

The Influence of IoT on Employee Engagement in Healthcare: A Comprehensive Review

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ABSTRACT

In recent years, the Internet of Things (IoT) has changed the healthcare industry by improving operational efficiency and optimizing labour management. Employee participation is an important factor that affects healthcare operations. This is because engaged staff are more productive, satisfied, and devoted to their role. This article analyses various IoT applications such as intellectual plans and HR analysis, which considers into account the effects of IoT on the participation of medical personnel. This study considers whether IoT improves emotional, cognitive, and physical participation, reduces work duration, provides real-time feedback, and improves decision-making and mainly emphasizes how the Job Demand-Resources model (JD-R) is integrated with IoT to maintain the balance of the requirements for work and resources to manage the exhaustion and improve the welfare of the employee. Topic research on major healthcare industries showed the successful implementation of IoT, which increases employee satisfaction and efficiency. However, IoT offers significant opportunities, but fear of employee data confidentiality, security, and observation remains a major problem. This article also recommends a strategic approach to hospital managers and IoT integration by contributing to a transparent, supportive, and effective culture at work. Furthermore, the study also suggests that future research should focus on the long-term impact of the IoT, the ethical consideration of data management, and the analysis controlled by artificial intelligence in the personalized employee strategy. By effectively using IoT, medical organizations can create an innovative and adaptive work environment that increases the satisfaction of employees.

Keywords: Internet of Things (IoT), Healthcare, Employee Engagement and IoT, Smart Hospitals and Digital Transformation, Wearable Technology for Employee Well-being, Job Demands-Resources (JD-R) Model, Artificial Intelligence in Workforce Management

INTRODUCTION:

The healthcare sector encounters numerous obstacles, such as in terms of employee management and maintaining their engagement. When employees actively participate in decision-making processes, workplace efficiency is enhanced and significantly improved. Unfortunately, numerous healthcare organizations face challenges in engaging employees in meaningful activities because of strict management structures and a lack of trust. According to a study conducted by O'Donoghue et al. [1], employee engagement is only achieved when management recognizes the clear advantages it brings. Even in organizations with robust unions and job security, participation in the program was restricted. Hierarchical structures and inadequate communication were significant obstacles to employee participation [1]. One significant concern is work-related stress, which has a direct impact on employee engagement. In a real-time scenario, when employees feel appreciated and valued, they are more inclined to remain with the company. Healthcare institutions must prioritize strategies that enhance employee motivation and engagement [2].

Furthermore, employee engagement is a foundation of system-level effectiveness in healthcare since it has direct impacts on organizational performance, workflow operations, and the implementation of innovations such as the Internet of Things (IoT). Engaged employees will likely accept IoT-enabled solutions, including real-time workforce performance monitoring and optimization tools and automated workflow systems, which maximize processes and

minimize inefficiencies. The key factors that measure the success of the system are levels of engagement, nonappearance, and retention. Nurses who are highly engaged have greater retention rates and lower turnover intentions which are vital for ensuring continuity in patient care and lowering recruitment expenses [3]. The study conducted by Collini et al. [4] shows that a 25% rise in nurse engagement leads to a 4-20% increase in the quality of care as engaged employees follow safety guidelines and also utilize IoT-based solutions to reduce faults. Frequent staff turnover raises expenses and disrupts the continuity of care which results in patient dissatisfaction and potential safety hazards. It is observed that 90% of highly engaged employees stay with their organizations, retaining skilled staff and reducing recruitment and training expenses [5]. Engagement also aids in decreasing turnover which is a major issue in the healthcare industry. Engaged workforces within organizations experience 40% fewer safety incidents, highlighting the contribution of engagement to a culture of safety and operational excellence. IoT enables insights into staff and performance via data-driven facts so that healthcare systems can align engagement approaches efficiently. IoT-supported analytics can provide insights into disengagement patterns or absenteeism, allowing healthcare systems to address these patterns via targeted interventions [6].

Employee engagement has a big impact on how well IoT is adopted in healthcare settings. It increases the likelihood that they will embrace digital transformation and take the initiative to incorporate IoT solutions into their regular work. The adoption of IoT improves communication, automates repetitive tasks, and permits real-time decision-making, all of which increase workplace efficiency [7]. Company objectives and their perception of the advantages of these technologies, however, have a significant impact on their readiness to embrace IoT-driven solutions. When introducing new IoT systems, companies with a strong engagement culture typically have easier transitions because their staff members are more open to innovation and change [8].

IoT solutions create a data-driven and networked workplace, and this influences employee engagement to a great extent. Access to real-time data enhances decision-making, and IoT wearable sensors support enhanced monitoring of worker performance. Automation powered by IoT also minimizes labor, where employees can now concentrate on higher-level and critical work. Organizations that use IoT to engage workers tend to show enhanced employee retention, productivity, and job satisfaction. By developing a seamless and optimized working setup, intelligent workplace solutions like AI-driven scheduling and sensor-driven offices enhance employee engagement even further [9].

The healthcare sector has challenges with managing employees. Strict hierarchies and poor communication make it hard to engage workers. When employees are engaged, they work more efficiently and are more open to using new technologies, such as IoT systems. These systems improve employee efficiency by making it easier to work and automate repetitive tasks which make it easier for staff to concentrate on patient care and boost job satisfaction and performance. Higher engagement leads to lower turnover, better retention of staff, and improved safety compliance. This helps reduce costs and ensures that care remains consistent. Engaged staff are also more willing to embrace digital changes, using IoT for real-time decision-making and task automation. This increases productivity and job satisfaction. Environments that use IoT allow employees to monitor performance and focus on crucial tasks. AI and sensor solutions can further improve engagement. Thus, prioritizing employee engagement is vital for healthcare institutions to use technology effectively and enhance patient outcomes.

The structure of this paper is as follows: Section 2 describes employee engagement in healthcare using the JD-R model. Section 3 provides key IoT technologies that are relevant to employee-centric applications. Section 4 discovers IoT-driven tools and methods that enhance engagement. Further, section 5 examines the correlation between IoT and various engagement dimensions. Section 6 tells the study methodology and is followed by adoption trends in Section 7. Sections 8 and 9 present theoretical and practical implications. Lastly, Section 10 concludes with key insights and future directions.

