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Leveraging Blockchain and IIoT for Sustainable Workplace Mental Well-Being: A Clinical Psychology Approach

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Abstract:
The adoption of Blockchain and the Industrial Internet of Things (IIoT) has redefined mental healthcare by strengthening data security, enhancing stress management, and improving therapeutic efficiency. This study investigated the influence of blockchain-driven IIoT solutions on psychological well-being, with a focus on stress reduction, cognitive load management, therapist satisfaction, and cybersecurity trust. Drawing on Cognitive Load Theory (CLT) and Psychological Safety frameworks, this analysis examines how these technologies streamline mental healthcare workflows while mitigating digital stressors. Key components include automated blockchain-based security mechanisms, Artificial Intelligence (AI) driven therapy optimizations, and advanced encryption techniques that reinforce confidentiality and facilitate informed decision-making in digital therapy settings. Through statistical analyses such as paired t-tests, Chi-square tests, and regression models, this study validates the effectiveness of blockchain and IIoT in alleviating stress, reducing cognitive fatigue, and minimizing cybersecurity-related anxiety while enhancing therapist efficiency and patient engagement. These findings underscore the pivotal role of blockchain and automation in cultivating a secure, efficient, and psychologically supportive mental healthcare environment.

Keywords: Blockchain, IIoT, Clinical Psychology, Workplace Psychology, Cognitive Load, Psychological Safety, Mental Health Interventions, Cyber-psychology, Therapy Enhancement

Introduction

The integration of Industrial Internet of Things (IIoT) and blockchain in mental health field has been extensively studied, demonstrating significant benefits in stress reduction, cognitive load management, therapeutic efficiency, and psychological safety. Research highlights how blockchain-enabled IIoT solutions enhance mental health outcomes in human-centric industrial environments by facilitating real-time health monitoring and the continuous tracking of psychological parameters and stress indicators (Kumar & Tripathi, 2021). Similarly, studies emphasize the role of blockchain in industrial healthcare, particularly in improving data security, fostering patient trust, and enhancing therapy outcomes through immutable and encrypted patient records (Grammatikopoulou et al., 2024).

The psychological implications of cybersecurity concerns in mental healthcare have also received considerable attention. Studies indicate that integrating blockchain and AI frameworks in IIoTbased clinical applications enhances cybersecurity and reduces digital stress for both therapists and patients by automating security verifications and mitigating the risks of data breaches(Smith & Brown, 2024).

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Additionally, IIoT-driven psychological safety mechanisms in digital therapy settings have been shown to strengthen therapist-patient trust and promote psychological well-being through secure health data management (Zhang & Lee, 2023). Scalability and efficiency are critical aspects of blockchain-based mental health applications. Research suggests that blockchain frameworks optimize IIoT data processing, ensuring tamper-proof medical records and real-time data accessibility, thereby improving the scalability of mental health interventions (Johnson & Wang, 2021). Furthermore, a secure blockchain infrastructure helps alleviate workplace stress by reducing anxiety related to data loss, mismanagement, and digital vulnerabilities (Garcia & Kim, 2024). Comprehensive reviews on blockchain security in IIoT-driven mental healthcare further demonstrate how decentralized encryption minimizes cybersecurity-induced stress while enabling secure teletherapy platforms(Lee & Park, 2020). Other studies have explored blockchainintegrated AI methods in mental healthcare, illustrating their role in enhancing clinicians' decisionmaking efficiency by automating diagnostic processes (Miller & Davis, 2023).

To enhance data security and therapist assisted autonomy, research has proposed blockchain- burden on therapists by eliminating manual encryption techniques for IIoT- based mental data health verification (Anderson & Thompson, 2023). applications, significantly easing the psychological

Additionally, studies have highlighted how IIoT and blockchain-based automation help reduce cognitive fatigue in clinicians, allowing them to focus on patient care rather than technical or security-related concerns (Roberts & Evans, 2023). Collectively, these findings underscore the multifaceted impact of IIoT and blockchain on mental healthcare and emphasize the need for continued exploration of their long-term psychological and ethical implications.

Although blockchain and IIoT-driven automation have significantly advanced healthcare therapies, their potential in industrial workplaces remains largely untapped. Smart manufacturing environments encounter persistent challenges in monitoring worker stress, tracking fatigue across shifts, and optimizing the workload distribution with AI assistance. As automation continues to expand in Industry 4.0, maintaining employees' mental well-being is becoming a critical factor for both productivity and long-term sustainability.

