

Critical Analysis of Internet of Things (IoT) And Artificial Intelligence (AI) Applications in Mental Health Assessment

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Abstract

The integration of Internet of Things (IoT) and Artificial Intelligence (AI) technologies is driving a paradigm shift in mental health assessment by facilitating continuous, real-time monitoring and personalized insights. This paper critically examines the deployment of smart devices—such as wearables and ambient sensors—combined with AI-driven analytics to augment traditional approaches. By analysing behavioural indicators like sleep, activity levels, and social interaction, these systems can help detect early signs of mental health conditions including depression and anxiety. Remote monitoring capabilities offered by IoT further enhances its benefits. Through a systematic review of current technologies and real-world implementations, the paper evaluates their effectiveness, scalability, and ethical viability. It also addresses critical challenges such as data privacy, algorithmic fairness, and the cultivation of user trust. The findings underscore the need for transparent algorithm design, inclusive development practices, and robust regulatory oversight. Ultimately, the paper advocates for AI-IoT ecosystems that advance proactive, equitable, and clinically meaningful mental health interventions.

Keywords: Internet of Things, Artificial Intelligence, Smart Devices, Mental Health, Sensor.

1. Introduction

Mental health is a fundamental component of overall health and well-being, extending beyond the absence of illness to include positive psychological and social functioning. According to the World Health Organization (WHO), (World Health Organization, 2023) it represents a state in which individuals realize their abilities, cope with everyday stresses, work productively, and contribute to their communities. Mental disorders—marked by significant disturbances in cognition, emotional regulation, or behavior—are highly prevalent and disabling. In 2019, about 1 in 8 people worldwide (nearly 970 million) were living with a mental disorder, with anxiety and depression being the most common. This figure has since risen to over 1 billion, underscoring the increasing global burden. Such conditions are a leading cause of disability, reducing

life expectancy by 9–13 years in severe cases like schizophrenia and bipolar disorder, while depression and anxiety alone generate annual productivity losses of approximately €850 billion. Despite their scale, mental health services remain critically under-resourced. Governments worldwide allocate, on average, only 2% of health budgets to mental health, and many low- and middle-income countries have fewer than one mental health professional per 100,000 people. Treatment gaps are alarming, with 76–85% of individuals in need in low- and middle-income countries, and 35–50% in high-income countries, receiving no care. The COVID-19 pandemic further intensified these challenges, fueling a 25% surge in anxiety and depression within a single year and widening existing disparities, particularly among women and younger populations.

Table 1 indicates the statistics published by WHO regarding Mental Health in the world [1].

Table 1 Statistics Published by WHO

Metric	Statistic
Global prevalence of mental disorders (2019)	~970 million people (~1 in 8)
Current prevalence (latest WHO data)	Exceeds 1 billion
Disability and life expectancy impact	Severe mental conditions reduce life expectancy by 9–13 years; significant productivity losses (€850 billion/year)
Funding and workforce gap	Only ~2% of health budgets allocated to mental health; extreme shortages of professionals, especially in low- and middle-income countries
Treatment gap	76–85% in low- and middle-income countries; 35–50% in high-income countries
Impact of COVID-19 on mental health	>25% surge in depression and anxiety in one year

The growing global prevalence of mental health disorders, such as depression and anxiety, has highlighted significant limitations in traditional in-clinic assessment and intervention methods. These traditional approaches often rely on subjective reporting, are not always accessible, and fail to provide continuous, real-time monitoring of an individual's mental state. This can lead to delayed diagnoses and interventions, which can have a profound impact on a person's quality of life. In response to these challenges, the integration of the Internet of Things (IoT) and Artificial Intelligence (AI) is emerging as a transformative force in mental healthcare. IoT devices, including wearable sensors and smart home technology, can continuously and unobtrusively collect a vast amount of physiological and behavioral data. This data, which includes heart rate, sleep patterns, physical activity, and even vocal and textual cues, provides a rich, objective source of information about an individual's well-being. (Li, Wang, Wang, & Zhang, 2024) When coupled with AI, this data becomes a powerful tool for early detection and personalized care. AI algorithms, particularly those based on machine learning and deep learning, can analyze these large datasets to identify subtle patterns and trends that may be indicative of a developing mental health issue. By

detecting these early warning signs, AI can alert individuals, caregivers, or healthcare professionals, enabling timely intervention before a condition becomes severe. This synergistic relationship between IoT and AI holds the promise of revolutionizing mental health services, moving from a reactive model to a proactive, patient-centered approach.