EMPLOYEE ENGAGEMENT AND THE JD-R MODEL:

Employee commitment has become a critical aspect of modern organizational success that affects workplace productivity, employee loyalty, and general satisfaction. Organizations in all industries are increasingly focused on promoting a dedicated workforce to promote innovation and maintain a competitive advantage. Understanding

factors that contribute to commitment allows employers to create an environment that improves motivation, reduces burnout, and promotes the general wells of employees. It is a state of mind that brings joy, satisfaction, and productivity to your work, and it is characterized by enthusiasm, commitment, and focus. Employees who are committed to showing high levels of energy, mental resistance, and a strong passion for what they are doing. They are open to additional responsibility and are proactive in the success of the organization. According to S. L. Albrecht, C. R. Green, and A. Marty[10], commitment occurs when employees devote their mental, emotional, and physical energy to their roles, leading to increased performance and job satisfaction. Companies with highly committed employees tend to achieve higher productivity levels, lower sales rates, and promote more innovative ideas. Bakker et al. [11]divided work characteristics into two main categories: work requirements and work resources. Work requirements are related to the physical, emotional, or cognitive effort required to fulfill a task, but work is a tool, support, and opportunity that helps employees manage their workloads. Through automated processes and real-time data collection, the Internet of Things reduces cognitive and physical stress among employees. For example, an automated planning system with IoT sensors running can optimize workforce allocation by pursuing employee availability and operational requirements. Similarly, portable wellness devices provide real-time knowledge to monitor employee health metrics, reduce stress, and prevent burnout. Intelligent badges equipped with sensors can facilitate seamless communication, recognize employee services, and promote cooperation. The company also uses the feedback tool managed by artificial intelligence to analyze the behavior of the employees and provide effective management information. These systems contribute to more advanced labor by allowing real-time recognition at work and allowing timely solutions to the problem at work. This automation not only reduces business requirements but also creates opportunities for technology development. Employees who can access the knowledge controlled by data can make public decisions and improve autonomy and opportunities. This aggressive approach reduces burnout, increases productivity, and increases general satisfaction with work. Ultimately, a company that determines the priority of technology innovation and the wells of employees is the best place to motivate and maintain powerful labor. According to the JD-R model, if the work requirements are surprising, it can lead to stress and exhaustion. However, working resources are important for the motivation of employees and for strengthening their participation. The model is based on two psychological processes: the health impairment process, where high job demands result in exhaustion, and the motivational process, where job resources promote employee engagement and job satisfaction.

Fig 1 demonstrates the relationship between job demands, job resources, stress, and outcomes based on the JD-R model. It depicts how job demands can either lead to strain and negative outcomes or can be balanced by the job resources to promote positive outcomes. By effectively managing demands and resources, organizations can establish a work environment that fosters employee engagement and productivity organizations.

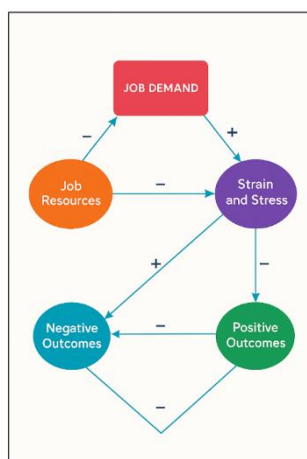


Fig 1. Job Demands-Resources (JD-R) model, showing the impact of job demand on stress, job resources, and employee outcomes [12]

Job demands are job tasks and workloads that require continuous effort and may be stressful if poorly handled. Some of these issues include being overloaded with work, having stringent deadlines, coping with emotional labor, and not being sure of job security. Whilst some aspects of job demand, including complicated work, can be motivating, excessive workload without adequate assistance can cause burnout and decreased performance [13].

Job resources are elements of a job that assist workers in managing demands and attaining work objectives. These include the support of colleagues and supervisors, chances for career advancement, the ability to make independent decisions, and well-defined job responsibilities. Working resources are the work elements that help employees manage their requirements and achieve their work goals. This includes the support of colleagues and managers, the possibility of experience growth, the ability to make independent decisions, and clearly defined duties. Working resources act as a protective element of stress, satisfying basic psychological demands. Employees who can access resources are more likely to work, perform well in work, and present creative ideas [10]. The JD-R model is particularly applied to a medical environment where employees face high business requirements, but can access the most important resources. These requirements for these tasks can reduce stress, exhaustion, and work satisfaction if they are not properly controlled. Nevertheless, resources such as teamwork, social support, education, and autonomy can greatly improve employees in the health industry. For example, if a nurse receives appropriate support from a colleague and an administrator, it can effectively handle work and guarantee exclusive patient treatment. Similarly, medical institutions that determine priority in the current education system enable employees to strengthen their abilities to increase their trust and needs. In addition, medical institutions that create a rotation program that takes into account shift work and mental health support programs can promote negative results of excessive work requirements. In addition to maintaining a peaceful balance between business requirements and available resources, medical institutions can increase their staff, prevent exhaustion, and guarantee high-quality patients. When a medical institution implements the JD-R model then employees create an organizational environment that gives motivation and dedication to provide quality medical services. In the upcoming section, we will cover IoT technologies and Zigbee applications and the role of cloud computing in healthcare HR management. Then we will see use cases for Near-Field Communication (NFC), implementation of Grafana for data visualization, and the impact of AI-driven analytics in HR management. Fig 2 demonstrates an integrated framework based on the Digital JD-R model which shows how demands and resources influence employee behavior, engagement levels, and outcomes in healthcare.

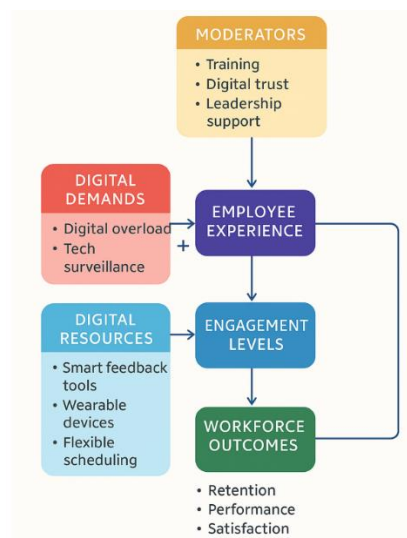


Fig 2. Integrated Framework of the IoT-Driven Digital JD-R Model for Healthcare Workforce Engagement.

