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Review article

Artificial intelligence and Psychiatry: An overview

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ABSTRACT

The burden of mental illness both in world and India is increasing at an alarming rate. Adding to it, there has been an increase in mental health challenges during covid-19 pandemic with a rise in suicide, loneliness and substance use. Artificial intelligence can act as a potential solution to address this shortage. The use of artificial intelligence is increasingly being employed in various fields of mental health like affective disorders, psychosis, and geriatric psychiatry. The benefits are various like lower costs, wider reach but at the same time it comes with its own disadvantages. This article reviews the current understanding of artificial intelligence, the types of Artificial intelligence, its current use in various mental health disorders, current status in India, advantages, disadvantages and future potentials. With the passage of time and digitalization of the modern age, there will be an increase in the use of artificial intelligence in psychiatry hence a detailed understanding will be thoughtful. For this, we searched PubMed, Google Scholar, and Science Direct, China national Knowledge Infrastructure (CNKI), Globus Index Medicus search engines by using keywords. Initial searches involved the use of each individual keyword while the later searches involved the use of more than one word in different permutation combinations.

1. Introduction

The burden of mental illness across worldwide including India is increasing at a great rate. According to the global burden of disease the contribution of mental illness towards total Disability adjusted Life Years (DALY) has increased from 2.5% in 1990 to 4.7% in 2017 (India State-Level Disease Burden Initiative Mental Disorders Collaborators, 2020). At the same time India has got a shortage of psychiatrist approximately about 0.75 psychiatrists per 1 lakh population, which is more severe in rural areas (Gururaj et al., 2016). Adding more to the burden there has been an increase in mental health challenges during covid-19 pandemic with a rise in suicide, loneliness and substance use (Manzar et al., 2021). Artificial intelligence can act as a potential solution to address this shortage. Although the technologies used in artificial intelligence are expensive but AI systems have the potential to reduce unwarranted variation in clinical practice, improve efficiency and prevent avoidable medical errors, which might eventually prove to be cost effective (Kelly et al., 2019).

The use of Artificial intelligence in medical fields like radiology, oncology and dermatology is increasing but its use in mental health care is limited (Bi et al., 2019; Hosny et al., 2018; Zakhem et al., 2020). The existing reviews on artificial intelligence in mental health are either disease specific or focused on special population. This articles aims to provide an overview of role of artificial intelligence in relation to psychiatric disorder, its current status in India and future prospects.

2. Methodology

An extensive search on PubMed, Google Scholar, and Science Direct, CNKI, Globus Index Medicus search engines was made, by using keywords such as Artificial intelligence, types, use, affective disorders, psychotic disorder, child and adolescent disorder, sleep disorder, anxiety, geriatric psychiatry, substance use disorder, advantages, drawbacks, future, Artificial wisdom. The search was guided to address the research questions (Table) and involved the use of more than one word in different permutation combinations. The relevant references were selected. The information was retrieved from these articles as concepts, which are discussed under different pre-defined sections, based on the research questions.

1. What is the role of artificial intelligence in various psychiatric disorders?
2. What is the current status/application of AI in mental health in India?
3. What are the disadvantages and gaps in knowledge of AI applications?
4. What are the future applications/prospects of AI in India?

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2.1. Artificial intelligence: History and approaches

The term AI was originally coined by a computer scientist, John McCarthy, who defined it as "the science and engineering of making intelligent machines." (Russell et al., 2009; McCarthy, 1989) Alan Turing, "father of AI" authored a 1950 article "Computing Machinery and Intelligence" that discussed conditions for considering a machine to be intelligent (Turing, 1950). Since then artificial intelligence has experienced several waves of optimism, followed by waves of disappointment and setbacks (McCorduck, 2004). Now a days, Artificial intelligence is being used to facilitate faster disease detection and their management with discovery of innovative treatments both in physical as well as mental disorders.

2.1.1. Subsets/types of AI

2.1.1.1. The subsets of AI include.

- Machine learning is the study of computer algorithms that improve automatically through experience and by the use of data, which means that it involves data driven algorithms to learn from data and thereby estimates for new data or future events (Bzdok and Meyer-Lindenberg, 2018). More focused on hypothesis generation rather than being hypothesis driven (Graham et al., 2019).

