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PSYCHIATRY IN THE DIGITAL AGE (J SHORE, SECTION EDITOR)

Review of Use and Integration of Mobile Apps Into Psychiatric Treatments

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Abstract
Purpose of Review Mental health practitioners should understand the features of current, publicly available apps; the features of novel, research apps; and issues behind the integration of mobile apps and digital health services into clinical workflows.
Recent Findings The review is based on a research literature and the authors' clinical and healthcare administration experiences. Articles searched—on telepsychiatry, telemental health, mobile mental health, informatics, cellular phone, ambulatory monitoring, telemetry, and algorithms—were restricted to 2016 and 2017. Technologies are used in a variety of clinical settings, including patients with varying mental illness severity, social supports, and technological literacy. Good practices for evaluating apps, understanding user needs, and training and educating users can increase success rates. Ethics and risk management should be considered.
Summary Mobile apps are versatile. Integrating apps into psychiatric treatment requires addressing both patient and clinical workflows, design and usability principles, accessibility, social concerns, and digital health literacy.

Keywords Mental health apps · Smartphone apps · Psychiatric services · Telepsychiatry · Clinical informatics · Ambulatory monitoring

Introduction

Psychiatric treatments have included psychotherapy, pharmacotherapy (the use of medications), surgical procedures, and self-help bibliotherapy. The use of information technologies—which fall under various industry monikers of digital health, e-health (electronic health), mhealth (healthcare on mobile devices), and connected health—is a new form of psychiatric care delivery that can provide elements of psychotherapy and bibliotherapy, coupled with interactive features and new assessment and intervention mechanisms.

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Self-help psychoeducation encompasses—in order of increasing interactivity—books, videos, standalone computer programs, personal digital assistants (PDA's), Internet websites, and mobile apps. The most widely available and accessible tools are mobile apps on portable devices like smartphones and tablets [1, 2]. Mobile apps have a large penetration rate as defined by a higher smartphone prevalence rate in developed countries versus developing countries [3] and have been used in randomized clinical trials with increasing research rigor. And, mobile devices are associated with positive consumer marketing—for instance, fitness trackers can be perceived as desirable and socially acceptable [4], and can even be embedded in wearable jewelry.

The notion of apps for consumer psychiatric care builds upon earlier e-health and e-therapy research studies and products that were previously published on compact disc (CD) media for desktop personal computers (PC). These studies and products then became web-based applications accessible from any web browser [5•]. These products all required users to own desktop or laptop computers—which were not ubiquitous—and had higher electricity requirements. They were also often harder to use compared to modern day smartphones.

Smartphones, in contrast, have more advantages and are much more personal and discreet. In fact, more recent studies show that smartphones have a higher penetration rate than desktop and laptop computers [6]. Despite this, psychiatric patients are less likely to own such devices compared to the general population. For instance, in a study of 100 minority and severely mentally ill (SMI) patients in Georgia, 85% of respondents owned a cell phone, but of these respondents, 37% owned a smartphone. But, primarily because of financial barriers, smartphone ownership among SMI patients is lower than that reflected in Pew Survey data of the US general population (53%), and even lower in low socioeconomic status populations (44%) [7]. Similar accessibility issues also affect veterans: A survey of veterans engaged in outpatient care had high interest in mobile health technologies, where nearly all veterans had a cell phone (97%, $n = 74$) but a minority owned a smartphone (47%) [8].

Age may also play a factor; for instance, a majority of child patients discharged from an inpatient child psychiatric unit in Ontario, Canada, found 66% (50/76) owned a smartphone [9•]. And, even in war-torn territories, there are no general patterns of smartphone ownership. For instance, ownership of smartphones was higher among Palestinians in West Bank, where a high percentage (254, 93.4%) owned a mobile phone. Among such owners, 79.9% had smartphones. Within the same study, ownership rates did not differ among the different settings: refugee camps (91.0%), urban areas (97.6%), and rural areas (91.2%) [10].

We anticipate that smartphone use will continue to increase and smartphone-driven therapies will be more usable and acceptable. In a review of 24 studies on mobile phone for psychotherapy, such interventions were found to have good retention and acceptability, though with limited data on real-world effectiveness [11]. And, ecological momentary assessment (EMA) techniques in apps have been used in many research and consumer-focused apps and are feasible and acceptable for even the most severely mentally ill, such as recently hospitalized patients with psychotic spectrum disorders [12].

