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

The Future of Digital Psychiatry

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Abstract

Purpose of Review Treatments in psychiatry have been rapidly changing over the last century, following the development of psychopharmacology and new research achievements. However, with advances in technology, the practice of psychiatry in the future will likely be influenced by new trends based on computerized approaches and digital communication. We examined four major areas that will probably impact on the clinical practice in the next few years: telepsychiatry; social media; mobile applications and internet of things; artificial intelligence; and machine learning.

Recent Findings Developments in these four areas will benefit patients throughout the journey of the illness, encompassing early diagnosis, even before the patients present to a clinician; personalized treatment on demand at anytime and anywhere; better prediction on patient outcomes; and even how mental illnesses are diagnosed in the future.

Summary Though the evidence for many technology-based interventions or mobile applications is still insufficient, it is likely that such advances in technology will play a larger role in the way that patient receives mental health interventions in the future, leading to easier access to them and improved outcomes.

Keywords Mental health · Digital psychiatry · Telepsychiatry · Social media · Mobile applications · Artificial intelligence

Introduction

The practice of psychiatry has been changing over the last century but is still strictly based on the patient-psychiatrist. In fact, when patients experience certain symptoms, they would typically go to see their doctors in person, either at their clinics or at a hospital. The doctors would then make a diagnosis and prescribe the appropriate treatment, which may include medications or other forms of psychological treatment. Patients would only receive the next round of counselling or psychotherapy when they see their doctors or psychologists again. Doctors would learn about patient's mental state through their observations in person during the real-life interviews or by asking collateral information from patient's friends and families. The final prognosis of the patient would depend on the literature available and doctor's assessment.

The future of psychiatry, however, will be upended by the incorporation of digital technology. Some of the changes in practice are already taking place nowadays, whilst research has pointed towards certain directions of what may be coming. This review article will examine four major trends that will certainly influence the future of digital psychiatry and how these changes will shape the practice of psychiatry and lead to improvements in terms of patient's outcomes and experience.

Telepsychiatry

Telepsychiatry is defined as the provision of psychiatric care remotely through various forms of telecommunication. Drago et al. defined telepsychiatry as the "*the use of electronic communication and information technologies to provide or support clinical psychiatric care at a distance*" [1•]. The most widely used form of telepsychiatry is videoconferencing. This would often involve the clinician sitting in front of a computer to speak to a patient at a distant site in real time via the internet. Videoconferencing has the ability to transcend

regional and international limitations, allowing patients to have easier access for mental health treatments, particularly in rural areas or low-income countries. Videoconferencing can also connect patients and clinicians with similar cultural backgrounds, enabling more effective communication without the hindrance of cultural gaps and misunderstandings [2]. Hubley et al. analyzed telepsychiatry in various aspects, namely, patient and provider satisfaction, reliability, treatment outcomes, implementation outcomes, and cost-effectiveness, and found that telepsychiatry is comparable to face-to-face interviews in terms of the reliability of treatment outcomes and assessment [3]. In the same review, telepsychiatry has also been found to be cost-effective and this finding is applicable in many countries around the world, including the USA, UK, Canada, and Israel. This result may be particularly important given the global rising costs of healthcare. In certain cases, the patients may actually *prefer* to see their doctors via videoconferencing, as they may perceive the distance between them and the clinician to be an added layer of security for patient confidentiality and may avoid the perceived stigma of walking into a mental health clinic [4].

One special scenario worth noting is the use of videoconferencing in prisons. Every time a prisoner is transported out to a mental health clinic for treatment, there are tremendous costs associated with the transfer, including staff and transportation costs. There may be a risk of the prisoner running away as well. As such, the use of videoconferencing is welcomed by many correctional institutes, especially in the USA. In Hong Kong, clinician's use of videoconferencing to interview the inmates has been found to be cost-efficient and scored high in terms of patient acceptability [5].

