Terra *et al.*
Egypt J Neurol Psychiatry Neurosurg (2023) 59:80
https://doi.org/10.1186/s41983-023-00681-z

The Egyptian Journal of Neurology, Psychiatry and Neurosurgery

REVIEW

Open Access

Opportunities, applications, challenges and ethical implications of artificial intelligence in psychiatry: a narrative review

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Abstract

Background Artificial intelligence (AI) has made significant advances in recent years, and its applications in psychiatry have gained increasing attention. The use of AI in psychiatry offers the potential to improve patient outcomes and provide valuable insights for healthcare workers. However, the potential benefits of AI in psychiatry are accompanied by several challenges and ethical implications that require consideration. In this review, we explore the use of AI in psychiatry and its applications in monitoring mental illness, treatment, prediction, diagnosis, and deep learning. We discuss the potential benefits of AI in terms of improved patient outcomes, efficiency, and cost-effectiveness. However, we also address the challenges and ethical implications associated with the use of AI in psychiatry, including issues of accuracy, privacy, and the risk of perpetuating existing biases in the field.

Results This is a review article, thus not applicable.

Conclusion Despite the challenges and ethical implications of using AI in psychiatry, the potential benefits of this technology cannot be ignored. Further research and development are required to address the limitations and ensure the safe and ethical integration of AI in the field of psychiatry. By doing so, AI has the potential to greatly improve patient outcomes and enhance the delivery of mental healthcare services.

Keywords Artificial intelligence, Psychiatry, Deep learning, Mental illness

Background

Artificial Intelligence, or AI, is a broad field of computer science that involves creating machines and software that can perform tasks that would typically require human intelligence [1]. This can include tasks such as understanding natural language, recognizing objects in images, and making decisions based on data [1]. AI can be divided into two main categories: narrow or weak AI, which is designed to perform specific tasks, and general or strong AI, which can perform any intellectual task that a human can [2]. Advancements in AI have the potential to bring significant benefits to society, such as improved healthcare, but also raise some concerns. It is a rapidly growing field, with new development and research happening all the time.

AI is increasingly being used in the healthcare field to improve patient outcomes, streamline processes, and make medical research more efficient [3]. Applications of AI in medicine include natural language processing for medical records, computer vision for medical imaging, and machine learning for precision medicine [3]. In psychiatry, AI is being used to improve the diagnosis and treatment of mental health disorders. It includes natural language processing for analyzing patient data, such as speech and text, machine learning for identifying patterns in large datasets, and computer vision for analyzing

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brain imaging [4]. AI-powered chatbots and virtual assistants are also being used to improve patient engagement and provide mental health support, for example, they are being used to provide diagnostic support, cognitive-behavioral therapy, and other mental health interventions to patients [5–7].

AI can also be used to develop new drugs and therapies for mental health disorders. Machine learning algorithms are being used to analyze large datasets of genetic and molecular data to identify new targets for drug development [8, 9]. Furthermore, AI-powered virtual assistants can help to improve the accessibility of mental health services by providing self-help tools and connecting patients with mental health professionals [10]. However, there are also concerns about the potential ethical and societal implications of AI in psychiatry, such as issues related to data privacy and bias in algorithm decision-making [10–12]. Despite these concerns, the use of AI in psychiatry is expected to continue to grow in the coming years as technology advances and the healthcare industry becomes more data driven.

This review discusses the uses of AI in psychiatry, including its role in diagnosing, predicting, and treating psychiatric disorders. It also discusses the challenges and limitations currently facing the field.

Opportunities of AI in psychiatry

AI has the potential to revolutionize the field of psychiatry by providing new methods for the diagnosis, treatment, and prevention of mental health disorders.

One of the key opportunities for AI in psychiatry is the ability to analyze large amounts of data from various sources, such as genetics, neuroimaging, and patient-reported outcomes [8]. This can enable the identification of new biomarkers and risk factors for mental disorders, as well as the development of more personalized treatment plans [8, 13]. For example, AI-based methods can be used to predict the response to different medications or psychotherapies or to detect early signs of illness onset or relapse.

Another opportunity for AI in psychiatry is the development of automated screening and assessment tools [5, 14–17]. These tools can be used to quickly and accurately identify individuals at risk of mental disorders, such as depression or suicide, and to monitor their progress over time. AI-based methods can also be used to analyze social media data, text messages, or speech patterns to detect signs of emotional distress or suicidal thoughts [15, 16]. This can help to identify individuals in need of support or intervention before they reach a crisis point [18].