- Deep learning is a class of machine learning algorithms that uses multiple layers to progressively extract higher-level features from the raw input. In deep learning, each level learns to transform its input data into a slightly more abstract and composite representation. For example in an image recognition application, the raw input may be a matrix of pixels; the first representational layer may abstract the pixels and encode edges; the second layer may compose and encode arrangements of edges; the third layer may encode a gyri and sulci; and the fourth layer may recognize that the image is of a brain. A deep learning process, by itself learns which features to optimally place in which level (Schmidhuber, 2015).

- A research problem in machine learning that focuses on storing knowledge gained while solving one problem and applying it to a different but related problem (Tajbakhsh et al., 2016).

Few other important terms related to artificial intelligence include:

- An expert knowledge system is a computer program which uses artificial intelligence and is designed to solve complex problems and to provide decision-making ability. It performs this by extracting knowledge from its knowledge base using the reasoning and inference rules according to the user queries (Leondes and Cornelius, 2002).
- A neural network (NN), in artificial intelligence is an interconnected group of artificial neurons that uses a mathematical or computational model for information processing based on a connectionist approach to computation. It is an adaptive system that changes its structure based on external or internal information that flows through the network and can be used to model complex relationships between inputs and outputs or to find patterns in data (Hopfield, 1982).
- Predictive analytics is the use of data, statistical algorithms and machine learning techniques to identify the likelihood of future outcomes based on historical data. The goal is to go beyond knowing what has happened to providing a best assessment of what will happen in the future (Hahn et al., 2017).

2.2. Artificial intelligence: Physical disorders

Artificial intelligence is at present being used to facilitate faster disease detection, enable better understanding of disease progression, enhance medication/treatment dosages and discover innovative treatments (Fei et al., 2017). As artificial intelligence is data science a huge strength of artificial intelligence is swift pattern analysis/ rapid screening of large datasets. Areas of medicine which have till now been most successful in using artificial intelligence for pattern recognition include ophthalmology, oncology, and radiology, where artificial intelligence algorithms have performed at par or even better in some instances compared to experienced clinicians in evaluating images for abnormalities or acuity undetectable to the human eye (Brinker et al., 2019; Hosny et al., 2018; Vidal-Alaball et al., 2019).

For example convolutional neural networks have been used for automated detection of liver tumors on CT scans and it has shown both high accuracy and precision of 93% and 67% respectively (Afifi, and Nakaguchi, 2015). Machine learning has been used for breast density segmentation on mammography and it has shown results which are accurate as manual ones (Kallenberg et al., 2016).

2.3. Artificial intelligence: Mental disorder

Although use of artificial intelligence technology has become quite popular in medicine for physical health applications but in the discipline of mental health its use is much restricted (Miller and Brown, 2018). Mental health relies on softer skills like rapport building, forming relationships with patient and observing patient's emotions and behavior (Gabbard and Crisp-Han, 2017). Clinical data of mental health is more subjective and qualitative like patient statements and written notes. But still, mental health has a lot to benefit from Artificial intelligence (Luxton, 2014a, 2014b).

Artificial intelligence has immense potential to re-define our diagnosis and help in better understanding of mental illnesses. A person's mental health depends on his/her unique bio-psycho-social profile; however, we have a comparatively narrow understanding of the interactions between these biological, psychological, and social systems. There is substantial heterogeneity in the pathophysiology of mental illness and identification of biomarkers will help to get more objective and refined definitions of these illnesses. Artificial intelligence technologies may have the ability to develop better pre-diagnostic screening tools and work out risk models to determine an individual's predisposition for, or possibility of developing mental illness (Shatte et al., 2019).

2.4. Affective disorder

Much work has been done using artificial intelligence on affective disorders. Electroencephalogram (EEG) has been used extensively to study mental illness such as depression as it is a non-invasive, portable and inexpensive method and also because it has high temporal resolution information. Studies involving EEG based deep learning methods like one or two dimensional convolutional neural network have been used to discriminate depressive patients from healthy controls with accuracy of more than 90% (Saeedi et al., 2021). The three D convolutional neural network has also been used to extract short-term dynamic visual representation of depression from video segments. And studies have proved that these network systems can accurately predict depression from video segments (Jazaery and Guo, 2018).

