

## Smart IoT for Mental and Well Being Monitoring

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### Abstract

This article focuses on the concept of the Internet of Things and how IoT has revolutionised multiple aspects and domains in our lives. Integrating intelligent Internet of Things (IoT) technologies into mental health and well-being monitoring is an important step forward in healthcare. IoT refers to a network of interconnected devices that collect and exchange data in real-time, providing a non-intrusive, continuous, and data-driven approach to health monitoring. IoT offers the potential to transform mental health by enabling early detection, assessment, and treatment of mental disorders, improving patient outcomes and quality of life. Monitoring mental health is very important because it helps identify symptoms of disorders such as depression, anxiety, and stress, which can have a significant impact on a person's life, productivity, and relationships. As mental health problems increase worldwide, innovative solutions are needed to address this growing concern. IoT plays a key role by using wearable devices and biometric sensors to monitor physiological signals such as heart rate, sleep patterns, physical activity, and stress levels. For example, smartwatches and fitness trackers can provide continuous information about a person's health indicators and provide insight into their mental and emotional state.

The importance of mental health monitoring cannot be overstated. Early detection and timely intervention can significantly reduce the severity of mental health problems and improve overall well-being. IoT tools for monitoring well-being and mental health include wearable devices, mobile health apps and home health monitoring systems. These tools provide valuable information to help healthcare providers develop personalized treatment plans and provide preventive care. However, implementing IoT in mental health monitoring presents several challenges. Privacy and security are paramount as sensitive personal data is collected and transmitted. It is important to ensure data integrity and protect against unauthorized access. In addition, adoption of IoT technologies in mental health has been slow due to mental health stigma and misconceptions that these technologies may pose risks to patients. Real cases, such as using the Internet of Things to monitor stress levels among urban workers in India, highlight both potential benefits and obstacles in this field. In conclusion, while IoT for mental health and well-being monitoring offers promising solutions to improve mental health care, addressing privacy, security, and social challenges is essential for its widespread adoption and success. The phenomenon of the Internet of Things has revolutionized many aspects of our domains in life, from home automation to industrial operations. However, one aspect where the Internet of Things is poised to make a significant influence is in the field of mental health and well-being monitoring. By leveraging various digital devices and advanced interpretation of analytics of data, one can gain valuable insights into our emotional and psychological states, enabling early intervention and personalized support.

**Keywords:** IoT; Mental Health; Well Being; Monitoring Health; Wearable Health Related Devices

## Introduction

The rise of mental health disorders worldwide represents an urgent and critical health crisis that requires immediate attention and intervention. Rapid urbanization and socioeconomic pressures have worsened the situation in India. For example, a 2020 study found that about 197 million Indians suffered from mental health problems, including anxiety and depression. Pressure for academic excellence, job instability, and mental health stigma have created an environment of stress and hopelessness among young adults and professionals. Real-life examples include the tragic increase in student suicides, with the National Criminal Records Bureau reporting over 10,000 student suicides in 2019 alone. This alarming trend underscores the need for comprehensive mental health strategies that include awareness campaigns, accessible mental health services, and destigmatization efforts.

Globally, the COVID-19 pandemic has further highlighted the fragility of mental health. In countries such as the United States, long-term social isolation, economic insecurity, and fear of disease have led to a significant increase in mental health problems. According to a 2021 report from the Centres for Disease Control and Prevention (CDC), about 40% of adults reported having a mental health or substance use problem. Similarly, mental health organizations in the UK reported a 30 per cent increase in calls and requests for help during the pandemic. These real-life examples highlight the multifaceted causes of the mental health crisis, including socioeconomic disparities, health crises, and inadequate mental health infrastructure. Addressing these challenges requires a multifaceted approach that includes policy reform, increased funding for mental health services, and global collaboration to share resources and strategies.

## Definition and Components of IoT

It is a process of a network of physical things incorporated with software, sensors and other technologies that connect and share data with other devices and systems via the Internet. Key components of IoT include:

**Sensors and Actuators:** Devices that collect data (e.g., heart rate monitors) and perform actions (e.g., adjusting a room's lighting).

