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Perspectives on the Use of eHealth in the Management of Patients With Schizophrenia

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Abstract: Mobile devices, digital technologies, and web-based applications—known collectively as eHealth (electronic health)—could improve health care delivery for costly, chronic diseases such as schizophrenia. Pharmacologic and psychosocial therapies represent the primary treatment for individuals with schizophrenia; however, extensive resources are required to support adherence, facilitate continuity of care, and prevent relapse and its sequelae. This paper addresses the use of eHealth in the management of schizophrenia based on a roundtable discussion with a panel of experts, which included psychiatrists, a medical technology innovator, a mental health advocate, a family caregiver, a health policy maker, and a third-party payor. The expert panel discussed the uses, benefits, and limitations of emerging eHealth with the capability to integrate care and extend service accessibility, monitor patient status in real time, enhance medication adherence, and empower patients to take a more active role in managing their disease. In summary, to support this technological future, eHealth requires significant research regarding implementation, patient barriers, policy, and funding.

Key Words: Schizophrenia, eHealth, web-based applications, health information technology, mobile

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There is a growing appreciation among a range of stakeholders that mobile devices, digital technologies, and web-based applications, collectively described in this paper as eHealth, offer considerable potential for improving health care. Globally, personal digital devices such as smartphones and tablets are almost ubiquitous and offer not only extensive social connectivity but also enable people to capture, monitor, and share biometric and other forms of health-related data through extensive wireless communications networks and cloud-based storage (Proudfoot, 2013). In the United States, 85% of the adult population owns a mobile phone, and nearly 46 million smartphone owners used health or fitness applications (apps) in January 2014 (Fox and Duggan, 2012; Nielsen, 2014). At the same time, the use of electronic health records (EHRs) and health information technology (HIT) has been expanding in response to federal incentives offered by the Affordable Care Act (ACA) and the 2009 Health Information Technology (HITECH) Act (Buntin et al., 2010; Centers for Medicare & Medicaid Services, 2015; Paget et al., 2014; United States Department of Health and Human

Services, 2013). Similarly, industry reports note a 40% increase among health care professionals who use electronic and digital tools for patient communications, and more than 20% of physicians now use mobile technologies for remote patient monitoring (Terry, 2014).

A number of these eHealth innovations are being used to augment point-of-care medical practice and represent a significant area of opportunity in mental health management for diseases such as schizophrenia. Schizophrenia is a complex, costly, chronic disease that affects approximately 1.1% of the adult population in the US and continues to be associated with profound stigma for patients and their families (Wilson et al., 2011; Wu et al., 2005; National Institutes of Mental Health. Schizophrenia. Cited April, 2015). Pharmacologic medications and psychosocial therapies are the primary treatment modalities used to support individuals with schizophrenia and encourage recovery (Kasckow et al., 2014); however, nonadherence to treatment is high, and substantial mental health and specialist psychiatric resources are required to prevent potential relapse, rehospitalization, incarceration, suicide, homelessness, and substance abuse (Feldman et al., 2014; Millier et al., 2014; Velligan and Kamil, 2014; Velligan et al., 2013). Many patients with this condition also have extensive comorbidities that require ongoing primary-care management, yet access to such care is often fragmented (Cahoon et al., 2013) and compounded by considerable variability across states in insurance coverage (Feldman et al., 2014). Finally, the human cost of this disease is extensive. People with schizophrenia often experience deteriorating cognitive functioning before their first psychotic episode, which can impair social relationships, self-care, and independent living skills, as well as the ability to gain and hold employment or remain in school (McGurk et al., 2013). Given the extensive economic and human burden of schizophrenia, the implementation of innovative health technologies may improve patient access to care, provide remote patient monitoring, and augment behavioral therapy.

METHODS

A group of patient care team members consisting of psychiatrists, a medical technology innovator, a mental health advocate, a family caregiver, a health policy maker, and a third-party payor met in Baltimore, Maryland, on February 27th, 2015 to discuss the opportunities and challenges associated with eHealth technologies in mental health with a specific focus on schizophrenia. The panel was selected based on their expertise in management of schizophrenia, health policies, medical technologies, and/or mental health advocacy. There was no patient in attendance at the roundtable. With the exception of Alexandra Howson, all the authors attended the roundtable discussion. Johns Hopkins School of Medicine (JHU) and Med-IQ, a medical education company (the Collaborators), proposed this activity and selected these multidisciplinary expert faculty to develop this paper to discuss the use of eHealth in managing schizophrenia and address how these technologists can support quality improvement efforts and optimal health outcomes for patients with schizophrenia. A thorough search of literature was performed and, whenever possible, references were added to support the ideas from the roundtable discussion.

