juarascio, Manasse, Goldstein, Forman, & Butryn, 2014; Nicholas, Larsen, Proudfoot, & Christensen, 2015), ethical challenges of using mobile technology in clinical practice (Prentice & Dobson, 2014), the need for new research designs and analytic methods for evaluating mHealth interventions (Kumar et al., 2013), and the need for alternative criteria for certification and reviewing of apps (Powell, Landman, & Bates, 2014), but what is lacking is the empirical evaluation of the efficacy or effectiveness of apps. There is increasing proliferation and consumer adoption of apps without equal attention to their efficacy, and there has not yet been a review that examines the evidence for the effectiveness of mental health mobile apps across diagnostic categories based on treatment outcome studies. Indeed, Mohr and colleagues (2010) conducted an early review of behavioral intervention technologies and concluded that "mobile technologies have received limited attention for mental health outcomes" (p. 332). Thus, the current review examined the following questions: (a) What is the current empirical basis for different mobile apps for treating different mental health problems?; (b) Are there evidence-based apps?; (c) What are common features of apps that are efficacious or that show promising results?; (d) What are some methodological concerns among treatment outcome studies involving mental health apps?; and (e) What are the implications of such findings for practitioners?

Method

Study Selection

A literature search was conducted using PsycINFO with the following terms in the subject parameter: "mobile tech*" OR "mobile app*" OR "smartphone" OR "mHealth" or "mobile" OR "application" OR "digital assistant*" OR "text messaging" OR "SMS" OR "ecological momentary"[1] OR "sensor technology" AND "psychotherapy" OR "treatment" OR "therapy" OR "mental health service*"OR "intervention" OR "clinical trial" OR "RCT."[2] Further specifications included articles that were peer-reviewed and in the English language. The search was not limited to clinical samples because apps are often not marketed for clinical populations and are widely available for anyone to download. Articles were reviewed at the title and abstract level and were excluded if a study (a) involved individuals under the age of 18; (b) did not include an intervention; (c) solely targeted physical and/or medical conditions in the intervention (e.g., medical adherence for a medical illness, weight management); (d) did not include mobile technology; (e) used mobile technology solely to increase attendance or engagement; (f) used mobile technology to enhance communication and practice adherence among providers; or (g) involved an intervention in speech/language, hearing, academic, or physical therapy.

[1] Here, *ecological momentary* refers to both ecological momentary assessments, where participants repeatedly provide self-monitoring data and ecological momentary interventions, where interventions are provided to individuals in real time.

[2] The Boolean operator "and" between search terms yields results that contain all search terms. The Boolean operator "or" between search terms yields results that contain at least one of the terms. The asterisk yields results based on variations in the ending of the word. For example, "tech*" will yield "tech," "technology," "technological," etc.

This approach resulted in 227 articles, including 23 reviews and meta-analyses.

These articles were then examined for inclusion in the current review. Because the primary aim was to evaluate the evidence of efficacy or effectiveness of mobile apps for psychological treatments, articles were further excluded if (a) no outcome data were reported ($k = 72$); (b) outcomes were limited to feasibility or user acceptability, satisfaction, and utilization ($k = 27$); (c) outcomes focused on professional and ethical issues related to mHealth ($k = 9$); (d) the use of mobile technology was for electronic momentary assessments ($k = 20$); (e) the use of mobile technology was solely to access the Internet ($k = 6$); (f) the use of mobile technology was limited to texting, short message services, or phone calls ($k = 37$); and (g) the intervention involved were not smartphone-based or app-based (e.g., wearable devices, podcasts, $k = 10$). Finally, three articles were excluded because they were case studies. The reference lists of articles were also examined for relevant literature. One additional article was identified from references. This approach resulted in 21 articles for the present review.

The initial search also yielded 23 reviews and meta-analyses. Four of these articles reviewed mobile apps as interventions for a clinical problem (i.e., Donker et al., 2013; Juarascio et al., 2015; Lindhiem, Bennett, Rosen, & Silk, 2015; Quanbeck, Chih, Isham, & Gustafson, 2014). Others focused on risks, costs and benefits, gaps in mHealth research, nonclinical health problems, and/or texting or computer Web-based interventions. No additional articles were identified from the four relevant reviews. Juarascio et al.'s (2015) review of mobile apps was purely descriptive and did not include any treatment outcome studies. The other three reviews only included a small number of articles that used mobile apps to target clinical problems in adult samples (i.e., Donker et al., 2013; Lindhiem et al., 2015, and Quanback et al., 2014 each identified three relevant studies). Thus, because 21 articles were included, the current review greatly expanded upon previous reviews. It should be noted that four articles described the same two clinical trials involving SmartQuit (e.g., Bricker et al., 2014; Heffner et al., 2015) and Location-Based Monitoring and Intervention System for Alcohol Use Disorders (LBMI-A; Dulin et al., 2014; Gonzales & Dulin, 2015).

