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AI in schizophrenia treatment: personalizing therapy and predicting relapses

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Summary

The aim of the article is to present the potential of artificial intelligence (AI) in the treatment of schizophrenia, with particular emphasis on the personalization of therapy and the prediction of relapses of the illness. The significance of schizophrenia as a serious health problem and the therapeutic challenges associated with it are discussed, such as the low effectiveness of traditional treatment methods and difficulties in adherence to recommendations by patients.

The application of AI in the analysis of large datasets, such as biometric, behavioral, or genetic information, which support the individualization of therapy, is analyzed. Examples of projects using AI are presented, such as the analysis of patients' language for the early detection of relapses or devices monitoring the health status of patients in real time. It is indicated that such solutions may lead to an improvement in treatment effectiveness and a reduction in the number of hospitalizations.

Particular attention is paid to predictive algorithms based on machine learning, which enable the prediction of relapses of schizophrenia based on complex data patterns. The importance of the integration of AI with VR and AR technologies is also emphasized, which can support patients in learning to cope with symptoms. The paper ends with a reflection on the future of AI in psychiatry, indicating its potential in improving the accessibility and quality of healthcare, especially in regions with limited resources.

Key words: schizophrenia, artificial intelligence, therapy personalization

1. The significance of the issue and the role of AI in psychiatry

1.1. Definition and importance of schizophrenia

Schizophrenia is a severe mental disorder affecting approximately 1% of the global population, which translates to around 78 million people worldwide [1]. It is characterized by symptoms such as hallucinations, delusions, and cognitive difficulties, which can significantly impair patients' daily functioning. Schizophrenia remains one of the major challenges in psychiatry, both in terms of diagnosis and treatment. Treatment primarily involves pharmacotherapy, which helps reduce psychotic symptoms, and psychological interventions, including cognitive-behavioral therapy, which supports patients in managing their symptoms [2].

1.2. Challenges in schizophrenia treatment

The treatment of schizophrenia presents numerous challenges, particularly in maintaining patient adherence to therapy and managing the side effects of antipsychotic medications. These side effects include weight gain, metabolic disorders, and other complications. According to the World Health Organization (WHO), approximately 30–40% of patients with schizophrenia do not respond adequately to traditional treatment methods [1].

Additionally, non-compliance with therapeutic recommendations often leads to relapses and increases the risk of hospitalization [3].

1.3. The role of artificial intelligence in schizophrenia treatment

Artificial intelligence (AI) holds immense potential in schizophrenia treatment. By analyzing large datasets, such as behavioral patterns, biometric data, and genetic profiles, AI can assist clinicians in closely monitoring patients' health and predicting relapses. AI enables therapy personalization, which can result in better symptom management and improved treatment effectiveness [4].

Research conducted by Justyna Sarzyńska-Wawer, Aleksander Wawer, Izabela Chojnicka, and Łukasz Okruszek, published in *Cognitive Computation*, explores the use of AI in diagnosing schizophrenia based on language analysis [5]. In this study, AI algorithms were trained on textual data collected from clinical interviews with adults diagnosed with schizophrenia. The algorithm demonstrated high accuracy in identifying speech patterns of individuals with schizophrenia, achieving a precision rate of nearly 90%. The input data included both general and abstract interview questions, such as personal beliefs and perceptions of society. Patients were not in an active psychotic phase, making the language differences more subtle and the diagnosis more challenging. Nevertheless, the AI algorithm outperformed experienced psychiatrists in diagnosing schizophrenia from the same interview texts.

The results highlight the potential of AI tools to support psychiatrists and psychologists in diagnosing schizophrenia, especially in tracking therapy progress and monitoring subtle changes in patients' language patterns. This research represents a step toward developing AI tools that can assist the diagnostic process in psychiatry, offering objective support in identifying mental disorders [5].

Another example of AI application is a patient monitoring system developed by Harvard Medical School. This system uses wearable devices, such as activity trackers and smartwatches, to collect real-time health data. The system analyzes changes in circadian rhythms and other biometric parameters to detect early signs of health deterioration in patients. Studies show that this approach reduces unplanned hospital visits by 20% and improves symptom management in patients with schizophrenia [6].

In initiatives like the *AI4Africa* project, AI has been used to improve psychiatric care access in rural areas where there is a shortage of specialists. According to the project's data, AI solutions have improved psychiatric care access by 40% in rural regions, marking a significant step toward better healthcare provision in underserved areas [7].

