RESEARCH PAPER

IoT Driven Medication Safety Systems in Clinical Pharmacy

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ABSTRACT

Medication safety is a very important aspect of clinical pharmacy that guarantees the administration of drugs to patients correctly without adverse drug reactions (ADRs) or medication errors. Medication errors are a major issue even after the improvement of pharmacy practices. Internet of Things (IoT) technologies can be used to enhance the safety of medication through the integration of these technologies into healthcare systems. The article examines the design and implementation of IoT-driven medication safety systems with reference to clinical pharmacy settings. The suggested system will use smart medication dispensers, real-time monitoring devices, and data analytics to provide proper medication administration and minimize the possibility of medication-related errors. There are key performance measures that determine the effectiveness of the system, and they include the reduction rate of errors, real-time monitoring, and user satisfaction. Findings indicate that the IoT-based solutions have the potential to make a significant contribution to medication safety, optimize pharmacy workflow, and patient outcomes. The paper will finish by discussing the future developments of IoT-based medication safety systems, such as artificial intelligence and machine learning to predict analytics and prevent errors.

Keywords: IoT, Medication Safety, Clinical Pharmacy, Smart Medication Systems, Healthcare Technology, Patient Safety

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1. Introduction

Patient outcomes and the quality of the healthcare systems, in general, depend on medication safety as a key element of clinical pharmacy. Although the administration of medication is aimed at facilitating the health of patients, the health of patients is at high risk when the medication is not managed properly[1]. Medication errors, or errors in the administration of a patient with the incorrect dose, drug or delivery route remain one of the primary causes of morbidity and mortality in the healthcare facility[2]. The reality is that medication errors cause a significant part of the adverse drug reactions (ADRs) that can be prevented, which leads to extended hospitalization, higher healthcare expenditures, and worsening of patient health outcomes[3]. Medication safety is an extremely critical topic because it will guarantee that patients get the appropriate drug at the appropriate dose, by the appropriate route, and at the appropriate time[4].

Medication safety plays a vital role in clinical pharmacy with respect to avoidance of errors as well as maximization of therapeutic outcomes. Pharmacists are important in the evaluation and monitoring of medication use, selection of drugs and counseling of patients about the safe administration of therapeutic drugs[5]. The changing nature of the drug regimens especially in the treatment of long-term conditions and polypharmacy, heightens the possibility of errors. Thus, it is necessary to improve medication safety systems to provide better patient care and minimize the number of adverse events that can be prevented. Moreover, the growing worldwide rates of chronic illnesses that may necessitate life-long treatment using various drugs and medications underscore the pressing need to find better medication safety approaches. The paper discusses how the use of high-level technologies like the Internet of Things (IoT) can be applied to the

medication safety system to help to overcome those challenges and provide a safer healthcare environment.

1.1 Introduction to IoT in Healthcare

Internet of Things (IoT) is a network of devices, which interact and exchange information with one another via the internet. In the sphere of healthcare, IoT technologies are transforming the manner in which healthcare providers handle the healthcare of patients, such as medication delivery and monitoring[6]. The IoT-based devices, like smart medication dispensers, wearable health trackers and connected sensors, enable the healthcare professionals to monitor patient data in real time and automate key care processes[7]. IoT in healthcare is a phenomenon that has been maturing very fast owing to the necessity of having more effective and precise systems of patient management[8]. These technologies guarantee a smooth interconnection between patients, healthcare providers, and medical devices to make sure that correct information is constantly collected and shared to be used in clinical decision-making[9].

Within the framework of clinical pharmacy, the IoT technologies allow creating systems that will monitor drug administration, adherence, and possible mistakes in real-time. IoT systems are capable of warning healthcare providers about any problem, including missed doses or wrong drug delivery by collecting and transmitting data through medication dispensers[10]. Also, IoT devices are able to monitor the health parameters of a patient, which can be used to gain important insights into the performance of a patient under medication[11]. This stream of information aids in timely interventions hence patients will get the best care. The application of IoT in the healthcare sector will most likely keep on growing, and in the future, the technology will be enhanced to help in the accuracy of diagnostic devices, better patient monitoring systems, and to ease the administrative load on medical professionals[12]. With the ongoing development of the IoT, it has the potential to radically transform the medication safety approach in clinical practices.