AI can also be used to improve the efficiency and effectiveness of mental health care delivery [7, 19]. For example, AI-based methods can be used to automate routine tasks, such as scheduling appointments or collecting patient information, freeing up time for clinicians to focus on more complex tasks. Additionally, AI-based systems can be used to provide remote or virtual care to individuals living in areas with a shortage of mental health professionals.

Applications of AI in psychiatry

AI can be used in monitoring, treatment, prediction, diagnosis, and deep learning by analyzing data from various sources such as wearable devices, electronic health records, and self-reports as shown in Fig. 1.

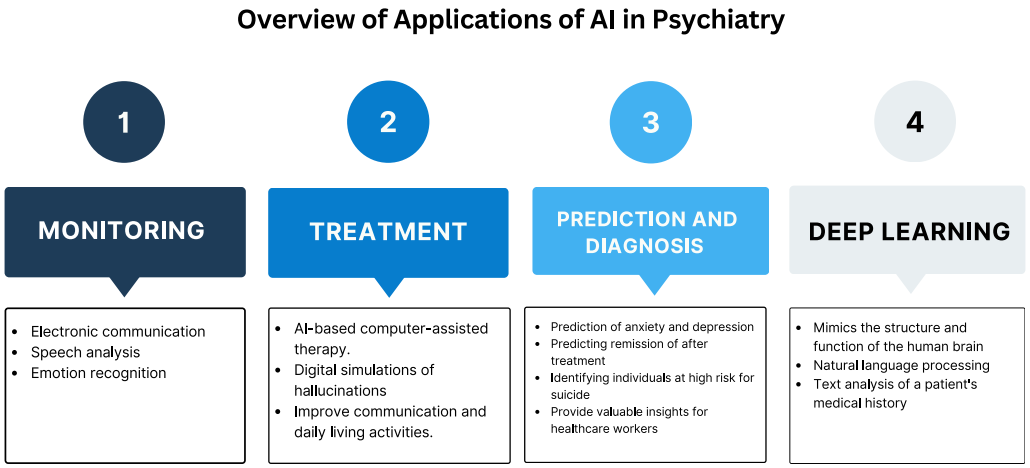

Fig. 1 Overview of applications of AI in psychiatry

Monitoring

AI has demonstrated promise in the realm of monitoring mental illness and increasing patient involvement in treatment. In Table 1, the various AI monitoring techniques for mental illnesses are summarized. One area of particular interest is the use of AI in the monitoring of schizophrenia [20]. Studies have shown that cardiovascular mortality rates are significantly higher in individuals with schizophrenia, reaching up to two-thirds of the reference population [20]. It is unclear whether this increase is a result of the pro-arrhythmic effects of antipsychotic medication or if it occurs in unmedicated patients. By utilizing electrocardiography (ECG) to measure heart rate variability, researchers have been able to monitor changes in autonomic dysfunction during acute psychosis, to predict sudden cardiac death [21]. A study involving 20 participants found a remarkable decrease in heart rate complexity during acute episodes when non-linear complexity measures were used. These findings have the potential to aid in the early identification of patients at high risk for intervention and ultimately reduce mortality rates [21].

In recent years, the widespread availability of smartphones has presented an opportunity for the use of electronic communication in the monitoring and diagnosis of mental illness. In the case of bipolar disorder, digital footprints have been studied for their potential to form a connection between mood disturbances and specific data. An experiment involving a 1-min writing session was found to be remarkably successful, with a prediction accuracy of 90.31% [22]. The use of passively sensed data, such as calls, SMS, activity, speech, and location, has also been explored. The Social Rhythms Metric (SRM) has been tested as a clinically reliable marker for rhythmicity and stability in bipolar disorder, with the ability to identify patients in stable or unstable states [22]. Furthermore, the use of these tools can empower patients to feel more in control of their treatment.

Clinical research has also highlighted the potential of speech analysis as a non-invasive and non-intrusive tool for monitoring and predicting both depression and suicidal risk [23]. A clinical trial found that patient speech, specifically vocal jitter, and glottal flow slope could be used to predict near-suicidal patients, as the toneless and hollow speech was found to be indicative of this risk [24]. Similarly, in depressed patients, changes in voice tone, reduced prosody, and a "lifeless" speech pattern have been observed [25]. A study conducted in 1999 involved two experimental studies exploring the ability of humans and computers to identify different emotions in speech [26]. The computer recognition technique utilized neural networks and K-nearest neighbors. The first study used 700 short sentences from college students expressing five basic emotions, while the second study used 56 (15–90) second long telephone messages mostly expressing anger and normal. Both studies found that the main cue for emotion recognition was fundamental frequency (voice pitch), with diagnostic accuracy rates of around 70%.