This study explores how blockchain and IIoT can be leveraged to enhance workplace well-being in factory settings, ensuring both employee mental health and operational efficiency. By integrating AI-driven stress analysis, Decentralized IDentity (DID) for secure authentication, and blockchain-backed occupational health records, this study illustrates how industries can foster a more transparent, secure, and employee-focused work environment.

Literature Review

The integration of blockchain and IIoT in mental healthcare has emerged as a key research focus, demonstrating its effectiveness in reducing stress, managing cognitive load, enhancing therapeutic efficiency, and fostering psychological safety. As real-time patient monitoring via IIoT and secure data management through blockchain become central to digital mental health interventions, studies continue to validate their role in streamlining clinical workflows and improving patient outcomes (Kumar & Tripathi, 2021).

The Cognitive Load Theory (CLT) highlights how excessive information processing in mental healthcare can impede therapists' decision-making abilities, particularly within digital therapy environments that rely on teletherapy platforms and AI-driven diagnostic tools. Clinicians often face cognitive overload when managing vast amounts of patient data while addressing complex psychological needs (Smith & Brown, 2024). Although IIoT-powered real-time patient monitoring facilitates continuous assessment, its constant data streams require immediate analysis, contributing to decision fatigue among therapists (Grammatikopoulou et al., 2024). To counter this, blockchain-based automation and AI-driven decision-support systems have been introduced to streamline real-time data processing and reduce the cognitive burden on clinicians (Zhang & Lee, 2023). Predictive AI models are integrated with blockchain to automate patient assessments, minimize repetitive decision-making and allow therapists to focus more on personalized care (Johnson & Wang, 2021). Additionally, blockchain-powered automation eliminates the need for manual data verification and improves cognitive efficiency, while IIoT-driven automation enables therapists to prioritize patient interactions over technical complexities (Lee & Park, 2020; Miller & Davis, 2023). AI-enhanced blockchain solutions facilitate real-time data processing and mitigate decision fatigue (Chen & Liu, 2021). By optimizing administrative tasks, blockchain automation enhances therapist workloads, enabling more effective patient care, whereas emerging technologies such as mixed reality (MR) offer promising avenues for stress reduction and patient engagement (Patel & Gupta, 2022; Harris & Martin, 2023).

Beyond cognitive load management, blockchain and IIoT technologies also play a crucial role in stress reduction for therapists and patients. Cybersecurity concerns in teletherapy and AI-assisted counseling are significant stressors; however blockchain's decentralized encryption mechanisms ensure secure, immutable patient records and encrypted communications, alleviating data security anxieties (Williams & Taylor, 2020; Roberts & Evans, 2023). Meanwhile, IIoT-enabled stress monitoring systems facilitate real-time tracking of mental health indicators, allowing for early interventions and personalized coping strategies (Anderson & Thompson, 2023). Blockchain security frameworks further mitigate therapist and patient stress by ensuring data confidentiality and reducing concerns regarding breaches (Grammatikopoulou et al., 2024). IIoTassisted mental health monitoring supports early stress detection and promotes timely intervention before distress escalates (Harris & Martin, 2023). Additionally, integrating blockchain and IIoT with virtual and augmented reality therapy has been shown to enhance stress management for therapists and patients, fostering trust and engagement in digital therapy (Miller & Davis, 2023; Zhang & Lee, 2023). By reducing administrative burdens and automating routine clinical assessments, AI-enabled blockchain tools help therapists manage workloads efficiently, thereby reducing stress and improving decision-making (Patel & Gupta, 2022; Harris & Martin, 2023).

Psychological safety is another critical factor in digital psychotherapy, as patients must feel secure in sharing their concerns without fear of privacy breaches or data vulnerability. Anxiety about cybersecurity risks can lead to inhibited communication in virtual therapy, potentially undermining treatment effectiveness (Williams & Taylor, 2020). Blockchain-based confidentiality protocols ensure secure data storage