IOT TECHNOLOGIES OVERVIEW:

In this section, we will discuss Zigbee technology and its applications, the importance of cloud computing in overseeing healthcare human resources, instances of near-field communication (NFC) applications, leveraging

Grafana for data visualization and monitoring, and the influence of AI-driven analytics in managing human resources.

ZigBee technology functions work based on IEEE 802.15.4 standard and is a wireless communication protocol that is known for its minimal power consumption. It is particularly suited for Internet of Things (IoT) applications, which include smart homes, industrial environments, and healthcare settings. One of ZigBee's main benefits is its ability to form a collection of mesh networks that supports a maximum of 65,000 devices within a range of around 100 meters, all while ensuring low energy usage and cost-effectiveness, along with robust security features [14]. In the healthcare sector, ZigBee plays a crucial role in enabling efficient monitoring and real-time communication between medical devices. Through ZigBee-enabled badges and sensors, healthcare professionals can also track staff movement and optimize workplace layout for enhanced collaboration and safety and optimize the overall procedures, resulting in timely alerts that not only improve patient care but also enhance working conditions and efficiency of healthcare professionals. Additionally, its scalability makes it easy to expand networks, making ZigBee a great choice for environments with limited resources [15].

The employment of cloud technology is transforming HR management in the healthcare sector by streamlining processes such as recruitment, payroll, performance evaluation, and overall employee engagement. Vital information is conveniently available to HR specialists promptly, and traditional computer system and application costs are significantly reduced while still observing data privacy requirements relevant to the healthcare industry. Such systems enable remote access which grants HR managers the ability to monitor employees across different regions, thereby promoting intra-employee collaboration and interaction. To appreciate the hesitation of HR managers regarding the use of cloud technologies, a qualitative Delphi approach was utilized. This method collects experts' insights using several surveys until a consensus is achieved. This was done with the intent to explore what is preventing the implementation of the technologies, the key determinants of adoption, and the impacts of cloud computing on HR effectiveness and organizational performance. By using the Delphi technique, we capture important insights from HR and business practitioners that will help in formulating algorithms for developing commonsense policies for the use of clouds in healthcare HR systems [16]. The incorporation of cloud services within the healthcare sector greatly affects HR management by increasing operational effectiveness, scalability, and security protocols. Furthermore, these systems simplify the processes of recruitment, payroll, employee training, and performance assessment. This technology enables instant access to important information and the completion of work tasks outside of traditional office settings. When combined with basic AI analytics, it helps improve decision-making processes, reduce costs associated with infrastructure systems, and adhere to compliance regulations set forth for the industry. As stated above, cloud computing aids the healthcare industry by optimizing operational HR functions while increasing employee engagement and productivity. A study was done to see how cloud computing affects productivity in human resources. It used questionnaires completed by 55 participants. The answers were analyzed with the SPSS program to identify trends, challenges, and benefits of using cloud technology in managing the workforce [17].

Near-field communication (NFC) technology is changing the healthcare industry by offering secure and efficient solutions to many problems. It helps automate tasks like controlling access to facilities, tracking medical devices, issuing patient IDs, and making contactless payments for services. NFC enables devices to transfer data over short distances, thus enhancing workflows and minimizing errors in clinical settings. Health professionals can use their devices to access the information by simply tapping it [18]. Furthermore, NFC technology enables the real-time updating and accuracy of information crucial for inventory management as well as monitoring medical supplies. Having analyzed the basic principles of NFC, we now turn to its methods of communication—peer-to-peer, reading/writing, card emulation—and its relationship with RFID technology. This study looks at how effective, safe, and easy to use NFC technology is in healthcare. It highlights NFC's versatility, especially for quick authentication and data sharing without needing complex systems. Other important uses of NFC in healthcare include patient identification, medication tracking, hospital access control, and real-time patient data management. For example, wristbands embedded with NFC can store critical medical information that providers can access with a simple tap of a tuned medical NFC device. NFC also enhances the security of medical facilities by regulating access to authorized medical personnel and restricting unsolicited entry. To analyze lightweight medical equipment and their control, a

systematic literature review (SLR) was performed that incorporated various academic materials from IEEE, ScienceDirect, and Web of Knowledge. This research intends to investigate the existing gaps, benefits, and potential for future exploration [19].

Real-time monitoring Grafana has rapid application possibilities across clinical domains. It enables hospitals to monitor health metrics, patient data, and even infrastructure performance vis-a-vis interactive dashboards. Integration with multiple data sources such as IoT devices and Electronic Health Records (EHRs) allows providers to draw insights into Grafana and improves early problem detection, thus increasing the overall patient outcomes [20]. This work studies the integration of Grafana with Jenkins and Prometheus for real-time monitoring in software systems. It provided an iterative approach that includes requirements analysis, tool selection, design of the dashboard, and host in the cloud Azure decision-making at the Ivorian University and performance improvement for the healthcare system. Besides, a Virtual Unix-based server was created with Prometheus for healthcare network switch's virtual machines data collection and real-time dashboards with Grafana for data presentation [21].

This aids in encouraging proactive monitoring and operational effectiveness in the healthcare domain. AI-powered predictive models transform the management of human resources in healthcare for organizations, allowing anticipating shifts in recruitment, retention, workforce planning, and increasing employee engagement. Applying machine learning algorithms allows HR departments to predict employee attrition, detect high-potential employees, and assess internal organizational skill gaps from current and historical data. This paradigm shift allows HR specialists to develop training and development programs along with comprehensive career progression strategies, improving outcomes. AI chatbots and virtual assistants help HR by automating repetitive tasks and offering personal career advice. In healthcare, these tools use data analysis and machine learning to spot staffing shortages and make better use of resources. They help identify patterns in behavior, streamline recruitment, and connect HR functions with company goals, which improves employee performance. The use of artificial intelligence in the HR domain is revolutionizing traditional approaches. With the adoption of predictive analytics, machine learning, and automation, these organizations enhance significant activities, including talent acquisition, performance evaluation, and human resource management. AI provides valuable insights that assist businesses in recognizing top talent, predicting employee attrition, and formulating focused strategies to boost engagement. This ultimately enhances job satisfaction and employee retention. Furthermore, AI chatbots and virtual assistants effectively manage daily administrative tasks, enabling HR professionals to focus on strategic initiatives that lead to significant improvements. A comprehensive research methodology that incorporates literature reviews, case studies, expert interviews, and surveys examines the influence of AI on HR practices within the healthcare sector. This study reveals both the advantages and the difficulties associated with AI integration, encompassing ethical issues and the necessity for workforce upskilling. The primary goal is to promote a careful and effective adoption of AI in healthcare HR management [22]. Table 1 presents benchmarking.