Treatment

AI has been increasingly utilized in psychiatry for the treatment of mental illness. Table 2 provides a clear explanation of the different AI applications used for the treatment of some psychiatric diseases. One of the key advantages of using AI in this field is the ability to process large amounts of data, which can aid in predicting the outcomes of medication treatments and assist in treatment selection [27, 28]. A randomized controlled trial conducted by Dr. Russel Fulmar in 2018 evaluated the effectiveness of an AI model called "Tess" in reducing self-reported symptoms of anxiety and depression [6]. The trial, which involved 75 participants and lasted for 2–4 weeks, found that those who had access to Tess

Table 1 AI monitoring techniques for mental illness

Mental illness	Monitoring technique	Key findings
Schizophrenia	Electrocardiography (ECG)	- Cardiovascular mortality rates are significantly higher in individuals with schizophrenia - Changes in autonomic dysfunction during acute psychosis can predict sudden cardiac death - Non-linear complexity measures can aid in the early identification of high-risk patients
Bipolar disorder	Digital footprints	- One-minute writing sessions have a prediction accuracy of 90.31% - Passively sensed data, such as calls, SMS, activity, speech, and location, can be used to identify patients in stable or unstable states - The Social Rhythms Metric (SRM) is a clinically reliable marker for rhythmicity and stability
Depression and suicidal risk	Speech analysis	- Vocal jitter and glottal flow slope can predict near-suicidal patients - Changes in voice tone, reduced prosody, and a "lifeless" speech pattern have been observed in depressed patients - Fundamental frequency (voice pitch) is the main cue for emotion recognition, with diagnostic accuracy rates of around 70%

Table 2 AI applications for treatment of psychiatric disorders

Application of AI in psychiatry	Description
Treatment selection and prediction	AI is used to process large amounts of data to predict treatment outcomes and assist in treatment selection
Computer-assisted therapy (CAT)	AI is used to enhance traditional therapies such as cognitive-behavioral therapy (CBT) through computer-delivered CBT (cCBT). This method is effective, less intimidating for patients, and more cost-efficient
Treatment of auditory hallucinations in schizophrenia	AI is used to create a digital simulation of a patient's distressing hallucinations, allowing the patient, therapist, and avatar to communicate through it. One example is the AVATAR system, which has been shown to result in a reduction in anxiety and an improvement in voice frequency
Communication and daily living activities for individuals with autism spectrum disorder (ASD)	AI is used to improve communication and assist with daily activities for individuals with ASD. Examples include Apple's virtual assistant Siri, SideKick, and iPrompts, which consider individual preferences and dislikes

experienced a significant reduction in symptoms and reported higher levels of satisfaction and engagement compared to the control group.

Another application of AI in psychiatry is the use of computer-assisted therapy (CAT) [19]. This method is highly effective, less intimidating for patients, and more cost-efficient compared to traditional therapies. For example, cognitive-behavioral therapy (CBT), a well-established treatment option, can be enhanced using computer-delivered CBT (cCBT) [7, 29, 30].

AI has also been applied to the treatment of auditory hallucinations in schizophrenia [31]. One example is the AVATAR system, which uses digital simulations of a patient's distressing hallucinations to facilitate three-way conversations between the patient, therapist, and avatar [32]. This has been shown to result in a reduction in anxiety and an improvement in voice frequency.

We can simply say it is a digital (visual and audible) simulation of a patient's distressing hallucination. This means that the patient, therapist, and avatar are all able to communicate through it. There are two steps involved [32]. The first is a simulation of the voice in the form of a mirror image. This includes the voice's content, nature, qualities, and specific words. The second is that the software can alter the therapist's voice to resemble the patient's disturbing hallucinations. The therapist can converse with the patient using either his voice or the patient's hallucinations simultaneously. Then The patient exemplifies the sound of the voice. It revealed a significant decrease in anxiety and an increase in people's frequency of speech.