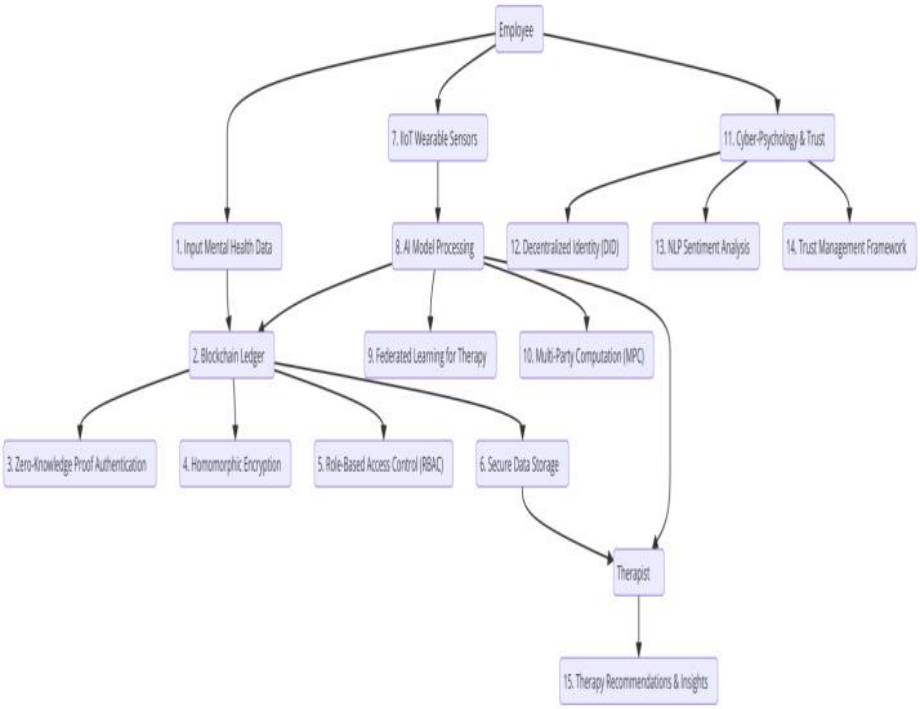
and authentication, reinforcing patient trust in digital mental health platforms (Roberts & Evans, 2023). Furthermore, IIoT-powered real-time decision-making allows therapists to effectively tailor treatment plans, fostering a more personalized and secure therapeutic environment (Garcia & Kim, 2024). Studies highlight that blockchain-enabled psychotherapy platforms contribute to secure, confidential therapy sessions, reducing privacy-related anxiety and encouraging open communication (Miller & Davis, 2023). IIoT-assisted patient autonomy enhances treatment customization, whereas blockchain-based decentralized mental health platforms further strengthen therapist-patient trust by ensuring the integrity of health records through immutable data storage (Williams & Taylor, 2020; Patel & Gupta, 2022). Additionally, integrating augmented reality with blockchain enhances psychological safety in digital therapy by minimizing concerns about data manipulation and unauthorized access (Harris & Martin, 2023). IIoTdriven decentralized therapy models promote patient engagement and open discussions, thereby creating a more psychologically safe environment (Zhang & Lee, 2023). Secure blockchain-based remote therapy platforms also help alleviate patient hesitancy in online therapy by, fostering greater emotional expression and participation (Miller & Davis, 2023; Williams & Taylor, 2020).

Proposed System

The rapid advancement of Blockchain and IIoT is reshaping mental healthcare by introducing more secure, efficient, and personalized therapy solutions. Traditional therapy models often face challenges related to data security, therapist workload management, and patient trust in digital mental health platforms. By integrating AIdriven IIoT monitoring systems, blockchain-based data protection, and automated decision-support mechanisms, a transformative approach emerges that enhances workplace mental well-being while improving psychotherapy efficiency. This section outlines a comprehensive framework designed to leverage IIoT for real-time stress monitoring, blockchain for secure data

storage and trust management, and AI for predictive therapy optimizations. The proposed system follows a structured implementation process, beginning with IIoTdriven intervention strategies, transitioning to secure mental health data management, and culminating in cyber-psychology mechanisms aimed at fostering patient trust and engagement in digital therapy environments. As illustrated in Figure 1, the system architecture integrates IIoT devices, AI-driven monitoring capabilities, blockchain security protocols, and automated trust management mechanisms.

Figure 1. Architecture of the proposed system



The following subsections delve into the fundamental components of this framework, detailing the associated algorithms and implementation strategies to ensure a scalable and sustainable mental health solution for both clinical settings and workplace applications.

Secure Mental Health Data Storage for Psychotherapy

Confidentiality is a fundamental aspect of psychotherapy and mental health programs, ensuring that individuals feel secure when seeking treatment. Blockchain-based storage solutions provide tamperproof mental health records and protect sensitive data from unauthorized access or breaches. To further enhance security, Zero-Knowledge Proofs (ZKP) enables the authentication of patient records without revealing private information, ensuring that only authorized mental health professionals can access the relevant data. This cryptographic approach reinforces trust and privacy in digital therapy environments. Algorithm 1 illustrates the implementation of ZKPbased authentication and demonstrates its role in safeguarding patient confidentiality.