**Connectivity:** The communication networks that link devices, such as Wi-Fi, Bluetooth, and other Mobile phone networks.

**Data Processing:** Data assessment tools often involve cloud computing and artificial intelligence (AI).

**User Interface:** Platforms (e.g., mobile apps) where users interact with IoT systems to monitor and manage their health.

## Concept of Mental Health Monitoring

"Mental health is essential for general well-being, but it is often neglected or stigmatized. Depression, anxiety, and stress can seriously affect a person's quality of life, productivity and relationships. For example, chronic stress can lead to burnout, poor performance and job satisfaction. Anxiety can cause social withdrawal, and strain friendships and family relationships. Depression often causes a lack of motivation and a lack of interest in daily activities, which seriously impairs general well-being. These mental health problems can disrupt personal and professional life and highlight the need for effective intervention and support.

With the rise of the Internet of Things (IoT) and related concepts like ubiquitous computing, the prevalence of mental health issues has surged significantly. Consequently, it is crucial to explore how IoT can aid in the detection, assessment, treatment, and potential alleviation of mental health disorders [1-3]. Traditional methods of mental health assessment and treatment have relied heavily on self-report and regular visits to mental health professionals. However, these approaches have limitations because they only provide a snapshot of an individual's mental state at a given moment. Continuous real-time monitoring can provide a deeper understanding of an individual's emotional and behavioural patterns, allowing early detection of potential problems and timely intervention.

The healthcare industry is one of the areas where the Internet of Things is expected to have a major impact. IoT has advanced this field with innovative solutions for monitoring, well-being measures, Personal data monitoring, and Knowledge data services, Boosting patient life satisfaction and health and well-being [4,5]. Despite these advances, there is still much room for further research in this area, especially in mental health. IoT technologies have great potential to diagnose, treat and cure mental health because they can collect real-time data that shows activity and behaviour patterns [6]. In addition, these solutions allow patients to communicate remotely with healthcare professionals, facilitating conversations about their findings, health and conditions, and improving monitoring and evaluation [7]. However, the adoption of IoT technologies in mental health has been slow, in part due to the misconception that these technologies may pose greater risks to patients and others.

## Importance of Mental Health Monitoring

The well-being of mind and body is an integral and important factor of overall well-being, influencing individuals' overall sensory functioning. Effective mental health monitoring can benefit in the following manner:

**Prevent crises:** Early detection of mental health issues can prevent severe outcomes.

**Provide personalized care:** Monitoring enables tailored interventions based on individual needs.

**Improve quality of life:** Continuous support can enhance daily functioning and well-being.

**Early Detection of Depression:** Imagine an IoT-enabled smartphone app that analyses users' text messages, social media posts, and voice patterns. By detecting subtle changes in language or tone, the app can identify early signs of depression. Early intervention can prevent worsening symptoms and improve overall mental health.

**Smart Wearable's for Anxiety Management:** Smart watches equipped with heart rate sensors can detect spikes in anxiety. When a user's heart rate exceeds a certain threshold, the wearable sends calming prompts or suggests mindfulness exercises. This real-time feedback helps manage anxiety levels.

**Virtual Reality:** (VR) Therapy headsets can create immersive environments for exposure therapy. For instance, patients with phobias can gradually confront their fears (like flying or heights) in a controlled virtual setting. This approach reduces anxiety and improves mental resilience.

**Smart Homes for Dementia Patients':** sensors placed around a dementia patient's home can monitor daily routines. If deviations occur (e.g., forgetting to turn off the stove or wandering at odd hours), caregivers receive alerts. Such monitoring ensures safety and provides peace of mind.

**Emotion-Sensing Chatbots:** AI-powered chatbots analyse users' text messages or voice calls to gauge emotional states. These chatbots can offer empathetic responses, recommend coping strategies, or escalate urgent cases to human professionals.

**Biofeedback Devices for Stress Reduction:** Wearable biofeedback devices measure physiological parameters (such as skin conductance or muscle tension). Users receive real-time feedback on stress levels, helping them practice relaxation techniques.