2. Methods of therapy personalization in schizophrenia treatment

2.1. Multidimensional patient data analysis

A key component in personalizing schizophrenia treatment is the analysis of multidimensional patient data, which includes genetic, biometric, neuroimaging, and behavioral information. Artificial intelligence (AI) uses this data to model patients' responses to various therapeutic interventions, enabling more precise treatment adjustments.

2.1.1. Genetic data

An increasing number of studies emphasize the significant role of individual genetic differences in drug metabolism and response to psychotropic therapies. AI algorithms can analyze genomic data to identify patients who are more likely to respond well to specific active substances and to avoid adverse side effects. One example involves the use of an AI algorithm that examines genetic polymorphisms in drug-metabolizing genes (e.g., cytochrome P450 enzymes, responsible for metabolizing antipsychotic medications) to predict which medications a patient will tolerate best. This approach helps minimize adverse reactions and improve treatment effectiveness [8].

2.1.2. Biometric and behavioral data

Behavioral data, such as physical activity levels, sleep patterns, and other changes in daily functioning, are equally important. For instance, disruptions in biological rhythms, such as sleep disturbances, can serve as early indicators of schizophrenia symptom relapse. Wearable devices (e.g., fitness trackers and sleep monitors) enable real-time data collection. By analyzing this data using machine learning algorithms, it is possible to predict a patient's deterioration before more apparent psychotic symptoms emerge [9].

2.1.3. Implementation examples

A practical example of AI in therapy personalization is a system that uses a patient's genetic and biometric data to predict the most effective pharmacological treatment. Machine learning models, such as Random Forests or Support Vector Machines, integrate data from various sources to forecast treatment responses, enabling individualized care. These systems help clinicians choose medications with the highest potential efficacy and the lowest risk of side effects, thereby improving the quality of patient care [10].

2.2. Natural language processing (NLP) systems

Natural language processing (NLP) is one of the most promising approaches in psychiatry, particularly for monitoring speech patterns in schizophrenia patients. Speech disorders, such as disorganized thinking or reduced fluency, are common in schizophrenia and serve as key indicators of mental health deterioration. NLP-based analysis of patients' speech allows for the detection of subtle changes that may signal early signs of relapse.

2.2.1. NLP in speech monitoring

Advanced NLP models, such as BERT, GPT-3, or LSTM, can process large text datasets, including transcripts of patient interviews. These models identify slight changes in sentence structure, vocabulary, and speech fluency. These changes are usually associated with a deterioration in the patient's mental state, which can be useful for real-time monitoring. For example, the TRUSTING project developed a system that analyzes patients' daily conversations to detect speech complexity and identify patterns that may indicate an upcoming psychotic episode [11].

2.2.2. Implementation examples

In practice, NLP can be used in schizophrenia therapy through speech analysis software integrated with mobile applications for patients. Such systems monitor changes in speech in real-time and send alerts to clinicians for prompt intervention. This enables the early detection of relapses or changes in a patient's condition, allowing healthcare providers to respond faster and adjust the therapy accordingly [12].

2.3. Physiological monitoring

The integration of wearable devices and mobile applications is becoming a crucial tool in monitoring the physical and mental health of schizophrenia patients. Continuous tracking of physiological parameters, such as physical activity, sleep, heart rate, and heart rate variability, allows for the early detection of symptoms that may indicate health deterioration.

2.3.1. Sleep and activity monitoring

Sleep disturbances are an early warning sign of worsening conditions in schizophrenia patients. Wearable devices continuously monitor sleep quality, phases, and overall physical activity, providing valuable insights into a patient's health. AI systems can analyze changes in sleep rhythms that precede psychotic episodes, enabling clinicians to intervene earlier. For example, an AI model could identify patients with abnormal sleep and activity patterns and send alerts to healthcare providers for immediate action [13].

2.3.2. Implementation examples

Mobile applications integrated with wearable devices, such as smartwatches, can monitor physical activity, sleep, and heart rate variability. AI-based systems analyze these data to predict relapses or health deteriorations. Such technologies facilitate faster interventions and help both clinicians and patients manage mental and physical health more effectively.

Wearable devices are particularly useful in monitoring sleep patterns, which can indicate impending psychotic episodes. Examples include platforms that integrate data from various sensors to support personalized therapeutic approaches [13].

3. Predicting schizophrenia relapses

3.1. Predictive algorithms

Predictive algorithms based on artificial intelligence (AI) enable the analysis of complex patient data to forecast schizophrenia relapses. The key mechanism is machine learning, which allows models to be built based on identified patterns [14].

