APPLICATION OF SMARTPHONE TECHNOLOGY IN THE MANAGEMENT AND TREATMENT OF MENTAL ILLNESSES

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Abstract:

Background: Mental illness continues to be a significant Public Health problem and the innovative use of technology to improve the treatment of mental illnesses holds great public health relevance. Over the past decade telecommunications technology has been used to increase access to and improve the quality of mental health care. There is current evidence that the use of landline and cellular telephones, computer-assisted therapy, and videoconferencing can be effective in improving treatment outcomes. Smartphones, as the newest development in communications technology, offer a new opportunity to improve mental health care through their versatile nature to perform a variety of functions.

Methods: A critical literature review was performed to examine the potential of smartphones to increase access to mental health care, reduce barriers to care, and improve patient treatment outcomes. The review was performed by searching several electronic databases using a combination of keywords related to smartphones and mental health interventions using mobile devices. Literature concerning the use of cell phones, handheld computers, and smartphones to improve access to mental health care and improve treatment outcomes was identified.

Results: The majority of studies identified were feasibility and pilot studies on patients with a variety of diagnosed mental illnesses using cell phones and PDAs. Authors report that most study participants, with some exceptions, were capable of using a mobile device and found

them acceptable to use. Few studies extensively measured treatment outcomes and instead reported preliminary results and presented case illustrations. Studies which used smartphones successfully used them collect data on patients and deliver multimedia interventions.

Discussion: The current literature offers encouraging evidence for the use of smartphones to improve mental health care but also reflects the lack of research conducted using smartphones. Studies which examine care provider use of smartphones to improve care is encouraging but has limited generalizability to mental health care. The feasibility of patient use of smartphones is also encouraging, but questions remain about feasibility in some sub-populations, particularly schizophrenia patients. Pilot testing of mobile devices and applications can greatly increase the feasibility of using smartphones in mental health care. Patients who are unfamiliar with smartphones will likely need initial training and support in their use.

Conclusion: The literature identified several ways in which smartphones can increase access to care, reduce barriers, and improve treatment outcomes. Study results were encouraging but scientifically weak. Future studies are needed replicating results of studies using cell phones and PDAs on smartphones. Larger and higher quality studies are needed to examine the feasibility, efficacy, and cost-effectiveness of smartphones to deliver multiple component interventions that improve access to mental health care and improve treatment outcomes.

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1.0 BACKGROUND

It is estimated that over the course of a given year that 25% of the United States population meets DSM-IV diagnostic criteria for a psychiatric disorder and that over the course of a lifetime 50% of the United States population meets diagnostic criteria for one or more psychiatric diseases. Unfortunately, a majority of diagnosable individuals do not receive treatment due to a variety of structural and perceived barriers which limit access to care. Structural barriers may include limited access due to a lack of providers and resources in a geographic area, prohibitive cost of care, transportation restraints or time restraints. Perceived barriers such as the stigma of seeking treatment for mental health conditions and cultural or ethnic barriers also limit access to care.[26] Even when an individual successfully accesses and initiates treatment many providers face a problem of maintaining patient engagement and adherence with treatment and patient dropout. [11] Over the past two decades mental health professionals have attempted to overcome these barriers by utilizing technology to increase access to mental health services and improve the quality of care and health outcomes. Particularly, there has been a focus on ut ilizing telephones, cell phones, computers, and the internet as means to extend the reach of providers and provide more cost-effective care.

Recent literature reviews of the use of these technologies have found encouraging evidence to support their use. Mohr et al. conducted a meta-analysis of telephone administered psychotherapy and concluded that psychotherapy over the phone was capable of significantly

reducing depression symptoms and had a lower attrition rate when compared to face-to-face therapy. [35] Additionally, there is evidence that cell phones can enhance care with both cell phone voice and text message interventions to improve disease monitoring and management.[12,15,30] Hailey et al et al.'s recent review of the literature found the strongest evidence to support the use of telephone and internet-based interventions for mental health. The authors also found encouraging evidence that using videoconferencing to deliver "Telepsychiatry", which can include mental health assessment, treatment, education, and monitoring may show equivalent efficacy to face-to-face treatment. [23] Studies which have used computer-assisted treatment and the internet have also shown the ability to produce significant changes in depression and anxiety symptoms. Effect sizes, however, were smaller than those seen with face-to-face therapy and varied with the amount of face-to-face support that patients received; leaving questions about efficacy as a standalone treatment.[13,23] The successful use of these technologies has set the stage for the possible use of a new technology, smartphones, to also be used to improve mental health care. This is especially relevant in the context of the recent healthcare reform legislation passed in the United States, which emphasizes the use of health information technology(HIT), telehealth services, and innovative new ways to deliver health services. The role of smartphones as the successor to technology previously used to enhance mental health care and the recent impetus to utilize telecommunications technology to enhance healthcare encourages a critical review of the literature on the possible use of mobile devices in general and of smartphones in particular in enhancing mental health care. The following critical literature review will address the research question of whether smartphones can increase access to mental health care, reduce barriers to accessing and completing treatment for mental illnesses, and assist mental health providers with patient follow-up and relapse prevention.

2.0 METHODS

A search of electronic databases including PUBMED, OVID, PsycINFO, PsycARTICLES, MEDLINE, EBSCOhost The Cochrane Library, ERIC, and using the internet search engine Google Scholar was conducted to identify articles that examined the use of mobile devices and smartphones in mental health care. Searches were conducted using various combinations of keywords using synonyms for smartphones, cell phones, and PDAs and interventions involving mobile communication technology. Keywords used were smartphone, iPhone, Blackberry, Android, UTMS phone, 3G Phone, cell phone, cellular phone, mobile phone, Personal Digital Assistant, PDA, Palmtop Computer, telemedicine, telemental health, telepsychiatry, mobile health, mhealth, mental illness, mental disorders, psychotherapy, and mental health. Titles and abstracts of search results were manually read and if determined to be relevant, the full text was manually read to be considered for inclusion. Additional articles were found by checking the references and citations of included articles and by utilizing the "Related Articles" and "Cited By" feature of the electronic databases and search engines used.

Inclusion Criteria: Cell phones and Personal Digital Assistants (PDAs) are considered the predecessors of smartphones and are capable of performing many of the same functions that smartphones are. Additionally, given the fact that smartphones are a recent technology and anticipating few articles dealing strictly with smartphones, articles that examined applications of

cell phones and PDAs in mental health care were included. Studies which examined voice communication to mobile telephone lines, text messaging, and data input into PDAs was included.

Exclusion Criteria: Studies which exclusively used landline telephone calls as a means of intervention or study were excluded. Studies which examined smartphone, cellular phone, and PDA application in physical health (e.g. diabetes management, physical activity, etc.) were excluded. Studies which examined smartphone, cellular phone, and PDA application in substance abuse studies (e.g. smoking cessation, alcohol abuse, and illegal substance abuse) were excluded. Proposed study protocols were excluded.