In addition to its use in treating auditory hallucinations, AI has also been applied to improve communication and daily living activities for individuals with autism spectrum disorder (ASD), An article by Judith Newman titled "To Siri with Love" was published in The New York Times, which discussed the impact of technology, specifically Apple's virtual assistant Siri, on the social-emotional growth of her son, who has autism spectrum disorder (ASD) [33]. The author notes that her son, Gus, was able to improve his communication skills and maintain friendships by engaging in conversations with Siri about his interests and staying informed about weather patterns and train schedules. Furthermore, similar applications such as SideKick and iPrompts were noted to be more effective in assisting with daily activities for individuals with ASD, as they consider individual preferences and dislikes.

Prediction and diagnosis

AI has been demonstrated to have significant potential in the prediction and diagnosis of psychiatric illnesses, to improve patient outcomes. One example of this is research conducted in 2022, in which an electronic health record spanning 7 years was utilized to develop a machine learning (ML) model for predicting mental health crises [5]. By using this model, healthcare workers can anticipate and potentially mitigate these crisis events.

In addition to predicting mental health crises, AI also has a diversity of applications in the prediction of anxiety and depression. One study utilized data collected from blog posts and experimented with text encoding techniques such as Bag-of-Words (BOW), topic model features, and Term Frequency-Inverse Document Frequency (TFIDF) [34]. The encoded data were then run through a Convolutional Neural Network (CNN) and Support Vector Machines (SVM) classifier to differentiate between control and clinical subjects.

Another study aimed to develop an AI-automated system for predicting anxiety and depression among geriatric patients [17]. Various socio-demographic data, such as age, sex, literacy, socio-economic status, and family environment, were collected from 510 geriatric patients. The data were tested through ten classifiers, with the

highest accuracy recorded at 89%. This information can serve as a valuable aid for healthcare workers to have a more proper and sympathetic approach when encountering geriatric patients.

Research has also shown that depressed individuals tend to have more emotionally negative and angry tweets than healthy individuals. A supervised machine learning classifier was developed to discriminate between depressed and healthy groups using data collected from social media platforms such as Twitter [16]. This study suggests that this approach is an accurate, inexpensive, and accessible method to help patients with depression, and even suggests the ability to detect depression several months before clinical diagnosis using Twitter data.

In a recent cross-trial, ML was utilized to predict the remission of depression after treatment with problem-solving therapy (PST) for 6 months [14]. Furthermore, this study established a model-agnostic explanation to aid with clinical decision-making.

In terms of suicide prevention, identifying individuals at high risk for suicide for early intervention is considered a significant milestone in the application of AI in psychiatry. A case-short study in 2021 was able to identify suicide risk cases after discharge from psychiatric hospitals within 30 days [35]. Machine learning algorithms were capable of classifying individuals as at high risk for suicide or not using Twitter data [15]. Additionally, by using tweets related to suicide, deep learning was able to recognize suicide-related stressors.

In the realm of schizophrenia, the disease has a notable effect on brain structure, including decreases in the volume of both white and grey matter, changes to the temporal and anterior lobes of the hippocampus, and increases in cerebrospinal fluid (CSF). These changes make it possible to use magnetic resonance imaging (MRI) to diagnose schizophrenia (SZ). A comprehensive overview of the potentiality of using AI-automated deep learning (DL) and ML diagnosis through MRI modalities was conducted, as the disease currently lacks specific biomarkers [18]. The results of the review of studies indicate that using structural magnetic resonance imaging (sMRI) and functional magnetic resonance imaging (fMRI) is a highly accurate method to diagnose SZ, as it provides doctors with insight into how the brain of SZ patients differs structurally and functionally from that of healthy individuals. Table 3 displays some of the AI applications that have been developed for the prediction and diagnosis of various psychiatric disorders, based on the studies that we have reviewed.

Deep learning

Deep learning, a subset of machine learning and a component of AI is a method of processing data that mimics the structure and function of the human brain. It utilizes neural networks, which take raw data as input and evaluate it through multiple layers or perceptrons to assign weights to specific information. The output is then generated. Deep learning models can process a wide variety of data types, including numbers, images, text, molecular information, medical signs, and natural language [36]. Figure 2 reveals the complex structure of deep learning, showcasing the numerous layers that must be navigated to achieve a desired outcome. It provides an insightful visual representation of the hidden layers that are essential to the deep learning process, making it easier to grasp the concept of deep learning and how it works.

