Effective influence of Community Pharmacists in Public Health Using Blockchain Technology to Secure Patient Data and Enhance Healthcare Delivery

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KEYWORDS

Blockchain Technology, Patient Data, Healthcare Delivery, Internet of Things, Unmanned Aerial Vehicle, Drones, Smart Contracts, Community Pharmacists

ABSTRACT

The advent of healthcare delivery drones, a novel unmanned aerial vehicle (UAV), has opened the door to a more comprehensive approach to developing smart health services. Internet of Things (IoT)-based healthcare delivery via UAVs has not been fully realized because of a lack of augmentation-aware concepts. Despite community pharmacists' strong clinical expertise and ease of patient access, they cannot provide comprehensive clinical services due to a lack of access to patient data. Blockchain could be a solution if it's concerned about the reliability and security of drone deliveries over untrusted open channels. Hence, this study proposes the Internet of Things and Blockchain Technology-assisted Drone Healthcare Delivery System (IoT-BT-DHDS) for enhancing access to healthcare information in the community pharmacy environment. Ensuring the security of drone operations is crucial to protect users from any breaches that might result in physical and financial loss. This research suggests an oT-BT-DHDS that authenticates and registers the involved entities, such as objects (healthcare supplies), warehouses (healthcare centres), and drones, to address these security concerns and make the delivery progression visible. This research achieves its goals by analyzing several parameters that impact the time and number of transactions required for authentication on the Ethereum platform, which is used to build smart contracts and blockchain. The suggested strategy is shown to be effective by results acquired from a simulated environment compared to alternative models based on an access control ratio of 98.9%, data management ratio of 97.4% and resource utilization ratio of 96.4% to other existing models.

1. Introduction

The healthcare industry is rapidly embracing new information technology, which poses major risks to patient's privacy and the security of their medical records. Approaches that may prevent cyber-attacks that emerge quickly should be implemented [1]. Better protection of patient rights and consent management should drive the use of cyber security measures in healthcare [2]. Healthcare providers and the pharmaceutical supply chain rely on the knowledge and medication provided by community pharmacists [3]. Community pharmacies can now access patient records, and important pharmacists can link their Patient Medication Records (PMRs) with Electronic Health Records (EHRs) [17]. PMR systems can be integrated into digital referral and consultation booking platforms, delivery management systems, and patient-facing apps to enhance patient experience [5]. Over the last decade, healthcare data has been transformed by new technologies used by electronic health record (EHR) suppliers. Predicting network behaviour and preventing security breaches are both made easier with big data security technologies like blockchain. [6]. Recent developments in blockchain and the IoT have shown great promise as potential enhancements to smart healthcare systems[10]. Smart healthcare systems combining blockchain with Integrated IoT may improve patient outcomes and operational efficiency, increasing data security, interoperability, and transparency [18]. Blockchain technology allows data exchange without compromising privacy, enabling pharmacists to confirm the medicine's origin [8]. Since blockchain technology can distribute, validate, secure, and manage data transactions on a decentralized system, it may open up the following opportunities in the pharmaceutical supply chain: improving patient safety by tracking medicines back to their sources; better-managing inventory to prevent drug shortages and their effects; and taking part in a more efficient drug recall process when it occurs [9]. Adopting the Internet of Drones (IoD) in delivery systems may decrease delivery times in Healthcare 5.0. IoD consists of flying robots, known as robotic unmanned aerial vehicles (UAVs), controlled from a distance via wireless communication channels established at ground stations (GSs)[16]. Consequently, by recording each event in the chain of blocks, blockchain lessens the security issues around UAVs. Additionally, if it begins to veer off course, the drone may depend on a smart contract to bring it back to base [22]. The paper's main contribution is the design of the Internet of Things and Blockchain Technology-assisted Drone Healthcare Delivery System (IoT-BT-DHDS)

to enhance access to healthcare data in the community pharmacy environment [19]. A blockchain-based drone path planning network is implemented for Healthcare 4.0, describes the threat model, and provides security analysis to verify the strength of the suggested healthcare data access [4]. The numerical outcomes have been implemented, and the suggested IoT-BT-DHDS model increases the data transmission ratio and reduces transaction time, latency and delay compared to other existing methodologies [13]. The remainder of the article is pre-arranged: section 2 deliberates the related works, section 3 proposes the IoT-BT-DHDS model, section 4 reflects the results and discussion, and Section 5 concludes the research paper.