3.1.1. Neural networks (deep learning)

Neural networks, particularly deep learning models, form the foundation of modern methods for predicting schizophrenia relapses. These networks, inspired by the functioning of the human brain, process information hierarchically. Thanks to hidden layers, they can analyze various types of data, such as brain images (e.g., fMRI), changes in patient speech, physical activity, or sleep patterns [15].

Example: A neural network analyzes brain images to detect subtle structural changes that may indicate a risk of relapse. Additionally, Long Short-Term Memory (LSTM) algorithms – a specialized type of neural network – track changes over time, such as in patient speech. Studies show high effectiveness of these algorithms in predicting periods of increased relapse risk [16].

3.1.2. Decision trees and random forests

Decision trees are classification models that segment patient data based on specific features, such as treatment history, neuroimaging results, or behavioral changes. They work by dividing data into "branches" that lead to specific conclusions, such as predicting schizophrenia relapse risk. Although decision trees are easy to interpret, they may struggle to capture more complex relationships [17].

To improve model accuracy, random forests are used. These create multiple decision trees and aggregate their results. Such a model is more resistant to errors, handles large datasets better, and accounts for the variability of different variables, such as brain structure changes or daily patient behaviors [18].

3.2. Multisource data integration

Integrating various data sources – such as linguistic, biometric, neuroimaging, and environmental data – is essential for obtaining a comprehensive picture of a patient's health and effectively predicting schizophrenia relapses. This approach considers a broader context and identifies variables that may trigger relapses, even if they are not significant individually [19].

3.2.1. Linguistic and behavioral data

The use of natural language processing (NLP) to analyze patient speech is an innovative method for diagnosing schizophrenia relapses. Changes in speech patterns, fluency, word usage, or grammatical structure can indicate an impending relapse. NLP algorithms, such as BERT and GPT-3, can detect subtle changes in patient speech by analyzing the context and style of expression. These changes often go unnoticed in traditional clinical interviews but serve as valuable early warning signals for AI systems [20].

Combined with biometric data, such as heart rate or physical activity (monitored by wearable devices), algorithms can predict relapse risk in a more comprehensive way. For example, monitoring stress levels, which affect sleep quality, can indicate an increased relapse risk [21].

3.2.2. Biometric and neuroimaging data

Integrating biometric data with brain imaging (e.g., MRI, fMRI) provides a holistic view of a patient's health. Imaging techniques, such as diffusion tensor imaging (DTI), enable the detection of subtle brain structure changes that may indicate relapse risk. When analyzed by AI, these changes, combined with patient activity data, allow for more accurate relapse predictions compared to using individual methods [22].

3.3. Case studies and clinical research

In studies such as TRUSTING, artificial intelligence (AI) is used to monitor schizophrenia patients in real time. AI algorithms analyze data from various sources, such as wearables, speech monitoring, and behavior analysis, to predict upcoming relapses. For example, the TRUSTING team developed an app that analyzes patient data daily and sends early warnings if patterns indicating relapse risk are detected. This approach enables faster intervention and reduces hospitalizations [23].

Another research project, PsychAI, integrates neuroimaging, genetic, behavioral, and environmental data to predict schizophrenia relapses. AI-based models analyze these data to identify relapse risk factors that may be overlooked by traditional diagnostic methods. An example of this approach is using AI to assess environmental influences, such as moving to a new location or work-related stress, on disease progression. Studies show that this approach can improve prediction accuracy by 20–30% compared to traditional methods [23].

4. Challenges and implementation barriers

Implementing artificial intelligence (AI) in the treatment of schizophrenia poses several challenges that may impact the effectiveness of implementation, accessibility, and acceptance by the users. Below is a more detailed description of key barriers, including specific data and practical examples.

4.1. Ethics and data privacy

4.1.1. Risks associated with storing and analyzing sensitive medical data

Effective use of AI in schizophrenia treatment requires collecting and analyzing vast amounts of data, such as patient medical records, health history, genotype, and even daily activities. A study conducted by the European Commission found that 70% of individuals are concerned that their medical data could be misused or disclosed, significantly affecting patient trust in AI systems used in psychiatry [23].

4.1.2. Ethical frameworks and legal regulations

To comply with regulations such as GDPR, strict data privacy rules must be followed. For instance, medical data must be collected with patient consent, and access to it should be strictly controlled and limited to authorized individuals. Additionally, advanced data encryption methods must be used, and full transparency regarding AI algorithms analyzing the data should be ensured. Research shows that 65% of patients are more accepting of AI when assured of full control over their data [23].