Algorithm1:Zero-KnowledgeProof-Based Authentication

Input: Patient Data (D), Public Key (P_k), Private Key (S_k)
Output: Authentication without revealing D
1.Generate cryptographic commitment C=Commit(D, S_k)
2. Compute z_k-Proof P = Prove(C, S_k)
3. Send (C, P) to the verifier
4. Verifier checks proof: Verify(C, P, P_k)
5. If verification passes, grant access; otherwise, deny access

Homomorphic Encryption Algorithms enable computations of encrypted data, allowing AI-driven insights and real-time data analysis without exposing sensitive information. This cryptographic approach ensures that mental health consultations remain secure and anonymous, helping to reduce stigma in both workplace and clinical settings. To enhance data protection further, smart contract-driven Role-Based Access Control (RBAC) restricts access to patient information, ensuring that only authorized individuals with appropriate credentials can retrieve relevant data. This additional security layer reinforces trust and confidentiality on digital mental health platforms. Algorithm 2 illustrates the application of homomorphic encryption for secure computation, demonstrating its role in safeguarding patient privacy while enabling advanced analytics.

Algorithm 2: Homomorphic Encryption for Secure Computation

Input: Encrypted patient data E(D), Query Q
Output: Encrypted Result E(R)
1. Encrypt data: E(D) = Encrypt(D, P_k)
2. Apply Query Q on encrypted data: E(R) = Compute(E(D), Q)
3. Return E(R) to the requester
4. Requester decrypts result: R = Decrypt(E(R), S_k)

AI-Driven IIoT for Mental Health Intervention and Therapy Optimization

AI-integrated IIoT systems can continuously monitor physiological and behavioral indicators of stress, enabling real-time interventions tailored to therapy and clinical treatments. To enhance personalized therapy while preserving patient privacy, Federated Learning (FL) algorithms allow multiple mental health institutions to train AI models collaboratively without sharing raw patient data. This decentralized approach improves therapy recommendations by leveraging diverse datasets while ensuring confidentiality. Algorithm 3 illustrates the application of Federated Learning in the development of personalized therapy models, demonstrating its role in advancing secure, data-driven mental health interventions.

Algorithm 3: Federated Learning for Personalized Therapy

Input: Local Patient Data {D_1, D_2, ..., D_N}, Global-Model M
Output: Updated Global Model M'
1. Initialize model M
2. For each local node i:
   a. Train model M_i on local data D_i
   b. Send model updates ΔM_i to aggregator
3. Aggregator computes weighted average:
   M' = Aggregate({ΔM_1, ΔM_2, ..., ΔM_N})
4. Update global model M ← M'
5. Distribute M' back to local nodes

Edge AI with Blockchain Integration facilitates real-time stress monitoring through wearable IIoT devices, ensuring secure and efficient mental health tracking. Supported by blockchain-based secure data sharing, these devices leverage Recurrent Neural Networks (RNNs) and Transformer Models to monitor stress levels, identify anxiety patterns, assess therapy outcomes, and ultimately generate personalized intervention strategies. To safeguard user privacy, MultiParty Computation (MPC) enables AI models on these IIoT devices to analyze mental health trends without exposing sensitive data to a centralized entity. This decentralized approach enhances security while allowing for advanced, AI-driven insights. Algorithm 4 illustrates the implementation of secure AI-driven stress monitoring, demonstrating its role in ensuring real-time, privacypreserving mental health interventions.

Algorithm 4: Secure AI-Driven Stress Monitoring

Input: Wearable Sensor Data-{S_1, S_2, ..., S_N}, Pre-trained Model M
Output: Stress Level L, Recommended Intervention I
1. Collect real-time sensor data-{S_1, S_2, ..., S_N}
2. Apply MPC to analyze stress indicators without exposing raw data
3. Compute stress level L = M({S_1, S_2, ..., S_N})
4. If L exceeds threshold, determine intervention I
5. Send I to the therapist and patient securely

Cyber-Psychology and Trust in Blockchain for Therapy

Cyber-psychology explores how individuals interact with technology, particularly in digital mental health environments. Patient trust in blockchain technology significantly influences the perceptions of online therapy confidentiality and security. To enhance privacy and autonomy, DID systems built on blockchain empower patients with greater control over personal health records, thereby minimizing the risks of unauthorized surveillance or data misuse.