One specific application of deep learning in the field of psychiatry is supervised machine learning (SML). In SML, the model is provided with a large base of data and a set of rules, and through training, creates a classifier

Table 3 Some AI applications developed for prediction and diagnosis of different psychiatric disorders

Author	Psychiatric illness	AI application	Data source	Result
Garriga et al. 2022	Mental Health Crises	Machine learning Model	Electronic health record	Prediction of crises and potential mitigation
Tyshchenko et al. 2018	Anxiety and Depression	Deep learning Model	Blog posts	Differentiation between control and clinical subjects
Sau et al. 2017	Anxiety and Depression	Machine learning Model	Socio-demographic data	Prediction accuracy up to 89%
Maciej Serda et al. 2012	Depression	Machine learning Model	Social media platforms (Twitter)	Accurate, inexpensive, and accessible method to detect depression
Kannampallil et al. 2022	Depression	Machine learning Model	Treatment with problem-solving therapy (PST)	Prediction of depression remission after 6 months of treatment
Reece et al. 2017	Suicide Risk	Machine learning Model	Twitter data	Classification of individuals at high risk for suicide
Sadeghi et al. 2022	Schizophrenia	Deep learning and Machine learning	Magnetic resonance imaging (MRI)	Highly accurate method to diagnose SZ

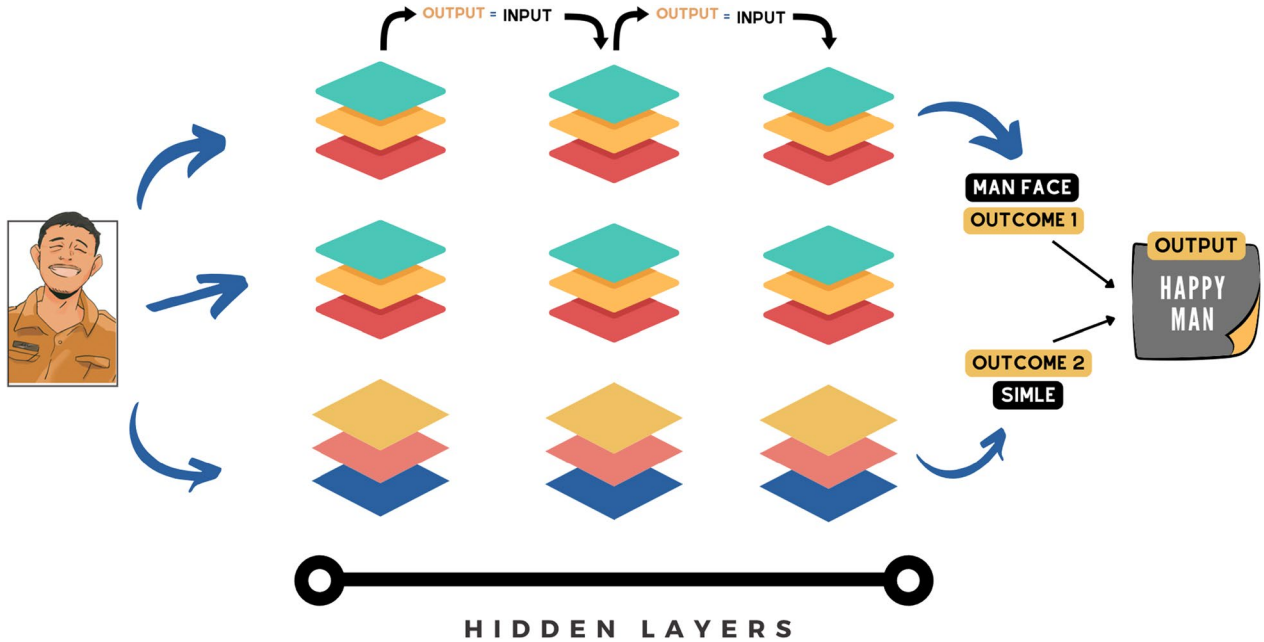

Fig. 2 Uncovering the multilayered architecture of deep learning: a journey through the hidden layers to reach the outcome: the image undergoes a series of algorithms and traverses through multiple hidden layers where the output of each layer serves as an input to the next layer. After all the layers have been processed, the final result is obtained, which in this case is the definition of the image

algorithm that can accurately predict outcomes [3, 37]. This technology has shown promise in pattern recognition techniques, such as detecting biomarkers for psychiatric diagnosis through the analysis of MRI neuroimaging [38]. A study in 2017 utilized multivariate pattern recognition to improve understanding of how thoughts and feelings originate in the human brain by creating a shareable signature [13].