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TABLE 1. Opportunities and Challenges With eHealth Technologies in Schizophrenia

eHealth technologies with applicability in schizophrenia

Personal digital devices	<ul style="list-style-type: none"> • Smartphones • Tablets • Apps
EHRs and HIT	<ul style="list-style-type: none"> • Clinical messaging centers • Electronic prescribing systems • Drug monitoring databases • Information kiosks
Online, web, or computer-based tools	<ul style="list-style-type: none"> • Patient social network sites • Social media networks • Information portals • Research/evaluation databases • Cognition remediation games
Telehealth	<ul style="list-style-type: none"> • Secure video-conferencing (e.g., Skype) • Land and mobile phones • In-home telehealth communication systems

eHealth opportunities in schizophrenia

Symptom recognition and assessment	<ul style="list-style-type: none"> • Identify prodromal symptoms • Raise public awareness of schizophrenia symptoms • Promote need for early intervention • Provide strategies for monitoring mood and feelings
Information dispersal	<ul style="list-style-type: none"> • Connect patients to resources about schizophrenia • Help patients navigate through fragmented services via electronic system guides • Coordinate primary and mental health care • Link patients to mental health clinicians in the transition from acute to outpatient setting • Navigate social entitlements • Enable health professionals to reach patients with information and resources
Integrating care and extending access	<ul style="list-style-type: none"> • Increase access to specialists • Provide real-time supplemental mental health and psychiatric services • Improve the capacity of clinicians to monitor patient mental and physiological status in real time • Assist caregivers with tracking and responding to patient needs
Medication adherence, patient engagement, and self-management	<ul style="list-style-type: none"> • Support efforts to improve medication adherence • Enable patients to self-monitor mood and feelings • Empower patients to take a more active role in managing their disease and its secondary medical complications
Rehabilitation	<ul style="list-style-type: none"> • Improve neurocognition via computer-assisted cognitive remediation (e.g., games)

eHealth challenges in schizophrenia

Patient challenges	<ul style="list-style-type: none"> • Suspicion of technology • Cognitive difficulties • Negative symptoms • Digital divide and costs of technology
Clinician/research challenges	<ul style="list-style-type: none"> • Low evidence base for eHealth technologies • Lack of regulatory oversight for apps (unless designated medical devices) • Attitudes and inertia
System challenges	<ul style="list-style-type: none"> • HIT infrastructure remains poor in mental health • Telehealth reimbursement is variable across states and providers • Potential for infringing security and privacy

source had no role in the planning and execution of the roundtable or the development of the resulting manuscript. None of the authors have any financial relationships with any commercial interests.

The insights presented here are drawn from the available research supporting opportunities and challenges in eHealth (Table 1), and were guided by a roundtable discussion among key stakeholders, including family members/caregivers, clinicians, and clinical researchers who

manage patients with schizophrenia and/or develop innovative health care technologies.

USES, BENEFITS, AND LIMITATIONS ASSOCIATED WITH eHEALTH IN SCHIZOPHRENIA

eHealth could potentially transform health care delivery for patients with schizophrenia by enabling early symptom recognition and intervention;