2. IOT for Mental Health

The Internet of Things (IoT) is poised to revolutionize mental healthcare by providing new ways to monitor, diagnose, and treat mental health conditions. By connecting physical devices, sensors, and software, IoT can collect a wealth of real-time data that offers a more holistic and objective view of a person's well-being. Various wearable devices, including belts, patches, and smartwatches from companies like Equivital, Zephyr, Hexoskin, Empatica, Fitbit, Garmin, and Xiaomi, are used to monitor physiological and behavioral parameters for mental health assessment. (Gomes, Pato, Lourenço, & Datia, 2023) This can lead to earlier interventions, more personalized treatment, and a greater understanding of the mind-body connection. The power of IoT in mental health comes from its ability to collect a wide array of data types that paint a more comprehensive and nuanced picture of a person's

well-being than traditional methods. IoT utilizes various sensors to collect physiological and behavioral data. Physiological data such as heartbeat, sleep patterns, respiratory rate and temperature of the body [2].

2.1. Physiological Data Analysis using IoT

A high heart rate can be a sign of stress or anxiety. More importantly, Heart Rate Variability (HRV), the variation in time between heartbeats, is a crucial metric. A low HRV is often associated with stress, fatigue, and poor emotional regulation, while a high HRV indicates a healthy nervous system. (Li, Wang, Wang, & Zhang, 2024) IoT devices can track the duration, quality, and stages of sleep. Poor sleep is a common symptom and a risk factor for many mental health conditions, including depression and anxiety. Analysing sleep data can provide critical insights into a person's mental state. Breathing patterns can change significantly with emotional states. For example, shallow, rapid breathing is often associated with panic or anxiety. Changes in body temperature can be linked to stress responses and sleep patterns, offering another physiological data point for analysis devices can monitor and track these changes.

2.2. Behavioral and Social Data Analysis using IoT

IoT devices can track steps, calories burned, and time spent on physical activity. A sudden decrease in activity levels can be a strong indicator of low energy, fatigue, and social withdrawal, all common symptoms of depression. Data from smartphones or connected social media apps can track social activity, such as call frequency, text message volume, and social media engagement. A decrease in these metrics can signal social withdrawal. (Fang et al., 2024) Data from smartphones and computers can track screen time, app usage, and a person's engagement with different types of content. Changes in these patterns, for example, increased time spent on social media or a shift to more negative content—can be indicative of a change in mental state [3].

3. Architectures and Approaches

The Internet of Things (IoT) offers several significant advantages over traditional mental health methods, addressing many of the long-standing challenges in the field. Traditional methods, while

foundational, are often limited by their reliance on episodic, subjective, and in-person interactions. IoT, on the other hand, provides a more continuous, objective, and accessible approach to mental healthcare. The basic architecture to implement IoT for mental health assessment is, wearable sensors (e.g., heart rate, activity, sleep trackers) and smartphones are used to continuously collect physiological and behavioural data, which is pre-processed on-device to extract features like Heart Rate Variability(HRV), sleep duration, or mobility patterns before being securely transmitted via protocols such as Message Queuing Telemetry Transport (MQTT) over Transport Layer Security (TLS) to a cloud backend. In the cloud, machine learning models—ranging from classical algorithms to multimodal deep learning—analyse these features to detect stress, depression, or mood changes, while clinician dashboards provide interpretable trends and alerts. Privacy is ensured through encryption, consent management, on-device processing, and optionally federated learning, while evaluation requires pilot studies validated against clinical scales like Patient Health Questionnaire-9 (PHQ-9). This pipeline enables early detection and intervention while maintaining user trust and regulatory compliance. Figure 1 summarizes the architecture flow Let us have a look at the features extracted. Smart home devices can track a person's behavior within their living space. For example, sensors can monitor sleep duration and quality, a person's time spent in different rooms, or their overall activity level. A significant change in these patterns—such as a person becoming more withdrawn or having a severely disrupted sleep schedule—could be an indicator of a mental health issue. IoT can passively collect data from devices like smartphones. This data can include a person's social media activity, text message content, and even their voice patterns. AI algorithms can analyze this information to detect changes in language or tone that may signal a mental health concern, such as a shift to more negative or depressive language IoT enables a proactive and preventive approach. By continuously monitoring data, algorithms can identify subtle changes that are early warning signs of a mental health crisis. For