Mental health practitioners of all kinds should understand the latest issues that underpin the use and integration of mobile apps in mental health treatments (see Table 1). We will review these concepts based on research literature and our own clinical and healthcare administration experiences. We performed searches in Pubmed using search terms of major research headings—telepsychiatry, telemental health, mobile mental health, informatics, cellular phone, ambulatory monitoring, telemetry, and algorithms—restricted to 2016 and 2017. An

Table 1 Key points towards effective use and integration of apps

Understand app capabilities and features	• Features of current, publicly available mobile apps include psychoeducational materials, audio-visual media, and mood and symptom tracking via ecological momentary assessment. • Features in new, research-grade mobile apps include conversational agents, augmented reality and virtual reality headsets, passive data techniques that tracks one's location and cross-references it with known data for a geographic area, voice and speech analysis, music services, and predictive analytics.
Address workflow issues	• Integrating into psychiatric treatment requires up-front work. Consider clinical workflow, patient's daily routines, and the patient's culture. Evaluate the app from clinical, business, and IT perspectives. • Address both patient and clinical workflows. Employ ethnographies and interviews, and do not use assumptions and stereotypes. Craft on-boarding education materials and habits. When providing to patients, consider using hands-on exercises. • Design an accessible, attractive product and workflow. The app must make a good impression, adopt good usability practices, be responsive, and not incur major delays. Otherwise, the app may frustrate and lead to abandonment.
Cultural and access issues can make or break an app	• Mitigate social concerns, such as avoiding alarms from an alcohol addictions app during embarrassing moments and sensitive social situations like weddings. • Be mindful of technological literacy and access issues. Income, education, age, and telecommunications infrastructure access factors may influence disparities in Internet access.

equivalent search was conducted in Google Scholar. Two hundred fifty-six articles were downloaded for review and a subset of 46 articles were further evaluated for content specific to use, integration, and evaluation of mobile apps.

Features of Current, Publicly Available Mobile Apps

Mobile apps can perform many functions useful for psychiatric care: psychoeducation, communication, context sensing, assessments, and interventions. Numerous features of smartphones are used in research studies today. However, many such apps are not widely commercially available; the converse is true as well, as most commercially available apps do not provide evidence of clinical efficacy, safety, and quality.

The most basic mobile apps are simply *psychoeducational materials* consisting of static text. More sophisticated mobile apps employ embedded *audio-visual media:* video recordings, animation, and audio guidance. Apps can employ interactive features, such as *mood and symptom tracking*—a variant of traditional therapy homework and worksheets—allowing users to select their mood from on-screen sliders, to enter symptoms, to answer questionnaires and surveys, and to visualize trends. The use of such tracking is also known as *ecological momentary assessment* (EMA).

Studies have thus far shown that EMA performance is comparable to recall-based, retrospective pen-and-paper questionnaires. In fact, EMA can enable more temporally granular assessments, allowing the system to track the users' frequency of answering EMA prompts, how long they engage with such prompts during a treatment period, and how timely they answer prompts [13]. EMA's other advantage is that it can also address issues of biased recall and memory distortions, in which participants overestimate intensity and duration of symptoms in retrospective questions or even fail to answer questions at the proper time—either answering ahead of time or catching up [14].

However, EMA has some disadvantages. EMA techniques may collect more data than usual. In one year-long study, 13,811 adult outpatients in a psychiatric clinic were offered an EMA-based app. Two thousand eight hundred thirty-eight active app users reported more thoughts about death, suicidal ideation, and stressful life events than the 10,973 non-active users [15]. EMA also requires good design to engage patients, which can be difficult to accomplish. In another EMA demonstration, 65 patients with psychotic-spectrum disorders used a study-provided smartphone and EMA app. The study found low EMA completion rates of 28 to 31%, with response rates decreasing over time. The authors found that barriers to EMA use include duration of period, lack of feedback to users, technical problems, user displeasure with the smartphone, and displeasure with the need to carry a separate device [12].

EMA's interactivity provides *active data* for the system, a type of data manually entered by the user, such as the number of meals eaten, new medications taken, and narrative journal entries. More advanced apps embed Internet connectivity for *communicating with others*. Communications take the form of peer-supported online forums, messages to and from clinicians and coaches, and submission of messages and feedback to a health system's electronic health record database.