TABLE 2. Mobile Technologies in Schizophrenia and Mental Health

Name	Features
Devices/apps studied in schizophrenia	
CrossCheck (Center for Technology and Behavioral Health, 2015)	<ul style="list-style-type: none"> • Uses a suite of smartphone-embedded sensors to create a profile of a patient's healthy behavioral and social patterns
My Journey (Schizophrenia.com, 2014; Amani, 2011)	<ul style="list-style-type: none"> • Helps young adults keep track of feelings • Includes set questions with an easy-to-use rating wheel that can help users make informed choices to improve mental health
Mental health apps with potential applicability in schizophrenia	
M3 Screen (What's My M3, 2015)	<ul style="list-style-type: none"> • Uses a score to identify the presence of treatable mood disorders (e.g., depression, anxiety, bipolar disorder) • Allows score monitoring to track mental health changes over time • Uses checklist responses to trigger a risk assessment page indicating the relative risk of depression, anxiety disorder, bipolar disorder, and PTSD
Priori (Karam et al., 2014)	<ul style="list-style-type: none"> • Attempts to spot the early signs of mood swings in people with bipolar disorder • Tracks the user's patterns of speech and silence, the pitch of the user's voice, and other acoustic features
Companion (Strickland, 2013, 2014)	<ul style="list-style-type: none"> • Analyzes both vocal characteristics and social behavior to detect symptoms of depression and PTSD
Mobilyze! (Strickland, 2014; Brooks, 2014)	<ul style="list-style-type: none"> • Uses sensors to automatically detect when patients require assistance
Durkheim Project (Durkheim Project, 2015)	<ul style="list-style-type: none"> • Continuously monitors social network user behavioral intent to enable interventions; facilitated by social/online/mobile data source • Applies computerized text analytics to unstructured medical records to estimate the risk of suicide • Focuses on identifying veterans at risk of suicide
Moving Forward (United States Department of Veterans Affairs, 2011)	<ul style="list-style-type: none"> • Provides a worksheet to walk users through the steps required to solve specific problems in a thoughtful and systematic way • Assesses problem-solving style and stress level and includes a stress tracker that allows users to see their scores over time • Includes seven tools to help users take the time to examine their thinking process and improve emotional regulation in the face of specific problems • Accesses user's personal contacts and other resources to support their problem-solving efforts
Virtual Hope Box (National Center for Telehealth & Technology, 2015)	<ul style="list-style-type: none"> • Contains simple tools to help patients with coping, relaxation, distraction, and positive thinking
Mood 24/7 (Mood 24/7, 2015)	<ul style="list-style-type: none"> • Asks patients how they feel every day • Tracks patients' daily moods, which can be shared with family and clinicians
Ginger.io (Ginger.io 2015; Matheson, 2014)	<ul style="list-style-type: none"> • Passively analyzes mobile data to detect whether a patient with mental illness, such as depression, anxiety, bipolar disorders, or schizophrenia, is acting symptomatic
Care4Today Mobile Manager App (Care4TodayTM, 2015)	<ul style="list-style-type: none"> • Sets up reminders, schedules prescription refills, tracks how often patients take medication, and shares information with physicians
Code Blue Mobile App (Code Blue, 2015)	<ul style="list-style-type: none"> • Sends an alert to users' chosen support crew with one tap to indicate that the user needs immediate help
PTSD indicates posttraumatic stress disorder.	

disseminating information at diagnosis and beyond; integrating care and extending service accessibility; and supporting medication adherence, patient engagement, self-management, and rehabilitation.

Early Symptom Recognition and Intervention

Identifying individuals at risk of schizophrenia is a crucial step toward early intervention that can prevent escalation and improve connection to care (Larson et al., 2010). Despite identifiable risk factors including family history of the disorder, age of onset (16–24 years), and prodromal changes such as social isolation and odd thinking, young adults who show early signs of schizophrenia often do not receive assessment or treatment, due in part to unfamiliarity with symptoms, concerns about stigma, and limited access to services (Gulliver et al., 2010; Robert Wood Johnson Foundation, 2013). Online social networking support (Alvarez-Jimenez et al., 2013) as well as mobile technologies and associated apps, such as My Journey (Table 2), present an untapped opportunity to raise public awareness about prodromal symptoms and promote the need for prevention and early intervention (Giota and Kleftras, 2014; Killackey et al., 2011). Although few smartphone apps have been evaluated for schizophrenia management, *Psyberguide*, a non-profit mental health resource established by the One Mind Institute, reviews research and provides expert ratings for apps and online tools (<http://psyberguide.org/>).

Online and web-based tools can engage young adults in mental health and wellness activities (especially after experiencing their first psychotic episode) by offering strategies for monitoring mood and feelings and seeking support (Giota and Kleftras, 2014; Killackey et al., 2011). Targeted efforts in other countries to increase public awareness of mental illness via community outreach programs have been associated with a reduction in hospitalization and psychotic episode rates among young people with early symptoms (Robert Wood Johnson Foundation, 2013). For instance, Headspace is an Australian program that provides country-wide accessible, user-friendly mental health services to youth (<http://headspace.org.au/>). Although no comparable programs exist in the US, the Adolescent Depression Awareness Program represents an effort to educate high-school staff and students about depression, and provides an important precedent for targeted efforts to increase public awareness of mental illness (Ruble et al., 2013).

Finally, telemental health—defined here as the use of technology in the mental health field to develop and apply preventive and patient-centered measures that empower patients in the treatment of psychiatric disorders—could have a role to play in the early identification and assessment of people at risk of psychosis and in expanding access to specialists for patients who reside in underserved areas (Hilty et al., 2013).

Information Dispersal at Diagnosis and Beyond

After diagnosis, mental health services can be daunting to navigate, especially for patients living in underserved areas in which care is not always geographically accessible. The current mental health delivery system in the US is a complex web of disparate public and private clinicians and services in which the public sector predominates (Horvitz-Lennon et al., 2009). Because patients with schizophrenia are often detached from family support systems, live in suboptimal housing, have low incomes, or lead transient lives that further compound access to care (Feldman et al., 2014), many patients do not receive adequate ambulatory treatment for their disorder. This can lead to relapse, emergency department (ED) visits, and hospitalization (Feldman et al., 2014; Kascow et al., 2014). eHealth-driven access to current, evidence-based information about mental health and primary care services could be a valuable navigation resource.