3.0 INTRODUCTION TO SMARTPHONES

Smartphones can be thought of as the combination of a cellular telephone and a handheld computer. They offer the communication ability of a cell phone to send and receive voice and text messages as well as the ability of a Personal Digital Assistant (PDA) to run computer programs. All smartphones come with several built-in features, usually including the ability to access the internet and e-mail, use electronic calendars and notes, take pictures and videos, view multimedia, and provide access to GPS. Smartphones, like computers, also run a hardware operating system (OS), which allows for the download of supplemental software applications (apps) to be run on the phone. [6] The apps that are available depends on the smartphone in question, with the most being available for Apple's iPhone, which currently has over 350,000 different apps available that can perform a variety of functions. [1] In America the most popular OS for smartphones are currently the Apple iPhone, Google Android, and Blackberry, with other options including Nokia, Palm, and Windows Mobile. [6] Smartphones are becoming increasingly widespread and popular among Americans, with Nielson estimating that by Christmas 2011 one in two Americans will own a Smartphone. [58] The increasing number of Americans who own smartphones and the versatility of smartphones to perform a variety of functions allows for the possibility of smartphones to be used as an innovative means to improve the access to and the quality of mental health care.

4.0 CARE PROVIDER SMARTPHONE USE TO ACCESS AND INPUT DATA

As of 2009 two-thirds of all physicians used smartphones and as of February of 2010 there were 1,567 apps available within Apple's Appstore for the iPhone that were targeted for health professionals.[50] With a high percentage of doctors already using smartphones and an ever increasing number of health-related apps, one possible way for smartphones to enhance mental health care is for mental health care providers to utilize them to provide more efficient care by increasing their access to information through smartphone apps. These apps can be free, cost a one-time download fee, or require a subscription fee and offer doctors a variety of information that they can access from their smartphone. Apps can vary from allowing the doctor or nurse to access patient electronic records, lab test results, medication information, reference systems, and decision-support tools. [22] Smartphones can be used to access electronic medical records(EMRs) from either an established computer network or other "lighter" options such as record apps for smartphones or internet-based EMRs. [50] Mental health professionals and therapists can also access reference information using an application such as Skyscape, which offers access to psychiatric textbooks and publications. [32] One of the most popular and well-known medical reference apps is Epocrates, an extensive drug database that gives doctors information on drug dosing, interactions, and adverse reactions. Additionally, doctors can electronically prescribe medications that do not require tamperproof paper from their smartphone; effectively allowing doctors to view information on a drug, calculate the dose, and prescribe it from their smartphone.

An example of a decision support app is the Differential Diagnosis i-pocket, which gives doctors information on over 800 signs, symptoms, and abnormal findings of various conditions to aid in the diagnosing of conditions. Features that are built into some smartphones can also aid doctors in diagnosis. For example, some smartphones, such as the iPhone, are equipped with motion sensors and accelerometers, which can be used as a tool to measure a patient's movement, agility, and activity level. This would aid in the diagnosis of mental health disorders which display symptoms that affect movement or result in decreased activity levels. Smartphone's audio/visual multimedia capabilities also allow doctors to access information that can aid them in providing care. Smartphones can be used to view medical imaging test results, such as MRI and CT scans to allow doctors to diagnose conditions and also easily display results to colleagues for consultation or to patients as a way to explain their diagnosis and educate them on the their disease. This ability of a doctor to use a smartphone as a resource to teach and train patients about their treatments offers an opportunity to improve patient knowledge on their treatment, adherence with that treatment, and satisfaction with care. Smartphones can also be used to store and play podcasts of medical presentations or conferences as a source of access for professional information that allows the doctor to stay updated on the latest developments in their field. [22] Doctors can also access professional information by networking their smartphone to alert systems like twitter or download widgets from the FDA or CDC that alerts them to new clinical guidelines and breakthroughs [50]. Additionally, smartphones allow doctors to access online professional networks such as "Braintalk", where neurologists, psychologists, and mental health professionals can discuss relevant treatment issues; increasing provider networking and communication. [6] The increased availability and timeliness with which doctors can access information through smartphones has the chance to allow doctors to make more informed

decisions; allowing for better productivity, reducing medical errors, increasing the speed of delivery of care, and improving the quality of care. [44]

In addition to just accessing and viewing data smartphones can also enhance mental health care by serving as data collection and entry tool. Smartphones, by their mobile nature, allow a doctor or therapist to enter new patient data while on the go and to share information with consulting doctors. Patient demographics and health records are usually written by hand manually by a nurse or medical assistant and then electronically transcribed into a database. The two step process introduces a chance for error in the patient records (e.g. misreading handwriting or incorrect transcription) and has a delay from the time that the record to written and appears in the electronic database. Smartphones allow a healthcare team to enter the data on the spot in a one step process, which reduces both the time and resources need for data entry, reduces the chance for transcription error, and offers immediate access to the electronic records. Furthermore, a smartphone can be used as a paperless survey and feedback tool that can be provided to patients after receiving care, which could allow doctors to more seamlessly collect information to improve patient care and their practice. [22]

4.1 MOBILE DEVICE USE TO IMPROVE SPEED OF CARE

Several studies have sought to measure the effects of smartphone use on quality of patient care. Three studies examined the ability of smartphones to allow doctors to provide faster treatments to patients in emergency medicine situations. Two of the three studies examined the transfer of prehospital ECG images to cardiologists' smartphones as a measure to improve door-to-treatment time for inbound patients. Both studies showed a statistically significant improvement in median treatment time with a 46 minute improvement in one study and 54 minute improvement in another. The third emergency medicine study examined the quality of diagnoses from CT images examined on smartphones compared to diagnoses of the same image as it is typically viewed. The CT image quality as viewed on smartphones was rated as sufficient for making a diagnosis in each case that was examined and diagnoses made using smartphone images agreed 86% of the time, with the remaining 14% of cases having differences which were clinically insignificant. One study examined the ability of smartphones to improve interprofessional communication in a comparison of response time to calls on a smartphone compared to a conventional pager. The authors found that response times were shorter for doctors with the smartphone and were also less likely to fail to respond.

4.2 MOBILE DEVICE USE TO INCREASE SAFE PRESCRIPTION OF MEDICINE

Five studies examined the ability of smartphones to improve doctors' safety and effectiveness in prescribing medicine One study examined the safe prescribing of NSAIDs for physcians using

PDAs containing a decision support system(DDS) app which contained information on NSAID risk assessment and treatment recommendations. The study found a significant difference in error rates, but only due to the control group worsening from their baseline error rate and not an improvement in the intervention group. One study looked at quality of patient management due to information resources accessed on a PDA compared to paper text resources. The authors found a significantly higher change in patient management in the PDA group (e.g. changing a patient's prescribed medication), possibly because of additional information that was available electronically that was not available in paper format. Another study, found that doctors with a DDS app on their smartphones decreased the consumption of antibiotics and length of patient stay, showing a more effective prescribing process and improved patient outcomes. The ability of the DDS app was especially pronounced in younger, more inexperienced doctors who more frequently accessed information on their PDA than older, more experienced doctors. One study found that electronic prescriptions made from PDAs had a lower error rate compared to handwritten lists (8% vs. 22%), this difference, however, was not due to illegibility or transcription errors but due to erroneous exclusion of medicine from the handwritten lists. A study by Brigham Young University found that doctors who use Epocrates prevent up to 3 prescription mistakes a month. [50]