1.2 Challenges in Medication Safety

Medication safety is also a major issue in clinical pharmacy despite the improvements in the health care sector. Among the most urgent concerns, one must mention the presence of medication errors that may manifest themselves in various ways, such as wrong dosage, drug interactions, and wrong administration routes. Medication errors, due to studies, result in thousands of deaths every year, so it is one of the gravest issues in healthcare nowadays[13]. Such errors may be caused by different causes, including human errors, poor communication, and inefficiencies of the systems.

The adverse drug reactions (ADRs) are another one as they may occur due to improper use of drugs or peculiarities of patients who may not have been properly taken into account. ADRs can be avoided in most cases through appropriate medication and patient monitoring, but they still are a major cause of hospitalization and long term disability[14]. Increasing the number of medications applied to treat complex diseases exposes patients to ADRs, particularly when they are taking several medications at a time. Also, a significant weakness of existing medication safety measures is the lack of real-time monitoring systems[15]. The common traditional medication safety practices are based on manual checks and documentation which can easily lead to errors and inconsistencies. In the absence of real-time data, healthcare providers might not realize the presence of critical signs of medication errors or ADRs until the patient develops a worsening condition[16]. The absence of immediate feedback complicates timely intervention and makes treatment timely and accurate, which adds to delays in treatment and may aggravate patient outcomes[17]. To address these obstacles, there is a growing demand to have systems that can offer real-time, continuous monitoring and automation to minimize the risks involved in the medication administration.

1.3 Objective of the Paper

This paper aims to discuss the ways in which IoT technologies can be used to improve medication safety systems within the clinical pharmacy environment. With the help of incorporating IoT devices into the current medication management practice, one may decrease the number of medication errors, enhance patient adherence, and track medication administration in real-time[18]. The proposed system utilizes IoT-based technologies, i.e., smart medication dispensers, sensors, and connected health monitors, to track medication intake, notify patients about errors, and make sure that patients take the prescribed treatment on time. By means of the in-depth analysis of the current literature and the presentation of a new system based on IoT, this paper will serve to prove that the IoT can be an effective instrument of change in improving medication safety. IoT-based systems can reduce human errors, optimize medication regimens, and enhance patient safety in clinical pharmacy settings as they can automate the most important processes and provide healthcare providers with real-time information.

2. Literature Survey

The medication safety systems have been changing throughout the years, and old methods are getting further complemented by new technologies. Historically, medication safety in clinical pharmacy has been dependent on manual procedures and guidelines, such as visual examination, manual medication administration record, and supervision of pharmacists. Such traditional systems frequently involve the use of physical checks where healthcare professionals have to check drug doses and methods of administration, which are time-consuming and can be subject to human error. Medication errors may be caused by miscommunication, wrong labelling, shortage of drugs and fatigue which is hard to curb using manual systems only.

Besides manual checks, most healthcare facilities have adopted the use of computerized physician order entry (CPOE) systems, which are automated prescription order systems and are connected to pharmacy management software. CPOE systems are designed to minimize medication errors through removing illegible handwriting, drug interaction alerts, and correct dosage and route administration. Nevertheless, though these systems have been useful, they are not devoid of errors. The absence of real-time tracking is one of the major problems; CPOE systems are more concentrated on prescriptions and real medication administration remains under human control. Moreover, they might not give appropriate warnings on complicated drug interactions or particular illnesses.

Another technology developed in medication safety is automated dispensing systems (ADS), which assist in minimizing dispensing errors through barcode scanning and robots. These machines are able to release drugs according to the prescription order and automatically count pills and check their dosage. Nonetheless, despite these developments, ADS systems do not cover the whole procedure of medication administration. They fail to guarantee that the correct patient gets the medication and also they do not offer continuous monitoring to identify any adverse drug reactions or mistakes in administration of the drug. Even with these advances, medication safety systems are susceptible to both prescribing and administration medication errors. With the growing complexity of treatment regimens, particularly polypharmacy and the emergence of chronic disease management, conventional systems are failing to meet the safety problems of medication delivery. This brings out the necessity of more sophisticated and built-in systems to provide real-time tracking, streamlined data gathering, and improved communication between the medical team, patients, and the drugs themselves.