For instance, many patients with schizophrenia already use the Internet as an informal means of gathering information about treatment and peer-to-peer support (Daker-White and Rogers, 2013). Curated web-based or onsite electronic system guides (e.g., tablets or information

kiosks) could provide information to patients and their families about the benefits and risks of various treatment options for schizophrenia and, thereby, prepare them to discuss and make treatment decisions with their clinicians (Ben-Zeev et al., 2013a). In addition, such technology could offer contact information to easily link patients to mental health clinicians and connect patients who are transitioning from acute care to structured outpatient programs with wrap-around services (Andrews et al., 2010; Ben-Zeev et al., 2012, 2013a, 2013b). eHealth can also help patients navigate social entitlement materials such as geographically and culturally targeted information about relevant programs and treatment facilities. Moreover, mobile phone technology, social media networks, online blogs, and patient social network sites (e.g., PatientsLikeMe, Smart Patients, Patient Fusion) can enable health care professionals to reach patients with relevant information and services (Jones et al., 2014; Paget et al., 2014).

Integrating Care and Extending Service Accessibility

Continuity of care with psychiatrists, primary care clinicians, and mental health professionals is essential in preventing potential relapse and other sequelae (Feldman et al., 2014). However, patients with schizophrenia may delay in seeking primary care services or may receive care that is inadequate, leading to avoidable hospitalizations (Li et al., 2008). Access may be impeded by patients' inability to recognize or communicate symptoms that warrant primary care attention or by poor coordination between mental health services and primary care (Cahoon et al., 2013). In addition, although psychosocial interventions in schizophrenia can be effective, they are often underused due to barriers such as out-of-pocket costs and inaccessibility (Depp et al., 2010), which can increase patients' risk of rehospitalization (Mental Health Quality Forum, 2014).

Health Information Technology (HIT)

HIT, including electronic health records (EHRs) and telemental health, offer the potential to improve the quality, accountability, and cost-effectiveness of health care services (Clarke and Yarborough, 2014; Hilty et al., 2013). Thus, HIT is increasingly being implemented to integrate mental health and primary care into the health home model. For instance, some collaborative care programs are using HIT to link primary and mental health services under the Medicaid health home authority (Unützer et al., 2013). Similarly, New York State recently funded the Brooklyn Health Information Exchange to improve data exchange and care coordination among patients with schizophrenia and bipolar disorder in eight hospitals by using clinical event notifications. Admission to a participating ED triggers an automated alert to the patient's psychiatrist, who can access information through a secure "Clinical Messaging Center" and proactively check in with his or her patient while the patient is still in the ED (Galvez, 2013; Lape and Miller, 2013). In 2013, this project was serving more than 5,000 patients with schizophrenia and bipolar disorder and had generated more than 10,000 alerts.

Telehealth

Telemental health is increasingly being used to extend therapy beyond the conventional office setting and is considered an effective means of increasing access to care (Hilty et al., 2013). Real-time, secure video-conferencing; land and mobile phones; computer-based Internet tools; and in-home telehealth communication systems that link phones to additional services support virtual interactions across remote locations (Kascow et al., 2014). Clinicians can use telehealth technology to assess, treat, and educate patients, as well as ensure faster access to psychiatric consultations. Telehealth can also support "booster" psychosocial sessions, which a recent systemic review found to have similar outcomes as standard care (Välimäki et al., 2013). A recent meta-analysis concluded that telepsychiatry can help patients feel less

stigmatized and more engaged and that 90% of patients would use these services if they were available (Kasckow et al., 2014).