example, a sudden and sustained decrease in physical activity and social engagement could be a red flag for a depressive episode. This allows for timely intervention, such as an automated reminder to exercise or a notification to a therapist, potentially preventing the condition from escalating. IoT provides a wealth of data that can be used to create highly personalized treatment plans. A therapist can see how a patient's lifestyle choices (sleep, diet, exercise) are affecting their mental state in real time. This allows for data-driven adjustments to a treatment plan. For example, if a patient's stress levels are consistently high on certain days, the therapist can help them identify the triggers and develop specific coping strategies for those days.

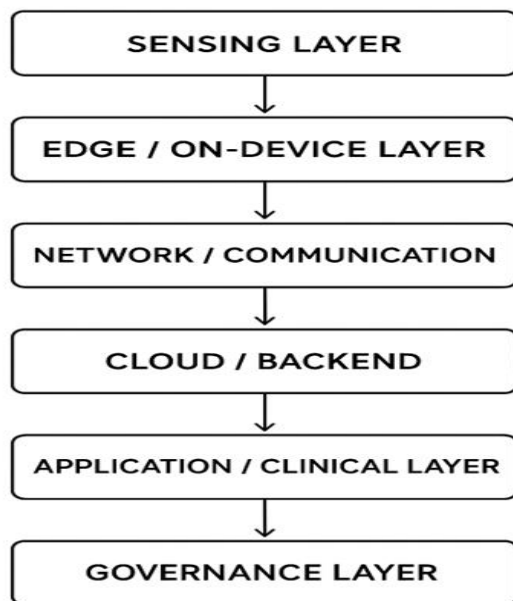


Figure 1 Architecture Flow

IoT can lead to greater efficiency and potentially lower costs. Remote monitoring can reduce the need for frequent in-person visits, saving both time and money for the patient. For healthcare providers, IoT can help with administrative tasks like tracking medication adherence and monitoring patient progress, freeing up time for more focused, therapeutic work. IoT devices enable healthcare professionals to monitor patients remotely. (Hussein, 2019) This is especially beneficial for people in rural areas or those who face barriers like stigma or transportation issues. A therapist can review a

patient's data from their wearable devices to get a more complete picture of their well-being between sessions, leading to more informed and effective treatment plans [4].

4. AI for Early Detection

Artificial intelligence (AI) is a revolutionary force in healthcare when coupled with the streams of data provided by Internet of Things (IoT) devices. Combined, these two technologies facilitate real-time monitoring, improved understanding of patient health, and more accurate, targeted care. Among AI methods, machine learning models are particularly useful, since they can interpret IoT data to identify patterns that forecast disease progression and direct personalized treatment options. Through learning from past datasets, these models are able to identify subtle variations or anomalies in patient health parameters, enabling early detection of potential medical issues. In medical use cases, AI systems analyze data from wearable sensors and IoT devices to monitor vital functions, physical activity, sleep patterns, and other key measures. Ongoing monitoring of such information gives clinicians timely warnings of health setbacks or recurrences, enabling proactive interventions and enhanced patient outcomes. In addition, AI has the ability to turn raw IoT data into individualized care plans (Wang et al., 2024). Through the integration of each patient's own profile, medical history, and real-time data, these systems have decided the best treatment plans. AI-powered tools provide accessible and on-demand support, often in the form of chatbots and virtual assistants. Apps like Woebot and Wysa use AI to provide emotional support and therapeutic exercises based on evidence-based techniques like cognitive behavioral therapy (CBT). (Haque & Rubya, 2023) They offer a non-judgmental space for users to vent and learn coping strategies. AI can create personalized treatment plans by analyzing a user's data and progress, tailoring exercises and resources to their specific needs. AI combined with VR is being used for exposure therapy, particularly for conditions like PTSD and phobias. AI can dynamically adjust the virtual scenarios to meet the patient's needs, creating a controlled environment for gradual exposure. The combination of AI and IoT is