4.3 MOBILE DEVICE USE TO INPUT PATIENT DATA

Four studies looked at the effect of smartphones on doctors' management of patient data. One study compared PDA and paper documentation and coding of patient diagnoses and found that

PDA documentation had a significantly higher quantity and quality of diagnoses compared to paper documentation. There was, however, a higher rate of false or redundant codes associated with the PDA coding comparing to paper coding. One study examined the ability of smartphones to reduce documentation discrepancies in daily notes on patient progress notes in a neonatal intensive care unit. The authors reported a significant reduction in discrepancies in only one of three documentation areas that were measured. Studies on the ability of smartphones to reduce the time it takes to document beside patient information were mixed, with Chan et al. reporting no difference in time to document demographic and clinical data, whereas VanDenKerkhof et al. showed faster and more complete documentation of pain assessment information on smartphones compared to paper forms. [44]

4.4 FACTORS AFFECTING ADOPTION OF SMARTPHONE AMONG DOCTORS

Smartphone use by doctors and nurses offer an opportunity to improve the coordination and quality of care. Smartphones allow doctors and nurses access to calling capability, access to e-mail and the internet for research and communication, access to word processors and presentation documents, electronic prescription and access to patient records. In order for these opportunities to be realized, however, doctors and nurses must first choose to adopt and use smartphones. As such, studies have used theoretical constructs from the technology acceptance model(TAM) and the innovation diffusion theory(IDT) to look at the factors which affect the acceptance and utilization of smartphones by doctors and nurses. Such theoretical concepts

include perceived usefulness (PU), perceived ease of use (PEOU), attitude towards the smartphone, computer self-efficacy, compatibility, observability, and trialability. Park and Chen surveyed a sample of doctors and nurses in a Midwest hospital network and found that smartphone adoption was largely influenced by PU and attitude towards smartphones, suggesting that doctors' view on the ability of smartphones to improve their daily job activities and performance. Doctors were more likely to have a positive attitude if they had a higher PEOU, which in turn was positively affected by computer self-efficacy. Observability was also positively correlated with smartphone adoption, where a doctor was more likely to adopt a smartphone if they saw their peers and coworkers using a smartphone and improve their opinion on smartphones. Additionally, organizational characteristics of the hospital also positively influenced smartphone adoption, where a larger hospital that had top managerial support for smartphone use increased smartphone adoption. [41] Putzer et al. surveyed practicing nurses in southeastern hospitals and also found that PU, observability, and organizational factors positively influenced smartphone adoption. Additionally, the authors found that when nurses perceived the smartphone as being compatible with other technology in the hospital that adoption was more likely and that necessary infrastructure within hospitals to support smartphone use was important. The authors also inferred that trialability, the ability to try technology on a short-term basis with no commitment, was import to users who were new to smartphones. Similarly, Hafeez-Baig and Gururajan also found that PU, compatibility, observability, and organizational characteristics positively influenced adoption. Of note was that none of the studies found that individual characteristics such as age directly influenced adoption, although Hafeez-Baig and Gururajan postulated that it a mediating effect on other variables. [21]

5.0 PATIENT USE TO ENHANCE TREATMENT

Just as doctors can utilize a smartphone's versatility to improve their ability to provide care, a patient who carries a smartphone can also utilize it to access care and improve their treatment results. A person can utilize the smartphone as a phone to communicate with mental health providers to access treatment or to manage treatment that is ongoing. Text messaging is an effective means for some individuals who initially hesitant to start treatment to begin the process. This is due to the benefit that text messaging provides of being an anonymous means of seeking help. As such, mental health providers can encourage individuals to seek help by allowing potential clients to communicate via text message. Examples include The Samaritans, a United Kingdom based charity which offers emotional support services aimed at suicide prevention. In 2006 The Samaritans launched a text message response service to supplement their phone hotline and experienced high satisfaction, with 70% of texters saying they would use the service again. [10] Similarly, the Mississippi Department of Mental Health runs a text message response service that directs users to resources for addressing multiple mental health issues. [34] Mental health providers can take a more proactive approach in some cases and use text messaging to reach out and inform the general population of available services. Joyce and Weibelzahl reported on an ongoing study at a university where students who provide their cell phone number were texted information about available mental health resources along with other more general messages concerning exams, sporting events, etc. These approaches are largely targeted at young adults

who tend to favor text messages as a mode of communication and may experience stigma or hesitation when considering seeking help [25] .Additionally, this mode of communication can also be continued once a young adult decides to enter into therapy by using text messaging as a means to enhance their relationship with their therapist and to quickly communicate with questions about appointments or their medication. [17] In this manner utilizing the communication abilities of smartphones (e.g. voice communication or text messaging) offer a patient's treatment team the ability to maintain and foster the patient/therapist relationship in-between sessions when face-to-face communication is not possible. Furthermore, the mobile nature of the smartphone increases the chances that the therapist can reach the patient or vice versa if the therapist also has a smartphone.

Smartphones can also allow patients to access commercial apps that can assist them in managing their health. Personal health records (PHRs), which like EMRs allow the patient view their own health information. PHR data can either be recorded on the smartphone itself or be internet-based; both of which are largely consumer controlled where the patient inputs the data. PHRs can also be connected to a larger EMR system that is physician controlled and allows the patient to only view or edit parts of the record. Another example is medication management apps such as "Medication Tracker", "MedsLog", and "Pillbox" which can alert a patient when it is time to take their medications. [50] There are also mental health specific apps available such as the "Depression by BMJ Group", which provides users with basic information on depression, questions to ask your doctor about depression, and information on various treatments available for depression. [7] In addition to a patient using their smartphone to access information and manage their health it can also be used to assist in their course of treatment. This can be done by utilizing smartphones to help the patient comply with treatment guidelines, facilitating the

application of coping techniques that are taught in therapy sessions and serving as either adjuncts of treatment and/or as a method of delivery of treatment.