Whilst videoconferencing is the most commonly used form of telepsychiatry, there are other modes of delivering it. In certain situations where the real-time dialogue is not possible, either due to technical difficulties or language barriers, asynchronous telepsychiatry may be helpful. In these cases, the patients will record themselves and send the video to the psychiatrists for their review. If there is a language barrier between the clinician and the patient, the video may be edited with a translation provided. In such cases, a real time translator may not be required, which may be more cost-effective in certain situations and avoids the potential complication of interactions between the patient, interpreter, and the clinician with no interference on the therapeutic relationship [6]. Telepsychiatry may be delivered via a decision support system for mental health problems, incorporating screening questions, functional and severity assessment, a descriptive clinical diagnosis, and suggestions for the appropriate treatment modality [7]. This is particularly useful in countries where there is an insufficient supply of mental health professionals to meet the demands of the patients, or where the clinicians have not received enough training on mental health treatments. The use of a decision support system would therefore allow other types of clinicians or even para-professionals to deliver mental healthcare.

Given the low cost of videoconferencing and the rising healthcare costs, the use of the videoconferencing is expected to further increase in the future with services offered to a wider population. Apart from the prison population, other people living in institutional settings may also benefit from telepsychiatry. There has been research examining the use of telepsychiatry at old aged homes, even across a country in order to connect the clinicians with similar backgrounds to the patients [8]. Furthermore, with more sophisticated algorithms being developed, decision support systems are expected to be even more refined and accurate in making diagnoses and suggesting the correct type of treatment. These new developments would greatly improve the mental health delivery in many low-income countries, as the shortage of manpower is unlikely to improve in the near future. One health technology company in China intends on introducing "health booths" across the country, where patients can talk to a virtual therapist about their symptoms and the decision support system will facilitate the clinician to suggest a possible diagnosis and treatment [9].

Social Media

Several authors have described the impact of social media on the general public mental health. People who are very active on social media may be influenced by what they see online and suffer from various mood or anxiety symptoms [10]. There have been various theories postulating the reasons why one would be affected by being on social media, including mental comparisons with one's peers, poor sleep, poor body image or hate, and derogatory speech [11]. On the other hand, many young people may feel more comfortable expressing their feelings or emotions on social media with a post or an Instagram story. Using machine learning techniques, research has suggested that markers of depression are observable in some Instagram users' behavior and these signs of depression may be noted even before depression has been clinically diagnosed [12]. Similar findings have been reproduced in other social media platforms, such as Twitter and Facebook [13]. In fact, Facebook, one of the most popular social media application in the world, has introduced an algorithm to help detecting behaviors or statements that may be suggestive of a person intending to commit suicide [14••].

Given the increasing popularity of social media, with an estimated 2.77 billion users worldwide, up nearly three-folds compared to 10 years ago, more attention needs to be paid on the interactions of social media and psychiatric illnesses and how psychiatrists can leverage on social media to monitor and promote mental health [15]. There is

still debate on the extent to which psychiatrists should interact with their patients on social media. On the one hand, staying connected with the patients allows the psychiatrists to be more aware of a patient's mood fluctuations and conduct a more all-rounded assessment of their patient's mental state. When the patients post certain statuses, posts, or images that suggest the patient is intending on committing suicide, psychiatrists can refer the patient to the relevant crisis intervention team or suggest the patient to seek earlier medical attention. On the other hand, this increased interaction with the patient may blur the boundaries of the relationship between the psychiatrist and the patient. Online "friendship" may lead to a slippery slope to romantic involvement, loss of patient confidentiality, increased stigma, and social disadvantage [16]. In certain instances, the maintenance of a strict boundary between the patient and his own psychiatrist is extremely important for the therapeutic relationship. There are also other worries on what people post on social media may not be true or accurate as the posts may only be a facet of their actual lives rather than a complete representation, so clinicians have to carefully assess the utility of certain posts [17].

On the other hand, psychiatrists can use social media to their advantage in order to spread messages. Beyond their daily clinical care, psychiatrists also need to promote awareness about mental health and educate the general population on ways to improve their own mental wellbeing. For many people, social media is the main source of information, shunning traditional news, or health information websites. In China, for example, WeChat is an all-encompassing application that provides a social media platform, but also news or a method to pay bills. Psychiatrists can leverage on these various social media platform to educate others on useful medical information [18].

Given the increasing popularity of social media, it would be unwise to completely shun social media despite the benefits and dangers that social media might bring to mental health treatment and the therapeutic relationship. Psychiatrists should explicitly explain how information obtained online through social media accounts will be used. Furthermore, psychiatrists should be vigilant of what they post online and refrain from making writing anything that could potentially lead to their patients being identified. They should also be aware that their own patients might look through their profiles online on social media, perusing their personal lives, pictures, and posts if the privacy settings are set rather loose. Whilst a degree of personal revelation may be intended and beneficial towards strengthening the therapeutic relationship, many doctors would feel uncomfortable if their patients are able to pry into their personal lives, much like what a close friend could do [16].