Results

Overview of Studies

The 21 articles included in this review involved a wide range of target populations, including individuals with anxiety-related disorders (Dennis & O'Toole, 2014; Enock et al., 2014; Newman et al., 2014), mood-related disorders (Ahmedani et al., 2015; Burns et al., 2011; Roepke et al., 2015; Watts et al., 2013; Wenze, Armey, & Miller, 2014), posttraumatic stress disorder (Miner et al., 2016; Possemato et al., 2016), schizophrenia (Ben-Zeev et al., 2014), and substance use disorders (Bricker et al., 2014; Carpenter et al., 2015; Dulin et al., 2014; Gamito et al., 2014; Gonzalez & Dulin, 2015; Gustafson et al., 2014; Heffner et al., 2015; Hertzberg et al., 2013; Rizvi, Dimeff, Skutch, Carroll, & Linehan, 2011; Witkiewitz et al., 2014). Sample sizes varied across studies, ranging from $n = 8$ to $n = 429$. Thirteen studies included samples of predominantly female participants, 16 studies included samples of predominantly White participants, and 16 studies included samples of participants with an average age of 30 to 45 years. Overall, studies are overrepresented by middle-aged White females, although there are samples that were majority males and of older age groups (e.g., Ahmedani et al., 2015; Carpenter et al., 2015).

Regarding research design, 66.7% of studies used random assignment or included a comparison group, and 33.3% were single group trials (see Table 1). Studies that involved randomization typically compared the proposed mobile app intervention to an active treatment group and sometimes included a waitlist control group (see Table 2 for a list of apps reviewed). The majority of studies provided the participants with monetary compensation. Specifically, a third of all studies incentivized the use of the mobile app (e.g., Carpenter et al., 2015; Dulin et al., 2014; Gonzalez & Dulin, 2015; Hertzberg et al., 2013; Rizvi et al., 2011; Wenze et al., 2014; Witkiewitz et al., 2014), whereas another third included incentives for the completion of baseline and follow-up assessments (Ahmedani et al., 2015; Ben-Zeev et al., 2014; Bricker et al., 2014; Burns et al., 2011; Heffner et al., 2015; Miner et al., 2016; Possemato et al., 2016).

Evidence of Efficacy or Effectiveness

The main findings and descriptions for each intervention are presented in Table 1. Studies with mobile apps that targeted anxiety symptoms generally demonstrated positive outcomes. Two studies involved serious games (i.e., games that are intended for educational purposes and/or to help achieve a determined goal beyond pure entertainment; Michael & Chen, 2006) to modify attention bias for anxiety. Both studies (Dennis & O'Toole, 2014; Enock et al., 2014) found that attention bias modification training via mobile apps was associated with a significant reduction in anxiety relative to control groups (placebo training in Dennis & O'Toole, 2014, and waitlist control in Enock et al., 2014). Newman and colleagues (2014) found that the addition of an app intervention to six sessions of group cognitive–behavioral therapy (CBT) was associated with significantly greater reduction in anxiety symptoms relative to a six-session standalone group therapy, as well as comparable results to 12 sessions of standalone group therapy at posttreatment.

Studies that targeted mood disorders involved a range of mobile apps and similarly demonstrated promising findings. Four of the five studies targeted unipolar depression, and one targeted bipolar depression (Wenze et al., 2014). All studies found a significant reduction in depressive symptoms from pre- to posttreatment irrespective of the length of treatment using a variety of mobile apps (Ahmedani et al., 2015; Burns et al., 2011; Roepke et al., 2015; Watts et al., 2013; Wenze et al., 2014). Some studies also found a significant reduction in comorbid symptoms and level of disability (Burns et al., 2011; Watts et al., 2013), whereas others did not (Ahmedani et al., 2015; Wenze et al., 2014). Overall, across studies, improvements appeared to be significantly greater than waitlist control conditions but generally equivalent to other active treatment conditions (e.g., General SuperBetter in Roepke et al., 2015).

