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Smartphone Apps for Psychological Health: A Brief State of the Science Review

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In this brief state of the science review, we provide a synopsis of the literature on psychological health mobile applications (apps) and discuss the impact of mobile technology on psychological health practice. We describe the variety of psychological health app uses from self-management, skills training, and supportive care to symptom tracking and data collection; and we summarize the current evidence for the efficacy and effectiveness of psychological health apps. Finally, we offer some pragmatic suggestions for evaluating psychological health apps for quality and clinical utility.

Keywords: mobile technology, smartphone, apps, state of science, behavioral health

Advances in the evidence base for smartphone apps and other mobile apps to improve psychological health have undergirded their increasing use by patients and clinicians. The benefits of mobile health technologies are numerous. Ideally, they can overcome barriers to accessing care (Prentice & Dobson, 2014), extend health care beyond face-to-face visits (Bush et al., 2017), and effectively supplement medical care (Coulon, Monroe, & West, 2016)—especially for geographically dispersed patients (Poropatich, Lai, McVeigh, & Bashshur, 2013). Moreover, apps offer a potentially cost-cutting complement to conventional care (Cortez, 2013; Luxton, Hansen, & Stanfill, 2014). Clearly, personal technologies are revolutionizing health care and are forcing radical changes in the way providers serve their patients.

Until recently, however, the formal scientific evidence base for mobile psychological health utility and effectiveness has been somewhat scant, especially when compared with the vast number of psychological health apps available on the marketplace today. The purpose of this brief state-of-the-science review is to offer an introductory overview and discussion of the literature on psychological health apps and to discuss the implications of mobile technology for psychological health practice. Our intent is to give a convenient synopsis of the background and issues for providers to consider when confronted with health-related apps in everyday practice. To that end we first will cover broadly the types and purposes of current and emerging mobile apps for psychological health. Next we will summarize findings from recent meta-analyses and reviews. We then will highlight the impact of apps on clinical practice, and will describe common provider concerns about the technology. For the provider faced with too many choices we will offer practical suggestions for evaluating psychological health apps for quality and clinical utility. Finally we will discuss briefly the best practices of psychological health apps in clinical care, including the need for provider education and training and the future impact of apps on care delivery and cost.

Smartphone Usage for Health

Smartphone apps and mobile technology, in general, have become so familiar and profuse in our everyday lives that it is easy to forget how very new they are. These apps and psychological health-specific apps are a relatively recent technological development, with widespread public access beginning in 2008 (Schueller, Munoz, & Mohr, 2013). The dramatic increase in smartphone ownership since then has represented one of the most unprecedented adoptions of a new technology in history. Users of mobile devices worldwide are now numbered in the billions (Pew Research Internet Project, 2017).

The personal smartphone has proved to be a popular vehicle for health self-education and health management (Proudfoot et al., 2010). In a 2015 survey of 934 mobile phone users in the United States, more than half (934) reported having downloaded at least one health-related app. Among those 934 respondents, the most frequently downloaded health apps were to track how much physical activity they were getting (493 of 934 respondents, 52.8%), to track what they ate (445/934, 47.6%), to lose weight (437/934, 46.8%), and to learn exercises (318/934, 34.0%; Krebs & Duncan,

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2015). The majority of mobile phone users in the United States have downloaded at least one health-related application (Krebs & Duncan, 2015) and nearly two thirds of smartphone users have looked up information about health on their phones (Smith, 2015). Estimates from iOS and Android application marketplaces suggest that there are at least 165,000 health applications for mobile devices on the market today (Karlamangla, 2016).

New Developments for Psychological Health Apps

Recent literature appears to emphasize the development of smartphone apps primarily for self-management (Barrio, Ortega, López, & Gual, 2017). Self-management topics are extensive, including weight management and exercise, stress regulation, and posttraumatic stress disorder (PTSD) symptom management, through common therapeutic exercises such as diaphragmatic breathing, meditation, muscle relaxation, mindfulness, and behavioral activation. A recent report from the National Institute of Mental Health (2016) has additionally highlighted recent trends in the development of apps for skills training (e.g., cognitive remediation, focus, attention, coping), illness management and supported care (e.g., provider-patient data exchange, monitoring, education, peer support), passive symptom tracking (e.g., movement patterns, social interactions, vital signs), and for data collection, including data accrual from self-assessments via apps.