There is therefore a suggestion that doctors can keep two separate social media accounts, one for personal use and another one for professional use in order to safely use social media for learning about their patients' mental state and disseminating health information through the professional account. The doctors can maintain their online presence through their personal social media. With the advances in artificial intelligence, doctors can even be flagged on the changes in their patients' social media activity as a precursor or indicator of the changes in their mental state in order to deliver an appropriate intervention.

Mobile Applications and Internet of Things

Smartphones are becoming popular in the everyday life all over the world with a rate of usage of 75% in developed countries and 60% in developing countries in 2019 [19]. Many mobile phone applications have been developed in association with a tool on health. According to a survey conducted in 2015, out of 15,000 disease-specific mobile applications, 29% are focused on mental health issues, amounting to approximately 4500 different mobile applications [19]. This abundance of mobile applications offers different services covering a wide range of conditions. Some of them provide information on certain mental health conditions and give advice on mental wellbeing, such as stress relief methods and ways to calm oneself down through breathing exercises. Others allow users to track their mood on an online mood flowchart. Certain applications, such as Ginger.io, connect the user to a therapist who is able to provide counselling anytime [20]. A few applications make use of the global positioning system on the smartphone and can offer push notifications at specific locations. One example may be an application designed to help users to cut down on alcohol consumption. If the user is found to be close to an area where there are many bars or clubs, the application will provide the appropriate reminders and nudges [21].

There is increasing evidence about the effectiveness of smartphone applications in treating specific mental disorders. One meta-analysis published in 2017 found that smartphone applications seem to be helpful in reducing depressive symptoms, though the effect seems to be more prominent for those with less severe illnesses [22•]. Another article published by the same group of authors found that smartphone applications seem to help reduce anxiety symptoms as well [23•]. Many of the applications are rooted with cognitive behavioral therapy techniques as the theoretical basis for the algorithm. Chandrashekar suggested that the success of these applications may be due to their simple user interface and experience, high patient engagement, transdiagnostic capabilities, and self-monitoring features [24••]. However, there is insufficient evidence to suggest any specific application to be more effective than another, given the heterogeneity in the methodology of the treatment outcome studies [25].

It is likely that there will be plenty of smartphone applications designed for mental health treatment in the future. Psychiatrists can use these applications to review patient's mood diaries and understand consequences of any mood fluctuations. They can also provide more information on mental wellbeing or connect the patients with other allied health professionals. One application developed by a technology company in association with the Department of Veteran Affairs of the US Government allows clinicians to monitor the mental wellbeing of veterans through the application sending data on *how* the users are using their smartphone, such as the frequency of use and geolocation [26]. Compared with other mobile applications which may require active use or participation, this application can operate in the background and gather the relevant information. However, more research is needed to demonstrate the efficacy, safety, and effectiveness of these applications. Some authors have suggested that clinicians should only cautiously incorporate smartphone applications as an adjunctive treatment, given the limited evidence and the potential risk of iatrogenic harm to certain patients [25].

Management of mental health issues is further advanced by the developments in Internet of Things (IoT). IoT is the interconnection of multiple everyday objects via the Internet, enabling the devices to record and send data to each other. IoT devices have been widely used in other medical specialties, such as continuous blood glucose monitoring through a patch on the skin. On the other hand, IoT devices are less common for the management of mental health disorders. For instance, some sport watches with IoT capabilities may offer a glimpse of the wearer's sleep architecture and duration, so to provide more information for those who suffer from insomnia. Apart from watches, even medications can incorporate IoT technology. The US Food and Drug Administration issued its first approval for a "smart" medication in 2017. Abilify Mycite is a tablet of the antipsychotic aripiprazole with an embedded sensor in the pill, so information on whether the pill is actually consumed will be relayed [27]. Even mirrors can have IoT technology installed to give suggestions on one's postures [28]. Real time monitoring through the applications or IoT devices will allow the patients to receive personalized assessments, treatments, and interventions [29], and it is conceivable that smart mirrors will one day be able to detect changes in one's mood through differences in facial expressions.