Two studies targeted posttraumatic stress symptoms using the mobile app PTSD Coach. Miner and colleagues (2016) compared PTSD Coach to a waitlist control, and Possemato and colleagues (2016) compared a self-managed mobile app group to a clinician-supported mobile app group. Both studies found a significant

Table 1
Description of Study and Intervention Characteristics

Author & app name	Target population	Comparison/control group	Theoretical basis	App features	Main findings
Dennis & O'Toole (2014)	Anxiety (undergraduates)	Y	Cognitive bias/Attention modification	• Standalone app • Serious Game	1. Short attention-bias training showed significantly reduced anxiety and stress reactivity relative to short and long placebo training, long attention-bias training 2. Long attention-bias training showed significantly reduced threat bias relative to long placebo training and short attention-bias training
Enock et al. (2014)	Social Anxiety	Y	Cognitive bias/Attention modification	• Standalone app • Serious Game	1. Both attention-bias training and control training participants had significantly greater symptom reduction from pre- to posttraining than waitlist on social anxiety, worry, and depression 2. Symptom declines in attention-bias training and control training did not differ significantly on social anxiety, worry, and depression 3. Attention-bias group had significant decrease in bias score from pre- to post-training, control group did not
Newman et al. (2014) "The Stress Manager"	Generalized Anxiety Disorder	Y	CBT	• Adjunct • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Positive reinforcement contingent on user response	1. Posttreatment: 6-session mobile group > session no mobile, but not significantly different from 12-session no mobile group on anxiety symptoms 2. 6- and 12-month follow-up: 6-session mobile group did not significantly differ from 6- or 12-session no mobile groups 3. % individuals with reliable change on 2/3 anxiety measures favored 6-session mobile group over 6-session no mobile group at each time point, and 12-session no mobile group at posttreatment and 12 month follow-up
Ahmedani et al. (2015)	Depression	N	CBT & motivational interviewing	• Standalone app • Psychoeducation; • Testimonials; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Positive reinforcement contingent on user response	1. Significant reduction in mean depression score at 2 weeks follow-up 2. No significant reduction in disability score
Burns et al. (2011) "Mobilyze!"	Depression	N	Behavioral	• Adjunct • Symptom monitoring; • Recommends therapeutic skills contingent on user response; • Context Sensing	1. Significant reduction in depressive symptoms 2. Less likely to meet criteria for major depressive disorder 3. Significant reduction in comorbid anxiety symptoms

Table 1 (*continued*)

Author & app name	Target population	Comparison/control group	Theoretical basis	App features	Main findings
Roepke et al. (2015) "SuperBetter"	Depression	Y	CBT	• Standalone app • Serious Game; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Positive reinforcement contingent on user response; • Enlist social support	1. Greater reduction in depression in both SB groups than waitlist at posttest and follow-up 2. SB with CBT did not perform better than General SB
Watts et al. (2013) "The Get Happy Program"	Depression	Y	CBT	• Standalone app • Psychoeducation; • Testimonial; • Menu of therapeutic skills	1. Posttest: Both mobile and computer groups had significant reductions in depressive symptoms, # days lost from work, # days underproductive at work 2. No significant difference between mobile and computer groups
Wenze et al. (2014) "IABD"	Bipolar Spectrum Disorders	N	CBT	• Adjunct • Psychoeducation; • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Enlist social support	1. Significant reduction in depression scores 2. No significant change in mania scores
Miner et al. (2016) "PTSD Coach"	PTSD (Community)	Y	CBT	• Standalone app • Psychoeducation; • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Enlist social support	1. Post-test: PTSD Coach group had significant improvement in PTSD symptoms, waitlist did not 2. Follow-up: PTSD Coach and waitlist both had significant reduction in PTSD symptoms
Possemato et al. (2015) "PTSD Coach"	PTSD	Y	CBT	• Standalone app • Psychoeducation; • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Enlist social support	1. Both self-managed and clinician-supported groups showed significant reduction in PTSD symptoms at post-treatment 2. No significant difference in improvements across groups
Ben-Zeev et al. (2014) "FOCUS"	Schizophrenia/ Schizoaffective Disorder	N	CBT	• Adjunct • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response	1. Significant reduction in positive psychotic symptoms, depression, general psychopathology 2. No significant change in negative psychotic symptoms
Dulin et al. (2014) "LMBI-A"	Substance Use: Alcohol	N	CBT	• Standalone app • Psychoeducation; • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Context sensing	1. Significant reduction in % heavy drinking days, # of drinks per day, drinks per drinking day