**Smart Pill Dispensers for Medication Adherence:** IoT-enabled pill dispensers help patients remember to take their medications by sending reminders. If a dose is missed, caregivers are notified. Ensuring proper medication adherence is essential for effectively managing mental health conditions.

## The Role of IoT in Mental Health Monitoring

The integration of IoT in well-being monitoring for mind and body represents a ground-breaking advancement in healthcare, using data collection and analysis based on real-time data to offer unprecedented insights into patients' mental and emotional well-being. IoT devices, such as smart watches, wearable, and home sensors, continuously

gather data on various physiological and behavioural parameters like heart rate, sleep patterns, physical activity, and even speech patterns. For instance, a study by Canzian L [8] demonstrated that smartphone sensors could predict depressive symptoms by analysing users' movement and social interaction patterns. This continuous, non-intrusive data collection helps to detect of mental health issues in early age, enabling timely interventions and personalized treatment plans.

Moreover, IoT applications extend beyond mere monitoring; they facilitate proactive mental health management. In real-world settings, smart environments equipped with IoT devices can significantly enhance patient care. For example, the deployment of smart home systems for elderly individuals living with cognitive disorders can provide real-time alerts to caregivers and healthcare providers about unusual behaviour patterns or potential safety hazards, as highlighted by the work of Rashidi P [9]. These systems not only improve patient safety but also empower individuals to maintain their independence while ensuring they receive appropriate care. Thus, IoT in mental health monitoring not only revolutionizes how data is collected and analysed but also fundamentally enhances the quality and responsiveness of mental health care. IoT technology has the potential to transform mental health monitoring by offering a non-intrusive, continuous, and data-driven method. By incorporating various sensors and devices into our daily routines, we can gather extensive data that can be analysed to gain insights into our mental and emotional well-being.

## Tools for Monitoring Wellbeing and Mental Health

**Wearable Devices:** Smart watches, fitness trackers, and other wearable's provide continuous, non-intrusive monitoring of individuals' mental well-being. These devices collect data on pulse beat rate, sleeping timings, Exercise and workouts activity, and work pressure and stress indicators.

- **Heart Rate Variability (HRV):** HRV parameters are commonly used for detecting anxiety and stress. Electrodermal activity sensors also show promise in stress detection.
- **Predictive Analytics:** Machine learning algorithms can analyse behavioural patterns and predict mental health fluctuations.
- **Telehealth Services:** Remote consultations, therapy sessions, and mental health apps enable personalized support.

**IoT Plant Monitoring:** Surprisingly, even indoor plants can contribute to mental well-being. An IoT plant monitoring system continuously senses and monitors plant health, potentially enhancing mood and positivity.

## Wearable Devices and Biometric Sensors

Wearable technologies like smart watches and trackers to map fitness are equipped with a variety of sensors that can monitor signals of a physiological nature like Cardiac rhythm, epidermal temperature and disturbed sleep patterns. These biometric data points can be correlated with emotional and psychological states, providing valuable insights into an individual's mental well-being. For example, increased heart rate variability and elevated skin temperature may indicate heightened stress or anxiety levels. Disrupted sleep patterns could be a sign of depression or other mental health issues. By continuously monitoring these physiological signals, IoT systems can detect potential mental health concerns and alert individuals or healthcare professionals for further evaluation or intervention.

Smart watches and fitness trackers, such as the Apple Watch and Fitbit, are commonly used to monitor physical activity, heart rate, and sleep patterns, which are essential markers of mental health. These devices can detect deviations from normal patterns, prompting users to seek help when needed.

**Example:** The Apple Watch includes features like the Breath app, which encourages mindfulness and relaxation exercises. Research has shown that such interventions can reduce anxiety and stress.