5.1 ENHANCING PSYCHOTHERAPY

A common treatment for many mental illnesses is cognitive behavioral therapy, an evidenced based treatment which attempts to allow patients to realize and address distorted cognitions which affect their illness. The process involves a series of activities that the patient does both in sessions with a therapist and between sessions as homework. These activities typically involve paper questionnaires, registering plans and the activities, and recording thoughts, emotions, and reactions to situations as they occur. Oftentimes patients are unable to immediately record their thoughts on paper, which can result in distorted recording of the thoughts later or not recording them at all; reducing the effectiveness of the therapy. Furthermore, these paper forms are often uniform and do not allow for customization for individual patient's needs. One example a project utilizing smartphones to address this problem is SCOPE (Supporting Cognition Outlines on Psychological Evaluation), a multiple component software program, which can be used to aid therapists in administering the various parts CBT to patients and facilitate homework adherence. SCOPE includes ScoNOTES, ScoFORMS, ScoTHERAPY, and ScoALYSIS. ScoNOTES allows the therapist to input patient data and take notes during therapy sessions. ScoFORMS allows the therapist to create custom questionnaires, custom activity plans, and custom thought-forms and share those forms from their smartphone to the patient's smartphone or PDA. ScoTHERAPY is the patient's part of the program, which is designed to allow the patient to quickly fill out

questionnaires and related CBT homework. The resulting data from ScoTHERAPY can then be transferred to the therapist's ScoALYSIS, a data analysis tool which allows the therapist to chart patient progress without having to consult paper forms or transcribe the forms into electronic records. SCOPE also features adjustable help and reward features which the therapist can adjust depending on the amount of initial help the patient needs using the program and amount of reinforcement. SCOPE can also be set to issue warnings if certain situations are met (for example if a patient chooses the same answer X times in a row, suggesting that they are just going through the motions of their completing their homework). This allows for better adherence to homework assignments and better therapy results as a consequence. [8,9,49]

Mathews et al. tested the application of assigning CBT homework on mobile phones in healthy adolescents. The program "Mobile Mood Chart" was installed on the adolescents' personal phones and they were asked to fill out the mood questionnaire for 2 weeks. This group's completion rate was compared to a group of adolescents who were given paper and pen diaries to keep track of their mood. The authors reported that they only retrieved 18 paper diaries (35% of the paper and pen group) compared with an 81% completion of diaries in the mobile phone group; which was a statistically significant difference. In post-study interviews with the paper and pen group participants many of the adolescents admitted to backfilling the diary entries at once as opposed to completing them daily as instructed. The authors noted that the mobile phone diaries were time stamped and thus backfilling was not possible. An exit survey of both groups (N=64 combined) showed that when given a choice between pen and paper diaries and mobile phone diaries that 88.7% of participants would prefer the mobile phone diary. [33]

Software on smartphones can also be used to support CBT during in-person sessions by assisting in the analysis of patient outcomes. Software programs can be used to deliver computerized assessments (e.g. symptom rating scales) before a patient begins an in-person session and then analyzed so that feedback on patient outcomes is available to both the therapist and patient at the beginning of the session; allowing for better use of in-person session time. [42]

In addition to facilitating the completion of homework, smartphones can also be used as an adjunct of CBT to be used in-between in person sessions. Flynn et al. in a case study of two patients utilized a mobile phone to speak with and assist the two patients during exposure therapy for treating a phobia of driving. The patients were allowed unrestricted calling of their therapist for the first four weeks of the study and then the amount they were allowed to call was gradually reduced. One patient successfully overcame her phobia of driving but the other patient regressed after he was unable to call his therapist while driving; leading the authors to conclude that cell phone contact during exposure therapy could be beneficial in some patients but that some patients may become dependent on it and use it as a crutch. [11]

Przeworski and Newman utilized a PDA as a medium to deliver Computer-Assisted CBT (C-CBT) as a treatment for social phobia in group therapy sessions. At the start of the intervention the PDA was programed to ask the participant periodic questions about their baseline levels of anxiety, highest level of anxiety, and percent of time spent worrying. The participant was also asked to input specific physiological, cognitive, and situational anxiety cues into the PDA as a means to help themselves identify initial signs of worry. The PDA would give the participant positive feedback if they reported feeling low levels of anxiety and if they reported high levels of anxiety it would allow them access to therapeutic modules based on CBT concepts including “relaxation training”, “imagery retraining”, “a cognitive module”, and a “self-

control desensitization module". [46] Similarly, Norton et al. utilized a PDA to assist in the treatment of bulimia by providing patients with PDAs on which they could modules that supplemented their treatment. The modules consisted of educational materials, tips on how to avoid and cope with urges to binge or purge, and when to use taught coping strategies. The authors reported that patients reported enjoying the modules and liked how they forced them to consider their thoughts and eating behaviors [39]. Two studies compared this type of C-CBT to standard in-person CBT for Panic Disorder [27] and Social Phobia [20] found that C-CBT produced significantly better improvements in symptoms compared to wait list controls but was not as effective as face-to-face CBT.

5.2 CELL PHONE INTERVENTIONS FOR COMMUNITY-LIVING SCHIZOPHRENICS

A person with a mental illness may face a variety of socioeconomic or symptomatic challenges which make it difficult for them to maintain treatment adherence either in-between sessions or after completing a course of in-patient treatment. Common problems with lack of adherence can include missed appointments and forgetting or refusing to take medication, which can result in poorer health outcomes. Relapse is also a concern for many diseases. Furthermore, a therapist's inability to contact a patient can result in a lack of continuity of care and loss of follow-up. Previously, studies such as Beebe et al.(2008) utilized landline telephones as a means to improve treatment adherence and improve symptom management for schizophrenic outpatients. During

phone calls nurses would provide problem solving support to the outpatients to help them address common problems such as medication adherence, coping with symptoms, attending appointments, and social interaction. This intervention was successful in improving medication adherence and prompted Beebe et al. to initiate a pilot study to test the feasibility of extending the intervention to cell phones. Beebe et al's pilot study tested the ability of ten schizophrenia outpatients to regularly accept cell phone calls. A cell phone was provided for 5 months and the patients would receive a weekly call from a registered nurse(RN). The RN would ask the patient about problems they experienced with the cell phone and also recorded the number of successful and unsuccessful contacts. If a RN was unable to contact a patient then the patient would be asked for the reasons for the unanswered phone call. Seven of the ten patients successfully completed the study with 59.3% of calls being successfully completed. Of the three patients who did not complete the study, one patient sold the phone for drug money and another had the phone stolen. The most common cause of missed calls were psychiatric hospitalizations and experiencing psychotic symptoms. The authors concluded that the majority of individuals were able and willing to accept cell phone calls as a form of therapeutic engagement but that a subset of individuals may have lifestyle factors that may be a barrier.[4] This feasibility of a cell-phone based voice communication intervention for schizophrenia offered by Beebe et al. was demonstrated by a study conducted by Depp et al.

Depp et al's study, The Skills Training and Empowerment Program (STEP), supplemented in-person counseling sessions with telephone sessions on mobile phones the patients were provided with. In the telephone sessions the counselor inquires as to how the patient is doing, summarizes skills taught in previous sessions, reminds the patient to do homework, assesses the patient's progress, and assesses and trouble shoot barriers to treatment

with the patient. 8 patients in the STEP pilot program showed better improvement when compared to matched patients who attended in-person sessions only. [14]

Two studies were identified which utilized cell phones to improve daily functioning and prevent relapse in schizophrenia patients. Pijnenborg et. al. conducted a full sized study of 62 diagnosed schizophrenia utilized text messaging as prompts to achieve patient chosen goals as a way to improve daily functioning. If a patient was unable to choose a goal then a goal was chosen for them by either a family member or treating nurse. Goals consisted for medication adherence, attending counseling sessions, attending training programs, activities such as "grocery shopping", and inhibitions against undesired activities. A text message prompt was sent one hour before the desired goal activity and ten minutes before. There was a significant increase in appointment adherence as a result of the text message prompts and there was 8% increase in medication adherence, but it was not statistically significant. The small number of participants who choose "activities" also saw an increase in the completion of their goals. Also, negative schizophrenia symptoms were lessened in people who had an increase in goals. 70% of patients gave a positive review of the intervention and 41% thought that the text messages were helpful. [43]