(*table continues*)

Table 1 (*continued*)

Author & app name	Target population	Comparison/control group	Theoretical basis	App features	Main findings
Gamito et al. (2014)	Substance use: Alcohol	Y	Cognitive rehabilitation	• Adjunct • Serious Game	1. Significant increase in general cognitive abilities, mental flexibility, psychomotor processing speed, attentional ability from baseline to follow-up in both experimental and TAU 2. Significant improvement in frontal lobe functions in experimental and not in TAU
Gonzalez & Dulin (2015) "LBMI-A"	Substance use: Alcohol	Y	CBT	• Standalone app • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Context sensing	1. Significant increase in % abstinence across 6 weeks in LBMI-A and not DCU + bib 2. Both groups had significant reduction in % heavy drinking days and drinks per week
Gustafson et al. (2014) "A-CHESS"	Substance use: Alcohol	Y	Self-determination theory	• Standalone app • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Enlist social support; • Context sensing	1. A-CHESS group had significantly fewer risky drinking days than control at post-test and follow-up 2. Odds of abstinence was greater for A-CHESS than control
Witkiewitz et al. (2014) "BASICS-Mobile"	Substance use: Alcohol and smoking (undergraduate)	Y	Motivational interviewing & mindfulness	• Standalone app • Psychoeducation; • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response	1. Both mobile groups had significant reductions in # cigarettes compared to minimal assessment at follow-up 2. More module used in mobile intervention was associated with lower likelihood of any drinking during 14-day period and significant reduction in smoking at follow-up 3. Mobile intervention did not result in significant reduction in heavy episodic drinking or concurrent smoking/drinking
Bricker et al. (2014) "SmartQuit"	Substance use: Smoking	Y	ACT	• Standalone app • Testimonial; • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Enlist social support; • Positive reinforcement contingent on user response	1. Significant difference in quit rate between SmartQuit and QuitGuide 2. 2-month follow-up: SmartQuit had significant increase in acceptance of cravings and higher acceptance is associated with abstinence at follow-up
Carpenter et al. (2015)	Substance use: Smoking (homeless veterans)	N	Behavioral	• Adjunct • Symptom monitoring; • Positive reinforcement contingent on user response;	1. Significant abstinence

Table 1 (*continued*)

Author & app name	Target population	Comparison/control group	Theoretical basis	App features	Main findings
Heffner et al. (2015) "SmartQuit"	Substance use: Smoking	Y	ACT	• Standalone app • Testimonial; • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Enlist social support; • Positive reinforcement contingent on user response	1. Viewing quit plan, tracking practice of letting urges pass, and tracking ACT skills practice significantly associated with quitting 2. Tracking smoking associated with lower likelihood of quitting at follow-up
Hertzberg et al. (2013)	Substance use: Smoking (w/PTSD)	Y	Behavioral	• Adjunct • Symptom monitoring; • Positive reinforcement contingent on user response	1. Higher quit rates in mCM than controls at 4 weeks 2. Higher quit rates in mCM than controls at 3-month follow-up
Rizvi et al. (2011) "DBT Coach"	Substance use: (w/borderline personality disorder)	N	DBT	• Adjunct • Psychoeducation; • Symptom monitoring; • Menu of therapeutic skills; • Recommends therapeutic skills contingent on user response; • Enlist social support	1. Significant reduction in emotional intensity and urges to use substances 2. Significant decrease in depression and general distress 3. Increased confidence in ability to use skill when needed

Note. ACT = Acceptance and Commitment Therapy; A-CHESS = Addiction- Comprehensive Health Enhancement Support System; BASICS = The Brief Alcohol Screening and Intervention for College Students; CBT = cognitive-behavioral therapy; DBT = dialectic behavior therapy; DCU + bib = drinker's check up plus bibliotherapy; IABD = improving adherence in bipolar disorder; LBMI-A = location-based monitoring and intervention system for alcohol use disorders; mCM = mobile contingency management; PTSD = posttraumatic stress disorder; SB = SuperBetter application; Y = yes; N = no; TAU = treatment as usual.