Example: The *AI4Health* project, which develops AI solutions for diagnosing mental disorders, employs advanced end-to-end encryption methods to protect patient data from unauthorized access. Furthermore, the system implements patient consent options at every stage of data processing, increasing both security and privacy [24].

4.2. User acceptance. Patient and physician concerns

The acceptance of artificial intelligence (AI) technology in psychiatry is not uniform. Studies show that 58% of schizophrenia patients express concerns about using AI in therapy, primarily due to fear of replacing the human element in care. Similarly, 47% of doctors are concerned that AI could take over part of the responsibility for clinical decision-making, potentially leading to a dehumanized treatment process [4].

4.3. Technology accessibility

4.3.1. Implementation costs and their impact on healthcare systems

The implementation of AI systems in psychiatry requires significant investment. A 2023 report by McKinsey & Company estimated that the total cost of implementing advanced AI systems in psychiatry in developed countries is around $500,000 per facility, with training costs for medical staff reaching up to $10,000 per person. For many lower-income countries, such costs pose a significant barrier [25].

4.3.2. Technology accessibility disparities

In developed countries such as the U.S., Canada, and Germany, AI technologies in psychiatry are becoming increasingly common, especially in larger medical facilities. In developing countries, such as India or parts of Africa, these costs present a major challenge. In these regions, implementing AI requires more economical solutions, such as mobile devices or AI applications that work on basic smartphones [26].

Example: The *AI for Mental Health in Africa* project focuses on using simple mobile technologies and applications that run on inexpensive smartphones, minimizing implementation costs. As a result, the project reaches 25,000 patients across various African countries, providing AI-based mental health monitoring for less than $2 per month. These technologies rely on local platforms that enable patients to use mobile devices to track symptoms and report health status, significantly reducing costs [27].

5. The future of AI in schizophrenia treatment

5.1. New research directions

5.1.1. Integration of AI with VR and AR therapies

In the treatment of schizophrenia, technologies such as artificial intelligence (AI) are increasingly combined with virtual reality (VR) and augmented reality (AR) therapies. These technologies help patients cope with symptoms such as anxiety or hallucinations by creating virtual environments where they can face controlled, stress-inducing situations while learning to manage them. AI monitors patients' responses in real time by analyzing data such as facial microexpressions, changes in speech, or heart rhythms, and adjusts the therapy accordingly.

Example: The *VR for Schizophrenia* project, conducted by the University of Oslo, uses VR to create interactive environments that help patients confront anxiety-provoking situations, such as crowded streets or large groups of people. AI analyzes the patient's emotional responses and adjusts the intensity and type of situations they face. Research has shown that most patients participating in these sessions experienced an improvement in anxiety levels, quality of life, and their ability to manage positive symptoms of schizophrenia, such as hallucinations and delusions [28].

5.1.2. Development of real-time learning algorithms

Artificial intelligence based on machine learning algorithms enables real-time patient monitoring, allowing dynamic adaptation of therapy to the changing health condition of the patient. AI can adjust treatment plans, such as medication dosages or therapy schedules, based on patient responses, eliminating the need for rigid treatment plans.

5.2. Automated therapeutic support systems

5.2.1. AI-based "home therapists"

Modern mobile applications utilizing AI provide emotional support and assistance to schizophrenia patients in managing their symptoms in everyday life. Applications like *Wysa* monitor the patient's emotional state in real time through interactions, helping them cope with stress, anxiety, or depression, which are common in schizophrenia. These systems also analyze patient activities, such as physical activity levels or sleep quality.

Example: *Wysa* is a mobile application supporting patients suffering from schizophrenia and other mental disorders. It enables daily interactions with patients, offering therapeutic advice and monitoring emotional states. Such applications provide significant support in daily care, helping not only in treatment but also in preventing symptom relapses [29].

5.2.2. Support for families and caregivers of patients

AI also facilitates care for schizophrenia patients by supporting families and caregivers. By monitoring data from wearable devices (e.g., smartwatches, fitness bands), AI systems can detect alarming behavioral changes in patients and inform caregivers about potential health crises.

Example: The *m-RESIST* project developed a system supporting the families of schizophrenia patients. By integrating data from wearable devices with patient-provided information, AI detects alarming changes in behavior, such as reduced physical activity, changes in speech, or lack of eye contact. The system informs caregivers in real time, allowing faster responses to patient health crises. This system reduces caregiver burden while improving their response time to critical situations [29].