Machine learning (ML) algorithms have been used to forecast BMI values based on psychological variables, like depression, with an accuracy of over 80% (Delnevo et al., 2021).

Other than diagnostic and predictive purposes, artificial intelligence supported virtually embodied psychotherapeutic devices are rapidly developing, for example, apps such as Tess and other "chatbots" such as Sara, Woebot, and Wysa, which work over short message, service text messaging. These applications have interactive screen presence (Sachan,

2018). The Woebot engage with patients in the form of virtual psychoreview, and helps patients to identify their emotions and thought patterns and to learn skills such as resilience or methods to reduce anxiety. Studies have shown that the use of the Woebot application can successfully reduce depressive symptoms (Fitzpatrick et al., 2017).

Tess is another application which uses, natural language processing, to flag expressions that indicate emotional distress and it has been proved to reduce depression and anxiety among users. In recent times even WhatsApp, or other internet platforms, are also being explored for addressing anxiety and depression (Sachan, 2018).

2.5. Psychotic disorder

Machine learning algorithms have successfully discriminated healthy patients from patients with psychotic disorders with the accuracy more than 70% (Antonucci et al., 2021).

Artificial intelligence has been used in studies to assay disordered language production and to differentiate speech samples of patient with psychotic disorders from healthy controls. Algorithms could localize where in speech sample incoherence occurred, predict levels of incoherence and was found to be sensitive to very subtle deviations in lengthy clinical interviews that were detectable by clinicians (Elvevåg et al., 2007).

Avatars have been successfully used in treatment of schizophrenia, to improve medication adherence (Bain et al., 2017). Similar to the Avatar Project, virtual reality–assisted therapy for schizophrenia usually encourages patients to engage with the voices they hear through the use of an AI avatar. Studies have found that this therapy could help in developing therapeutic targets (Dellazizzo et al., 2018).

Virtual reality therapy has helped in improvement of symptoms like visual and auditory hallucinations, depressive symptoms and in overall quality of life particularly in difficult cases of schizophrenia like treatment-resistant schizophrenia patients (du Sert etal, 2018).

2.6. Child and Adolescent disorder

Machine learning techniques have successfully been used to differentiate adult attention deficit hyperactivity disorder (ADHD) from healthy controls and in classification of ADHD subtypes based on power spectra of EEG measurements (Tenev et al., 2014).

Robot mediated interventions robots are being used for children with autism spectrum disorder. Six roles for KASPAR were identified: provoker, reinforcer, trainer, mediator, prompter and diagnostic information provider. Strengths of KASPAR are related to personalization possibilities, its playfulness, the action-reaction principle, its neutral expression, consistent and repetitive application of actions, possibilities to vary behavior in a controlled manner and having an extra hand. However, certain challenges like limited reaction possibilities, likelihood of children being afraid of KASPAR, difficulties with generalization or transfer, potential dependence on KASPAR, have also been identified (Huijnen et al., 2019).

RoboTherapy is another example of socially assistive robotics which was designed to help children with autism spectrum disorder to develop social skills, and robot Nao helps in enhancing facial recognition and appropriate gaze response. Such interventions mainly aim at improving social skills like, imitation, taking turns, staying engaged, and empathy, with the target that children can then apply these learned skills to their relationships with human peers. Initial studies have been very promising; children with Autism Spectrum Disorder (ASD) have been seen to perform better with their robot partners compared to human therapists; they respond with social behaviors toward robots, and their spontaneous language have improved during therapy sessions (Pennisi et al., 2016).

2.7. Geriatric Psychiatry

Companion robots commonly called ‘companion bots’ are increasingly been used to help patients with dementia. Artificially intelligent animal-like robots such as Paro, e-Bear engages individuals as at-home health care assistants, responds to speech and movement with dynamic ‘dialog’, or assists in helping elderly or depressed patients by providing companionship and interaction. Studies have found that such robots are fruitful in reducing stress, agitation and loneliness and improves mood and social connections (Wada and Shibata, 2007; Yu et al., 2015).

2.8. Addiction Psychiatry

Studies have shown that conversational agent can improve engagement in digitalized mental health care (Vaidyam et al., 2019). The research on psychoeducation delivery have found that text based conversational agents can lead to higher program adherence compared to verbal presentation (Tielman et al., 2017);also, such conversational agents cause significant reduction in substance use and cravings (Prochaska et al., 2021).