## Environmental Sensors

Our physical surroundings can have a significant impact on our mental well-being. IoT-enabled environmental sensors can monitor factors such as air quality, noise levels, and light exposure, which can influence mood, focus, and overall well-being. For example, subpar air quality or excessive noise pollution may lead to heightened stress and fatigue, whereas sufficient exposure to natural light has been demonstrated to enhance mood and alleviate symptoms associated with seasonal affective disorder (SAD). By integrating environmental data with other biometric and behavioural data, IoT systems can provide a holistic view of an individual's mental state and recommend appropriate interventions, such as improving air quality, reducing noise levels, or adjusting lighting conditions.

## Activity and Behavioural Monitoring

IoT devices can also track an individual's daily activities and behaviours, which can serve as indicators of mental health. Smart home sensors, for example, can monitor patterns of movement, sleep, and interaction with certain devices or appliances. Changes in these patterns, such as increased sedentary behaviour, disrupted sleep cycles, or loss of interest in previously enjoyed activities, could be early signs

of depression or other mental health issues. By analysing these behavioural data points, IoT systems can identify potential mental health concerns and provide personalized recommendations or interventions, such as encouraging physical activity, promoting social interaction, or suggesting relaxation techniques.

## Emotion Recognition and Sentiment Analysis

Advancements in computer vision and natural language processing (NLP) have enabled IoT systems to recognize and analyse emotional expressions and sentiment. Facial expression analysis can detect emotions like happiness, sadness, anger, or fear, while sentiment analysis can gauge emotional tone and sentiment from written or spoken language. By integrating these capabilities into IoT devices like smart cameras, virtual assistants, or chatbots, mental health monitoring systems can gain valuable insights into an individual's emotional state. For example, a smart home system could detect prolonged periods of sadness or frustration through facial expressions and vocal cues and suggest appropriate interventions or connect the individual with mental health resources.

## Personalized Interventions and Support

One of the key advantages of IoT-based mental health monitoring is the ability to provide personalized interventions and support based on an individual's unique needs and circumstances. By analysing the collected data from various sensors and devices, IoT systems can develop a comprehensive understanding of an individual's mental and emotional state, as well as potential triggers or contributing factors. Based on this understanding, IoT systems can recommend tailored interventions, such as mindfulness exercises, cognitive-behavioural therapy (CBT) techniques, or even virtual counselling sessions. These interventions can be delivered through IoT-enabled devices like virtual assistants, smart speakers, or mobile apps, making mental health support more accessible and convenient. Additionally, IoT systems can facilitate remote monitoring and support from mental health professionals. Real-time data from IoT devices can be shared with therapists or counsellors, enabling them to provide more informed and timely guidance, even when the individual is not physically present in their office.

## Challenges in the Role of IoT in Mental Health Monitoring

Integration of IoT technology incorporating mental health monitoring presents a promising opportunity to improve overall well-being and provide timely, personalized support. By leveraging a range of connected devices and advanced data analytics, IoT systems can continuously monitor

physiological, environmental, and behavioural data to gain insights into an individual's mental and emotional state. Nonetheless, the creation and implementation of such systems necessitate stringent privacy and security protocols, alongside a robust ethical framework, to guarantee the conscientious and respectful handling of sensitive personal information.

As IoT technology continues to evolve, and our understanding of mental health deepens, smart IoT solutions for mental and well-being monitoring have the potential to revolutionize the way we approach mental health care, promoting early intervention, personalized support, and ultimately, improving the quality of life for individuals worldwide. In our fast-paced, digitally driven world, the pursuit of optimal mental health and well-being has become a paramount concern. Traditional approaches to mental healthcare often fall short, failing to capture the nuances of our daily lives and the ever-changing landscapes of our emotional states. Enter the realm of Smart IoT (Internet of Things) technology, a game-changer that promises to revolutionize the way we monitor, understand, and nurture our mental well-being.

### Privacy Security and Ethical Considerations

Though the potential advantages of IoT-driven mental health monitoring are substantial, it's imperative to tackle the privacy, security, and ethical issues linked to the collection and management of sensitive personal data. The use of IoT technology for mental health monitoring raises important ethical questions. For instance, there is a risk of over-medicalization or pathologization of normal emotional responses or behaviours. IoT systems must be designed and deployed with a clear understanding of what constitutes healthy emotional and behavioural patterns and avoid overly broad or stigmatizing classifications. Additionally, the potential for IoT systems to influence or manipulate individuals' mental states through personalized interventions or nudges raises concerns about autonomy and free will. Clear ethical guidelines and oversight mechanisms should be established to ensure that IoT-based mental health monitoring systems are designed and used responsibly and ethically, prioritizing individual well-being and autonomy.