Telepsychiatry (*i.e.*, telecommunications access to psychiatric specialists) seems to be effective in improving quality of care and providing discrete access to patients who fear stigmatization or have limited access to services. For instance, in rural Florida, an independent behavioral health and wellness company, ValueOptions, partnered with community mental health organization David Lawrence Center and Verizon to implement a pilot project to improve access to specialist care. The project was able to provide telepsychiatry services to Medicaid beneficiaries through easy-to-use, real-time videoconferencing. In a 14-week period in 2010, they experienced a 62% increase in care delivery to clients compared with the previous year, with a 90% patient and clinician satisfaction rate. Based on its success, the project is expanding to include telebehavioral health services as well as mobile services using 4G wireless technology (Medicaid Health Plans of America Center for Best Practices, 2012). Other programs using telecommunications technology to provide patients with schizophrenia with stable phone access and preprogrammed mental health support phone numbers have reported improvement in key Healthcare Effectiveness Data and Information Set indicators, including higher diabetes screening rates for people with schizophrenia (Miller et al., 2014). Similarly, a telepsychiatry program in rural South Carolina linked psychiatrists to patients at 21 hospital EDs in underserved areas and has increased the daily number of patients receiving psychiatric consultations, reduced the average length of stay in the ED, and reduced average mental health care costs (South Carolina Department of Mental Health, 2014). State Medicaid plans are increasingly taking advantage of coverage within the home health model for remote, telemedicine patient assessment and monitoring from an appropriate specialist for patients with a single serious and persistent mental health condition (American Telemedicine Association, 2013).

Medication Adherence

Approximately 50% of patients with schizophrenia do not take their medications as prescribed, which can lead to symptom exacerbation, relapse, and repeated hospitalization (Velligan and Kamil, 2014). Electronic prescribing systems and drug monitoring databases—such as the Maryland Chesapeake Regional Information System for our Patients database—can help clinicians monitor patient medication adherence by allowing them to view patient and clinical data alongside dispensing information (Morris et al., 2012). Other technology-supported adherence strategies include automated voice or short message service (SMS) text messages generated within and linked to EHRs (Granholm et al., 2012; Ben-Zeev et al., 2013a), electronic diaries with ringtone reminders (Velligan and Kamil, 2014; Mutschler et al., 2012), or microelectromechanical systems. For instance, the Medication Event Monitoring System uses integrated microcircuits to not only remind patients to take their prescribed medications at the correct time but also record and store the date and time a patient opens a vial. It also tracks the intake of medication by asking the patient when the drawer was opened, whether the patient took the medication, and, if not, the reason for failing to do so (Brain et al., 2014; Remington et al., 2007). Because this technology may fail in patients who are reluctant to take medications and are not forthcoming about missing doses, “smart pills” can indicate whether the pills have actually been taken.

Patient Engagement and Self-Management

Patients with schizophrenia often struggle to remain involved in managing their illness due to cognitive impairment and other problems. Mobile technology guided by ecological momentary assessment or the experience sampling method could support treatment engagement and disease self-management by enabling patients to self-monitor their clinical status and provide real-time text- or audio-based data on their thoughts, feelings, and changes in symptom severity (Swendsen et al.,

2011; Palmier-Claus et al., 2012). Clinicians can use these data to suggest coping strategies for avoiding stressors, adjust antipsychotic medication, or recommend acute care when patients report symptom exacerbations or symptoms that predict relapse (Ben-Zeev et al., 2013a; Depp et al., 2010; Giota and Kleftras, 2014; Oorschot et al., 2012). SMS texts could also direct patients to relevant services and resources for recovery, such as skills training or housing support (Fuber et al., 2014; Jones et al., 2014). Because mobile monitoring technologies lack the geographical, temporal, or spatial constraints of face-to-face clinical encounters, they may offer patients a sense of immediacy and constancy that can establish rapport with clinicians and improve engagement (Daker-White and Rogers, 2013; Kasckow et al., 2014). Mobile technologies can also strengthen the therapeutic relationship because they allow patients more control over how and when they discuss their concerns with clinicians (Ben-Zeev et al., 2013a).

Rehabilitation

Computer-assisted cognitive remediation (CACR) is increasingly being used to improve neurocognition across a variety of conditions including schizophrenia and is a growing area of research (Reddy et al., 2014). For instance, cognitive rehabilitation programs using problem-solving games can help patients with schizophrenia improve cognitive functioning and negative symptoms, such as social withdrawal, affective flattening, and motor retardation (Genevsky et al., 2010; Eack et al., 2010; Eack et al., 2013). However, these programs vary widely in their methods, intensity, duration, and relationship to other psychiatric rehabilitation programs, and little evidence is available to guide payers in determining which programs are likely to have most benefit (McGurk et al., 2013).

The feasibility of several eHealth interventions for supporting medication adherence and self-monitoring in schizophrenia has been evaluated or is currently under investigation (Table 3).

CHALLENGES IN IMPLEMENTING eHEALTH

Despite the potential uses and benefits of eHealth, many implementation challenges lie ahead, as outlined below and in Table 1.