Table 2
Apps Included in the Review

App	Study
Attention bias modification training (ABMT)	Dennis & O'Toole (2014)
Cognitive bias modification of attention (CMB-A)	Enock et al. (2014)
The Stress Manager	Newman et al. (2014)
Mobilyze!	Burns et al. (2011)
SuperBetter	Roepke et al. (2015)
The Get Happy Program	Watts et al. (2013)
Improving Adherence in Bipolar Disorder (IABD)	Wenze et al. (2014)
PTSD Coach	Miner et al. (2016); Possemato et al. (2015)
FOCUS	Ben-Zeev et al. (2014)
Location-Based Monitoring and Intervention System for Alcohol Use Disorders (LMBI-A)	Dulin et al. (2014); Gonzalez & Dulin (2015)
Addiction- Comprehensive Health Enhancement Support System (A-CHESS)	Gustafson et al. (2014)
BASICS-Mobile	Witkiewitz et al. (2014)
The Brief Alcohol Screening and Intervention for College Students	
SmartQuit	Bricker et al. (2014); Heffner et al. (2015)
mCM	Carpenter et al. (2015); Hertzberg et al. (2013)
DBT Coach	Rizvi et al. (2011)

Note. BASICS = The Brief Alcohol Screening and Intervention for College Students; mCM = mobile contingency management; DBT = dialectic behavior therapy. Ahmedani et al. (2015) and Gamito et al. (2014)'s studies did not report the name of the mobile app used in their studies.

reduction in posttraumatic stress symptoms at posttest in the (self-managed) mobile app group with moderate effects. In Miner et al.'s (2016) study, participants in the waitlist condition did not evidence change at posttest, although they showed a significant reduction in symptomatology at follow-up. In Possemato et al.'s (2016) study, the self-managed and clinician-supported use of a mobile app were related to comparable improvements.

The single study that addressed schizophrenia or schizoaffective disorders found promising outcomes with the use of a mobile app intervention. The FOCUS app involves daily interactive assessments (e.g., severity of auditory hallucinations) and CBT-based interventions (e.g., strategies to manage hallucinations such as listening to music on headphones) as well as anytime access to resources and suggested coping strategies from a menu (Ben-Zeev et al., 2014). Ben-Zeev and colleagues (2014) found significant reductions in positive psychotic symptoms, depression, and general psychopathology at posttest, although there were no changes in negative psychotic symptoms.

The majority of treatment outcome studies involving mobile apps focused on substance use. Regarding alcohol use disorders, studies generally report positive results at posttreatment (e.g., within 1–2 weeks after intervention). For example, Dulin and colleagues found that the use of a mobile intervention, LBMI-A was associated with significant improvement in a number of indices of drinking behavior (e.g., number of drinks per day, percent of heavy drinking days, percent of abstinence; Dulin et al., 2014; Gonzalez & Dulin, 2015). Other mobile app systems also yielded significant reductions in drinking (Gustafson et al., 2014; Witkiewitz et al., 2014), although nonsignificant results were also evident. For example, Witkiewitz et al. (2014) did not find changes associated with heavy episodic drinking or concurrent drinking and smoking with the use of a mobile intervention (Witkiewitz et al., 2014). Gamito and colleagues (2014) focused on different outcomes and used serious games to promote cognitive rehabilitation among individuals with alcohol use disorders. They found significant improvement in cognitive abilities, particularly those associated with frontal lobe functions, via mobile app training.

The remaining studies on substance use targeted tobacco use and demonstrated positive results. In two studies, the mobile app SmartQuit (i.e., an app based on acceptance and commitment therapy for smoking cessation) yielded a significantly higher quit rate and acceptance of cravings, which was significantly associated with successful quitting (Bricker et al., 2014; Heffner et al., 2015). Hertzberg and colleagues used a mobile contingency management approach and found that participants demonstrated significant abstinence (above 50%), which was maintained at follow-up (Carpenter at al., 2015; Hertzberg et al., 2013). Witkiewitz et al. (2014) using a different mobile system found that participants showed a significant reduction in the number of cigarettes used. They also found that more module use in the app was associated with significant reduction in smoking. Rizvi and colleagues (2011) examined the effect of a mobile app on substance use within the context of in-person dialectical behavior therapy for individuals with borderline personality disorders. They found that the use of the app was related to significant reduction in urges to use substances as well as other emotional symptoms.