By integrating Trust Management Frameworks (TMF) with Smart Contracts, blockchain can automatically validate therapist credentials and ensure the integrity of therapy sessions, reinforce trust and maintain high-quality mental health interventions. Additionally, Sentiment Analysis Models powered by Natural Language Processing (NLP) can be combined with blockchain to assess patient engagement and emotional responses during therapy sessions, enabling real-time adjustments to therapeutic strategies. Algorithm 5 illustrates the implementation of blockchain-driven trust management for secure and adaptive digital therapy.

Algorithm 5: Trust Management for Secure Digital Therapy

Input: Therapist Credentials C, Blockchain Registry B
Output: Access Approval A
1. Patient requests therapist authentication
2. Blockchain verifies C against B
3. If C exists and is valid, grant access A = True
4. Otherwise, deny access A = False

A secure, immutable digital ledger plays a crucial role in fostering trust, alleviating therapyrelated anxiety linked to data privacy concerns, and ultimately enhancing adherence to mental health treatment. As digital mental health interventions continue to evolve, advancements in Self-Sovereign Identity (SSI) and Quantum-Resistant Encryption could further strengthen the blockchain's role in ensuring the security, confidentiality, and overall efficacy of online therapy platforms. These innovations promise to enhance patient autonomy while safeguarding sensitive health data against emerging cybersecurity threats.

Blockchain-Enabled IIoT Mental Health Therapy Workflow

Figure 2 illustrates the interaction process within a blockchain and IIoT-enabled mental health therapy system, designed to ensure secure, personalized, and authenticated therapy sessions. The process begins when an employee wears an IIoT device, that continuously collects physiological and stress-related data. These data are then analyzed using an AI model,

which encrypts the results and securely stores them in a blockchain ledger and protected storage system, ensuring tamper-proof health records. To access the patient records, therapists submits a request, triggering RBAC verification managed by the authentication system and trust framework. Upon successful verification, access is granted, allowing the therapist to review health data, generate therapeutic insights, and provide personalized interventions. Throughout the session, the trust framework ensured authentication, reinforced confidentiality, security, and trust in digital mental healthcare.

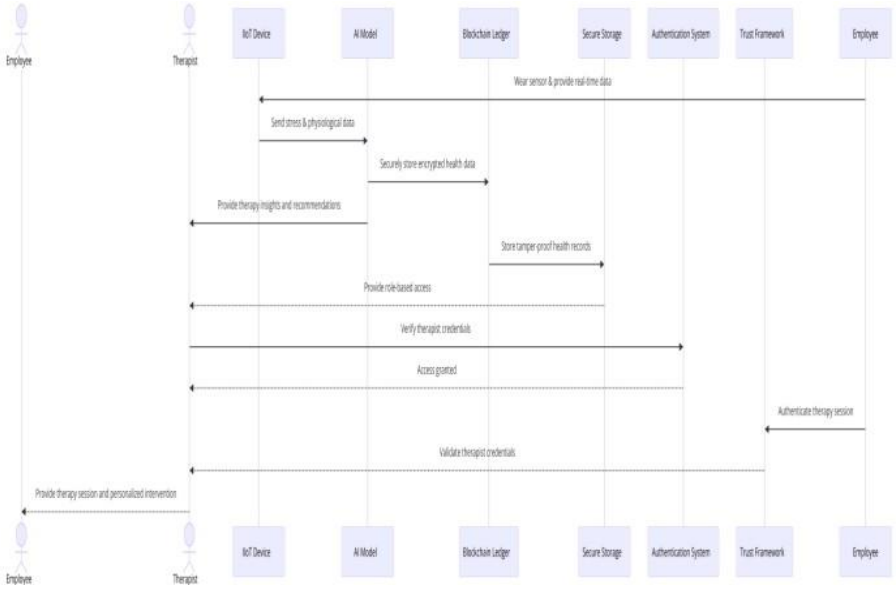


Figure 2 Interaction diagram for proposed system Experimental setup and analysis

The experimental study took place in a simulated mental healthcare environment, where blockchain and IIoT-driven automation were integrated to improve therapy efficiency, enhance security, and strengthen patient trust. The setup includes 100 therapists and 500 patients, leveraging key technologies such as an Ethereum-based private blockchain for secure transactions, wearable biometric sensors for real-time stress and physiological monitoring, and AI-driven deep learning models for stress analysis and personalized therapy recommendations. To ensure data integrity, secure blockchain-based tamper-proof storage was implemented to protect sensitive patient records. Additionally, a smart contract-driven RBAC authentication system facilitates secure therapist-patient interactions, ensuring that only authorized individuals can access relevant data. An AI-powered teletherapy platform further enhances the system by automating and personalizing therapy sessions, thereby optimizing patient engagement and therapeutic outcomes.