Features of Novel, Research Mobile Apps

Newer mobile apps can use *text messages* driven by computer systems. One such text messaging system uses natural language processing to understand a user's messages and produces responses in the form of text messages from a *conversational agent*, also known as a *chat bot*. In one university study of a commercially available chat bot, bots message users with cognitive behavioral therapy (CBT) self-help content, set goals, follow-up with the user on these goals, and provide motivation. This has found to reduce PHQ-9 and GAD-7 scores significantly versus those of a control group that were instructed to browse an information website. However, the study found that the bot would at times make for repetitive conversations and could not always understand user responses [16].

While such bots are not widely deployed in mental health, bots are already available as commercial virtual assistants in industries like customer support, scheduling, and commerce. And, all-purpose personal assistant bots, such as Google Now and Apple Siri, have basic though incomplete recognition of suicidal messages. When a user says, "I want to commit suicide," both bots offer suicide hotlines as a crisis intervention [17••].

Mobile apps can also encompass *augmented reality* (AR) and *virtual reality* (VR) *headsets*. Such headsets can include immersive audio and a 3D head-mounted display that essentially covers the eyes with computer displays. VR has been the most studied, with the earliest study in mental health published in 1995. VR has more recently become more feasible, affordable, and portable. A 2017 review found that VR has had most evidence in exposure therapy in anxiety disorders, cue exposure therapy for substance use disorders, and for acute pain distraction. There have been multiple shortcomings of VR studies to date, including small sample sizes, low methodological rigor, no controls, and limited research in the therapeutic process of VR [18••].

Future apps will also likely employ *passive data*, which is data generated without explicit input by a user. As of this writing, passive data is still an active area of research and used in few publicly available healthcare apps. One type of passive data is the detection of location, which provides *geographical context sensing* for psychiatric assessments. *Geographical*

momentary assessment (GMA) can use a phone's location-based sensors. These phone sensors can determine how long a user spends in a location; GMA can correlate geo-spatial-temporal sensors with duration and frequency of visits [19]. One study used GMA to observe homestay—an indicator of social disengagement—in persons with baseline higher social anxiety. These persons reported their mood in an app that used GMA to associate mood with location. The study found an association between time spent at home and negative affect [20]. A similar concept, *geographically explicit momentary assessment* (GEMA), uses public data to find out how one's location can be used to determine effects on mood and anxiety. This public data provides statistics for geographical areas: retail stores, pollution levels, crime reports, local economic factors, and other environmental conditions [19].

Apps can, in a research setting, use *voice analysis* and *computer speech analysis* (CSA) to analyze speech patterns. Studies can look at factors such as the length of pauses, duration of utterances, volume or loudness, and dynamics of such loudness. Such factors can be used to compare the changes in one's voice as an indicator of day-to-day stress. Extracting a precise clinical diagnosis from voice recordings has not yet been proven. Instead of a precise diagnosis, some researchers have proposed using voice to act as a cruder biofeedback measure, akin to heart rate [21].

One research paper noted that *music services* could be useful as a digital health intervention. The combination of music streaming services—which allows for immediate selection of music genres, rhythms, and tempos—allows apps to play particular types of music and thereby influence mood. Particular music structures can activate the parasympathetic nervous system, mediate oxytocin and vasopressin, and even reduce depressive symptoms [22].

The ultimate platform, therefore, uses a combination of passive and active data to provide new services such as "early warning systems," as described for bipolar disorder. Such a system uses longitudinal data from sensors that infer behavior, self-reports such as sleep quality, predictive statistical analytic methods, and decision rules, much like that found in credit card fraud monitoring and other non-health early warning systems [23]. Similar predictive systems for depression and PTSD have been performed in a DARPA-funded app using "digital trace data." The app ultimately predicts depressed mood, fatigue, interest in activities, and social connectedness based on variables such as the sum of outgoing calls, number of texts to unique numbers, absolute distance traveled, vocal pitch, and vocal rate [24]. Another model uses individual history to ascertain mood detection, aside from sensor input [25]. Algorithms from machine learning, like Support Vector Machines and Random Forest Classifiers, can take such data and infer behavior from sensors [26].