Spaniel et. al. studied the effects of administering a weekly, five minute, ten item Early Warning Signs Questionaire (EWSQ) by SMS to the patient and a family member if possible. The questionnaire was designed to detect worsening symptoms (e.g. feelings of unease or hearing voices) to predict the patient beginning to relapse and alert their psychiatrist of the need to contact and evaluate their patient. This was accomplished by the patient and/or family member responding by SMS, the result would then be automatically processed and if the symptom score was high enough an automatic e-mail would be sent to alert their psychiatrist. Additionally, the

patient would be instructed to increase their medication dose by 20% within 24 hou rs to immediately address the symptoms and the patient would be administered the EWSQ twice a week to keep a closer eye on the improvement or worsening of symptoms. Treating psychiatrists could access the longitudinal scores of their patients via a website. The program resulted in an overall 60% reduction in hospitalizations in all participants and a 100% reduction in hospitalizations among participants and family members who responded to more than 70% of the SMS EWSQs. [57]

5.3 ECOLOGICAL MOMENTARY ASSESSMENT (EMA)

Ecological Momentary Assessment is a data collection method which focuses on the capture of real-time data and information. A participant whose information is being collected by EMA will be prompted multiple times during a day to collect data on the research topic of interest. The prompting has been achieved in various ways including a beeping wristwatch, pager, cell phones, and PDAs. Smartphones are an ideal candidate for EMA as they allow for both a method of prompting, data entry, and data transmission. EMA has multiple benefits compared to retrospective recall of events of interest. EMA avoids the recall bias that is often present when a person is asked to retrospectively recall an event, which often leads a person to recall the most prominent memory over a time frame and neglect other possibly meaningful events. Also, a person's description of past events is often shaped by their thoughts on it afterwards, which can alter their perception of how it actually occurred while "in the moment". As such, by collecting data in a person's natural settings it greatly increases that data's generalizability and ecological

validity. EMA also allows for multiple data points across time to be collected and analyzed for relevant trends. [24,60] The validity of EMA gathered data was demonstrated by Goldstein et al., who gathered data on smartphones from a random sample of a clinic population (those most likely to use the technology) and determined that the data gathered on the smartphone was valid and comparable to paper assessments in a control group. [18]

5.3.1 EMA in Schizophrenia Patients

Kimhy et. al. piloted the ability of hospitalized schizophrenia patients to conduct EMA assessment compared to healthy controls in a one-day study. Both groups had similar response rates, however, the schizophrenia patients reported a statistically significant higher level of challenge in participating in the study. [29] Granholm et al. conducted a feasibility study to see if patients with mental illnesses, in this case 84 patients with schizophrenia, are able to input EMA data on a PDA. The patients were provided a PDA for seven days and were prompted to enter data 4 times a day. The authors reported 87% of the patients having good adherence with responding to the prompts to enter data with a mean response rate of 69% completed prompts. Most patients reported having few difficulties with inputting data. The authors also noted that the data which was gathered was valid in that it correlated with baseline clinical assessment (e.g. patients with higher Independent Living Scores more often reported doing household tasks and spending less time alone/inactivity). [19]

5.3.2 EMA in Depressed Adolescents

Reid et al. piloted smartphones as a method of EMA data collection in high school students regarding mood, stress, and coping with a self-designed app called "Mobiletype". Students were provided a smartphone and sent a text message at four random times a day and prompted to complete questions on their current activity, mood, stress, and alcohol and marijuana use. The study had a good rate of completion, with 76% of 504 possible entries completed. Students generally reported that the smartphone was easy to use and adequately captured their daily lives. The students liked that it made them think about their feelings but admitted to occasionally lying in order to avoid follow-up questions regarding stressful situations or substance use. The authors noted a weakness in the use of open ended questions regarding what the students "did" in response to stress, which often generated responses behavioral responses such as "nothing" or "sleep" when the intent was to capture data on cognitions. [47]

Axelson et al. piloted an EMA data collection in adolescents with depression, anxiety, and bipolar disorder using answer-only cell phones. For 8 weeks 16 adolescents and five healthy controls were called by interviewers 12 times between 4 PM on Friday to 10 PM on Monday for each week and asked brief questions on their mood, thoughts, and behaviors. 17 of the 21 participants were able to complete the entire 8 week study and the authors concluded that it was acceptable to use answer only cell phones for EMA data collection in adolescents. [2] This methodology was replicated in several studies afterwards with completion rates. Silk et al. reported a median call completion rate 55 of 60 calls (92%) using this methodology in a five week of study adolescents with depression. [53] Forbes et al. used this methodology over one 4 day course in 15 depressed adolescents and 28 healthy controls with a 95% call completion rate.

[16] Additionally there were two other studies who used the methodology but did not report call completion rate. [52,61]

5.3.3 EMA in Bulimia Patient s

Three studies successfully used PDAs to collect EMA data on patients with bulimia. Two studies did not report adherence rates but reported that few participants dropped out or provided data that was unusable for analysis. One study reported that out of 133 participants there was only seven drop outs and three that provided insufficient data [55] and the second reported that out of 143 participants there was only ten drop outs and 2 participants that provided insufficient data. [37] Smyth et al. reported good adherence rates and timeliness with responses to EMA prompts in a study of 131 bulimia patients. There was an average completion rate of 86% of EMA prompts and additionally 75% of the participants completed 83% or more of EMA prompts. [56]

5.3.4 EMA in Bipolar Disorder and Borderline Personality Patients

Scharer et al. tested the feasibility of using PDAs for long-term monitoring of patient outcomes for patients with Bipolar Disorder. Fifty patients with Bipolar Disorder were given PDAs and told to keep daily diaries of their life events, mood and mood swings, medication use and side-effects experiences as result of medicine, and social function/impairment. The authors reported that patients with little computer experience needed more support from the research staff by telephone at first, but the difference in support needed dismissed over time. Most patients felt

that the PDA was a strong benefit to their treatment by reminding them to take their medication, allowing them to better understand their illness, and to actively participate in their treatment. Additionally, most patients felt that the PDA was not a burden and in some cases that using the PDA was fun and an incentive to participate. [51] Trull et al. successfully used a PDA to collect data on 60 outpatients with Borderline Personality Disorder. The patients were provided a PDA and prompted about their mood for up to six times a day for one month. The authors reported a 87% adherence rate. [59] Similarly, Bopp et al. collected data on the symptoms of 62 adult patients with Bipolar disorder via text message prompts sent to cell phones once a week. Patients participated in the program for a range of 1-92 weeks, with an average participation of 36 weeks. Patients had an average of 75% of completed responses out of the total possible data entries.[5]