Overall, it appears that treatment outcome studies with mobile apps had positive findings indicating that the use of mental health apps can lead to significant reductions in primary symptoms. Effect sizes were generally in the moderate to large range and were clinically meaningful. However, none of these results have been replicated by independent research teams, and most studies were conducted by the same research team that developed the app under investigation. Many lacked a comparison group (42.9%), making it difficult to draw conclusions about effectiveness above and beyond the passage of time. Studies have included a range of mobile apps targeting a variety of clinical problems. Few independent studies examined the same mobile app for the same target population. The exceptions were two studies (Miner et al., 2016; Possemato et al., 2016) examining the use of PTSD Coach for posttraumatic symptoms, albeit in different populations (i.e., community sample of trauma survivors vs. veterans). Thus, the literature remains preliminary, and there is insufficient evidence to determine which mobile apps are empirically supported. Drawing

on American Psychological Association Division 12's guidelines (APA Presidential Task Force on Evidence-Based Practice, 2006) for establishing efficacy, it appears that none of the mobile apps reviewed would meet criteria for probably efficacious or well-established status, primarily because of insufficient number of studies by independent research teams.

Although empirical evidence may be lacking at present, most mobile apps appeared to have a strong theoretical basis and were extensions of empirically supported treatments to a new platform (e.g., CBT for depression adapted to a mobile app). As seen in Table 1, although all apps were informed by theory, the majority (57.1%) of mobile apps were based on CBT and its variants (e.g., acceptance and commitment therapy). Another 14.3% of mobile apps were based solely on behavioral principles (e.g., contingency management, behavioral activation). Thus, the current state of the literature is encouraging, although more research is needed.

Common Features of Mobile Apps

A summary of mobile app names, functions, and features is also presented in Table 1. A total of 18 mobile apps were represented across the 21 studies. There was roughly an equal number of apps designed as an independent intervention in place of face-to-face therapy (55.6%) and as those designed as an adjunct to traditional therapy (44.4%). The most common features across apps were symptom monitoring (66.7%) and offering a menu of therapeutic skills (61.1%). For many of these apps, monitoring was prompted by the app at specified times throughout the day, most typically once during morning, afternoon, and evening. Some apps also summarized the monitoring data and provided visual feedback to the user for progress monitoring. The majority of apps also included a selection of therapeutic skills (primarily CBT skills) that can be accessed at any time. Sample skills included cognitive restructuring, relaxation techniques, drink refusal skills, and scheduling pleasurable activities, among others. Such apps were also interactive and recommended relevant therapeutic skills to users contingent on their responses to self-assessments. For example, in The Stress Manager app for generalized anxiety disorder (Newman et al., 2014), if users rated high levels of anxiety, the app recommended practicing progressive muscle relaxation, diaphragmatic breathing, or pleasant imagery in response. Similarly, in PTSD Coach (Miner et al., 2016), if users rated high levels of distress, the app recommended relaxation skills, grounding, and stress inoculation training or connected users to a crisis hotline. Some apps even provided guidance on implementing the skills. For example, The Stress Manager encouraged users to examine evidence about a catastrophic thought, raised questions of probability estimation and logical errors, and provided examples of ways to challenge the relevant logic error (Newman et al., 2014).

Other common features across apps included psychoeducation (38.9%), enlisting social support (33.3%), and offering positive reinforcement (38.9%). Many apps offered psychoeducation on the disorder including symptomology, causes, prevalence, risk-factors or triggers, and treatment options. Several apps provided the options to enlist social support, either via the user's own personal contacts saved on the phone (e.g., PTSD Coach, A-CHESS), via social media by sharing progress on Twitter or Facebook (e.g., SmartQuit), or by directly contacting a therapist in cases where the app was used as an adjunct (e.g., DBT Coach, IABD). Others offered positive reinforcement such as earning "badges" for progress made in smoking cessation in the SmartQuit app (Bricker et al., 2014; Heffner et al., 2015) or earning points and "leveling up" for progress through therapeutic activities in the SuperBetter app (Roepke et al., 2015).