Deep learning algorithms have also been applied to social media platforms, such as Twitter and Reddit, to gain a deeper understanding of mental illness beyond clinical evaluation [39, 40]. By analyzing posts on these platforms, researchers have been able to identify non-clinical depression, anxiety, self-harm, and suicide ideation.

Another promising application of deep learning in psychiatry is natural language processing (NLP), which utilizes computerized methods to represent and analyze naturally occurring text and speech to create "human-like language processing [4]". NLP models learn from human language and syntax to establish efficient computer–human interactions and perform specific tasks. A systematic review of 327 articles found that NLP provides significant insights from unexplored data and is considered a highly topical issue in the field [4]. A study in 2017 developed an automated system that can predict the likelihood of post-traumatic stress disorder (PTSD) through text analysis of a patient's medical history [41]. Table 4 presents a comprehensive overview of the various applications of deep learning in the field of psychiatry.

Table 4 Different applications of deep learning in psychiatry

Application	Description	Benefits
Supervised machine learning	Trains a model with a large dataset and set of rules to create a classifier algorithm that can predict outcomes	Detecting biomarkers for psychiatric diagnosis through neuroimaging analysis
Multivariate pattern recognition	Creating a shareable signature	Improve understanding of how thoughts and feelings originate in the human brain
Social media analysis	Analyze posts on social media platforms	Identifying non-clinical depression, anxiety, self-harm, and suicide ideation
Natural language processing	Utilizes computerized methods to represent and analyze natural text and speech to perform specific tasks, such as	Predicting the likelihood of PTSD through text analysis of a patient's medical history

Challenges of AI in psychiatry

The current diagnostic system used in psychiatry relies primarily on human experiential terms, rather than objective markers of illness. This approach, which is often based on physician–patient questionnaires, is inaccurate and ineffective in providing reliable assessments of symptoms [42]. Psychiatry also faces challenges such as the demedicalization of mental disorders and conflicting theoretical orientations for conceptualizing mental distress [43] (Table 5).

AI in psychiatry involves the use of advanced computerized techniques, such as automated language processing and machine learning algorithms, to assess a patient's mental state beyond what can be measured through self-reports and clinical observations. While AI has the potential to revolutionize mental health care, it also presents challenges such as data safety and privacy, effectiveness, user experience/adherence, and data integration [44–46]. Additionally, AI techniques may not consider patient privacy and confidentiality, and may lack the ability to manage emergency situations where users' safety is at risk [47].

Moreover, AI techniques may lead to over-reliance on them, and increase addictive behaviors, which may lead to avoid face-to-face visits with mental health professionals [47, 48].

The time-varying nature of many mental disorders may not be adequately captured by current machine learning approaches and their clinical applications, which typically focus on cross-sectional findings [49]. Additionally, AI algorithms may suffer from shortcomings such as inapplicability outside of the training domain, bias, and brittleness [50].

Ethical and regulatory frameworks are also a concern, as some cultures may view interacting with a computer or robot instead of a human as insulting [47]. Furthermore, the consolidation of embodied AI in mental health could lead to the replacement of established services, which may exacerbate existing health disparities [12].

Finally, there is a lack of guidelines specific to the various forms of assistance provided by mental health professionals who deliver AI services, and laws are not defined to hold software developers accountable for glitches that occur due to technology malfunction [51]. Additionally, most AI-based intervention studies have been conducted by their designers, who may have a personal monetary stake in the outcome, leading to potential biases in the benefits of AI in the field of psychiatry [52].

Could AI fully replace the psychiatrist?

AI has the potential to play a role in psychiatry, but its impact on the field remains a topic of debate [52]. According to a study conducted in 2021, AI is unlikely to fully replace psychiatrists because the field relies heavily on human abilities such as empathy, understanding, and the therapeutic relationship between patient and psychiatrist [53]. It suggests that AI can assist in analyzing data and making predictions, but it cannot replace the human element of psychiatry that includes understanding patients, empathizing with them, and making judgments and decisions based on complex and nuanced information.