Table 1: Benchmarking on Existing Studies

Ref.	Objective	Key Findings	Limitations	Unique Contribution
Siddiqui et al [20]	Explore integration strategies for Jenkins & Grafana in software monitoring.	Jenkins and Grafana improve software performance monitoring, real-time visualization, and CI/CD pipelines.	Limited to Jenkins & Grafana; lacks empirical validation with large-scale implementations.	Provides practical implementation guidelines for DevOps teams
Leppänen [21]	Implement a visual monitoring system using	Prometheus offers flexible data collection, Grafana enhances visualization but lacks built-in alerts	Encryption and alert mechanisms need further implementation	Provides a practical example of Grafana & Prometheus in real-world network environments

	Prometheus and Grafana			
Bhosale et al. [22]	Investigate AI's role in transforming HR functions	AI automates talent acquisition, performance tracking, and workforce planning	Ethical transparency concerns, challenges in AI adoption	Discusses strategic benefits of AI in HR beyond recruitment
AL-OFEISH AT et al. [18]	Overview of NFC technology and applications	NFC facilitates wireless transactions and authentication, but security is a concern	Prone to relay attacks, limited real-world testing	Explores how NFC can integrate into modern wireless systems
Coskun et al. [19]	Conduct a comprehensive survey on NFC technology, security, and applications.	NFC plays a crucial role in IoT, smart payments, and short-range communication	Privacy risks, lack of extensive industry-wide adoption	Highlights NFC's role in emerging smart environments

IOT APPLICATIONS FOR EMPLOYEE ENGAGEMENT:

This section examines IoT applications that enhance employee engagement, based on literature from the past decade. Key examples include wearable devices for monitoring wellness, smart scheduling systems, IoT platforms for training and development, and real-time feedback systems that improve communication and engagement.

A review of the literature (past 10 years) via IoT applications to improve employee commitment. The involvement of Internet of Things Applications (IoT) in jobs has significantly improved employee commitment by creating a data-controlled, responsive, efficient work environment. Companies use IoT-enabled HR analytics, intelligent office environments, and portable devices to track employee health, efficiency, and work patterns. As an example, Siemens integrates intelligent smart office technology that uses IoT sensors to pursue employee movements, adjusting lighting and temperature according to real-time occupancy, providing valuable insight into work area occupancy. As a result of this change, workplace employees have experienced improved comfort, and increased productivity levels, leading to reduced energy consumption. Additionally, AI-driven HR chatbots allow you to receive immediate support, and personalized training suggestions and efficiently issue HR-related concerns. Using predictive analytics, businesses can predict burnout, and resolve employees, and HR teams can take proactive measures such as improving personalized training programs, flexible work plans, and collaboration tools [27]. In addition to traditional office environments, IoT changes the way people fall into distant, hybrid employment arrangements. Illustrations and Microsoft IoT-based collaboration tools are implemented to monitor virtual meeting commitments, pursue participation levels, analyze employee interactions, and increase productivity in remote work. According to a global survey by Cisco, integration into IoT technology and remote surveillance systems will increase flexibility and communication between employees, and increase and balance of commitment between work and life. Despite these benefits, IoT control commitment strategies raise privacy and ethical concerns, as constant surveillance causes a sense of surveillance. To mitigate this, organizations should implement transparent data guidelines and ensure that with employee consent, IoT applications are more likely to focus on improving happiness and productivity than intrusive persecution. The future of employee engagement will likely be shaped by AI-controlled IoT systems that provide personalized work experience, real-time feedback mechanisms, and seamless integration of physical and virtual work areas [28]. The IoT has transformed various aspects of workplace operations, enhancing efficiency, protection, and worker engagement. IoT programs may be categorized into numerous regions, along with wearable devices for employee health, clever scheduling structures, IoT-based total education structures, and actual-time remarks systems. These improvements permit organizations to improve team of workers' productiveness, optimize resource allocation, and create safer painting environments. As an example, the well-known electric-powered (GE) makes use of IoT sensors in manufacturing vegetation to screen device performance and predict protection desires, reducing downtime. In addition, Tesla employs IoT-primarily based automation systems to enhance assembly line

performance. In retail, Amazon's Simply Stroll Out era makes use of IoT to track consumer purchases without checkout traces, enhancing each worker's mission performance and purchaser experience. As IoT continues to evolve, agencies across industries are leveraging this technology to pressure operational excellence and personnel pride.

1. Change wellness wearables for internet-connected staff members.

Companies such as BP and Google use devices such as Fitbit and Apple Watch to monitor employee health metrics, including heart rate, stress level, and activity level. These devices provide real data that helps HR departments support the right presence of employees and reduce absenteeism. For example, BP implements a fitness program that will allow employees to reduce their health insurance premiums and reward them when employees meet fitness goals. Such real-time health monitoring solutions ensure safer work, promote physical activity and contribute to employee long-term satisfaction. Fig 3 shows an advanced wearable device that demonstrates the health monitoring technology companies like BP and Google are using to track and enhance employee wellness.



Fig 3. Smartwatch showing health metrics of the employee [29].

2. Smart scheduling systems.

An extended planning system operated by IoT and AI optimizes human resource management by automating shift tasks and adjusting working hours using actual data. These systems take into consideration employee availability, workloads, and business to create competition-free schedules, minimize fatigue, and increase productivity [30]. Similarly, hospitals use intelligent planning for nurse and physician shifts to ensure fair distribution of workload that enhances work-life balance. Integration of notifications and calendars reduces planning errors helping the professionals to manage schedules effectively hence maintaining a balance between both professional and personal lives [31].