### Cybersecurity Resilience: Fortifying Digital Sanctuaries

Mental health data is highly sensitive and personal. IoT systems must implement robust data privacy measures, such as secure data encryption, access controls, and anonymization techniques, to protect individuals' privacy and prevent unauthorized access or misuse of their data. Furthermore, individuals must provide explicit consent for the collection and use of their data for mental health monitoring purposes. Clear and transparent communication about data collection

practices, storage, and sharing policies is essential to build trust and promote informed decision-making. IoT devices and systems are vulnerable to cyber threats, such as hacking, malware, and distributed denial-of-service (DDoS) attacks. Compromised IoT devices could potentially expose sensitive mental health data or be manipulated to provide inaccurate or harmful information. To mitigate these risks, IoT systems for mental health monitoring must employ robust cyber security measures, including secure device authentication, regular software updates, and resilient network infrastructure. Ongoing security assessments and penetration testing should be conducted to identify and address vulnerabilities proactively safeguarding the digital sanctuaries where our most intimate mental health data resides.

### Ethical Guardianship: Preserving Autonomy and Well-being

The integration of Smart IoT technology into mental well-being monitoring raises important ethical considerations. There is a risk of over-medicalization or pathologization of normal emotional responses or behaviours, which could potentially lead to unnecessary interventions or stigmatization. Smart IoT systems must be designed and deployed with a clear understanding of what constitutes healthy emotional and behavioural patterns, avoiding overly broad or stigmatizing classifications. Additionally, the potential for these systems to influence or manipulate individuals' mental states through personalized interventions or nudges raises concerns about autonomy and free will.

### The Quiet Crisis: Mental Health in the Modern Age

Mental health challenges have long been shrouded in stigma and misconceptions, yet the statistics paint a sobering picture. According to the World Health Organization (WHO), anxiety disorders are the most common mental health concern globally, affecting nearly 275 million people worldwide [10]. Depression, another formidable foe, impacts over 264 million individuals, often in tandem with other physical or mental health issues [10]. Beyond the numbers, the ripple effects of mental health challenges on individuals, families, and societies are profound. Diminished productivity, strained relationships, and a compromised quality of life are just a few of the consequences that underscore the urgency of addressing this silent epidemic.

### The Conventional Approach: Limitations and Opportunities

Traditionally, mental health assessments have relied heavily on self-reported data, periodic consultations with mental

health professionals, and observational studies. While these methods have their merits, they often fail to capture the dynamic nature of our emotional landscapes, which ebb and flow with the tides of daily experiences. Enter Smart IoT technology, a paradigm-shifting solution that promises to bridge the gap between our lived experiences and the understanding of our mental well-being. By seamlessly integrating sensors and devices into our daily routines, Smart IoT systems can unobtrusively collect and analyse a wealth of data, providing unprecedented insights into our emotional and psychological states.

## The Mindful Tech Revolution: Smart IoT in Action

### Biometric Monitoring for Emotional Awareness

At the forefront of the Mindful Tech Revolution are wearable devices, unassuming guardians that silently monitor our physiological signals, translating them into invaluable insights about our emotional well-being. From smart watches and fitness trackers to cutting-edge biosensors, these unobtrusive companions track vital signs such as heart rate variability, skin temperature, and sleep patterns – all potential indicators of our emotional state. For instance, a sudden spike in heart rate variability coupled with elevated skin temperature could signal heightened stress or anxiety levels, prompting the Smart IoT system to suggest a mindfulness exercise or recommend a calming activity tailored to the individual's preferences.