Table 5 Challenges and ethical implications of using AI in psychiatry

Challenges of Application of AI in psychiatry	
1	Diagnosis relies on human terms and questionnaires, leading to inaccuracies and ineffectiveness
2	AI in psychiatry uses computerized techniques for mental state assessment beyond self-reports
3	Challenges of data safety, privacy, effectiveness, user experience, and data integration
4	lack the ability to manage emergency situations
5	Concerns of over-reliance on AI, addiction, and privacy violations
6	The time-varying nature of many mental disorders not being captured my current machine learning approaches
7	AI algorithms may suffer from shortcomings such as bias, inapplicability, and brittleness
8	Ethical and regulatory frameworks concern
9	Lack of guidelines, laws to hold software developers accountable, and potential bias in benefits due to personal stake of designers
10	potential biases in the benefits of AI in the field of psychiatry by their designers
Ethical implications of using AI in psychiatry	
1	Concerns of bias, unequal treatment of marginalized communities
2	Accountability and transparency in decision-making by AI
3	Privacy and confidentiality risk in processing sensitive personal information
4	Automating aspects of care and impact on therapeutic relationship

Other studies support these findings [49, 54, 55], stating that the use of AI in psychiatry must be done responsibly, taking into account its limitations and ethical implications. They highlight the importance of ensuring accountability and transparency, as well as protecting patient privacy and confidentiality in the use of AI. They also emphasize the need for AI to complement, rather than replace, the therapeutic relationship between patient and psychiatrist.

In conclusion, while AI has the potential to assist in the field of psychiatry, it is unlikely to replace psychiatrists. The human abilities that are essential to the practice of psychiatry, such as empathy, understanding, and the therapeutic relationship, cannot be replicated by AI. The responsible use of AI in psychiatry requires a nuanced understanding of its limitations and ethical implications.

Ethical implications

The use of artificial intelligence (AI) in psychiatry has the potential to revolutionize the field by providing more accurate diagnoses, personalized treatment plans, and improved access to care for patients [56]. However, the integration of AI into psychiatric practice raises significant ethical concerns that must be addressed (Table5).

One concern is the potential for bias in AI algorithms. AI systems are only as unbiased as the data they are trained on, and if the data are biased, the AI system will perpetuate these biases [57]. This can result in unequal treatment of patients, particularly those from marginalized communities, and perpetuate existing inequalities in the healthcare system [51].

Another issue is accountability and transparency in decision-making. The use of AI in mental health diagnoses raises questions about who is responsible for the accuracy of diagnoses and how decisions are made. It is important for AI systems to be transparent about their decision-making processes and for clinicians to understand the limitations and potential biases in AI diagnoses [56].

Privacy and confidentiality are also major ethical concerns with the use of AI in psychiatry. AI systems process and store large amounts of sensitive personal information, and there is a risk that this information could be used for unintended purposes or accessed by unauthorized individuals [51]. Additionally, there is the potential for AI systems to be used for surveillance or control purposes, infringing on patients' privacy and autonomy [55].

Finally, the integration of AI into psychiatric practice raises questions about the ethical implications of automating aspects of care and the potential impact on the therapeutic relationship between patients and their healthcare providers [51, 55, 56].

Conclusions

AI has the potential to greatly impact the field of psychiatry, offering new opportunities for improved patient outcomes, increased efficiency, and cost-effectiveness. In particular, the use of AI in monitoring mental illness, treatment, prediction, diagnosis, and deep learning has gained significant attention in recent years. The ability of AI algorithms to analyze large amounts of data, identify patterns and correlations, and make predictions about future outcomes is particularly well-suited for use in psychiatry. However, despite its many potential benefits, the use of AI in psychiatry is not without its challenges and ethical implications. One of the most significant concerns is accuracy, as errors in diagnosis or treatment could have serious consequences for patients. Additionally, the use of AI in psychiatry requires access to sensitive patient information, raising important privacy concerns. To fully realize the potential benefits of AI in psychiatry, it is essential to address these challenges and ethical implications.

Abbreviations

AI	Artificial intelligence
CNN	Convolutional neural network
SVM	Support vector machines
ML	Machine learning
DL	Deep learning

Acknowledgements

Not applicable.

Author contributions

MT and MB contributed equally to this work. MT and MB participated in conceptualization and wrote the original draft and reviewed it. SA and KE helped with the original draft preparation. All authors reviewed and approved the final manuscript.

Funding

There were no financial or commercial ties that may be viewed as having a possible conflict of interest.

Availability of data and materials

Not applicable.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Received: 23 February 2023 Accepted: 8 June 2023
Published online: 20 June 2023

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