Related Study

Chidera Victoria Ibeh et al. [11] suggested patient-centric approaches (PCA) for healthcare delivery using data analytics. Disease outbreaks may be better anticipated with the use of predictive analytics, which allows for the allocation of resources and the implementation of prevention measures. Critical factors that deserve careful consideration in the age of digital healthcare include data security, patient privacy, and the appropriate use of sensitive health data. Healthcare management stands to be radically transformed by incorporating advanced analytics into the sector's ongoing development, leading to a more tailored, efficient, and successful strategy for patients' health. Shumaila Javaid et al. [23] recommended Medical Sensors and Wireless Body Area Networks (WBAN) for Pervasive Healthcare Delivery. This analysis delves into how the emerging IoT revolutionizes sensor technology in the healthcare industry. Further, the author delves into the pros and cons of several newly suggested designs for integrating heterogeneous medical sensors with new paradigms and technologies, such as cloud computing, fog computing, Mobile Cloud Computing (MCC), and the edge. Finally, the author pinpoints upcoming obstacles that need fixing if medical sensor technologies are to reach their full potential and help bring about robust, scalable, dependable, and cost-effective healthcare [12]. Haritha Atluri and Bala Siva Prakash Thummisetti [20] proposed Remote Healthcare Delivery using a Holistic Examination of Healthcare Accessibility, Patient Results, and Technological Incorporation. This study analyzes telemedicine holistically by combining previous research, case studies, and practical applications. The paper guides how to optimize the deployment of telemedicine for the benefit of both patients and healthcare professionals in our rapidly digitizing healthcare system, addressing issues such as scalability, equitable access, and regulatory concerns. ALFRED ADDY [14] discussed the AI-augmented Governance for Healthcare Delivery System (AIG-HDS). Patient data must be protected against cyberattacks by the Ghanaian healthcare system. If patient data enters the wrong hands, it violates privacy and puts patients at risk. AI-augmented governance has several advantages for Ghana's healthcare delivery system, yet ethics and patient privacy must be prioritized [7]. Patients should have more control over their healthcare data and have their data protected by stricter rules. These challenges must be addressed to fully use AI to improve healthcare results while respecting individual rights. Sulemana Bankuoru Egala et al. [15] deliberated the best-worst method with blockchain technology (BWM-BC) for primary healthcare (PHC) delivery. This research adds the perceived e-readiness model to the Task-technology fit model. This article examines the choice of PHC management to accept BT for PHC delivery in Ghana, drawing on the best-worst technique. In terms of importance, the report ranks task technology, infrastructure, and individual traits as the top three determinants of BT implementation and adoption. To manage PHC in economies with limited resources, the research suggests several techniques to make BT sustainable. Based on the investigation, there are several issues with existing models in attaining high access control, data management, and resource utilization ratio. Hence, this study proposes the Internet of Things and Blockchain Technology-assisted Drone Healthcare Delivery System (IoT-BT-DHDS) for enhancing access to healthcare information in the community pharmacy environment.

2. Methodology

Enhanced patient care, especially in mobile health, is possible with the broad use of interoperability standards, which allow for the smooth transfer of real-time healthcare data between different clinicians.

More efficient, individualized treatment for each patient is possible because of this paradigm shift's potential to enable secure, decentralized data exchange and analysis. Electronic medical records (EMRs) have been revolutionary when managing patient data and providing effective treatment. The data's privacy and security aspects are crucial to accepting interoperability. When it comes to patient care and better health outcomes, community pharmacists provide a reliable setting. Pharmacists ' vast clinical expertise and intensive training substantially support quality services like pharmaceutical therapy, chronic illness care, and regular dispensing activities. Although community pharmacists may provide services like adherence support and accurate medical information, their ability to optimize treatment, conduct follow-ups, and monitor patients is hindered due to their lack of access to patient data. Using this approach, we may be able to uncover previously unseen connections, trends, and insights across many different medical conditions and patient populations. With blockchain technology and electronic medical records (EMRs), precision medicine has the potential to completely transform the way healthcare is provided.