3. IoT-based training and development platforms.

IoT applications revolutionize training programs with the help of virtual reality (VR) and augmented reality (AR). These immersive platforms provide a practical learning experience, especially in industries with high-risk environments. Walmart also uses Oculus VR headsets for Black Friday sales, revealing employees simulating high-pressure scenarios. These platforms pursue learning advancements, provide real feedback, personalize training content, and lead to increased knowledge and productivity knowledge [32].

Fig 4 shows the application of Virtual Reality (VR) technology in medical education, where a doctor uses a VR headset to engage with a 3D anatomical model. This virtual method enriches medical training by enabling hands-on learning without using physical cadavers and real patients [25].



Fig 4. Doctors using VR in medical analysis [33].

The VR-based system helps doctors to better analyze complex human anatomy. Similar to Walmart's Black Friday VR training that makes employees ready for high-stress situations, VR-based medical training provides a secure and controlled environment for doctors and medical students to practice surgeries and diagnoses before treating actual patients. The system improves learning by monitoring performance, providing instant feedback, and adapting training modules according to individual requirements, thus enhancing knowledge retention, procedural precision, and overall efficiency in the medical profession [24].

4. Real-time employee feedback systems.

Real-time feedback systems allow companies to measure and resolve employee moods immediately. Cisco's intelligent kiosks and mobile applications allow employees to give immediate feedback on workplace situations and management performance. Similarly, Accenture uses AI-driven mood analysis to assess morality and improve HR policy. As a result, businesses experience improved employee satisfaction, retention rates, and a more committed workforce [34]. The following table 2 presents various IoT applications and their corresponding impact on different dimensions of employee engagement such as physical, cognitive, and emotional along with associated benefits and relevant technologies used in healthcare settings.

Table 2. Mapping of IoT Applications to Engagement Dimensions, Outcomes, and Enabling Technologies in the Context of Healthcare Workforce

IoT Application	Engagement Dimension	Outcome/Benefit	Relevant Technology
Wearable Health Devices	Physical	Reduced fatigue, improved well-being	Smartwatches, biometric bands
VR/AR Training Modules	Cognitive	Enhanced learning, reduced errors, motivation	Virtual simulations, AR overlays
Real-Time Feedback Tools	Emotional	Improved morale, real-time recognition	AI dashboards, sentiment analysis
Smart Scheduling Systems	Physical & Cognitive	Balanced workload, burnout prevention	AI-based rosters, IoT-linked calendars
Predictive HR Analytics	All Three	Personalization, proactive support, retention	IoT + AI models

CORRELATION BETWEEN IOT AND EMPLOYEE ENGAGEMENT:

IoT has a significant contribution to make towards emotional engagement by promoting smooth communication, increasing workplace morale, and aiding mental health. IoT-enabled communication platforms enhance collaboration, increasing team efficiency and productivity. Intelligent meeting rooms and live performance monitoring improve workplace engagement, with IoT implementation resulting in enhanced job completion and project timeliness [23]. An interconnected feedback system in healthcare also encourages motivation and behavioral adjustment by rewarding and allowing anonymous patient ratings, enhancing staff morale and patient satisfaction. IoT-based monitoring of mental health also enables healthcare workers to monitor emotional well-being, sensing early burnout and fatigue. Yet, privacy and data protection remain essential in ensuring trust in these technologies. Decision-making supported by AI streamlines the processing of intricate data, decreasing stress and boosting productivity. Healthcare IoT has transformed remote patient monitoring by allowing real-time insights, predictive analytics, and cloud-based sharing of data, resulting in improved patient outcomes [24]. Artificial intelligence developments, especially in natural language processing and image recognition, continue to greatly enhance diagnostic procedures as well as tailoring treatments. These advances in technology are central in the health sector in allowing an easy exchange of knowledge, which is essential for triggering innovation and improving the quality of service provision. Montenegro's healthcare system exemplifies the way digital resources are impacting efficiency. In the current rapid world, stress has a considerable effect on both physical and mental well-being, highlighting the need for IoT technologies to monitor stress in real-time as a useful tool in health outcome management [35]. Technologies like Biometric stress sensors use wearable technology to track healthcare professional's physiological information in real-time. This is done by monitoring heart rate variability, skin temperature, or even cortisol. The data received gives the levels of staff stress, and appropriate interventions are taken to prevent burnout and fatigue. Ongoing monitoring keeps high-quality care at maximum levels by protecting the health and well-being of care workers. It also facilitates a more positive work environment by allowing for tailored stress management solutions, which are imperative in stressful environments such as hospitals [36].

IoT-based platforms that use AI and automatic learning to deliver customized training modules, track employees' progress, and provide automated comments have likewise changed training and development. These technologies reduce the workload of trainers while assisting employees in upskilling more effectively. Gamification and interactive learning resources increase participation, which enhances the efficacy and enjoyment of training [37]. It involves incorporating game-like aspects into the workplace to make everyday tasks more interesting and interactive. Dashboards may show real-time data about user and team performances, bring in challenges, and create benchmarks that encourage employees to reach certain goals. This technique enhances job satisfaction, leads to a healthy working environment, and boosts productivity. Gamified systems also allow training and professional development by offering an engaging learning process that compensates users for new skills or knowledge acquisition [38].

Models like the healthcare digital twin are efficient in optimizing the workforce by providing a virtual copy of the healthcare ecosystem that includes all interfaces, equipment, and processes. In this model, the administrators can test different scenarios and implement the changes without involving real services or compromising patient safety. The workflow also gets streamlined for the medical professionals as situations like emergency response or patient flow through departments are optimized which makes daily operations more efficient and less stressful. This also aids in determining where resources can be allocated more effectively hence improving resource management so that staff are not overwhelmed and have what they need when they need it. It also provides a secure environment for workers where they can practice new procedures and equipment which improves skills and confidence without the pressures of real time. This technology forecasts outcomes and simulates responses which enables facilities to correct potential problems before they impact the workplace hence facilitating Anticipatory problem-solving. In the end, all these enhancements contribute to higher job satisfaction and fewer turnovers, since employees can concentrate more on patient care within a properly managed and positive environment [39].

Evaluating workplace satisfaction, monitoring employee well-being, and improving work-life balance through stress management and intelligent scheduling have a beneficial impact on retention rates. Organizations that address the causes of employee unhappiness and turnover by utilizing IoT-enabled predictive analytics have an engaged workforce. IoT is essential to contemporary workplaces because it promotes better decision-making, greater

transparency, more training, and more effective employee retention tactics. These technological advancements facilitate work happiness, increased productivity, and organizational success [40].