Drug repurposing is a strategy that can help identify potential new therapies for complex diseases (Ashburn and Thor, 2004). An integrated drug repurposing strategy which combined computational-based drug prediction, patient Electronic Health Records (EHRs)-based clinical corroboration and mechanisms of action analysis was used in a study which could identify five repurposed candidate drugs for treating opioid use disorder patients (Zhou et al., 2021).

2.9. Sleep disorder

Information support robot (ISR) has been used to influence the daily activities of older people. With changing times, the proportion of older people living alone has increased. Living alone in old age increases risk factor for cognitive dysfunctions, low mood, and disturbed sleep wake cycle. Robots can support older people in maintaining their independence and daily activities. Older people with balanced daily activities have been seen to have lesser disturbance of sleep wake cycle. Information supported robots have been used to remind people time to wake up, go to bed, eat. And study has shown that after use of ISR subjects showed faster wake-up times, decreased sleep duration, and improvement in amount of activity during the day (Mizuno et al., 2021).

2.10. Anxiety spectrum disorder

Artificial intelligent models have been used in the times of COVID-19 to investigate predictors of fear and perceived health using machine learning Results showed that the model could accurately predict fear of virus using factors like worrying about shortage of food supplies and perceived health using factors like physical exercise, attachment anxiety (Eder et al., 2021).

‘Avatar coaches’ have also been utilized for treatment of fear of heights as part of an immersive virtual reality situation (Freeman et al., 2018).

2.11. Indian research on Artificial intelligence and Mental Health

Studies related to artificial intelligence and mental health are limited in India, however research has boosted in the recent decade where artificial intelligence have been used for diagnosis and classification of schizophrenia based on EEG, for assessment of cognitive and functional impairment in Alzheimer’s disease and for differentiation of depressed patients from normal subjects based on EEG (Tikka et al., 2020; Prabhakar et al., 2020; Vinutha et al., 2020). In India machine learning techniques have been used to explore abnormalities in microstates that can identify patients with Temporal Lobe Epilepsy (TLE) in the absence of an inter-ictal discharge (IED) (Kiran et al., 2018). Artificial intelligence have been used to find potential markers like retinal vascular changes in patients of schizophrenia and bipolar disorder (Appaji et al.,

2019). Artificial intelligence have not only been used to detect depression (Ay et al., 2019), but also have proven it's efficacy in classification of severity of depression (Mahato et al., 2020). Machine learning methods have been successfully used for diagnosis of dementia (Bhagyashree et al., 2018), to differentiate adults with ADHD from healthy controls (Kaur et al., 2020), to predict depressive symptoms in post-partum (Andersson et al., 2021). During the COVID times, machine learning methods have been used to detect burn out in health care workers (Gupta et al., 2021).

2.12. Advantages of Artificial Intelligence

There are many benefits to application of artificial intelligence in psychiatry that may not be apparent at first. One of the issues is that patients hesitate in revealing their personal problems and history to the doctor. It would be rather easier to divulge their symptoms to a clinician through artificial intelligence, without fear of being judged (Houston et al., 2002).

In developing countries, owing to the scarcity of mental health professionals in rural areas, AIcan be used as a means to deliver services to patients in remote geographical areas and allow access to specialty care (Luxton, 2016).

In addition, Artificial Intelligence framework can assist to lower overall healthcare costs through ventured care approach. In this process, a triage like system could be tailored so that the least resource utilizing care is given to most people first, and more intensive care is provided to patients that need it the most (Bower and Gilbody, 2005).

Machines are devoid of human factors such as distraction, stress, fatigue, are unsusceptible to individual inclinations that human therapists, and thus may have better results in treating patients (Luxton, 2014a, 2014b). Finally, Artificial intelligence machines are equipped to convey the most suitable treatments or coordinate various methodologies based on a patient's diagnostic profile, inclinations or treatment progress. AI machines can tailor to specific aspects of a patient's culture such as race/ethnicity or socioeconomic status. For instance, a virtual therapist could change its idiosyncrasies (e.g., eye contact), speech dialect and other characteristics to match a given cultural group, which would improve affinity with a patient and improve overall communication.