Less common features across apps included serious games (22.2%), testimonials (16.7%), and context sensing (16.7%). Mobile apps with serious games or a game platform typically targeted cognitive processes (i.e., attention bias modification: Dennis & O'Toole, 2014; Enock et al., 2014; cognitive rehabilitation: Gamito et al., 2014). A few apps included testimonials from individuals who had recovered from the same disorder and noted the resulting positive changes in their lives from being symptom free as a way to enhance motivation for users (e.g., Ahmedani et al., 2015; Bricker et al., 2014). Finally, some apps incorporated context sensing (e.g., A-CHESS, LBMI-A, Mobilyze!) such as using GPS data and providing interventions in response. For example, LBMI-A and A-CHESS used GPS data and provided prompts to users when they were in high-risk locations for substance use and offered suggestions for maintaining control (Dulin et al., 2014; Gonzalez & Dulin, 2015; Gustafson et al., 2014).

Discussion

The findings of this review suggest that there is presently insufficient empirical support for any one particular mental health mobile app. Although almost all studies reported mental health app use being associated with significant reductions in symptoms, few of the results have been replicated, and some of these improvements did not differ significantly from placebo conditions (e.g., Roepke et al., 2015). Virtually no studies in this review examined the same mobile app for the same target population or for the same clinical problem. Without independent investigations and replicated data, the evidence of the efficacy or effectiveness of apps is not yet sufficiently supported. Furthermore, every app included in this review focused on a specific diagnostic category rather than on symptoms that may be transdiagnostic. Not only is there insufficient empirical evidence for mental health apps, it is also unknown if there are iatrogenic effects from the use of such apps. In fact, Witkiewitz et al. (2014) found that a sizable portion of participants (13.3%) in the mobile intervention condition reported increased urges to smoke or drink, although they nonetheless reported comparable reductions in their substance use relative to other participants. The authors attributed this effect to possible reactivity to frequent assessment by the app. This finding parallels a few other reports of possible detrimental effects of mental health apps. For example, Gajecki et al. (2014) found that men who used the Promillekoll app significantly increased the frequency of alcohol consumption relative to a control group, possibly due to reliance on the app to reduce the negative effects of drinking afterward. Nicholas and colleagues (2015) identified two apps for bipolar disorder that contained incorrect and arguably harmful information (e.g., that the disorder is contagious and recommending the use of alcohol as a strategy to manage a manic episode). Apps for medical purposes have highlighted the potential for malfunction, including erroneous calculation of "disease activity" scores (Phillips, 2011) and misdiagnosis of melanoma as benign based on automated algorithms (Wolf et al., 2013). Such misinformation and malfunctions could extend to mental health apps, especially those that use

sensory data and algorithms to predict user's states and needs. Further complicating the use of mental health apps are risks associated with privacy and confidentiality, particularly if the apps involve location monitoring. Most of the studies included in the review did not report how they addressed this issue through the use of apps. Thus, given the preliminary nature of the current results, practitioners should exercise caution when recommending mental health apps to clients and/or adopting apps as an adjunct to psychotherapy. Caution appears most warranted for apps designed to be used independently in place of traditional therapy (e.g., PTSD Coach, SmartQuit).

Furthermore, the literature has significant methodological concerns that complicate conclusions regarding the efficacy or effectiveness of existing mobile apps. For example, many of the studies did not include a control or comparison group (42.9%). Positive findings from such studies cannot be disentangled from spontaneous recovery with the passage of time or nonspecific factors such as positive expectancy or a sense of support. Among studies that involved randomization, some found comparable results between the mobile app treatment group and the control/placebo group (e.g., Enock et al., 2014; Roepke et al., 2015; Witkiewitz et al., 2014), raising questions about the efficacy and utility of the mobile apps. Participants across studies were also predominately early to middle adult-aged White women. It remains unknown how these apps function for individuals of other demographic profiles. If one of the promises of mHealth is to increase access to underserved populations, this promise may not be borne out. However, it is also possible that such populations are simply not involved in research but are in fact using these apps, suggesting the need to improve engagement strategies to include other demographic groups in research. Additional methodological concerns include heterogeneous outcome measures even for the same clinical problems, a lack of differentiation between primary versus secondary outcome measures (and outcomes were not always positive for supposed primary measures; e.g., Wenze et al., 2014; Witkiewitz et al., 2014), and minimal evidence for sustained improvements at follow-up (e.g., Bricker et al., 2014; Hertzberg et al., 2013). Perhaps more concerning was the use of incentives and the high level of attrition in the studies. A third of the studies included incentives contingent on the use of the mobile app, thereby increasing adherence and motivation. The use of incentives greatly limits the generalizability of findings to actual consumers of the app where utilization will not be encouraged by monetary compensation and may therefore result in fewer benefits. Furthermore, there was significant attrition beyond the point of randomization across studies. Over half of the studies had attrition rates between 20% to 35% (e.g., Carpenter et al., 2015; Enock et al., 2014; Heffner et al., 2015). Although studies typically conducted intent-to-treat analyses or differentiated intent-to treat sample results from completer sample results, such significant dropout rates limit the generalizability of the findings and raise questions about the feasibility and acceptability of the mobile apps studied. It is also unknown if participants dropped out of studies prematurely due to the experience of unintended negative effects of using the apps. Finally, a file drawer effect may be present and should be considered whereby treatment outcome studies of mental health apps that yield null or negative findings remain unpublished, particularly if the researchers also had a financial interest in the app (i.e., were a developer of the app).