5.4 ECOLOGICAL MOMENTARY INTERVENTIONS (EMIS)

Mobile phones, PDAs, and smartphones have also been in one step beyond just gathering data through EMA and also incorporated an intervention component based on the received EMA data. Such studies have been called Ecological Momentary Interventions (EMIs), which focus on treatment during a person's everyday life. Smartphones, like cell phones, are an ideal candidate for EMIs for mental illnesses as they are small and convenient for people to carry during their daily routine and have the functionality to deliver either communication or multimedia based intervention components. EMI offers patients an extension of in-person therapy in clinical setting by prompting or assisting patients in applying skills and strategies that they are taught in managing their illness when it matters the most; in real life situations. The constant presence and

accessibility of smartphones also allows patients to practice basic tenets of treatment (e.g. relaxation training) on their own, allowing the therapist more time for complex tasks during in-person meetings. As such, EMIs are typically offered as a component of a larger treatment but in some cases the EMI can be the sole intervention. [24]

A potential area of mental health care that could benefit from EMIs is the recording of and response to psychotic symptoms seen in mental health issues such as schizophrenia. Psychotic symptoms can often wax and wane and have environmental and contextual risk factors which may reduce or exacerbate symptoms. The very nature of psychotic systems and poor recall of patients can make reporting of symptoms and the circumstances surrounding the onset of symptoms difficult. A patient carrying a smartphone could address this problem by immediately entering data when they begin to experience symptoms such as hallucinations and noting the situation in which the symptoms began. Smartphones could also be used in a capacity beyond just data collection to identify symptom triggers, and also be used as real-time intervention devices which respond to input data that suggests present symptoms and responds accordingly. For example, studies have shown that increased anxiety and decreased self-esteem can trigger paranoia; based on this knowledge a patient who inputs feelings of anxiety into a smartphone could be provided with automated feedback to help themselves reduce anxiety and prevent increasing paranoia. [38] A similar application has been proposed for diseases such as Post Traumatic Stress Disorder (PTSD), where a smartphone application could be used to help users find a safe place and deliver stress management techniques. Additionally, a person who is susceptible to PTSD could use the smartphone to access social support networks to combat feelings of loneliness or to contact a therapist or first responders in a time of crisis. [31]

Depp et al. piloted an EMI called the Personalized Real-Time Intervention for Stabilizing Mood (PRISM) for ten patients with bipolar disorder. Patients first meet with a clinician for an in-person session in which they identify the patient's individual symptoms of depression and mania, symptom triggers, and adaptive strategies which are programed into their PDA. The patients were then sent automated questions to their PDA about their mood. When the patient's response indicts the beginning or presence of symptoms the PDA displays one of the personalized coping strategies that the patient selected for the symptom, such as walking their dog when they feel depressed. The participants reported a high level of satisfaction with the intervention, had little difficulty using the device, and said they would use the device again. [14]

Depp et al. also piloted an EMI called the Mobile Assessment and Therapy for Schizophrenia (MATS) program. The participants in MATS were sent a survey three times a day via SMS as a means of cognitive assessment and brief cognitive intervention in one of three symptom domains; hallucinations, medication adherence, and socialization. Based on the participant's responses a text message is sent that addresses the relevant symptom e.g. "The voices are just noises and can't hurt you". 75% of the eight participants who completed the program consistently responded to the text messages with 25% having a declining response rate as the study continued over 12 weeks. 2 participants dropped out of the study who had severe negative symptoms, suggesting that they lacked the motivation to stay interested in the study. [14]

A series of three studies also utilized text-message EMI aftercare of patients with Bullimia Nervosa. Bauer et al. launched a pilot program centered on weekly text messages in which the patient would report on binge eating episodes, their body image, and compensatory behaviors (e.g. purging). Patients were also allowed to send free text messages to the study about thoughts, feelings, and positive and negative life events. A semi-automatic response system was

in place that generated a response based on the weekly text message, which was then reviewed along with the additional text messages that the patient sent by the authors who had the option of creating a personalized response if needed. The pilot study was well received, with 80% of the participants saying they would participate again.[3] Robinson et. al replicated this pilot study with 21 participants and had poor results, with only nine participants completing the full six month study with a median of 13 out of 26 possible weekly texts answered. 14 participants completed a questionnaire on the acceptability of the intervention, most of which said they would not participant again or recommend the program to a friend.[48]

A more intensive text-message intervention was enacted by Shapiro et al. which featured a daily text each night which requested information on the participant's binging and purging episodes and on the strength of the urge to binge or purge. An automated text message would be then be sent that was tailored to the input data (e.g. Good job on resisting the strong urge to binge today!). If the patient did not input their data at night they would receive a text the following morning requesting the previous night's data. This supplemented 12 sessions of group CBT that the participants also attended and they were also encouraged to keep paper and pencil self-monitoring diaries as well. 87% of the possible nightly text messages were completed and patients reported higher satisfaction with the text message self-monitoring over the paper and pencil diaries. The authors reported a statistically significant reduction in the number of binging and purging episodes.[54]

5.5 SMARTPHONE USE TO DELIVER THERAPUTIC MULTIMEDIA AND APPS

In comparison to cell phones and PDAs, smartphones offer the unique ability to play multimedia and apps; offering patients the ability to access therapeutic videos and apps at any time. Preziosaa et al. studied the use of a smartphone's audio/visual capabilities to deliver a mental health intervention which sought to help college students manage exam stress by delivering a "mobile narrative" through a smartphone. The intervention was based on a previously established approach to control exam anxiety, the Stress Inoculation Training (SIT) method, which was administered by the authors using different mediums; an audio CD, a udio MP3, DVD, and on a smartphone. The study compared the different groups and reported that the smartphone group had the highest percentage of students who had a stress reduction and also had the highest percentage of students who were able to relax before taking an exam. Preziosaa et al. also conducted a similar intervention in train commuters, who were either in a control group, provided with a video with tropical imagery and new age music, or a similar six minute mobile narrative that was viewed on a smartphone. The study showed that only the smartphone group had a significant reduction in stress and that the smartphone group reported a higher level of engagement with the narrative. [45]

Morris et al. pilot tested smartphones to deliver CBT-inspired therapeutic apps to provide in-the-moment support for ten participants who reported high levels of stress. The study made use of EMA through development and use of a "Mood Map" app, which would prompt the participants to report on their mood several times a day to increase emotional awareness of mood patterns over time and in different situations and then access the therapeutic apps to cope with stress as needed. The therapeutic apps consisted of a b reathing exercise app that encouraged deliberate and slower breathing, a "Body Scan" app that encouraged physical relaxation, and a

"Mind Scan" app that encourage cognitive reappraisals by offering rhetorical questions. Essentially the program focused on the CBT concept of a person being aware of their thought and behavioral patterns and modifying them to prevent negative emotional reactions. The authors highlighted case studies of the participants and narrative interview excerpts to illustrate the participant's utilization of the mobile phone apps and the CBT concepts to manage their various sources of home or work-related stress and improve their mood over the course of the one-month study. [36]

Another example of using smartphones to deliver therapeutic apps is the development of the "Dialectical Behavioral Therapy Field Coach App", which offers patients with Borderline Personality Disorder access to a variety of resources. The app allows patients to access information on specific therapeutic skills and instructions on how to use them, a log to record when they use them, access to supportive audio and visual messages from their clinician and support network, and access to music and games to use as a distraction from intense emotional urges. [26]