Psychological Health Data Collection and Monitoring Through Apps

The multiple features, functions, and capabilities of the latest smartphone devices allow the collection of a broad variety of psychological health-related data. For example, physiological, social, emotional, and behavioral data can be collected, often in real time, with a limited burden on the user/patient (Glenn & Monteith, 2014).

Self-report data (data that require responses from the client, such as electronic self-reporting of symptoms). Self-assessment data collected via smartphone has been shown to be as psychometrically valid and reliable as those collected on paper or by computer, with the smartphone preferred by patients as a collection medium (Bush, Skopp, Smolenski, Crumpton, & Fairall, 2013). In a systematic review of smartphone use to measure physical activity, Bort-Roig, Gilson, Puig-Ribera, Contreras, and Trost (2014) cite examples of self-report data collection by app used to enhance client engagement in treatment through customizable symptom tracking and regular feedback to users.

Performance data (data that require clients to engage in a task to assess, e.g., cognition). A number of studies have reported successful trials of smartphone apps for assessing cognitive function. For example, Brouillette and colleagues (2013) have demonstrated the feasibility, reliability, and validity of a smartphone app for assessing cognitive processing speed. Timmers et al. (2014) have shown that smartphones can be used to assess short-term memory outside a laboratory setting. Zorluoglu, Kamasak, Tavacioglu, and Ozanar (2015) have tested a cognitive screening battery for mobile devices that is able to differentiate individuals in control and dementia groups for executive, visual, memory, attention, and orientation functions.

Phone-based sensor data (data that can be collected from sensors contained within smartphones). The native GPS, accelerometer, and audiovisual components of modern smartphones allow for new ways to measure psychological health. For example, data on changes in daily physical activity collected with smartphone GPS and accelerometer technology have been found to be predictive of mood states before phone users themselves reported changes in mood (Saeb et al., 2015). Ambient noise recorded via smartphone microphones has been collected as a means of measuring activities of daily living (Stucki et al., 2014). Vocal data recorded via smartphone microphone has been shown to detect risk for the onset of depression and other serious mental illnesses (Ben-Zeev, Scherer, Wang, Xie, & Campbell, 2015).

Wearable sensor data (data that can be collected from external wearable sensors communicating with smartphones). Increasingly, smartphone devices are being accessorized with biofeedback devices (Dillon, Kelly, Robertson, & Robertson, 2016) or wearable technologies (Hodgetts, Gallagher, Stow, Ferrier, & O'Brien, 2017). For example, wearable actigraphy devices that connect to smartphones to measure disruptive sleep behavior are emerging (Domingues, 2015). Smartphones also have been used to monitor patients with bipolar disorder via wearable sensors (Puiatti, Mudda, Giordano, & Mayora, 2011).

Data from social media. Given the phenomenal incursion of social media into daily lives, it is perhaps not surprising that there is burgeoning research on social media content and user habits to help identify psychological health issues. Analyses variously have examined the quantity; frequency; patterns of online posts, discourses, and downloads; and smartphone calls and texting, and, in particular, the content of public messages via social media. For example, posts from the Twitter app have been analyzed for suicide risk factors (Jashinsky et al., 2014) and onset of depression (Cavazos-Rehg et al., 2016); even the types of apps downloaded have been proposed as markers for psychopathology (Glenn & Monteith, 2014).

Meta-Analyses and Systematic Reviews

There is no doubt that mobile devices and associated software applications are fast becoming an integral part of health care, if for no other reasons than advantages of access, convenience, and cost. The onus now is on researchers to demonstrate clinical proof of concept, feasibility, utility, efficacy, and effectiveness. Furthermore, research must catch up to the pace of development to show to an acceptable level of scientific evidence that apps add value to monitoring, education, prevention, and treatment in the health system. Recent meta-analyses and systematic reviews of multiple studies of mobile applications for psychological health have started to report clinical benefits. For example, mobile apps have been found to contribute moderate to large effect sizes and significant decreases in depression (Burns et al., 2011; Rizvi, Dimeff, Skutch, Carroll, & Linehan, 2011; Watts et al., 2013), anxiety (Burns et al., 2011; Grassi, Gaggioli, & Riva, 2011), coping (Grassi et al., 2011), and substance misuse (Rizvi et al., 2011).