### Environmental Empathy: Optimizing Surroundings for Well-being

Our physical environments exert a profound influence on our mental well-being, often in subtle yet profound ways. Smart IoT systems harness the power of environmental sensors to monitor factors such as air quality, noise levels, and lighting conditions, adapting our surroundings to foster an atmosphere conducive to mental clarity and emotional balance. Imagine a Smart IoT system that detects elevated levels of indoor pollutants, known to contribute to fatigue and cognitive fog. With a gentle nudge, it could suggest opening windows or activating an air purification system, simultaneously adjusting the lighting to mimic the natural rhythms of daylight, proven to enhance mood and focus.

### Behavioural Insights: Decoding Daily Patterns for Proactive Support

Our daily routines and behaviours can serve as powerful indicators of our mental well-being, often revealing subtle shifts before they manifest as more pronounced challenges.

Smart IoT systems, with their discreet presence in our homes and workplaces, can unobtrusively monitor our activity patterns, sleep cycles, and interactions with various devices and appliances. A sudden change in these routines, such as increased sedentary behaviour, disrupted sleep cycles, or a loss of interest in previously enjoyed activities, could signal the onset of depression or other mental health concerns. Armed with this valuable data, Smart IoT systems can initiate proactive interventions, gently encouraging physical activity, promoting social engagement, or suggesting mindfulness practices tailored to the individual's needs.

### Emotional Intelligence: Recognizing and Responding to Sentiment

Advancements in computer vision and natural language processing have ushered in a new era of emotional intelligence for Smart IoT systems. Through facial expression analysis and sentiment detection, these systems can now recognize and respond to our emotional states in real time, providing a level of personalized support that was once the exclusive domain of human interaction. Imagine a Smart IoT system that detects prolonged periods of sadness or frustration through facial cues and vocal tones. With empathy and discretion, it could initiate a supportive dialogue, offering personalized coping strategies or connecting the individual with a virtual mental health coach or counsellor.

### Personalized Pathways: Tailored Interventions for Holistic Well-being

One of the most compelling aspects of Smart IoT technology is its ability to provide personalized interventions and support based on an individual's unique needs and circumstances. By synthesizing data from various sensors and devices, these systems can develop a comprehensive understanding of an individual's mental and emotional state, as well as potential triggers or contributing factors. Armed with this invaluable insight, Smart IoT systems can curate tailored interventions, ranging from mindfulness exercises and cognitive-behavioural therapy techniques to virtual counselling sessions or guided meditation practices. These interventions can be seamlessly integrated into our daily routines through Smart IoT-enabled devices such as virtual assistants, smart speakers, or mobile apps, making mental health support more accessible and convenient than ever before. Clear ethical guidelines and oversight mechanisms should be established to ensure that Smart IoT solutions for mental well-being monitoring are developed and utilized responsibly and ethically, prioritizing individual well-being, autonomy, and dignity.

## Conclusion

The integration of Smart IoT technology and mental well-being monitoring represents a paradigm shift in our approach to mental healthcare. By leveraging a network of connected devices and advanced data analytics, we can gain unprecedented insights into our emotional and psychological states, enabling early intervention, personalized support, and ultimately, improved quality of life. Mental health concerns are becoming a global concern. For example, as a result of the present COVID-19 pandemic, social isolation and stress-related situations have grown increasingly widespread, resulting in mental health consequences for the vast majority of people who work from home [11,12]. As we embrace this Mindful Tech Revolution, we must navigate the intricate balance between technological innovation and ethical responsibility, ensuring that our pursuit of mental well-being is grounded in respect for individual privacy, autonomy, and human dignity.

Through a collaborative effort involving researchers, mental health professionals, technology experts, and most importantly, the individuals whose well-being is at stake, we can harness the transformative potential of Smart IoT solutions to create a future where mental health is no longer a silent struggle, but a shared journey towards wholeness and flourishing. The utilization of Smart IoT for mental and well-being monitoring can transform the way we approach mental healthcare. By leveraging the power of interconnected devices, we can gain valuable insights into an individual's mental state and provide personalized support and interventions. At the same time, it is equally important to focus on the challenges related to privacy, data interpretation, and ethical considerations to harness the full potential of Smart IoT in mental health monitoring.

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