Nonetheless, results regarding the effectiveness of mobile apps for mental health issues are promising. Although empirical evidence is preliminary, most apps were extensions of empirically supported treatments to a mobile platform. There were roughly equal numbers of apps designed to be used independently versus as an adjunct to face-to-face therapy. A number of features were common across apps, particularly features adhering to CBT principles. The majority of apps included symptom monitoring and information regarding how to implement therapeutic skills relevant to the symptomology (e.g., drink refusal skills for alcohol use; engaging in pleasurable activities for depression). To a lesser extent, mobile apps also included psychoeducation, enlisting social support, and contingent positive reinforcement.

Gaps and Future Directions

The current review only included treatment outcome studies involving mobile apps that primarily targeted a mental health issue. Studies focusing on other factors such as feasibility, acceptability, utilization, cost effectiveness, and legal/ethical issues were excluded. Efficacy and effectiveness are only a piece of the larger puzzle, and understanding these other factors is necessary to fully inform the promotion and adoption of mental health apps. As the literature on mobile app use in psychotherapy is still in its infancy, many questions are left unanswered and warrant future investigation. First, research on the efficacy and effectiveness of mobile apps should continue. The research base on these apps lags far behind the proliferation and utilization of such apps by the public. Indeed, many apps that are commercially available for mental health problems are understudied or unstudied (e.g., Lantern, Optimism, Talkspace, SAM, IntelliCare). Efforts should be made to conduct research by independent research teams beyond those that were directly involved in developing the app under investigation, given the allegiance effect (Luborsky et al., 1999) and the potential for financial conflicts of interest if developers/researchers profit from the app (e.g., fee for download or from advertisement). It is also unknown at present whether some apps work better for some types of problems than others because no study has compared the same mobile app for different clinical problems. Furthermore, few studies compare different apps addressing the same clinical problem to evaluate relative efficacy. However, given that most apps draw on CBT, and CBT is efficacious for a range of disorders, it is conceivable that a transdiagnostic CBT app may exist or may be developed to target a wide range of disorders. In most cases, studies also do not directly compare the use of mobile apps to face-to-face therapy; thus, we do not know whether apps are best used by themselves, in conjunction with traditional therapy, or both.

It also remains unclear whether mobile apps add value to traditional therapy or treatment as usual. Indeed, a study that compared the mobile app treatment to treatment as usual for cognitive rehabilitation among individuals with alcohol dependence did not find significantly greater benefits for the mobile app, suggesting a lack of added value (Gamito et al., 2014). In contrast, Newman and colleagues (2014) found that participants achieved comparable improvements in generalized anxiety disorder symptoms to traditional group therapy (12 sessions) with the addition of a mobile app intervention in half the time (six sessions). Future research may also address demographic differences (e.g., age, generation/

cohort, ethnicity, being tech savvy) in the utilization of mental health apps and/or specific features of apps (e.g., enlisting social support) or treatment by aptitude interaction effects where particular users (e.g., younger and tech savvy) may benefit most from, or continue to use, mental health apps. Finally, a question remains as to how to best evaluate efficacy or effectiveness of mental health apps. Should the same criteria for empirically supported treatments apply to this platform, or should there be alternative or additional criteria given increased risks of ethical complications (cf., Luxton et al., 2011)? Although promises about mHealth and mental health apps have been made, they are not yet substantiated by research. More attention and research are warranted.

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