a healthcare paradigm shift that will advance predictive accuracy, simplify processes, and focus on patient-centric, personalized care. Together, they form the platform for a future in which healthcare will not only be highly technological but greatly personalized [5].

5. Latest Trends

A Data driven IOT based approach was presented in April 2025 (Zamani, Nguyen, & Sinha, 2025) which proposed an IoT-based system for mental health monitoring that integrates big data analytics, fuzzy logic, and machine learning with a novel focus on environmental factors, particularly temperature and humidity. Using three public datasets, the system classified stress levels into five categories through Logistic Regression, Support Vector Machine, and Long Short-Term Memory models, with SVM achieving the highest accuracy (97.95%). Findings confirm strong correlations between environmental conditions and stress, highlighting the potential of IoT-driven models for real-time monitoring and predictive insights. Despite limitations such as class imbalance and lack of personalization, the study demonstrates a shift from reactive to proactive mental healthcare and outlines future directions for adaptive, data-driven intervention systems. A work in 2024 (Nagayo, Al Ajmi, Guduri, & Al Buradai, 2024) presents the Stress Level and Health Risk Monitoring System (SLHRMS), which integrates IoT, GSM, and AI to evaluate physiological and emotional stress in educational environments. Using Particle Photon microcontrollers, the system gathers biosensor data on temperature, blood pressure, heart rate, oxygen saturation, skin resistance, and behavioral symptoms. Processed data is stored on cloud platforms and accessed via a mobile app, which provides real-time stress scores, health risk levels, and management advice. Critical stress levels trigger automated alerts to counselors or medical staff. Validated against NEWS2 and DASS-21 assessments, the system achieved over 87% accuracy in stress detection and 93% in health risk evaluation, supporting early intervention and mental health awareness in academic settings. A proposed model published in 2020 (Jain, Gandhi, Burte, & Vora, 2020) integrates IoT sensors, computer vision, and

natural language processing to assess both physical and mental health. IoT devices monitor vital signs such as temperature and heart rate, while an emotion recognition module, trained on the FER2013 dataset using a miniXception model, analyzes live video streams to classify emotions with about 66% accuracy. Biomedical data are stored in a database, and an NLP-based chatbot acts as a virtual doctor, offering preliminary diagnoses by combining symptoms, emotional states, and vital signs. The system also provides alerts for negative emotions or abnormal readings and features a user-friendly HTML5/CSS GUI for easy interaction. Overall, it delivers real-time, multimodal health insights to improve accessibility and support medical professionals [6].

6. Ethical and Practical Challenges

While AI holds immense promise for transforming mental health care, its implementation is fraught with significant ethical and practical challenges that need to be addressed carefully. These challenges underscore the importance of a human-centered approach and strong regulatory oversight [7].

6.1. Privacy and Data Security

Privacy and data security are arguably the most critical ethical challenge. Mental health data, which includes personal histories, trauma, and vulnerabilities, is among the most sensitive information. (Gutierrez et al., 2021) The use of AI requires the collection and analysis of vast amounts of this data, which can come from therapy session transcripts, biometric data from wearables, and even social media activity. A data breach could have devastating consequences, leading to social stigma, discrimination, and a loss of trust in the healthcare system. It can be difficult to get truly informed consent when individuals may not fully understand how their data will be used, stored, and potentially shared with third-party companies. Even with anonymization, there is a risk of re-identification, where private information can be pieced together from different data sources [8].