Artificial Intelligence

Many of the advances in telepsychiatry, social media, mobile applications, and IoT listed above are powered by developments in artificial intelligence. The term "artificial intelligence" encompasses many different domains, including machine learning, natural language processing, and image processing. Leaps in computing power and capacity have enabled artificial intelligence to be applied in various fields of medicine, with many companies creating special divisions just to focus on the research and application of artificial intelligence to healthcare. Many of the future trends of digital psychiatry listed in the previous sections use machine learning to make the relevant predictions and interventions, such as image processing on photos posted on Instagram or Facebook or machine learning in deciphering posts on Twitter.

Artificial intelligence is already being used extensively in understanding how mental disorders affect the brain through the interpretation of functional MRIs of patients with psychosis or other mental illnesses [30, 31]. The technology will revolutionize the way that mental health disorders are currently diagnosed and treated. As mentioned earlier, the application designed to monitor the way users interact with their smartphones to detect mental health problems utilizes artificial intelligence in its algorithm. There is also a trend to detect individuals at risk of developing mental health problems prior to their progression towards a definite clinical diagnosis, such as using Instagram to predict those at risk of developing depression, so intervention may be applied at an earlier stage [12]. Researchers have developed a program which used automated speech analysis that predicted with 100% accuracy which young individuals at risk of developing psychosis eventually developed clinical psychosis [32]. Similar speech analytic technology has been applied to the diagnosis of post-traumatic stress disorder amongst warzone-exposed veterans and the algorithm was able to diagnose the illness with an AUC of 0.954 [33]. There has already been research published on how machine learning can shorten the gold standard diagnostic interview for autism with 100% sensitivity and 94% specificity [34]. As history taking is key in diagnosing mental illness in patients, university researchers have developed a program that aims to encourage people to divulge their deepest secrets, as it has been found that some people open up more to virtual humans as they feel that they will not be judged as much [35]. The program can detect changes in the facial expressions and changes in verbal communication and make the appropriate statements to encourage individuals to speak up [36]. The researchers emphasize that the program is only for research purposes, rather than acting in the role of a therapist.

In the future, individuals who have been diagnosed with a mental disorder will likely benefit from a more personalized treatment, tailored to the individual genome thanks to further understanding of the interactions between the medication and the pharmacodynamics of the patient [37]. Machine learning can already predict which individuals face a poorer prognosis and precision medicine enables even more effective treatment strategies to be delivered [38, 39•]. Patients will also be able to receive psychological treatment through conversations with therapists at a distant location or with a computerized conversational agent. A randomized controlled trial has shown that

young adults with symptoms of depression and anxiety have shown improvements in their mental health after they received an intervention with a fully automated conversational agent compared to the control group [40]. Such examples demonstrate the potential of artificial intelligence in changing how and who will deliver the appropriate interventions.

In fact, artificial intelligence might even change the way of classifying mental illness. Given that many mental health disorders share similar symptom clusters, machine learning can help to identify the associations between the symptoms, behavior, brain function, and real world function across different diagnoses, thus paving the road on how we will classify mental disorders in the future [41].

Ethical Considerations

Whilst the adoption of advances in digital psychiatry into the daily practice of psychiatry sounds promising, there are certain ethical issues that need to be addressed and considered. Machine deep learning is often known as a "black box," as the psychiatrists or programmers themselves might not fully understand how the algorithm was derived. This will lead to problems when the psychiatrists attempt to explain the rationale behind their opinion or diagnosis. The safety of the algorithm should also be addressed. Would the clinicians be ultimately responsible to ensure that the algorithm used is up to date and not tampered by others? There have been cases in which actions have been carried out deliberately to fool the machine learning algorithm in order to achieve some secondary gain, such as financial compensation or the prescription of a certain type of restricted medication [42]. The question of legal responsibility needs to be addressed as well. If the algorithm in use fails to identify a mental illness, leading to a missed diagnosis, or induces iatrogenic harm on to the patient due to a poorly carried out intervention, who should be responsible for this negligence? Would it be the psychiatrist in charge, or the encoder of the algorithm?