6.0 DISCUSSION

Broadly, the current literature on applications of smartphone technology in the management and treatment of mental illnesses shows the promise of smartphones while at the same time reflecting the fact that medical applications of smartphones is still in its infancy. As such, a majority of the literature consisted of either pilot or feasibility studies which had a low number of participants, limiting the generalizability of the reported results. These studies also generally reported on preliminary findings and/or focused on c ase studies in lieu of quantitative analysis of health outcomes. A recurring concern in the literature is the ability of individuals with mental illness to interact with and use mobile devices as well as the feasibility of using mobile devices to collect data. A strength of the literature is that it reported on individuals with a variety of mental illnesses from anxiety/phobias, bulimia, schizophrenia, bi polar disorder, borderline personality disorder, and depression; allowing for data on the use of mobile devices in different patient populations. Regardless of the diagnosed mental illness, individuals were generally able to successfully use mobile phones, PDAs, or smartphones to accept phone calls, accept and respond to text-messages, respond to EMA prompts and input data, or use therapeutic apps/media. This suggests that mental health professionals can use smartphones in the treatment of a variety of mental illnesses with minimal difficulty on the part of the patient using the smartphone. In fact, many studies offered anecdotal evidence, case illustrations, and surveys of participant satisfaction to demonstrate that mobile device interventions were not only acceptable to a

majority of participants but in the case of comparison studies, preferable to the use of pen and paper modes of patient assessment and homework administration.

Studies which reported on the completion rate of study activities (e.g. completed phone interviews or EMA prompts) all reported favorable completion rates, oftentimes over 85%. Whether community mental health providers could expect to see similar completion rates in their own patients, however, remains questionable. Many of the studies offered participants a monetary incentive to participate and in some cases, a bonus if the participant had a high completion rate of completed calls or EMA prompts. Such monetary incentives would be lacking in a community treatment setting; limiting the generalizability of these studies to demonstrate likely high rates of adherence with smartphone interventions. Additionally, studies varied with respect to duration from a short duration of several days [19,29,45,52,56] to the longest study period of one year[57], with many falling into the two to six month range. While many of these studies offered encouraging evidence for mobile device use in various populations of the mentally ill, they offer little information on the feasibility and acceptability of long-term smartphone use to assist with disease management and treatment. This is especially relevant for life-long diseases such as schizophrenia, where a patient will be in constant treatment. An additional question left about the potential of smartphone interventions is that many studies identified participant sub-populations in which smartphone use may not be feasible.

One group of study participants that were of some concern were patients with schizophrenia. While schizophrenia patients for the most part were able to successfully participate in mobile technology interventions, some study participants displayed difficulty in completing studies. Of concern is that in some studies schizophrenia patients with more severe negative symptoms (e.g. low energy and motivation) would refuse to participate during

recruitment, lose interest and drop-out, or have a low response rate to phone calls, text messages or EMA prompts. Similarly, Granholm et al. reported that patients with a higher cognitive deficit were significantly more likely to be noncompliant with EMA prompts and Depp et al. reported that 25% of their participants had declining responses over the course of their 12 week MATS pilot. Beebe et al. reported a schizophrenic participant who sold the study-provided phone for money for illegal substances, suggesting that patients with a history of substance abuse may be problematic. This is especially true in the use of smartphones, which are significantly more expensive than the low-end cell phones used in some of the studies. Depp et al. reported that schizophrenic participants in the pilot of their STEP intervention had worries of losing the provided phone or having it stolen, which limited their desire to enter the study. The fear of losing the phone or having it stolen was more likely to occur if the participant lived in a group home. This appears to be a legitimate concern, as Beebe et al. reported a participant having his phone stolen and Granholm et al. reported a participant losing a PDA. As such, a patient's living arrangements may affect the possible success of a smartphone intervention. Two studies [43,57] found that intervention success was correlated with family support of the patient, suggesting that smartphone interventions may require either for the patient to have a certain amount of independent living skills or else the support of family and friends. Positive symptoms (e.g. hallucinations and delusions) of schizophrenia were less of a problem, as evidenced by a case study of a psychotic high-risk patient who successfully used a smartphone to input EMA data [28] and a study of hospitalized schizophrenic patients with moderate psychotic symptoms who successfully input EMA data into PDAs [11,29] . However, Granholm et al. did report one patient who refused to participate because of paranoid delusions about phones.

Of note also is the Robinson et al. study which reported a poor response rate in bulimia patients receiving a text message intervention. While the other two studies examining bulimia patients reported favorable response rates the participants in the Robinson et al. study had a high attrition rate and had low satisfaction survey responses. The authors noted that many of the participants were dissatisfied with the content of the text messages and felt they were too formal and impersonal. Several participants also disliked the lack of human contact and said they would have liked phone calls as well. The authors also noted that participant selection may have contributed to the high attrition. Participants were selected regardless of the severity of their symptoms and the amount of treatment they had previously received. The authors noted that the Bauer et al. pilot study had recruited patients who had previously completed in-patient treatment, suggesting that mobile device interventions may not be effective as a standalone treatment for highly symptomatic patients. This mirrors the findings of Kenardy et al. and Gruber et al., both of whom found that PDA-assisted CBT was statistically more effective than waitlisted participants but not as effective as face to face therapy. As such, the literature leaves questions open as to the exact role that smartphones can potentially play in mental health care and amount of face-to-face time that a patient needs in order to achieve good outcomes.

Despite these questions, the evidence for supporting possible smartphone use to increase access to care, reduce barriers to care, and facilitate patient follow-up remains largely positive. The current literature offers some insight into how smartphone interventions can be made feasible and more likely to succeed. Several studies reported on a fairly complex development process and pilot testing of study materials to make them accessible for the study population in question. Some studies [4,14] reported on the extensive training of participants in relevant study activities (e.g. checking text messages) and provision of written manuals on how to operate the

cellular phone, PDA, or smartphone. Such training and the availability of written manuals to assist in the operation of the mobile device in question likely contributed to the success of interventions in sub-populations not familiar with mobile communication technology. Many studies [5,54,57] also allowed participants to use their own phones, which achieves the same effect as it allows people to use technology they are already familiar with. This also raises the question, however, of the nature of start-up and development costs for implementing smartphone interventions. If certain sub-populations require extensive training in device use or time-consuming support from a mental health service's staff then the ability for some smaller community mental health services who have fewer resources to make use of smartphones may be limited. Of similar concern is the fact that those people who live in rural areas, those who have less education, and those people in lower income brackets is less likely to have access to wireless internet access or have a smartphone. [50] Unfortunately, people with mental illnesses are more likely to make less money than a mentally healthy person and people living in rural areas have the most problems accessing mental health services. This means that the those people who stand most to benefit from smartphone use are more likely to either not own one and be familiar with it (increasing the feasibility of its use) or not have the network access to make use of all the smartphone's features. This potentially limits the feasibility of smartphone use in some areas of the country where network access is limited and in cases where a patient would be required to use their own smartphone.