At the system level, the use of smartphone apps for appointment reminders and calendar management is widespread and has proved advantageous to the efficiency of clinic systems (Guy et al., 2012),

with the potential for cost reductions across a broad range of health care activities (Cortez, 2013). In more direct clinical application, mobile technologies have shown effectiveness as interventions for smoking cessation (Rubhi et al., 2016), eating disorders (Juarascio, Manasse, Goldstein, Forman, & Butryn, 2015) and alcohol use (Fowler, Holt, & Joshi, 2016). Multiple studies have now demonstrated the benefits of mobile applications for illness management and preventative health care (e.g., de Jongh, Gurol-Urganci, Vodopivec-Jamsek, Car, & Atun, 2012), and as psychotherapeutic tools, either as standalone or as an added benefit to existing treatment for depression, bipolar disorders, schizophrenia, and other behavioral health issues (Lindhiem, Bennett, Rosen, & Silk, 2015).

Impact on Providers

The move toward patient-centered care and self-management is placing emphasis on technology as an alternative or complement to in-person clinical encounters (Barrio et al., 2017; Baysari & Westbrook, 2015). The penetration of smartphone apps and other personal multimedia into the health arena increasingly is pushing fundamental changes in practitioner workflow. Quite radical changes are emerging in how clinicians disseminate education to patients, how patients relay information (e.g., self-assessments) to providers, how patients and providers interact between visits, and how patients generally engage in their care (Bakker, Kazantzis, Rickwood, & Rickard, 2016).

Perhaps not surprisingly, the adoption of mobile health applications by providers has generally lagged behind adoption by their patients. A systematic literature review by Gagnon, Ngangue, Payne-Gagnon, & Desmartis (2016) highlighted several key obstacles to provider adoption of mobile health (mHealth), including a lack of awareness of mobile health applications built to support evidence-based treatments, substantial concerns about privacy and safety; and a widespread lack of understanding of the current level of the evidence-base for those tools. The aforementioned National Institute of Mental Health (2016) report identified the following five provider concerns about psychological health apps:

1. Effectiveness: In spite of the growing literature cited earlier, there often is insufficient scientific evidence that specific psychological health apps are effective and that they work as well as conventional methods.

2. Guidance: There are no enterprise-level standards to help providers or their patients know if an app has been shown to be effective. Too often stakeholders rely instead on misleading metrics such as number of downloads or online "star rating" rather than empirical evidence.

3. Privacy: It is critical that providers can assure privacy to their app-using patients. A few developers within the Department of Defense (DoD) and elsewhere apply industry-level standards of encryption to their apps to secure personal data. Unfortunately, this degree of data safeguarding is rare across the current marketplace.

4. Regulation: Conventional psychological health practice is strictly regulated and monitored to protect the welfare of health consumers. The emergence of apps and other mobile technologies is new. Regulatory agencies and standards such as the Food and Drug Administration and the Health Insurance Portability and Accountability Act are scrambling to catch up and keep up.

5. Overselling: There is a tendency in the sometime lucrative world of personal technology toward hyperbole. If an app or program promises more than it delivers, consumers may choose it at the expense of more effective therapies.

Quality of Content and Level of Evidence

In the conventionally sequenced approach to clinical research, considerable test time—typically between 3 and 7 years for medical devices and 12 years for drugs (Fargen et al., 2013)—is taken before a treatment or device is allowed into practice. For example, a new drug is carefully shepherded through phased trials to establish safety and tolerability in healthy volunteers (Phase 1), to determine the drug's efficacy and adverse effects at different dosages in patients (Phase 2), to establish the effectiveness and safety of the drug compared with placebo or current standard treatment (Phase 3), and to determine general risks and benefits after the drug has been licensed (Phase 4; Sedgwick, 2014).