Patient Challenges

Suspiciousness is a primary symptom of schizophrenia, and suspicion of technology (or paranoid delusions concerning it) can induce fear of computer-based devices at certain stages of psychosis (Freeman, 2008; Sendt et al., 2015). Cognitive difficulties—ranging from subtle to disabling—may require a focused intervention to familiarize the patient with new assistive technologies or simplifications/adaptations of existing ones (Young and Geyer, 2015). Research is ongoing to design self-management software for smartphone devices that incorporates user considerations, including compensatory considerations for patients with cognitive deficits (Table 2) (Ben-Zeev et al., 2013b).

Patients with schizophrenia also frequently manifest negative symptoms, including lack of energy and motivation, which can greatly derail mobile interactions if patients ignore messages, respond inconsistently, or become tired of mobile engagement (Depp et al., 2010; Foussias et al., 2015). Nonetheless, uptake of mobile technology among those with schizophrenia is growing closer to that of the general population, and interest in using such technology to monitor symptoms and connect patients to services is high (Ben-Zeev et al., 2013a).

Legitimate concerns have been expressed regarding the “digital divide” and the costs of accessing technological interventions; however, this divide may be narrowing. For instance, a 13% uptick was seen between May 2011 and February 2012 in smartphone use in rural populations (Smith, 2012). In addition, as cell phones and data plans become less expensive, the rate at which disadvantaged populations use them may continue to rise (Kurti and Dallery, 2014).

TABLE 3. eHealth Interventions Under Investigation to Support Medication Adherence and Self-Monitoring in Schizophrenia

Intervention	Features
Mobile Assessment and Treatment for Schizophrenia (Granholm et al., 2012)	<ul style="list-style-type: none"> • Cell-phone delivery used branched text messaging to remind patients with schizophrenia to take medication • Patients received daily text messages that incorporated CBT techniques to elicit patient thoughts about medication, socializing, and auditory hallucinations • Responded to patient texts by providing messages that questioned unhelpful beliefs (e.g., hearing voices) and encouraged patients to modify their behavior
Med-eMonitor and PharmCAT (Velligan et al., 2013)	<ul style="list-style-type: none"> • Med-eMonitor is an electronic medication monitor that prompts users to take medication, cautions patients if they are taking the incorrect medication or are taking it at the incorrect time, documents complaints, and informs staff members when patients fail to take medication as prescribed • PharmCAT is a cognitive adaptation training method that focuses on medication and appointment adherence only; it includes supportive techniques (e.g., alarms, checklists) and was delivered during weekly home visits • Evaluated the utility of an electronic intervention (Med-eMonitor) and an in-person intervention (PharmCAT) for improving adherence to oral medications versus treatment as usual
Medicus (Mutschler et al., 2012)	<ul style="list-style-type: none"> • A pocket-sized electronic diary programmed with individualized drug doses that reminded patients by ringtone to take their medications • Patients were able to document real-time mood and medication intake by pressing keys on the diary
PDA (Swendsen et al., 2011)	<ul style="list-style-type: none"> • PDA was used to monitor the association of substance use with psychological states and psychotic symptoms in patients with schizophrenia living in structured settings
PsyMate (Myin-Germeys et al., 2011)	<ul style="list-style-type: none"> • Prototype device that enabled real-time monitoring of thoughts, symptoms, and mood
FOCUS (Ben-Zeev et al., 2013b)	<ul style="list-style-type: none"> • Smartphone app with a home screen that allowed users to tap on categories such as “medication,” “voices,” and “social” • After patients answered brief assessment questions, they either received positive reinforcement or friendly advice (e.g., the social assessment might lead to the feedback, “You can’t control other people’s behavior, only how you respond to it”)
Telehealth (De Las Cuevas et al., 2006; Godleski et al., 2012)	<ul style="list-style-type: none"> • Telehealth was used to deliver mental health services in a 4-yr study from the VHA • In a separate study, patients in the Canary Islands received outpatient cognitive behavioral therapy treatments via videoconferencing over a 24-wk period
Mobile telepsychiatry (Thara and Sujit, 2013)	<ul style="list-style-type: none"> • Bus with a telepsychiatry consultation room and a pharmacy visited villages in India that have Internet connectivity; bus also showed films to raise awareness of mental health issues • Services focused only on those with serious mental disorders • Patients were referred to the bus by community health workers
Mobus (Sablier et al., 2012)	<ul style="list-style-type: none"> • Cognitive orthotic device supported ADLs by providing a schedule manager and options to report symptoms to caretakers
Information Technology Aided Relapse Prevention Programme in Schizophrenia (Španiel et al., 2008; Komatsu et al., 2013)	<ul style="list-style-type: none"> • Patients completed an automated text version of a validated 10-item Early Warning Sign questionnaire sent weekly to their phone; individual scores were sent to an information technology database • Scores exceeding a preset threshold generated an automated alert to a treating psychiatrist who would then increase the baseline maintenance antipsychotic dose within 24 hr; patients on alert were monitored more intensively for the next 3 wk

ADL indicates activities of daily living; CBT, cognitive behavioral therapy; PDA, personal digital assistant; VHA, Veterans Health Administration.