Case studies from healthcare settings.

The Peninsula Regional Medical Center (PRMC) in Maryland serves as a leading example of how IoT-driven innovations can enhance employee engagement by optimizing resource productivity and improving worker efficiency in an intelligent hospital setting. PRMC tracks biomedical equipment, patient flow, and environmental conditions through real-time location systems (RTLS) and RFID tags, allowing for predictive resolution of problems and efficient use of resources. IoT integration erases manual documentation, provides assurance of storage conditions for vaccines and medicines, and increases operational efficiency with decreased administrative workloads. The hospital realized \$250,000 in savings during its initial year of IoT use and recovered 1,700 staff hours a year through enhanced monitoring. Actionable insights are offered by data visualization tools, promoting transparency to staff and patients. Through the inclusion of IoT, PRMC optimizes workforce management, operational efficiency, and staff engagement, showcasing the potential for change that smart hospital systems can bring [41].

The study done to see the convergence of e-HRM (electronic Human Resource Management) tools and worker engagement in the healthcare industry centers on different e-innovations such as e-interaction platforms and data analytics, gauging their efficiency in motivating and involving employees. One of the most important statistical results from the study is a moderately strong positive relationship between the adoption of digital platforms and big data analytics, with a correlation coefficient of 0.609, which indicates that these technologies when well combined, can improve organizational performance and staff engagement. Yet the links with direct employee engagement are quite tenuous with correlations of 0.161 for digital interaction platforms and 0.169 for big data analytics, reflecting limited direct influence on engagement. In addition, chi-squared tests indicate a strong dependency relationship between digital interaction platforms and big data analytics with a value of 567.06, reflecting a strong connection between the usage of these tools. However, the immediate influence on employee engagement is weaker statistically, with values of 58.82 and 53.37 for digital platform engagement and big data analysis, respectively. These results attest to the nuanced nature of the influence of digital tools on employee engagement, positing that whereas digital HRM practices may revolutionize parts of employee interaction and performance management, their effectiveness in directly enhancing engagement is limited by larger organizational factors. To reap the optimum benefits of digital HRM systems, a systems approach involving encouraging managerial and organizational practices is essential [42].

IOT ADOPTION TRENDS:

With the developments in data analytics, cloud computing, and smart devices the use of the Internet of Things (IoT) is increasing at a rapid pace in the healthcare industry. IoT integration is being used by hospitals and other healthcare institutions to boost staff productivity, expedite processes, and improve patient care. IoT is changing how medical professionals use technology, from smart hospital management systems to wearable health monitors. Assessing the effect of IoT on employee engagement in the healthcare industry requires an understanding of these adoption trends [53].

Fig 5 demonstrates the growth of the Internet of Medical Things (IoMT) which is primarily due to the growing introduction of technologies based on sensors, wearable or autonomous devices for monitoring patients, and asset management. In addition, a change in the lifestyle of consumers and a growing concern for health and related to them will probably increase the adoption of the Internet of medical things in the coming years. However, the high costs associated with internet devices such as installation software, hardware maintenance, and networking are the main barriers to growth in this market. Also, there is a shortage of skilled professionals who could hinder market growth to some extent [54].

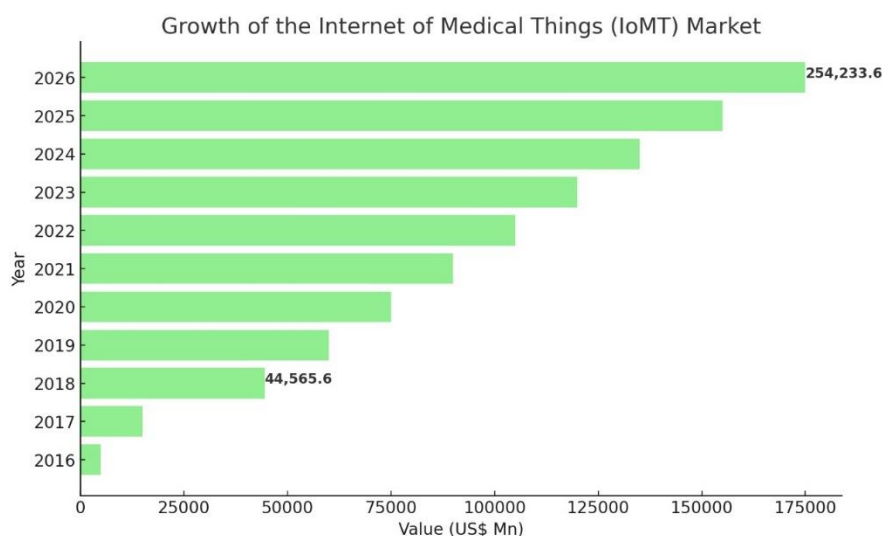


Fig 5. Worldwide Internet Of Medical Things(IoMT) market, 2016-2026 [54]

Fig 6 showcases major drivers for IoT adoption in healthcare, categorized into individual, technology, security, health, and environmental drivers. Technology drivers (34.8%) are the strongest drivers, where perceived usefulness and ease of use are the prime drivers for professionals to adopt IoT. Individual factors (29.2%), including social influence and attitude, also have a significant influence. Professionals are more likely to embrace IoT if they are supported by peers or managers. Security issues (11.2%), especially privacy threats and data security, are major challenges, as concerns about data breaches can discourage adoption. Health factors (12.4%), including perceived severity and health threats, also contribute to reluctance. Environmental factors (12.4%), such as cost and regulatory issues, also constrain adoption due to high up-front investments and maintenance costs. Where technology and individual factors stimulate adoption, security, health, and environmental issues act as inhibitors. Improved security, better regulation, and less cost can stimulate greater IoT deployment in healthcare.