Integrating Into Psychiatric Treatment

Implementation teams who want to integrate apps into the clinical workflow must consider clinical workflow, the patient's day-to-day life, the patient's culture, and the patient's socioeconomic status. For instance, implementation teams can map a clinic and hospital operations to identify which areas could be optimized with apps and IT platforms. The patient's upbringing may prevent them from being proficient with the use of a mobile phone. And, an unsupportive social environment may even prevent them from desiring to use such a device.

The app itself must be evaluated from clinical, business, and information systems perspectives. Numerous guidelines exist for evaluating apps (see Table 2). The app evaluation pyramid model, published by the American Psychiatric Association, evaluates apps based on an app's business model, developer, privacy, security, evidence base, ease of use, accessibility, and data interoperability [27••]. Researchers from Northwell Health's Feinstein Institute for Medical Research [28], Queensland University of Technology [29–31•], and commercial groups [32] have—within the last year—proposed criteria based on app design such as usability, visual design, and user engagement; app content such as content, therapeutic persuasiveness, therapeutic alliance, credibility; and information technology privacy and security.

Table 2 Summary of criteria

	Authors	Scale	Measures
APA pyramid model [27••]	American Psychiatric Association	Five-step qualitative heuristics	App's business model, developer, privacy, security, evidence base, ease of use, accessibility, and data interoperability
Enlight [28]	Northwell Health's Feinstein Institute for Medical Research	25-item five-point scale questions and 19-item checklists	Usability, visual design, user engagement, content, therapeutic persuasiveness, therapeutic alliance, general subjective evaluation of program's potential, credibility, privacy, basic security
Mobile App Rating Scale (MARS) [29–31•]	Queensland University of Technology	23-item questions, five-point scale	Engagement, functionality, aesthetics, information

To anticipate the success of implementation and the level of patient engagement, the implementation team should interview potential users, identify user needs, and gauge user perceptions of app use. For instance, a qualitative study of a mindfulness app found that users' busy lifestyles and a lack of a scheduled routine made it difficult to use the app [33]. These findings can compel implementation teams to redesign an app, redesign business operations, or even avoid creating unusable products that no one wants to use.

Address Both Patient and Clinical Workflows

When considering any technology, teams may fall into the trap of using assumptions and stereotypes of users and workflows. This contrasts with the harder but more informative ethnographic tasks of learning about work styles, workflow, and processes. These assumptions can be based on preconceived notions, from past experiences, cultural stereotypes, and, as a heuristic, requires very little time to use. One erroneous assumption that is frequently made: a technology's merit is obvious, that its usefulness stands on its own, and is therefore desirable—and that therefore, the technology will be used, adopted, and coveted.

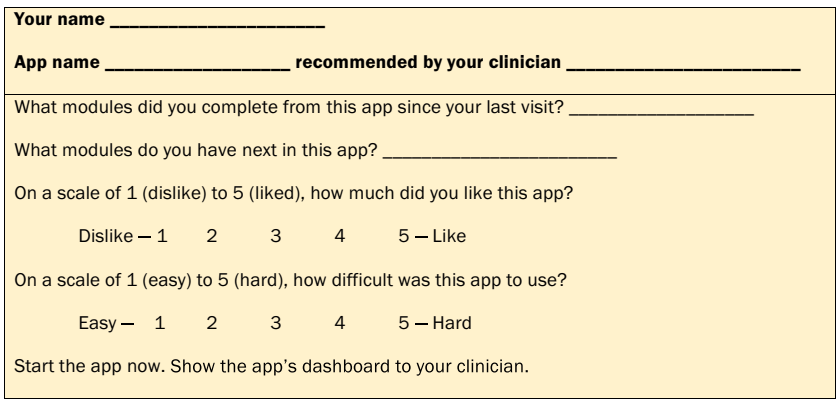
Actual implementation may require implementation teams to consider educating users and incorporating into existing training curricula. One recent paper suggests that including the app in nursing education can ease adoption of the app [34]. Such an implementation can be included in training sessions for providers. Understanding which providers have the time to discuss this with patients is important: In one study, three Federally Qualified Health Centers (FQHCs) serving underserved patients implemented Seva, a smartphone app targeting substance use disorders in the primary care setting. The centers found that behavioral health care providers were able to incorporate the app during appointments, track and view clinical reports of longitudinal data (such as weekly surveys and relapse reports), and discuss the app with patients. These providers contrasted with the physicians, who did not use the app due to a higher patient workload [35]. Thus, clinical time must be devoted to teaching and monitoring the app. The app has to be adopted by providers who are given sufficient clinical time for this process, and the app's communications must be monitored by staff who have time dedicated to this task.