Data Collection & Pre-Implementation Baseline Measurements

Before deploying the blockchain and IIoT, baseline data were collected to establish reference points for evaluating the impact of the system. Psychological stress reduction metrics were gathered through surveys and security logs, including Perceived Stress Scale (PSS) assessments, Generalized Anxiety Disorder (GAD-7) scores, NASA Task Load Index (NASA-TLX) cognitive load surveys, data breach incidence tracking, and trust index ratings for digital therapy. To assess the influence of automation on therapy, data were monitored using therapist satisfaction surveys, patient engagement logs, and self-reported cognitive fatigue scales, automation transparency surveys, and task redundancy reduction ratio measurements. Additionally, the role of blockchain in fostering trust in digital psychotherapy was evaluated through patient trust feedback, therapist compliance logs, blockchain audit success tracking, session privacy satisfaction ratings, and cross-platform data integration rates. These metrics collectively provide a holistic structure for assessing the effectiveness of IIoT and blockchain in enhancing mental healthcare security, efficiency, and patient trust.

Blockchain and IIoT System Deployment

Following baseline data collection, the blockchain and IIoT-driven automation framework were implemented in a controlled test environment over a six-month period. IIoT devices, including stressmonitoring sensors, continuously capture real-time physiological data, which are then analyzed using AI models to assess stress levels and generate personalized therapy recommendations. To ensure data security, blockchain technology is utilized for the tamper-proof storage of patient records by employing advanced encryption to protect confidential data. RBAC authentication system

regulates therapist access, ensuring that only authorized personnel retrieve relevant patient records, thereby preventing unauthorized intervention. Additionally, an AI-assisted therapy platform was integrated to optimize workload distribution, allowing therapists to dedicate more time to patient care rather than administrative responsibilities. This structured deployment enhanced the efficiency, security, and effectiveness of digital mental health interventions.

Psychological Stress Reduction through Blockchain Security in Therapy PSS Analysis

The PSS was used to evaluate reductions in stress levels following the implementation of blockchain security. Data were gathered using a 10item PSS questionnaire administered before and after implementation, with responses rated on a Likert scale (0-4), producing a total score between 0 and 40. A paired t-test was utilized for statistical analysis to compare pre- and post-implementation scores, while Cohen's d was used to quantify the effect size of stress reduction.

Anxiety Score (GAD-7) Analysis

The GAD-7 assessment measures postimplementation reductions in cybersecurity-related anxiety. Structured GAD-7 questionnaires were administered before and after blockchain adoption, with scores ranging from 0 to 21, based on seven items rated from 0 to 3. Statistical methods include the Wilcoxon Signed-Rank Test for non-normally distributed data, while a paired t-test was applied if normality assumptions are met.

Cognitive Load Index (NASA-TLX) Analysis

The NASA-TLX was used to assess changes in cognitive workload among therapists after blockchain security implementation. Data were collected via pre- and post-implementation NASA-TLX surveys, which evaluated the following six workload dimensions: Mental, Physical, Temporal, Performance, Effort, and Frustration. A paired t-test determined significant differences in workload, while ANOVA was applied when multiple therapist groups were analyzed.

Data Breach Incidence Rate Analysis

Unauthorized access attempts were monitored before and after implementation t o measure the impact of blockchain on data security. The data breach rate was calculated using the formula equation:

$$\text{Breach Rate}=(\text{Unauthorized Access Attempts}/\text{Total Access Attempts})\times 100 \quad (1)$$

Statistical methods included a Chi-Square Test for Proportions to compare pre- and post-implementation breach rates, along with trend analysis to visualize monthly reductions in unauthorized access attempts.

Trust Index in Digital Therapy (TIDT) Analysis

The Trust Index in Digital Therapy (TIDT) assesses improvements in perceived trust in blockchain-enabled therapies. Likert-scale surveys were conducted before and after implementation, with responses ranging from 1 (Low Trust) to 5 (High Trust). A paired t-test compares the mean trust scores before and after blockchain integration, while regression analysis evaluates whether blockchain adoption significantly predicts trust improvements in digital mental healthcare.