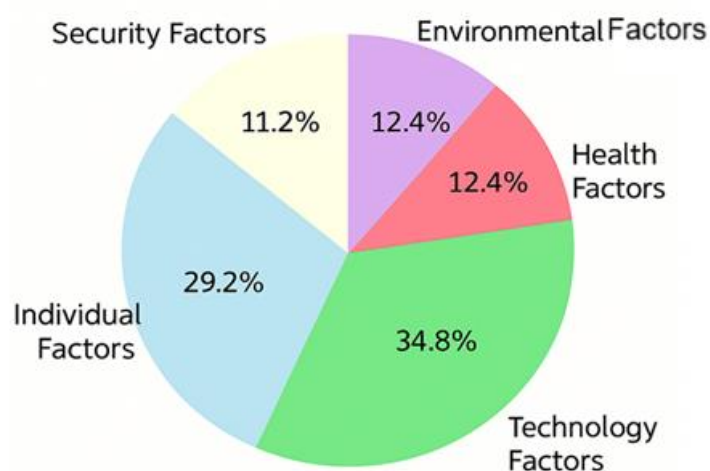


Fig 6. Distribution of IoT Adoption Influencing Factors in Healthcare [55]

Fig 7. IoT adoption indicators among various professional groups in the medical field. The doctor shows the highest adoption level (~ 45%) and a nurse (~ 25%). Administrators, equipment, and patients show that the adoption indicators are relatively low. These results correspond to the trend observed in previous studies, indicating that there is a greater tendency to integrate IoT among medical staff.

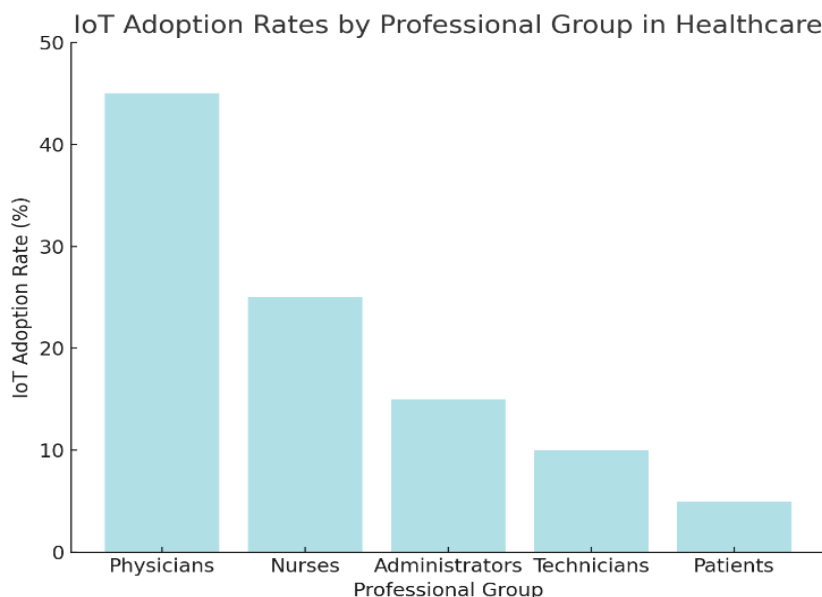


Fig 7. IoT Adoption rates by Professional groups [55]

THEORETICAL IMPLICATIONS:

Integration of the JD-R model (resources) into the Internet of Things (IoT) provides a promising framework for understanding and improving employee engagement, especially in high-voltage environments such as healthcare. The JD-R model developed by Bakker and Demerouti (2007) determines the fact that employee commitment is influenced by two main factors: work requirements and work resources. Jobs refer to the physical, emotional, and cognitive stressors that employees face, and jobs from tools, support systems, and opportunities help employees manage these requirements[56]. With the ability to automate tasks, provide real-time data, and improve communication, IoT technology has a major impact on both work requirements and resources and impacts employees. This has extended the JD-R model to a digital ordering requirement (D-JD-R) model (D-JD-R) model, including technical landscapes. D-JD-R reports on new digital requirements such as constant connectivity, data management stress, and technical learning curves, while simultaneously taking into account digital resources that provide IoT, such as automation, analytics, and adaptive learning platforms. This updated model helps businesses better understand and compensate for digital pressures, bringing the benefits that employees face in the technical environment. IoT-enabled devices such as portable sensors and intelligent surveillance systems can reduce cognitive stress for nurses and doctors by automating daily tasks such as patient monitoring and data entry. This allows health Classes that focus on more important aspects of patient treatment to reduce stress and increase work content. This example is to use of IoT in the local medical centre on the Maryland Peninsula. Real-time positioning system (RTL) and RFID tags to achieve biotechnology (PRMC) Patient devices and current. This IoT integration is not only operating efficiency but also It also reduces the burden of employee management and increases the level of promise [57]. On the other hand, the fatigue of technology called IoT fatigue is increasing Overreliance on intelligent systems can cause a sense of cognitive overload and reduce motivation. Employees who are overwhelmed by notifications, system warnings, or constant performance monitoring can experience stress rather than permission. The balance between digital requirements and supportive digital resources is extremely important to reduce fatigue and maintain a positive commitment [58]. The IoT-based platform offers personalized training modules and performance analytics that allow employees to identify areas of improvement and pursue progress. This corresponds to the motivational process of the JD-R model. In this process, work resources such as training and feedback can improve employee commitment by promoting a sense of competence and performance. Similarly, AI control analytics can provide real-time insights into employee performance, allowing managers to respond to the motivational aspects of the JD-R

model and provide feedback and support at a good time. However, overuse of IoT systems without mindful implementations can reduce the trust of technology employees. Employees are subject to data abuse or constant monitoring, undermining perceived fairness in digital performance assessments. Trust in technology is key to successful IoT adoption in the workplace. Companies need to implement transparent guidelines regarding data use and control their employees about their data use. For example, Cisco IoT collects real-time feedback from employees to help you meet, work situations, and leadership. However, the company ensures that employees know how to use their data and offers anonymous feedback options. This transparency helps build trust and ensures that technically communicated interactions improve employee commitment rather than hinder this. Employees have difficulties as the complexity increases Requirements for the technology system. This can appear with fatigue, disappointment, and resistance. Digital tool. For example, portable devices that control wells can be profitable. However, it can cause observation and can lead to stress and relaxation. In the case of the opposite, the expansion of rights and opportunities When employees recognize technology as support resources, they flock to IoT. IoT systems Provide realized knowledge, optimize the work process, and encourage technology. Development can contribute to autonomy and ability. For example, BP's fitness program reduces health insurance premiums for employees who meet certain fitness goals on portable devices. This initiative not only supports physical health but also strengthens the emotional bond between employees and the organization, demonstrating how IoT can advance reinforcement as stressful. A careful and compassionate implementation of IoT is extremely important for maximizing employee employees, and ensuring that technology acts as a resource rather than stress. Future research should examine the long-term impact of IoT on employee duties and develop best practices to integrate these technologies so that employee privacy and autonomy are respected.