Onboarding patients can help demonstrate proper use of apps and boost patient success rates. Two approaches include *prescribing the app* and *executing in-clinic hands-on exercises*. When *prescribing an app*, a clinician can meet face-to-face with a patient, discussing and assigning particular features of an app for patients to use to meet their needs. With *hands-on exercises*, the clinician may use the app with the patient, providing in-clinic exercises, guiding the patient, and then discussing how the exercise went (see Fig. 1). Performing an onboarding process can help moderate patient expectations, reduce patient anxiety, and help patients overcome fears of failure [34]. Onboarding processes can also accommodate patients who are less confident, proficient, and comfortable with using information technology, particularly patients with psychosis [36].

Onboarding patients can be extended beyond the clinic and as part of inpatient discharge planning, though there is no other known research on smartphone use in inpatient psychiatric units. One study instructed patients to use the Be Safe app, which helps users create suicide safety plans and locate local resources, on discharge from an inpatient child psychiatric hospital in Canada. The app was downloaded by 18% of youth before discharge, and 68% reported they would download the app after discharge. The authors suggest that integrating the app earlier in the hospital stay would increase these numbers [9•]. Implementing the app can also be performed following residential treatment for alcohol—and, if designed properly, has an effect on patient engagement with outpatient providers. The Addiction Comprehensive Health Enhancement Support System (A-CHESS) intervention, for instance, was provided throughout outpatient addiction treatment in one study, increased the odds that patients were engaged in outpatient addiction treatment, and was a factor in reducing the number of risky drinking days by 11% [37].

Design an Accessible, Attractive Product and Workflow

Clinical apps must be designed with a user-experienced focus to make the end product attractive, desirable, easy-to-use, and



Your name _____

App name _____ **recommended by your clinician** _____

What modules did you complete from this app since your last visit? _____

What modules do you have next in this app? _____

On a scale of 1 (dislike) to 5 (liked), how much did you like this app?

Dislike — 1 2 3 4 5 — Like

On a scale of 1 (easy) to 5 (hard), how difficult was this app to use?

Easy — 1 2 3 4 5 — Hard

Start the app now. Show the app's dashboard to your clinician.

Fig. 1 Sample follow-up visit form to evaluate the patient's use of an app

accessible by persons with disabilities, cognitive issues, and low health literacy. These principles are similar to the considerations that psychotherapists make in assigning appropriate, achievable homework, and to prescribing practices physicians make in making sure patients can take medications and not be overwhelmed by burdensome, complex regimens.

First, an app must make a good impression. A qualitative study of smokers and drinkers felt that the immediate look and feel of the app—with icons and screenshots—helped attract users, with a preference towards minimalist and modern designs versus "childish" and "amateurish" designs. Brand recognition; realistic, relevant titles; and social proof based on other users' ratings helped increase the impression of an app on users [38].

Second, an app must adopt good usability practices. For instance, persons with schizophrenia and schizoaffective disorder had more issues with finding information on a set of tested e-health websites. They had difficulties because webpages were too complex, navigation was too complex, and pages were not understandable [39]. Such usability issues can also affect apps; in a study of 100 apps randomly selected from a set of 766 identified smoking cessation apps, researchers found three common usability issues: text-heavy content, abstract symbols and icons, and subtle directions to edit features [40].

Finally, apps must be responsive and not incur major delays. In one test, a smartphone app for HIV and substance use disorder patients employed EMA to ask about symptoms and behaviors twice a day. However, the app interfaced with a difficult-to-access server app where patient data could not be reviewed in real-time. The server app also provided a dashboard that failed usability practices: it was not designed to be easy to visualize or interpret, thus contributing to the lack of usage. Ultimately, peer navigators did not use this data [41].

Mitigate Social Concerns and the Digital Divide

Any intervention must be able to address social concerns of patients. Addictions and substance use disorders, for example, require more sensitivity due to stigma and shame. In a qualitative study of smokers and drinkers using smoking cessation and alcohol reduction apps, social media and sharing elements were found to be embarrassing to users. Elements traditionally thought to be palatable for other disease states—such as gamification and reminders—were not desirable as users were concerned that others may have negative reactions, feared appearing rude to others, and felt "bullied" by too many reminders. Insensitive design of education, such as education about government recommended limits on drinking, annoyed users [38]. Finally, an individual's attitude can also influence their engagement in app use. In a mindfulness app study, barriers to using an app were higher with users with strong negative perceptions of mindfulness and strong negative emotions [33].