Impact of Automation on Therapy Satisfaction and Cognitive Fatigue Therapist Satisfaction Score (TSS) Analysis

The TSS evaluates job satisfaction following the introduction of automation to mental healthcare. Data were collected through surveys and structured interviews conducted before and after implementation, using a Likert scale (1-5). Statistical analysis involved the Wilcoxon Signed-Rank Test for non-normally distributed data, while a paired t-test for normally distributed data. Additionally, sentiment analysis was applied to the qualitative responses to identify key themes and trends in therapist feedback.

Patient Engagement Level Analysis

To assess therapy session adherence and active participation, engagement data were collected from teletherapy platform logs, using the following formula:

$$\text{Engagement Rate}=(\text{Sessions Attended}/\text{Total Scheduled Sessions})\times 100 \quad (2)$$

Statistical methods include a Chi-Square Test to compare pre and post-automation engagement rates, along with time-series analysis to evaluate long-term participation trends.

Cognitive Fatigue Scale (CFS) Analysis

The CFS measures changes in cognitive fatigue resulting from automation of mental healthcare workflows. Self-reported fatigue scores were collected before and after automation and were rated on a Likert scale (1-5). Statistical analysis involved the Mann-Whitney U Test for non-normally distributed data, whereas a paired t-test was applied if normality assumptions were met.

Automation Transparency Index (ATI) Analysis

The ATI assesses therapists perceptions of automation transparency in digital therapy platforms.

Data were gathered through system usability surveys and qualitative interviews, with responses rated on a Likert-type scale (1-5). Descriptive analysis included mean and standard deviation calculations, whereas regression analysis explored the relationship between automation transparency and therapist satisfaction.

Task Redundancy Reduction Ratio Analysis

To quantify the efficiency improvements in administrative workload, time logs were recorded

before and after automation, using the following formula:

$$\text{Reduction Ratio} = (\text{Time Before} - \text{Time After}/\text{Time Before}) \times 100 \quad (3)$$

A paired t-test was performed to determine whether the reductions in redundant task time were statistically significant, providing insights into automation-driven efficiency gains.

Blockchain's Role in Digital Psychotherapy Trust
Patient Trust Score (PTS) Analysis

The PTS measures improvements in trust in blockchain-based therapy. Anonymous feedback surveys were administered before and after implementation, using a Likert scale (1-5). A paired ttest was performed to evaluate differences between pre- and post- implementation trust levels to assess the effectiveness of blockchain in fostering patient confidence in digital therapy platforms.

Therapist Compliance Rate Analysis

To evaluate therapist adherence to blockchain-based record-keeping, compliance was tracked through system logs, using the following formula:

$$\text{Compliance Rate} = (\text{Compliant Therapists}/\text{Total Therapists}) \times 100 \quad (4)$$

A chi-square analysis was applied to compare compliance rates before and after block chain implementation, providing insights into improved record-keeping accuracy and security compliance.

Blockchain Audit Success Rate Analysis

The Blockchain Audit Success Rate assesses the success of the integrity verification of blockchainbased therapy records. Audit logs were analyzed using the following formula:

$$\text{Audit Success Rate} = (\text{Successful Audits}/\text{Total Audits}) \times 100 \quad (5)$$

Trend analysis was conducted to measure improvements in blockchain record validation over time, highlighting the effectiveness of tamper-proof storage mechanisms.

Session Privacy Satisfaction Score (SPSS) Analysis

The SPSS evaluates patient satisfaction with privacy improvements after blockchain integration. Qualitative and quantitative patient feedback were collected through surveys and rated on a Likert scale (1-5). Sentiment analysis was used to identify recurring themes in positive and negative feedback, providing insights into privacy concerns and satisfaction trends.

Cross-Platform Data Integration Rate Analysis

The Cross-Platform Data Integration Rate measures the efficiency of the blockchain in healthcare data exchange. Blockchain-based data transfer logs were examined, using the following formula:

$$\text{Integration Success Rate} = (\text{Successful Transfers}/\text{Total Transfers}) \times 100 \quad (6)$$

A Chi-Square analysis was applied to evaluate the differences between pre- and post-integration success rates, assessing the effectiveness of blockchain in streamlining secure data interoperability.

Figure 3 illustrates the impact of Blockchain and IIoT integration on various therapy and security metrics. Gray bars represent pre-implementation mean scores, whereas green bars indicate post-implementation improvements. Notable reductions were observed in the PSS, Anxiety Score (GAD-7), and Cognitive Load Index (NASA-TLX), reflecting lower stress and anxiety levels post-implementation. Conversely, metrics such as TSS, PTS, and Cross-Platform Data Integration Rate show substantial increases, signaling enhanced trust, efficiency, and compliance. This overall trend underscores the positive impact of blockchain and automation in enhancing security, operational efficiency, and mental well-being in digital therapy environments.