Nearly 20 years ago, Sackett and colleagues published a seminal work proposing a hierarchy of levels of evidence for evidence-based practice, ranging from expert opinion as the lowest quality to systematic review as the highest (Sackett, Straus, Richardson, Rosenberg, & Haynes, 2000). Numerous variations of that hierarchy have since been introduced, but while the number of levels may differ between models, the highest quality of evidence typically encompasses systematic reviews, meta-analyses, or one or more randomized control trials (LoBiondo-Wood & Haber, 2010). The fast pace of app innovation, however, is producing a tension between a need for traditional levels of clinical evidence and the pressure to launch, disseminate, and implement before the product becomes obsolete. There exists a glaring disparity in the relative time it takes to build a mobile app—as little as 18 weeks (Rice, 2013)—versus the 3 to 5 years required to conduct a randomized clinical trial (Anguera, Jordan, Castaneda, Gazzaley, & Areán, 2016). Among the several hundred thousand health-related apps publicly available today, likely only a small minority has received any formal testing at all and very few have undergone randomized controlled trials before release. We know of only a handful of examples of health apps that meet conventional levels of evidence for efficacy or effectiveness, as well as for usability (Coulon et al., 2016).

A major benefit of smartphone apps is that they can be quickly updated in response to emerging evidence and features. This advantage is easily lost if traditional randomized controlled trial standards are applied to each new or updated application. Consequently, there can be an understandable temptation to view an app simply as a technology-based vehicle for delivering content or functions that have already established empirical validity/effectiveness in conventional practice. The therapeutic value of the app may be accepted based on the prior literature on its content. Even though the delivery medium is different, there is little evidence to suggest that delivery modality is important in this context (Bush et al., 2013). Any research on that app might then be confined to

specific questions of mobile adaptation examined in smaller samples (Baker, Gustafson, & Shah, 2014); or to small-scale, iterative, target-audience user experience, feasibility, and acceptance testing during development and early piloting (Moumane, Idri, & Abran, 2016).

We suggest that a psychological health smartphone app might be evaluated minimally by the following criteria, depending very much on the purpose of the app (e.g., educational, self-management, skills training, supportive care, symptom tracking, data collection, or therapeutic intervention).

Potential Criteria for Psychological Health App Quality

1. User experience/human factors tested during design and development, ideally with participants representative of target audience
2. Pilot tested in target environment with target audience showing feasibility and acceptance
3. Currency and accuracy of content and/or efficacy/effectiveness of functionality already well-established in other settings
4. Randomized controlled published trial or quasi-experimental study showing efficacy/effectiveness in target environment with target audience
5. Replication in at least two randomized controlled published trials or quasi-experimental studies showing efficacy/effectiveness in target environment with target audience

At a very minimum, we contend that a psychological health app should not be introduced into a public or clinical setting without adequate user experience testing, some degree of piloting, and already established evidence of effective underlying mechanisms (No. 3). A more aspiration, but perhaps unrealistically choice, would be a psychological health app with formal demonstration of efficacy/effectiveness through experimentation (Nos. 4 and 5). In practice, however, more effortful and time-consuming testing often is addressed after launch and concurrently with use in practice.

Examples in Psychological Health Practice

To illustrate these criteria, we present three examples of popular psychological health apps that exemplify different degrees of evidence base. Each comes from the military or veteran health domains. Mobile device ownership and use by military service members and veterans very much mirrors those of the general population (Bush & Wheeler, 2015). Even many homeless veterans own mobile phones with Internet capability (McInnes et al., 2014). Active duty soldiers enrolled in psychological health care have reported that they prefer to communicate with their providers using their mobile phone and text messages (Stanfill, Kinn, & Bush, 2014). Similarly, there is significant interest among treatment-seeking samples from the Department of Veterans Affairs (VA) health system in utilizing mobile technology for psychological health care and to improve communication with providers (Miller, McInnes, Stolzmann, & Bauer, 2016). The following psychological health apps were developed by the military:

Breathe2Relax. The Breathe2Relax mobile app is a portable stress-management tool developed by the National Center for Telehealth and Technology (T2). The app employs hands-on diaphragmatic breathing exercises. Breathe2Relax is possibly the most popular psychological health app currently in clinical and public use. Lifetime downloads had reached more than 1.26 million, with 53,371 active users and at least 130,000 uses each month (Google Play Developer Console, April, 2017; iTunes App Store, April 2017). Breathe2Relax satisfies two of the five criteria for psychological health app quality listed earlier:

1. Criterion 1: Breathe2Relax underwent rigorous and iterative user experience/human factors testing with active duty military service members throughout design and development.
2. Criterion 2: Breathe2Relax has undergone no direct pilot testing to date.
3. Criterion 3: Breathe2Relax employs previously established evidence-based practices. Breathing exercises have been well-documented over many years to decrease the body's fight-or-flight stress response, and help with mood stabilization, anger control, and anxiety management (Jerath, Crawford, Barnes, & Harden, 2015).
4. Criterion 4: Breathe2Relax has undergone no direct efficacy/effectiveness testing to date.
5. Criterion 5: Breathe2Relax has undergone no direct efficacy/effectiveness testing to date.

Virtual Hope Box. The Virtual Hope Box mobile app, also developed by T2, contains a suite of simple tools to help patients with coping, relaxation, distraction, and positive thinking. Lifetime downloads have reached more than 330,000, with approximately 10,000 active monthly iOS users and 20,000 current Android users, and an average monthly download count exceeding 11,000 over the past 12 months (Google Play Developer Console, October 2017; iTunes App Store, October, 2017). Virtual Hope Box satisfies four of five ad hoc criteria for psychological health app quality:

1. Criterion 1: Virtual Hope Box underwent rigorous and iterative user experience/human factors testing with active duty military service members throughout design and development.
2. Criterion 2: Virtual Hope Box was pilot tested in the target clinical environment with VA behavioral health treatment, high-risk patients, and their clinicians and found to be popular, feasible, and acceptable for clinical use (Bush et al., 2015).
3. Criterion 3: Virtual Hope Box employs previously established evidence-based practices, including identification and affirmation of reasons for living (Bagge, Lamis, Nadorff, &

Osman, 2014); controlled, diaphragmatic-breathing techniques (Jerath et al., 2015); progressive muscle relaxation (Isa, Moy, Razack, Zainuddin, & Zainal, 2013); guided mindfulness meditations (Hoge et al., 2013); distraction activities (Smoski, LaBar, & Steffens, 2014); coping cards (Wright, 2006); and facilitated activity planning (behavioral activation; Soleimani et al., 2015).

4. Criterion 4: A randomized controlled trial of the Virtual Hope Box was conducted with two groups of United States service veterans in active mental health treatment who had recently expressed suicidal ideation. Published results showed that Virtual Hope Box users reported significantly greater ability to cope with unpleasant emotions and thoughts than did control patients (Bush et al., 2017).

5. Criterion 5: Tests of Virtual Hope Box effectiveness have not yet been repeated.

PTSD Coach. The PTSD Coach mobile app was developed by VA's National Center for PTSD to assist veterans and active duty personnel (and civilians) who are experiencing symptoms of PTSD. The app provides education about PTSD, information about professional care, a PTSD self-assessment, and tools that can help users manage the stresses of daily life with PTSD. PTSD Coach has been downloaded more than 290,000 times, with approximately 4,000 monthly downloads over the previous 12 months (Google Play Developer Console, April 2017; iTunes App Store, April 2017). The app satisfies five of five ad hoc criteria for psychological health app quality:

1. Criterion 1: PTSD Coach underwent rigorous and iterative user experience/human factors testing with veterans throughout design and development.

2. Criterion 2: PTSD Coach was pilot tested in the target environment with veterans receiving PTSD treatment. High rates of perceived helpfulness and acceptability were received, with overall results suggesting that the app is appropriate for self-management of PTSD symptoms (Kuhn et al., 2017).

3. Criterion 3: PTSD Coach employs previously established evidence-based practices. The app is built on a foundation of empirically supported CBT principles (Kuehn, 2011), and techniques for education and treatment engagement (Possemato, Kuhn, Johnson, Hoffman, & Brooks, 2017).

4. Criterion 4: PTSD Coach has undergone at least one randomized controlled trial.

5. Criterion 5: Published results from multiple randomized controlled trials and experimental studies have shown that use of PTSD Coach is positively related to improvements in PTSD symptoms (e.g., Kuhn et al., 2017), including primary care settings (Possemato et al., 2016) and community samples (Miner et al., 2016).