Studying one's users and addressing their social concerns can help avoid erroneous assumptions and stereotypes. Youth, for instance, have a tendency to adopt technology quickly. However, a study of *homeless* youth found they may not like using phones at all. Homeless youth perceived phones to be a nuisance: youth did not want to be reached by friends and family who may have traumatized or stressed them, youth did not want to deal with theft, youth did not want to be responsible for phone bills, and youth also wanted to avoid disputes and privacy issues should their phone be used by a significant other or another. In fact, homeless youth in this study were concerned that phones can be traced without their permission by government authorities [42•].

Technological literacy can affect use of the app. Income, education, age, and telecommunications infrastructure access factors may influence disparities in Internet access [43]. Disease states may also influence technological literacy: "digital exclusion" occurs more frequently with persons with long history of psychosis, and such persons generally are less confident and familiar with Internet and connected devices than persons with depression. As previously discussed, onboarding processes and extra support can help [36]. Support issues should address routine technology issues, such as battery failures and power faults that may affect research outcomes [43].

The patient's culture and economic status can also influence the use of app and devices. Implementation teams who want to provide digital services in India, for instance, should consider that India's culture relies more on family support instead of government programs for mental health and social services. This contrasts greatly from high-income countries, where persons are encouraged to live independently and rely on community care services that help persons stay independent [44]. This means that digital services should incorporate self-help support and family member participation, with considerations for impoverished environments, rural areas without reliable electricity and infrastructure, and persons without Internet access [45••]. These infrastructure deficiencies are also associated with shortages of mental health providers: for instance, Southeast Asia houses an estimated 0.2 psychiatrists per 100,000 individuals, compared to the USA with 16 per 100,000. Technology penetration also varies country by country within Asia: Japan and Singapore have a much higher Internet penetration rate versus East Timor and Myanmar [46]. Tailoring apps' intent for low-income low-resource settings can prioritize development where it can be most effective; for instance, healthcare workers with minimal psychiatric training used structured surveys to screen for mental health conditions in Kenya [47].

Finally, understanding disaster settings can help inform the psychiatric provider's psychosocial formulation and tailor digital services appropriately. For instance, screening for new-onset

post-traumatic stress disorder (PTSD) could occur following tsunamis in Asia. In a study of screened children in Gaza, culturally sensitive Arabic workers familiar with Gaza interviewed war victims with questionnaires built in Open Data Kit mobile platform for mental health screening, to classify 17 distinct war experiences such as house shelling and house demolition [48].

Conclusion

Mobile apps are versatile, incorporate numerous features that are currently used for psychiatric care, and are still being researched for future diagnosis, assessment, and treatment. Integrating apps into psychiatric treatment requires addressing both patient and clinical workflows, design and usability principles, accessibility, social concerns, and digital health literacy. Most studies of information technology for patient use have been performed in academic research studies, and one such area emerging from the literature is the management of risks and ethical issues for apps.

Thus far, most risk management discussions are limited to recommending compliance with federal privacy laws, such as HIPAA. A more extensive discussion of legal issues recommends clinicians not recommend apps unless an app demonstrates evidence of efficacy. Liability can arise if, say, a medication adherence app malfunctions, an app stores recordings of a patient assaulting a young child, or an app records the patient's GPS coordinates around the same location and time of a crime. Clinicians can instead establish an agreement regarding app use and consider potential worst-case scenarios should an app malfunction [49].

Finally, to affirm the ethical use of such apps, clinicians must ensure that the patient benefits from the app or device, manage potential risks to the therapeutic alliance, obtain informed consent, discuss confidentiality issues, and ensure that the app is in line with treatment goals and expectations [50•]. Clinicians should not assume that the patient wants to use apps, particularly with passive monitoring, where patients may not feel in control, may feel a loss of dignity, and may not want constant reminders of their disease [43]. Ethical use of apps is part of a broad spectrum of tele psychiatric competencies [51], on a range of e-behavioral health care options from people seeking health information to mobile apps to tele psychiatric care [52].

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- • Of importance
- •• Of major importance

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