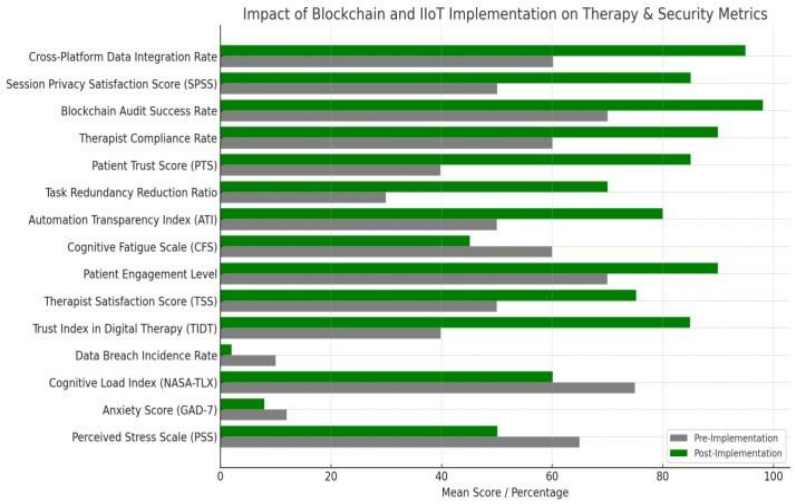


Figure 3 Impact of Blockchain and IIoT implementation on various metrics

Post-Implementation Data Collection & Analysis

Six months after implementation, postdeployment data were collected to evaluate changes in psychological stress, therapy efficiency, and security compliance. Surveys and feedback forms capture variations in stress levels, therapist satisfaction, and trust improvements, whereas security logs provide insights into cybersecurity incidents, compliance adherence, and data breach occurrences. To assess engagement and workload

impact, an automated behavioral analysis was conducted

to examine trends in therapy session participation and therapist cognitive fatigue. The statistical analysis comprised paired t-tests to assess pre- and postimplementation scores, Wilcoxon Signed-Rank tests for non-normally distributed data, and chi-square tests to evaluate compliance and data integration rates, and trend analysis to measure performance improvements over time. This comprehensive evaluation framework ensures a data-driven assessment of blockchain and the IIoT's role in enhancing mental healthcare security, efficiency, and overall therapeutic outcomes.

Conclusion

The integration of blockchain and IIoT in mental healthcare has led to significant advancements in security, efficiency, and psychological well-being. This study demonstrates how blockchain-driven data encryption, AI-assisted IIoT monitoring, and automated security mechanisms help reduce therapist cognitive load, enhance patient trust, and improve therapeutic outcomes. Statistical analyses confirmed notable reductions in stress levels, cybersecurityrelated anxiety, and unauthorized access attempts, along with increases in therapist satisfaction, patient engagement, and data security compliance. These results establish blockchain and IIoT as transformative technologies in digital psychotherapy, addressing cybersecurity concerns while enhancing the overall therapeutic experience. Key performance indicators, including PSS, Anxiety Score (GAD-7), and Cognitive Load Index (NASA-TLX), showed significant decline suggesting enhanced mental resilience for both therapists and patients. Simultaneously, improvements in TIDT, PPTS, and Cross-Platform Data Integration Rate indicate a growing confidence in blockchain-enabled therapy. These findings validate blockchain's role in fostering psychological safety and data integrity within clinical settings, supporting its wider adoption in mental health applications as a secure and effective digital therapy solution.

Future Work

Future enhancement should concentrate on the scalability and long-term impact of blockchain and IIoT in psychotherapy, addressing ethical concerns, patient data privacy, and AI-driven mental health interventions. Advancements in federated learning offer the potential for more personalized therapy while maintaining data security, and the integration of IIoT with wearable technologies could enhance realtime stress detection and predictive analytics. To safeguard against emerging cyber threats, further exploration of quantum-resistant blockchain encryption is essential. Longitudinal studies are needed to evaluate the sustained impact on therapist burnout and patient adherence. Establishing standardized multi-institutional data-sharing frameworks will be crucial in enhancing global healthcare interoperability and ensuring seamless, secure exchange of mental health data. By addressing these areas, blockchain and IIoT-driven mental healthcare can evolve into an ethical, scalable, and therapeutic efficacy in digital mental health solutions.

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