The increasing popularity of social media has led to questions about data privacy. As the researchers at Facebook have noted, when building suicide prevention tools, or other tools that help to detect mental health issues through constant monitoring, there needs to be a fine balance between privacy and efficacy. Many users of social media are often asked to accept the lengthy terms and conditions of the use of certain applications, only to find out that a lot of their personal information has been collected in the process. The data privacy of each user needs to be handled with care, with safeguards to ensure that there will not be unauthorized access or use of personal data. The level at which the machine learning deems the person at risk of mental illness or suicide is up for scrutiny as well. If human input is warranted for secondary screening, this would invite further privacy concerns.

What's Next

According to the emerging literature and encompassing current clinical needs and concerns, authors may suggest that:

–   Medical students and trainees should be trained on the use of technology in the field of health care;
–   Psychiatrists should be updated on the newer technologies and the potential applications in the field of mental health care;
–   A panel of experts, including mental health opinion leaders and experts from the major technology companies, should be formed to discuss about the possible application of technology in the daily clinical practice;
–   More clinical trials should be encouraged and supported by the technology companies in order to test the efficacy of newer interventions and sort out some ethical issues related to patient's privacy and treatment of sensitive data;
–   An international committee on digital psychiatry should be formed with the participation of some international psychiatry associations, World Health Organization, and major technology providers in order to discuss on research data, sort out ethical issues, and provide guidance on how adapt or integrate the changing technologies and shifting models of care.

We believe that these steps are needed in order to discuss and approve the efficacy and ethical standards required for the introduction of technologies in the daily practice of mental health care. The practice of psychiatry needs to be updated in its diagnostic and therapeutic procedures to incorporate technology and make advances as well as in nearly all other branches of medicine [39•].

Conclusion

With rapid advances in technology, it is likely that the practice of psychiatry will be rather different compared to the present day. The days of a patient receiving treatment solely during the consultation with the clinician are numbered. In the future, patients will be able to receive treatment through their mobile phone applications or talk to their clinicians via videoconferencing. They may also interact with their clinicians on social media or converse with chatbots programmed to provide supportive counselling. Clinicians can receive live updates on their patient's mental health status, not just by what the patients input into an application or information gathered through devices with Internet of Things capabilities, but also on how they interact with others and how they use their smartphones. Developments in artificial intelligence can even help to advance our understanding of mental illness through research in the neural networks and brain scans, deliver

personalized treatment or create a new classification of mental disorders rather than the current phenomenological approach [39•]. It has already been proven that the prediction of risk of suicide or unplanned readmissions can be improved through machine learning and such algorithms may be further incorporated into daily clinical practice in the future [43••,44].

Developments in digital psychiatry will allow more patients to have access to mental health treatments. There is often a shortage in the number of mental health professionals in many developing countries. Even in developed countries, such as the USA, some therapists do not accept insurance payment, rendering access to treatment limited as well [45]. Certain modes of technology can be used right now to improve the accessibility for patients, such as telepsychiatry, given the maturity of the underlying technology. Furthermore, advances in artificial intelligence will further perfect the algorithm used for the decision support systems, facilitating healthcare providers without advanced training in psychiatry to provide mental health treatment, or enable patients to seek alternative sources of treatments. However, the relevant ethical considerations and debates have yet to be resolved. The important privacy concerns and data security need to be fully disclosed and debated on. Digital psychiatry will inevitably create large amounts of personal data and there should be clear guidelines on how this information will be used. Whilst the future of digital psychiatry appears promising, more work still needs to be done on reviewing the efficacy, evidence, and ethical issues prior to further incorporation into daily clinical workflow [46•].

With so many technology companies, such as Google and Apple, making large investments in artificial intelligence and healthcare, it is likely that one will continue to read news stories or articles on how technology will change the future of the practice of psychiatry. However, the application of artificial intelligence in everyday life is still rather limited, in particular in health care where the routine use has hardly started [47]. The decision to incorporate social media or artificial intelligence into daily clinical use would probably require institutional level assessment and adoption, given the high costs of implementation and upgrading the software. Furthermore, the evidence for the benefits of using artificial intelligence and social media should be more robust before such technologies should be used in the daily clinical practice. There are only some research papers published that have supported their efficacy. Given the potential harm and the ethical violations, further experiments should be conducted with a larger population sample before such technology could be routinely used. Future doctors would also have to be more versed and adept in understanding how to use artificial intelligence and knowledge management in order to make full use of these developments in technology [48].

Compliance with Ethical Standards

Conflict of Interest   The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent   This article does not contain any studies with human or animal subjects performed by any of the authors.

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