Clinician/Research Challenges

Although clinician attitudes about implementing mobile mental health technologies are not well characterized (Jones et al., 2014), some research suggests high receptivity among psychiatrists and other clinicians toward the potential benefits of telehealth in engaging patients, supporting self-monitoring, increasing access to services, and reducing costs (Daker-White and Rogers, 2013). However, with the exception of a small group of cross-sectional, noncontrolled, nonrandomized

studies, most apps with potential use in schizophrenia lack an evidence base (Donker et al., 2013; Giota and Kleftras, 2014). Currently, the US Food and Drug Administration (FDA) does not provide regulatory oversight for apps unless they are deemed to be “medical devices” (Center for Devices and Radiological Health, 2015).

The convergence of sensor, global positioning, vocal pattern, and other data associated with mobile technologies can be overwhelming to many clinicians, though the effect of such data on the therapeutic relationship is also under-researched (Clarke and Yarborough, 2014).

Stakeholders must not only continue to track real-time patient-reported data but also consider designing formative research on optimal methods for distilling such data (Ben-Zeev et al., 2013b). Innovative research designs (e.g., single-case design) should be implemented to evaluate the applicability of technology-based tools at the point of care (Lillie et al., 2011).

System Challenges

HIT Infrastructure

A lack of HIT infrastructure is a key barrier to high-quality care in schizophrenia (Horvitz-Lennon et al., 2009). Indeed, many mental health professionals were ineligible to receive the EHR incentives allocated by the HITECH Act (Miller et al., 2014). It is anticipated that enacting the Behavioral Health Information Technology Act would provide financial incentives for behavioral health professionals to adopt EHR/HIT (National Council for Community Behavioral Health, 2012) and help them meet the 2014 federal requirements for Meaningful Use incentives, such as secure e-mail and a system for allowing patients to view and download electronic clinical information (Paget et al., 2014).

Telehealth Reimbursement

Although studies suggest that telehealth technologies can be cost-effective when capital expenditure costs are weighed against long-term savings (Kasckow et al., 2014), no clear reimbursement models are available for electronically delivered schizophrenia-related services (American Telemedicine Association, 2013). Although 39 states have some form of Medicaid coverage and reimbursement for mental health services provided via telemedicine, state policies for reimbursement vary in specificity and scope (American Telemedicine Association, 2013). Consequently, several organizations (e.g., Healthcare Information and Management Systems Society) are exploring innovative payment structures and policies to streamline licensure, practice standards, and e-prescribing across states. The American Medical Association has recently produced a new set of standards and safeguards intended to ensure appropriate telemedicine reimbursement, codify standards of care, and improve access to remote medical care (American Medical Association, 2014). Moreover, in January 1, 2015, the Centers

for Medicare & Medicaid Services (CMS) began reimbursing previously uncovered telehealth services (United States Department of Health and Human Services, 2015). For instance, the new Chronic Care Management code reimburses clinicians for remotely managing patients with at least two chronic conditions, including conditions like schizophrenia that place patients at risk of functional decline (Centers for Medicare & Medicaid Services, 2015). The CMS reimbursement process is important because most private payers are likely to implement similar policies. Indeed, some private payers (e.g., Aetna, Cigna, United Health, and Anthem BlueCross and BlueShield) are beginning to reimburse delivery of remote behavioral health services via interactive audio, video, or data communication (Anthem BlueCross and BlueShield, 2012).

Security and Privacy Concerns

The precise real-time location and biometric data collected by mobile technology software potentially infringes on freedom of movement and may be viewed by some patients as a form of unwelcome surveillance (Daker-White and Rogers, 2013). Privacy concerns also pertain to the upload/download of personally identifiable or clinical data to mobile devices, which can be destabilized by battery or Internet connection failures (Kumar and Lee, 2012). Additionally, “eavesdropping” on communication channels raises privacy concerns as well as questions about who should use the data and to whom the data can be revealed without patient consent (Kumar and Lee, 2012). To ensure privacy and protect the confidentiality of users, the expansion and clarification of HIT—currently broadly defined—will require oversight of wireless security measures, such as cryptography and user authentication (Giota and Kleftras, 2014; Kumar and Lee, 2012).