2.13. Drawbacks of Artificial intelligence

Based on above arguments, AI undoubtedly seems superior to human medical practitioners in terms of treating psychiatric patients. AI algorithms have the potential to suffer from a host of shortcomings, including inapplicability outside of the training domain, bias and brittleness (Kelly, C.J., 2019). The short comings are more in case of mental health issues as mental health relies on softer skills like rapport building, forming relationships with patient and observing patient's emotions and behavior. So the use of artificial intelligence technology has become quite popular in medicine for physical health applications but in the discipline of mental health its use is much restricted (Miller and Brown, 2018). Its other drawbacks include, most prominently the lack of human empathy and compassion, which are crucial components when treating patients who have suffered mental trauma or are experiencing a mental condition (Luxton, 2016; Fakhoury, 2019). Further, in order to save financial costs, the consolidation of embodied AI in mental health could be reasoning for replacing established services, resulting in existing health disparities (Fiske et al., 2019). It is also seen that patients could get over-attached to AI applications in long term. Robots that are intended to reduce loneliness or provide emotional comfort carry the danger that the patients they work with could become reliant on them for company (Cresswell et al., 2018).

With the dependence on online servers and database, there is risk to patient privacy. There would be a potential of hacking and unauthorized monitoring and risk related to security of devices that store and convey personal health information. Worries around security may be magnified as the amount of data collected continues to expand (Fiske et al., 2019). In India, recognizing this issue, the Ministry of Health and Family Welfare had released a draft of Healthcare Security Act, which besides maintenance of electronic health record standards, also proposes penalties for breach of data. Still, the regulatory framework in India needs upgradation with the developments in AI. There is lack of guidelines specific to various assistance received by mental health professionals who deliver AI services. For instance, error on the part of mental health professional will be penalized as per the law. However, if a similar glitch occurs due to technology malfunction, laws are not defined to hold the software developer accountable (Healthworld, 2018).

Finally, a significant concern is that most of the AI-based interventions studies have been conducted by their designers who might want to exhibit adequacy of their product with personal monetary stake in the outcome. Therefore benefits of AI in the field of psychiatry will be biased unless the studies are conducted by a third party (Luxton, 2016).

2.14. Gaps in AI application in mental health

Research is required on AI applications to prevent it from working unpredictably. AI gadgets would also require thorough risk assessment and administrative oversight that other medical devices are subjected to before they can be endorsed for clinical use. Guidelines are required for the usage of AI applications, either for research or clinical purposes, e.g. the steps to be taken in the event of encountering unusual situation like patient expressing ideas of harm to self or others. Adequate provisions for data protection and maintain confidentiality also need to ensured.[63] Certain studies have shown that few clients frequently talk to assistive gadgets in a ruder way than they would to a human. There exists a faint possibility that the human-machine interaction might not be translatable to human-human interaction or might even more limit human-to-human relationships. Therefore, there is need to reconfirm and replicate the findings of AI research.[63].

2.15. Future of Artificial Intelligence: Artificial Wisdom (AW)

The functioning of AI currently is limited; however its greater advancements and applications are expected in near future. It is not mere "intelligence" that best speak to the technological needs of a society, but "wisdom", that is related to noteworthy happiness, wellbeing, and life span of an individual and society (Jeste and Lee, 2019). The key objective of AW would be to serve as assistants to people to make a better world. Their component would include pro-social behaviors (empathy, kindness), self-reflection, and enthusiastic control, accepting differing qualities of perspectives, definitiveness and social prompting (Jeste et al., 2020).

3. Conclusion

In summary, discoveries gathered in the recent years support the utility of AI-based interventions in the analysis, forecast and treatment of mental health issues. The AI framework can be set to aid in making the current medical treatment more efficient and accessible. A collaboration of mental healthcare professionals, ethicists, technologists, engineers, healthcare administrators, entrepreneurs, and others is required in order to accomplish the full potential of AI and to address the challenges in its application, so that it rightly serves the mankind.

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All the authors have equal contribution in the preparation of the manuscript. AR and AB have drafted the initial manuscript. YKM and SS critically evaluated the existing literature and have drafted the final manuscript.

Conflict of Interest

None declared.

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