6.2. Bias in AI Systems

AI algorithms are only as good as the data they are trained on. If the data is imbalanced or reflects historical biases, the AI system will perpetuate and

even amplify those biases. If an algorithm is trained on a dataset that is predominantly from one demographic group (e.g., white males), it may not accurately diagnose or recommend effective treatment for individuals from other racial, ethnic, or gender backgrounds. This can lead to overdiagnosis or underdiagnosis in marginalized communities. Biased AI could worsen existing health inequalities by providing less effective care or resources to specific populations [9].

6.3. Accountability and Liability

The question of who is responsible when an AI-powered tool provides harmful or inaccurate advice is a complex legal and ethical problem. If a chatbot offers dangerous advice that leads to self-harm, who is to blame? Is it the developer, the healthcare provider who recommended the tool, or the user? Unlike a human therapist who is a licensed professional who is held to a code of ethics, there is no clear legal framework for holding an AI system accountable [10].

6.4. Therapeutic Alliance

A cornerstone of effective mental health care is the therapeutic alliance, the relationship built on trust, empathy, and a human connection. AI can mimic empathetic language, but it lacks genuine understanding or consciousness. This can be misleading and potentially harmful, as users may form a strong emotional dependence on an AI that cannot truly reciprocate. In a crisis, an AI might misinterpret a user's language or fail to recognize a critical situation, leading to inappropriate or even dangerous responses.

6.5. Regulation and Oversight

The field of AI is advancing faster than regulatory bodies can keep up. Many AI-powered mental health apps operate with little to no government oversight, unlike traditional medical devices or pharmaceutical drugs. (Gutierrez et al., 2021) This raises concerns about safety and efficacy. It is difficult to define and measure "psychological harm" caused by an AI, which complicates efforts to create and enforce regulations.

6.6. Transparency and Trust

Many AI models, particularly deep learning systems, are "black boxes." This means it can be difficult for

clinicians and users to understand how the AI arrived at a particular conclusion or recommendation. Clinicians may be hesitant to adopt AI tools if they cannot trust the reasoning behind the recommendations. Patients may also be wary of a diagnosis or treatment plan that is not clearly explained.

6.7. Data Limitations and Generalization

AI models require massive, high-quality datasets to be effective. Mental health data is often limited, fragmented, and not standardized, which can hinder the development of robust and accurate AI models. A model trained on a specific population in a clinical setting may not generalize well to the wider, more diverse real world.

6.8. Integration into Healthcare Systems

For AI to be useful, it must be seamlessly integrated into existing healthcare systems. Mental health professionals need to be trained on how to use these new tools effectively, understand their limitations, and interpret their output. Many healthcare systems are not technologically equipped to handle the large-scale data and computational needs of AI, making implementation difficult and costly [11].

Conclusion

In conclusion, while traditional methods remain a crucial component of mental healthcare, IoT offers a powerful complement. By providing continuous, objective, and personalized insights, it allows for a more proactive, accessible, and data-driven approach to mental well-being, ultimately leading to better outcomes for patients. Many people are hesitant to seek help for mental health issues due to stigma. IoT devices offer a more private and non-intrusive way to receive support. The data is collected passively, and interventions can be provided without the need for direct human interaction, which may be more comfortable for some individuals. While the potential of IoT in mental health is vast, it also raises important considerations around data privacy, security, and the accuracy of the insights generated. However, with careful development and ethical implementation, these technologies have the potential to make mental healthcare more accessible, personalized, and effective. AI helps to overcome barriers to mental health care by providing scalable

and cost-effective solutions. AI tools and chatbots are available around the clock, providing immediate support for individuals who may not have access to a human therapist during a crisis or who live in remote areas. AI-driven interventions are often more affordable than traditional therapy, making mental health support more accessible to a wider population. By offering a first line of support, AI tools can help people manage their mental health while they are on a waiting list for professional help. AI is being used to identify and support individuals at a high risk of suicide. AI models can analyze a combination of behavioral, clinical, and social data to identify individuals with an elevated risk of suicide. This allows for targeted prevention strategies and informs public health policies.

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