PRACTICAL IMPLICATIONS:

Healthcare's use of IoT has far-reaching consequences for hospital managers, HR executives, and overall employee motivation. With the aid of real-time information and automation, IoT boosts workforce productivity, streamlines HR operations, and enhances patient outcomes. This section discusses practical applications of using IoT in healthcare environments, with a focus on workforce productivity, HR policies, and leadership development [59].

1. Optimizing Workforce Productivity and Patient Care

IoT solutions are employed by hospital administrators to improve workflow effectiveness and patient engagement. Intelligent hospital management systems, real-time patient tracking, and AI-assisted diagnostics enable healthcare workers to concentrate on core tasks, limiting burnout and enhancing job satisfaction [60]. Wearable IoT sensors monitor stress levels, workload, and general well-being, allowing HR managers to craft wellness programs preventing burnout and improving employee engagement [61].

2. Improving HR Policy and Ethical Compliance

IoT implementation, according to HR managers, goes hand in hand with ethical codes and employee entitlements. Balancing productivity with employee privacy is the use of IoT-enabled spy tools like RFID badges and biometric tracking [62]. Transparent regulatory policymaking is instrumental in ensuring ongoing compliance and integrity and building staff trust [63].

3. Leadership Formulation for Digital Transformation

Successful adoption of IoT entails HR managers developing leadership competence in interprofessional healthcare practice (IPHP). With digitalization transforming healthcare functions, HR leadership training programs are integrated with IoT-related competencies to equip managers with the necessary skills for a changing technology world [64]

4. Effective IoT Implementation Strategies

An effective organizational plan is crucial in facilitating the successful adoption of IoT in the healthcare sector. It requires measures such as performing a technological readiness evaluation to verify if the present infrastructure is IoT-compatible or not [50]. Also, it requires making IoT systems interoperable with Electronic Health Records

(EHRs) and hospital management systems[51] and ensures the training of employees through multiple workshops to familiarize them with IoT technologies and their advantages[11]. Data security and privacy are also important with advanced technologies like blockchain, secure communication channels, and AI-driven threat detection mechanisms sensitive employee and patient data are protected while ensuring compliance with healthcare.IoT-powered HR analytics platforms monitor employee attendance, performance, and stress levels in real-time, enabling HR managers to design optimized work schedules, workload balance, and burnout prevention, thus creating a more engaged workforce [52].

5. Solving HR Issues through IoT

IoT-based HR solutions enhance recruitment and workforce planning through the use of artificial intelligence in applicant tracking systems which can collect candidate information from multiple sources, resulting in well-informed hiring decisions [65]. Additionally, facilities like RFID-based access cards can help track employee movement, thus improving workforce optimization. The problem of staff shortages can be solved using IoT automation which allows remote patient monitoring and AI-based diagnosis, reducing the need for constant on-site presence of healthcare professionals and allowing them to focus on serious cases, thus improving efficiency. Also, wearable IoT devices that track employee well-being metrics such as heart rate, stress, and fatigue, enable HR managers to create personalized well-being initiatives and adjust work schedules to create a healthier and more productive work environment [49]. Table 4 shows various IoT applications in healthcare and highlights their practical implications in enhancing employee engagement by improving well-being, reducing stress, enabling skill development, and supporting flexible, data-driven work environments. Table 3 shows that implementing IoT properly in healthcare facilities, administrators, and HR managers improves employee satisfaction, maximizes the efficiency of operations, and delivers better patient outcomes, leading to overall organizational success.

Table 4. Overview of IoT Applications in Healthcare and Their Practical Implications for Enhancing Employee Engagement

IoT Application	Practical Implication	Benefits to Employee Engagement
Wearable Health Devices [66]	Wearable sensors monitor employee health indicators like heart rate, stress levels, and fatigue.	Increases well-being, minimizes absenteeism, and increases productivity.
Smart Monitoring Systems [67]	IoT-based devices for real-time patient monitoring	Reduces workload stress on employees, ensuring better patient care and focus on value-added tasks.
Virtual & Augmented Reality (VR/AR) [68]	VR-based employee training and patient simulations	Enhances skill development, reduces training time, and improves decision making.
Remote Work & Telemedicine[69]	IoT for healthcare workers to conduct remote consultations and monitoring.	Increases work flexibility, helps in work-life balance, and reduces exhaustion.
HR Analytics & Employee Tracking [70]	IoT devices provide analytics employee performance and work pattern analytics.	Helps in performance-based analysis, career advancement, and reduction of inefficiencies.
Predictive Healthcare & AI Integration [71]	AI with IoT collected data for health risk prediction.	Proactive employee health management, resulting in lower medical expenses and improved engagement

CONCLUSION:

This presented review highlights the growing potential of IoT technologies in enhancing employee engagement within healthcare organizations. By leveraging tools such as wearable devices, VR/AR training, smart scheduling systems, and AI-driven analytics, healthcare institutions can improve workforce well-being, reduce stress, and foster

motivation. Framed through the Job Demands-Resources (JD-R) model, IoT serves as a valuable resource that moderates excessive demands while promoting autonomy, support, and performance feedback. These innovations contribute to better job satisfaction, reduced burnout, and improved efficiency among healthcare professionals. However, it seems like realizing these benefits requires careful consideration of data privacy, ethical concerns, and the risk of technostress. Transparent implementation, employee training, and organizational support are essential to ensure that IoT enhances rather than hinders engagement. As healthcare systems evolve, embracing employee-centric digital transformation through IoT can lead to a more empowered, satisfied, and future-ready workforce. In future studies, Further research is needed to explore long-term outcomes and the development of best practices for IoT-driven workforce engagement.

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ETHICAL APPROVAL:

After receiving approval from the relevant regulatory agency, the data was gathered from several healthcare facilities. We also assured each participant that, absent their express approval, their data would be kept private. The institutions are aware of our research and are not concerned about any ethical issues.

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