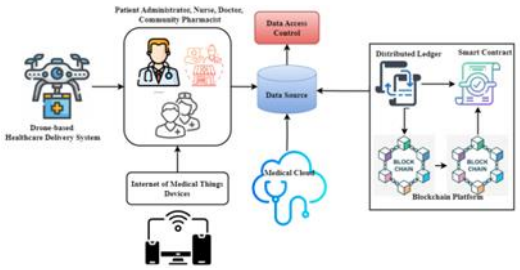

Figure 1. Proposed IoT-BT-DHDS model

Figure 1 shows the proposed IoT-BT-DHDS model. The data are taken from the Cyber Incident Detection for EHR Kaggle Dataset [21]. Due to home care, telemedicine, and lockdowns, drones have become more popular for patient medication delivery. By retrieving the patient's vital signs from the IoT healthcare system, the system establishes a new smart contract between the doctor and the patient. The doctor then checks the patient's vitals and administers the medication using the smart contract. At last, the smart contract transfers funds directly from the patient's wallet to the doctor's. For blockchain medical records to be implemented, there must be a connection between patients and physicians and records that detail each contact. Blockchain technology is being considered to address these concerns and expand the function of community pharmacists beyond medicine administration. In the dynamic field of public health, community pharmacists have the potential to enhance health outcomes for socially and medically disadvantaged groups by providing vital patient services as authorized users of the electronic health record system. Blockchain technology is rising in the healthcare industry, and this strategy is comparable. It is clear that blockchain, with its immutability of records, decentralized system, security of private patient health information and data provenance, can improve community pharmacies' access to patient data based on its successful establishment in other healthcare regions. In the community pharmacy context, a major obstacle is the lack of information available to pharmacists for each prescription. To provide patients with accurate prescriptions, pharmacists need access to more comprehensive health records than is presently accessible. Unlocking new medical insights might alter healthcare decision-making. Using the gathered intelligence of distributed EHR information, the suggested system may optimize healthcare delivery, improve patient outcomes, and aid in data access, disease prediction, therapy recommendation, precision medicine, and resource allocation.

To compute the supply-to-demand rate of every healthcare centre i. A healthcare resource of a healthcare centre i is shared by the population within the reachable ranges Q_l in equation 1, yet the accessibility reduces as the reachable ranges (e.g., the catchment region, D_r in Equation (1), where d_li is the travel time between resident points l and institutions i) gets further from the centre (e.g., the supply points i). Distance-weight (S_r in Equation (1)), the derivative from a distance decay functions represents the decreasing trends.

$$R_i=W_i/(\sum_{j\in(d_{li}\in D_r)}\llbracket Q_l S_r \rrbracket) \quad (1)$$

$$A_j^F=\sum_{i\in(d_{li}\in D_r)}\llbracket R_i S_r \rrbracket \quad (2)$$

Equation (2) computes the spatial access of every resident point j (A_j^F in equation 2). The healthcare centres that are closer to the resident points are considered more significant and have greater distance-weight (S_r). Let $U = \{u_1,u_2,u_3,...,u_m\}$ signify the set of vital signs that measure the patient, comprising heartbeat, pulse, temperature, etc. The health numbers (HN) are allocated by the hospital information system (HIS), whereas t is the timestamp. Hence, the transaction of the sensing information is signified by Expression (3).

$$Message=(HN,t,U) \quad (3)$$

The main purpose is to prevent unauthorized access and authentication since it is a crucial need for remote healthcare monitoring systems (RHMS). Furthermore, the RHMS system relies on traceability severely. Equation (4) represents a security model established in this research to solve these crucial problems.

$$Tx(message)=(E_l (message),W_l (message)) \quad (4)$$

As shown in Equation (4), the plain text message refers to the plain information that includes the HN, a set of vital signs and a timestamp. The encryption algorithm is signified as E_l (), was employed to secure this data and digital signatures, W_l (), has been added to authenticate the model. It is necessary to utilize cryptographic keys and distribute them to secure plain communications, as shown in Equation (4), the classic paradigm. Removing all third-party links from the HIS network, the suggested RHMS implemented a decentralized paradigm. Hence, smart contracts oversaw the security model, and the work's answer was to deploy a distributed database utilizing blockchain technology. A further benefit of this method is that it led to the automated incorporation of traceability. Equation (5) estimates the overall data transmission time between the end devices and the Blockchain platforms.