FUTURE APPLICATIONS AND INNOVATIONS

Despite these real obstacles, eHealth technologies could become support systems in schizophrenia management in a few years. For example, machine learning techniques could be implemented in smartphones to facilitate speech recognition that could accurately predict the initial stages of relapse in schizophrenia. Other instrumental ideas include providing each patient with a free cell phone, with the cost borne by payers. Such a strategy could empower patients, improve communication

TABLE 4. Select Examples of Emerging eHealth Innovations in Schizophrenia Management

Biosensory Monitoring

The LifeShirt is a multifunction ambulatory device consisting of a Lycra garment, data recorder, and computer-based analysis software. Currently used in clinical trial or experimental settings, this noninvasive device records heart rate via high-resolution echocardiogram and assesses respiratory parameters to monitor the relationship between breathing rate/rhythm and psychotic state during stress tasks (Bär et al., 2012).

Smart Packaging and Smart Pills

MedSnap uses smartphone camera technology to capture images of patient medications that can then be shared with clinicians. The technology also generates drug histories and identifies potential drug interactions (MedSnap, 2015).

In 2010, the US FDA approved a digestible microchip that is placed in medicinal tablets and can identify when medication has been taken. The microchip produces a voltage during digestion and communicates a signal to external sensors. When non-ingestion occurs, caregivers can be prompted to remind the patient to take the medication. Although this approval is currently for placebo medications only, the technology is being tested for treatments in mental health (Bosworth, 2012; Velligan and Kamil, 2014).

Socialization and Rehabilitation

Contingency management uses mobile technologies to support a target behavior, such as medication adherence, by providing tangible reinforcers that are contingent on achieving the target behavior and withheld when the target behavior is not met. Reinforcers can include vouchers that are exchangeable for goods or services or social reinforcers, such as online communities in which patients can share and receive social praise for reaching their target behaviors or earn “badges” (Kurti and Dallery, 2014).

Gamification platforms provide a reward system in which participants can earn access to video games contingent on providing objective verification of a target behavior (Kurti and Dallery, 2014). Games are among the most frequently downloaded and used apps on various smartphone app markets. Increased attention is being given to the potential to leverage video game technologies to promote health-related behaviors; this capability could also be extended to smartphone behavioral health apps (Luxton et al., 2011).

and access, and reduce hospitalizations. Other innovations with utility in schizophrenia are emerging, such as ambulatory biosensors to monitor mood and predict relapse, smart pills, and gamification platforms that improve cognitive function and support socialization (Table 4).

Many of the eHealth technologies described here as potentially transformative in schizophrenia (and in mental health more generally) have been—or are currently being—evaluated in other diseases and show that the transformation of care management toward a more individualized, patient-empowered, data-driven, resource-mindful approach is on the horizon (Topol, 2012). For instance, in cardiovascular disease, recent research shows that eHealth supervision of exercise-based cardiac rehabilitation, in which heart rate data are transmitted to a programmed smartphone to support remote monitoring, is a feasible alternative for patients unable to participate in hospital-based programs and is associated with comparable rehabilitation improvements (Worringham et al., 2011). Similarly, cost-effective “snap on” or embedded mobile technology is now available to screen for and detect atrial fibrillation in community settings (Lowres et al., 2014). These technologies, as well as the technologies described in this paper, will create momentum for further research as the foundation for an evidence base in eHealth.

CONCLUSION: THE VALUE OF eHEALTH

In the US, a lack of public awareness for mental health problems, persistent stigma, and inadequate political action regarding the need for resources have led to a chronic underinvestment in mental health care (DeSilva et al., 2014). The adoption of eHealth in the context of a service delivery system that is moving toward value- and performance-based payment models represents opportunities for investment and a critical building block in the path to quality improvement, although clinical trials measuring outcomes continue to be needed (Free et al., 2013). Moreover, although data are generally lacking on the costs of implementing eHealth, the evidence presented here suggests that technology-driven schizophrenia management has the potential to achieve the goals of the ACA's triple aim: improving population health, enhancing patient satisfaction, and reducing costs. The capacity to share patient-generated health information across clinician types and settings via remote access could help coordinate care, support self-management, and improve patient satisfaction with care, as well as reduce the cost of interventions such as ED visits or acute psychiatric hospitalization (Ben-Zeev et al., 2012, 2013a).

Despite this potential and the acceleration of eHealth use in schizophrenia by both patients and clinicians, no central agency currently exists to connect stakeholders who engage in eHealth, nor do mechanisms exist to align their interests in technology implementation. Therefore, stakeholders with the ability to bridge different worlds—academic and industry research, technology innovation, clinical practice, policy, and insurance/funding—must drive research, policy, and implementation agendas that harness technology to improve the lives of people with schizophrenia and their caregivers.

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