5.3. Global perspectives

5.3.1. Reducing inequities in access to psychiatric care in resource-limited countries

In developing countries, where access to specialized psychiatric care is significantly limited, artificial intelligence becomes a key tool in providing treatment access. AI applications allow patients to receive diagnoses and health monitoring remotely, enabling early detection of schizophrenia symptoms and faster responses.

Example: In India, in rural regions, patients can access remote psychiatric care through a project where AI applications assist in diagnosing schizophrenia and monitoring symptoms, enabling patients to consult psychiatrists online [30].

5.3.2. Use of AI in resource-limited countries

In countries such as Uganda, Kenya, and Tanzania, where access to psychiatric specialists is very limited, AI plays a crucial role in improving access to psychiatric care. AI systems monitor patient health and, based on the collected data, can quickly inform doctors about health risks.

Example: The *AI4Africa* project, implemented in African countries such as Uganda, Kenya, and Tanzania, provides psychiatric care access through simple mobile devices. Initial studies show that AI systems have increased access to psychiatric care by 40% in rural regions, enabling patients to receive support in managing schizophrenia symptoms [31].

6. Summary and conclusions

Artificial intelligence (AI) has the potential to become a breakthrough in the treatment of schizophrenia, bringing numerous benefits to both patients and medical professionals. However, the effective implementation of AI in psychiatry requires further research and a responsible approach to ethical, technological, and economic issues. Ensuring the availability of these solutions, particularly in developing countries, and evaluating their long-term effects are crucial.

The application of AI in schizophrenia treatment allows for the precise customization of therapy to individual patient needs. Through advanced machine learning algorithms, AI systems can monitor changes in patient behavior in real time and adjust treatment accordingly. An example is the *m-RESIST* project, which analyzes data from wearable devices (e.g., smartwatches, fitness bands) to adjust medication dosages and therapeutic schedules. Research indicates that AI can improve the effectiveness of schizophrenia treatment by 30% compared to traditional methods, especially in monitoring and optimizing pharmacological and psychotherapeutic therapies.

When combined with virtual reality (VR) and augmented reality (AR) therapies, AI enables the creation of interactive therapeutic environments that help patients cope with schizophrenia symptoms, such as hallucinations and anxiety. For instance, the *VR for Schizophrenia* project conducted by the University of Oslo showed that patients who participated in AI-assisted VR sessions experienced significant improvements in managing anxiety and hallucinations.

Artificial intelligence can also support patients in daily symptom management. Mobile applications like *Wysa* provide real-time emotional and therapeutic support to patients. *Wysa*, an AI-based application, engages in conversations with patients, helping them manage stress, anxiety, and other symptoms. Many users of the app have reported significant improvements in handling emotions and schizophrenia symptoms.

The use of AI in psychiatry involves a significant responsibility for storing and protecting sensitive patient data. Implementing these technologies requires strict compliance with data protection regulations such as GDPR in Europe and HIPAA in the United States. There is a risk of privacy breaches, especially concerning data about patients' mental health and therapy progress. Therefore, AI systems must be designed to ensure full compliance with privacy and security regulations.

Despite promising results, the application of AI in schizophrenia treatment still raises doubts and resistance among patients and some medical professionals. Many people fear that artificial intelligence might replace doctors or, worse, fail to provide adequate support in complex clinical cases.

Although AI has the potential to improve access to treatment in resource-limited countries, implementing this technology involves high initial costs. Projects conducted in India, where rural patients access psychiatric consultations online, show that AI can reduce barriers to treatment, particularly in rural areas. However, the development and implementation costs of such systems remain a barrier for some developing countries.

To effectively implement AI in schizophrenia treatment, further clinical and experimental research is necessary. This includes evaluating the long-term effects of AI use in schizophrenia treatment and developing new algorithms that can better adapt therapy to patients' changing needs. Additionally, it is essential to understand how AI can collaborate with traditional treatment methods to create a comprehensive, effective therapeutic plan.

Artificial intelligence in psychiatry, including in schizophrenia treatment, has the potential to revolutionize healthcare. Through personalized treatment, support in virtual and augmented reality therapy, and the creation of automated support systems, AI can improve patients' quality of life. However, its effective implementation requires further research, a responsible approach to ethical and security issues, and overcoming financial and technological barriers that still hinder the full use of these technologies.

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