$$T_{total}=T_{ED}+T_{WC}+T_S+T_B \quad (5)$$

As shown in Equation (5), with T_{ED} denotes the time the Arduino platforms spend preparing the Frame (headers and data encryption). This study does not consider data procurement from the sensors or data analysis. T_{WC} indicates the time spend in wireless communication via the Gateways. T_S resembles the runtime of gateway servers and application servers. Finally, T_B denotes the Blockchain information storage period, which is articulated in timestamps. The suggested model is based on a medicinal healthcare system where the data of every user is private; thus, it is essential to guarantee the data's safety. Firstly, this study considered three-dimensional coordinates for the coverage area of UAVs. This study used the Euclidean distance expression for three-dimensional coordinates in Equation (6) to compute the distance between the drone and the end device.

$$C=\sqrt{(\llbracket y^2 \rrbracket_{UAV}-\llbracket y^2 \rrbracket_{IoT})+(\llbracket x^2 \rrbracket_{UAV}-\llbracket x^2 \rrbracket_{IoT})+(\llbracket z^2 \rrbracket_{UAV}-\llbracket z^2 \rrbracket_{IoT})} \quad (6)$$

Equation (6) shows where C denotes the distance between the drone and IoT device, and x,y and z are their coordinates. Integrating the IoT networks with drones holds great promise for enhancing medical delivery in underserved and remote regions. Drone networks are often used for search and rescue, aerial surveillance, and package delivery applications.

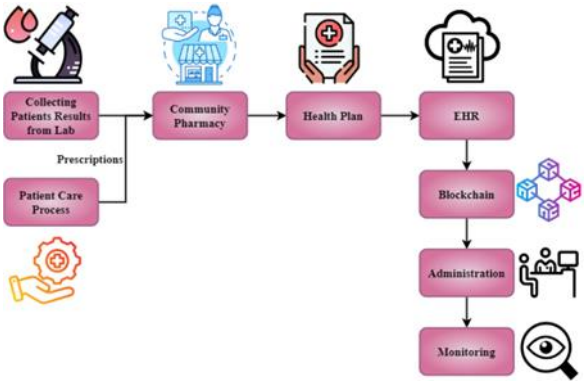

Figure 2. Community pharmacy environment

Figure 2 shows the community pharmacy environment. If pharmacists can access patients' electronic health records (EHRs) and lab results using blockchain technology, they might use this information to determine if a patient's medication regimen is safe and effective during the evaluation phase. Optimizing pharmacist care using blockchain technology is the second stage before plan implementation. The pharmacist may better understand the patient's health by reviewing their medical records and notes from other doctors. This way, this study can be confident that the plan will provide our patients with the best therapy possible without introducing any medication- or health-related complications. Improving patient health outcomes was shown by the study's participants' capacity to use data such as test results, medical problems, and recommended medicines. Community pharmacists cannot provide comprehensive medical treatment due to a lack of patient information. Blockchain technology has the potential to drastically cut down on prescription mistakes, such as the re-distribution of stopped drugs, by providing access to more comprehensive medical records. Medications are frequently the next course of action that is prescribed to patients. After receiving an electronic prescription, the local pharmacy processes the payment with the insurance company makes the necessary preparations for the patient's order, and then gives them their medicine. Pharmacists would use blockchain technology to review clinical metrics to verify that the order is for the correct medication treatment.

3. Results and Discussion

This study presents the Internet of Things and Blockchain Technology-assisted Drone Healthcare Delivery System (IoT-BT-DHDS) for enhancing access to healthcare information in the community pharmacy environment. The data are taken from the Cyber Incident Detection for EHR Kaggle Dataset [16]. Information gathered for ML-based EMR Cyber Incident Detection with 16,164 individuals (name, address, date of birth, gender, race, ethnicity, etc.) registered is considered normal. Outlier data includes 36,447 individuals. 68,775 patients comprise the dataset, including 2 sets of normal and 1 set of abnormal data.