Studies also took other considerations into account when implementing interventions on cell phones, PDAs, or smartphones to increase acceptability to the participants. When considering EMA or EMIs for smartphones it is useful to limit the time it takes to fill out the questionnaire, especially if the number of prompts per day is high. This is likely to reduce

respondent fatigue and facilitate long-term smartphone use, as respondents may become unwilling to input data over a long period of time if it consumes a large portion of their time or is otherwise intrusive to their daily lives. This can also be achieved by being flexible with the scheduling of EMA prompts to accommodate participant's sleeping schedules, programing prompts to be spaced out so as to avoid several prompts in a short period of time, and giving participants the limited chances to "silence" prompts for a period of time so that they are not interrupted at inconvenient times such as driving or during a meeting. [40]

The questions themselves should be self-explanatory and formatted in a manner that is not confusing so that they can be easily filled out. For example, Depp et al. found that participants would sometimes miss questions if they were forced to scroll down on the PDA's screen and reformatted the appearance of the questionnaire so that no scrolling was required and an alert would prevent the participant from continuing if a question was not filled out. Authors also responded to participant feedback to facilitate participant, such as programing phones to automatically delete texts after three days so participants would not be confused as to which text to respond to. [14] Many of these issues can be addressed by utilizing focus groups and piloting of data collection or therapy apps with stakeholders who will be using them to ensure that questions are worded properly, determine an acceptable number of EMA prompts, etc.. Even after a study begins, contact with the patient is also useful, allowing a patient a few days to attempt operation of the device and then contacting them to see if they have any problems or questions is an effective way to encourage use of the device and help the patient troubleshoot problems. [40] While the current literature suggests that interventions which utilize mobile devices are feasible in individuals with various mental illnesses and offer insight into how to increase acceptability in

this population there are still questions regarding the possible use of smartphones to enhance mental health care.

An important limitation found in the current literature on mobile technology interventions is that much of the research carried out in the identified literature utilized low-end cell phones or PDAs; the predecessors of smartphones. This is not unsurprising, as the rate with which new technology (especially new smartphone models) is released usually outpaces the time it takes for a study to be completed and published. While it is likely that using a smartphone in the same role as a low-end cell phone or PDA (e.g receiving phone calls, text messages, or to deliver EMIs) would produce similar results, replication of these results on smartphones is both useful and currently lacking in the literature. Currently identified studies using smartphones were concerned with anxiety and stress and were conducted in "technology friendly" groups such as high school students [33,47] and college-age young adults. [45] Given the occasional difficulties experienced with schizophrenia patients studies examining the feasibility of smartphone use in populations with more serious mental illnesses is needed. In additional to testing the ability of patient populations to use smartphones, future studies should examine multiple aspects of the feasibility of smartphone use to enhance mental health care. These aspects should include, but not be limited to, the technical feasibility of integrating smartphones into the current care delivery system of providers, the willingness of clinicians to incorporate them into care and interact with patients who use them, cost-effectiveness of smartphone interventions, the start-up costs and barriers associated with smartphone interventions, and measurable treatment outcomes beyond ability to use smartphones, completion rates, and user satisfaction. Given the lack of current evidence for smartphone use in mental health patient populations, these studies should consist of more feasibility and quasi-experimental comparison studies to establish an initial base of evidence.

Once this evidence is established there should be a focus on large randomized controlled trials which can more effectively demonstrate the ability of smartphone use to improve access to and quality of care.

Given the fact that the major allure of smartphones is their mobility and the fact that they can support a variety of functions, future studies should also test the ability of smartphones to provide multiple component interventions. Ideally, smartphones could serve as a client-centered point of care for patient-provider communication, an extension of therapy, tracking patient outcomes/conducting follow-up and being a source of information for patients and doctors alike. However, studies are currently centered on a single application of mobile devices (e.g. only delivering therapeutic apps) and do not look at the one of the most promising aspects of smartphone use to enhance mental health care; their versatility. When it comes to mental health professional use of smartphones to enhance delivery and quality of care the current literature is lacking, with the current literature being focused on hospital-based physicians treating physical health problems. While current evidence supports the ability of smartphones to improve the efficiency of doctors in providing care, the lack of studies on mental health providers limits the generalizability of the findings in these studies. Some aspects, however, are likely to still be germane to mental health professionals such as the ability to access information, input patient data, and prescribing medication in the case of psychiatrists. Nevertheless, future studies examining the ability of smartphone use among mental health professionals to improve care is also warranted.

7.0 CONCLUSION

In conclusion, the current literature offers encouraging evidence for the feasibility of using smartphones to improve access to mental health care, reduce barriers to access and completion of treatment, and preventing patient relapse but many questions remain. A critical review of the literature showed that a majority of the literature consisted of feasibility and pilot studies concerned with the ability of persons with mental illness to participate in studies which use mobile devices including mobile phones, PDAs, and smartphones. These devices were utilized in a variety of ways including as a communication device, a data collection device, and as a mechanism to deliver treatment. These devices were often used to increase access to care by serving as a means to extend the reach of mental health professions to contact their patients and to encourage help-seeking by providing an anonymous means to seek help through text messaging or the internet. Mobile devices were also used to reduce barriers to completing care by facilitating the completion of therapeutic homework through electronic forms and EMA data completed on PDAs and smartphones. Mobiles devices were also used in the literature to conduct patient follow-up and prevent relapse for mental illnesses such as bulimia, bi-polar disorder, and schizophrenia. In line with healthcare reform, the literature also examined the use of mobile devices to deliver healthcare through innovative means such as EMIs and therapeutic apps on smartphones. Smartphones also offer additional roles that are encouraged by healthcare reform, such as the use of HIT in the form portable EHRs, which can be accessed on

smartphones. Studies which examined the use of smartphones by doctors and nurses to improve care were all centered on hospital-based doctors and treatment of physical conditions. Efficacy studies showed that smartphones have the capability of improving care through improved speed of care, data management, and safer prescription of medication; however the generalizability of these findings to mental health care is most likely limited. The majority of these studies used low end cellular phones or PDAs and few used smartphones themselves. Most studies reported favorably on the ability of persons with mental illness to use mobile devices to enhance their care but also noted some difficulties with patients with schizophrenia.

Many articles reported extensive pilot testing and collaboration with stakeholders in the development of mobile device intervention materials, which likely enhances the acceptability and feasibility of mobile device interventions. It is likely that patient populations which are unfamiliar with smartphone technology will need some training in smartphone use and support in order for interventions to be successful. Future studies are needed to replicate interventions conducted on cell phones and PDAs on smartphones and report on several aspects of feasibility including technical feasibility, barriers to smartphone intervention use among providers and patients, and the ability of smartphones to produce measurable improvements in access to care, reduction of barriers, improved patient follow-up, a reduction in patient relapse rates, and an overall improvement in treatment outcomes. Additionally, future studies are needed to test the ability and efficacy of smartphones to provide multiple component interventions and on ways to fully utilize the versatility of smartphones in order to maximize their potential to enhance mental health care.

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