Best Practices

Future App Development

In 2016, Bakker and colleagues (2016) offered evidence-based recommendations for the future development of psychological health smartphone apps that encompass much of what we have summarized in this article. They posited that future apps could best prevent psychological health problems and ease the burden on health systems if they: (a) are CBT-based; (b) address both anxiety and low mood; (c) are designed for use by nonclinical populations; (d) include automated tailoring; (e) enable reporting of thoughts, feelings, or behaviors; (f) recommend activities; (g) incorporate psychological health information; (h) allow real-time engagement; (i) link activities explicitly to specific, reported mood problems; (j) encourage nontechnology-based activities; (k) leverage gamification and intrinsic motivation to engage; (l) log past app use; (m) generate reminders to engage; (n) have a simple and intuitive interface and interactions; (o) link crisis support services; and (p) are tested through experimental trials to establish efficacy.

In the current context, we view Bakker and colleagues' (2016) recommendations more as a set of useful considerations for researchers, developers, and practitioners than a list of concrete rules, especially as time passes and new apps emerge. For example, we too would recommend that apps "for therapeutic use" employ well-supported therapeutic methods such as CBT (Bakker et al., 2016, Recommendation 1). The most pervasive therapeutic apps currently could be categorized under a broad umbrella of CBT: behavioral activation, problem solving, dialectic behavior therapy, prolonged exposure therapy, and imagery rehearsal therapy all have been employed through smartphone apps. But we would not exclude less currently widespread, non-CBT approaches should they emerge and show promise. We would urge the reader to apply similar flexibility to other recommendations.

Provider Training

To recommendations about content and functionality, we would add the need for increased training of clinicians through graduate school curricula, certification, and continuing education. Through comprehensive education and training of the core competencies of mobile health in clinical care, providers can gain necessary skills and knowledge necessary to leverage those tools to augment clinical care. Provider training on mobile health core competencies should include how to evaluate the evidence base, clinical aspects of integration (including current benefits/barriers and how to introduce/prescribe/document), security and privacy issues, and ethical considerations. Pilot training programs are already being tested for military and VA providers ("DoD Mobile Health in Clinical Care," 2017).

The application of knowledge translation models to increase and accelerate the integration of research into clinical practice has gained greater attention in the past decade (Sudsawad, 2007). Recently, a joint DoD and VA knowledge translation pilot study entitled "Technology into Care" has been launched to develop and evaluate a provider technology training and implementation program using the DoD/VA Practice-Based Implementation Network. A primary goal of the study is to assist DoD and VA in creating individual technology implementation plans for their practices.

Cross-organizational efforts, such as this, serve to highlight effective, collaborative knowledge translation models.

The Future

The brief state of the science synopsis presented here focuses on psychological health smartphone apps. At this moment, apps on handheld hardware (most often smartphones using operating systems such as Apple iOS or Android) represent the current practice in personal psychological health technology. The near future, however, is moving toward a more platform-agnostic merging of technologies in which the consumer shares even more of their health management with their clinician (i.e., a symbiosis of electronic health records; remote diagnosis; treatment and prescription through telehealth, algorithms, and artificial intelligence; mobile devices; electronic homes; and wearables). Through networked technology, health systems will demand decreased costs and increased efficiencies, and consumers will expect increased convenience, access, and personal control. These advances represent a shift in the traditional delivery of care, and the emerging literature supports the benefits of the integration of mobile health to increase access to care and efficiencies in the delivery of care. The increasing role of mobile health apps to support the efficient delivery of psychological health care places demands on health care providers to remain current on the state of the science regarding these tools, allowing safe and ethical integration to improve delivery of care. Through effective training and awareness, providers can more fully leverage the benefits of these tools to support the delivery of clinical care.

Conclusion

To our knowledge, a formal clinical rating system or clinical practice guidelines for psychological health apps and other networked personal technologies has yet to be established by trusted authorities. In the meanwhile, providers still have to rely on their own evaluation of the literature and the app marketplace, the recommendations of colleagues, and/or the policies of the health systems in which they work. What does a provider do when faced with too many choices and too little evidence? The intent of this article was to help providers with limited knowledge and experience of mobile technologies in psychological health clinical practice to better appreciate the variety of apps becoming available, and to make reasoned judgments about their value, utility, and safety.

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