Access Control Ratio

The information system can restrict access to those who need protected health information (PHI) to carry out their tasks. Protecting sensitive information may be achieved using encryption, passwords, biometrics, or even physical restrictions like keys or cards only for authorized users. For further protection against man-in-the-middle assaults, another method employs cryptographic protocols like Secure Sockets Layer and its forerunner, Transport Layer Security. Security technologies for big data, such as blockchain, may aid in predicting network behaviour and preventing security breaches. Role-based access control rules, user login credentials and other pertinent characteristics produce the access keys. An access key is a digital token that, when entered, allows authorized users to access certain data objects within systems. Figure 3 shows the access control ratio.

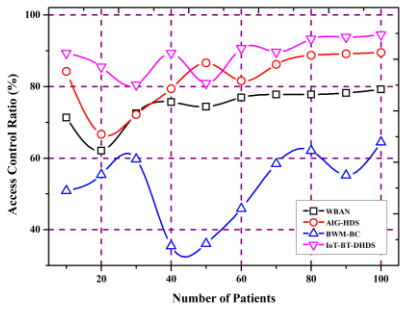

Figure 3. Access Control Ratio

Data Management Ratio

For healthcare data stored in IoT devices to remain safe and private, blockchain's immutable, transparent, and secure data management is essential. Blockchain technology enables frictionless data exchange while preserving anonymity and guarantees trust among stakeholders via decentralized consensus procedures. Through the integration of IoT, environmental variables and patient health data can be tracked in real-time. This permits for the early diagnosis of health distress and prompt therapy. Supply Chains can enhance outcomes and patient care research by efficiently transferring health information across a bigger data pool. Both research uses the electronic health record (EHR) inside the healthcare system to solve the incompatibility. Multiple healthcare data management initiatives have used blockchain technology with great success. By eliminating the need for a third party to access information, blockchain's decentralized qualities may be used to enhance security in medical data management. Figure 4 shows the data management ratio.

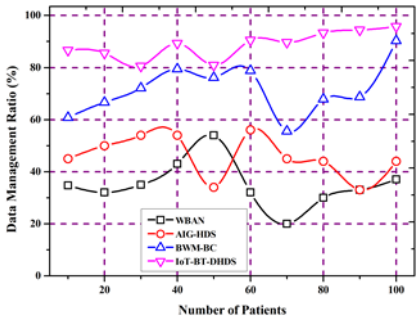

Figure 4. Data Management Ratio

Resource Utilization Ratio

Network calliper testing compares several nodes' performance by monitoring resource use across the board. This includes measures like memory, average CPU utilization, disk read/write operations, incoming and outgoing traffic, and more. According to the study, implementing the suggested method improved healthcare scheduling efficiency. According to the simulation data analysis, there was a 25% decrease in average patient wait times compared to the baseline scenario. Resource utilization indicators showed a 15% rise in examination room usage rate, indicating improved physician and nursing capacity deployment. Using our conceptual framework, researchers and designers may build tools for community pharmacists using blockchain technology in the future. For a healthcare system that is both safe and efficient, secure data access is essential. Figure 5 shows the resource utilization ratio.

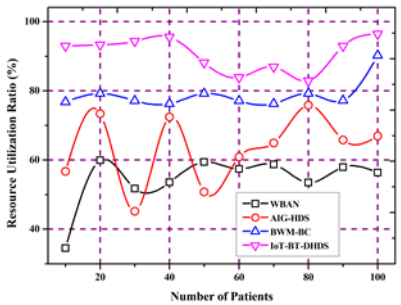

Figure 5. Resource Utilization Ratio

4. Conclusion and future scope

This research presents the Internet of Things and Blockchain Technology-assisted Drone Healthcare Delivery System (IoT-BT-DHDS) to enhance access to healthcare information in the community pharmacy environment. Blockchain technology can potentially enhance the efficacy of pharmacy workflow and systems. Pharmacists can make more informed therapeutic decisions and better monitor patients if electronic health records and test results are combined. Findings from this research show that IoT-BT-DHDS improves patient care, resource usage, and healthcare system efficiency by thoroughly examining critical components like digital signature creation, computational efficiency, and bibliometric trends. Users can effortlessly trade and track their healthcare items by tokenizing them, as our approach provides. Data analytics tools may perform their analyses directly from our solution's trustworthy, secure, dependable, and transparent database; this eliminates the need for a third party and eliminates concerns about the data's completeness and validity. The next step in understanding blockchain technology's potential benefits and drawbacks for community pharmacy should be applying and analyzing the model in a real world.

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