2.1 IoT-Based Medication Safety Systems

The introduction of Internet of Things (IoT) technologies into healthcare has created new opportunities that can be used to enhance medication safety in clinical pharmacy. IoT systems are based on a network of interconnected devices to track and control the medication process in real-time. Such systems gather and send information concerning the patient, the usage behaviors of the medications and other health indicators, which can be analyzed to make sure that patients obtain the right medications at the right time. Smart medication dispensers are one of the most important applications of IoT in medication safety as they are intended to dispense medications with precision according to a set of pre-determined schedules. Such devices usually come in with sensors to confirm the kind, dose, and time of medication intake so that the patient gets the right medication at the right time.

The IoT technologies also allow real-time tracking of health conditions of patients, which is essential to identify possible adverse drug reactions (ADRs) at an early stage. Smartwatches or patches that can measure vital signs like heart rate, blood pressure, or blood glucose levels can be used to monitor them and transmit the data to an analysis center. This information is then able to be utilized to monitor the reaction of a patient to a given drug and this will give healthcare providers sufficient information that can be used to make clinical judgments. In addition, such systems have the capability of alerting the healthcare professionals in the event that any discrepancies or abnormalities in the administration of medication are identified so that timely intervention can be taken before the errors escalate.

The implementation of medication safety systems based on the IoT has been studied by several authors, as these systems have the potential to increase patient safety and minimize medication errors. As an example, it was found that the implementation of the IoT-enabled medication management systems can drastically decrease the incidence of missed doses and misdeliveries of drugs. Moreover, the IoT solutions have been implemented successfully in the clinical pharmacy practice to monitor drug interactions and ADRs in real-time. There are machine learning algorithms in some systems that predict adverse events based on patient-specific data, which provides a further protection. Yet, despite the fact that the opportunities of IoT in medication safety are extraordinary, there are

numerous issues related to its extensive implementation and incorporation in the current healthcare processes.

2.2 Challenges and Limitations

Although the benefits of IoT in medication safety are promising, there are a number of challenges and limitations that prevent its large-scale application in clinical pharmacy. The first problem is that the cost of introducing the IoT systems is high and resources are limited in healthcare settings. The initial expense of buying IoT-enabled devices, as well as the expenses of the integration of the system and staff training, may be prohibitive. This is a financial obstacle to the availability of IoT-based solutions, particularly to smaller hospitals or clinics that might not be in a position to afford such advanced technology.

The second issue is that IoT systems are complex to integrate with the current healthcare systems. It is also true that many healthcare institutions are using legacy systems and it may be difficult to integrate new IoT-based technologies with the older systems. Interoperability challenges occur when various devices or systems do not effectively communicate with each other and this may lead to incomplete data or inaccurate data. Also, the adoption of the IoT solutions by healthcare providers might be hindered by the fear of system reliability and data security. The transfer of personal patient information via IoT networks brings up the issue of privacy, and strict rules like the HIPAA (Health Insurance Portability and Accountability Act) should be followed to ensure the confidentiality of patients.

Furthermore, user experience and clinical workflows should be taken into account when the IoT-based medication safety systems are implemented. One of the challenges that healthcare providers might experience is how to adjust to new technologies especially when the systems are viewed to be too complicated or time-consuming. As an example, healthcare specialists might have to use supplementary tools or interfaces to keep track of patients, which might add more workload to them and cause resistance to adoption. Whether the use of IoT systems will be effective or not is determined by whether the healthcare providers will be able to introduce them effectively into their lives without disrupting them much. Finally, IoT devices need to be maintained and calibrated to guarantee that they will continue to work over time. The devices should be updated and maintained regularly to make sure that they are functional and the failure of the devices may result in severe mistakes during medication administration. Moreover, IoT devices might be able to improve the monitoring process, but they are unable to exclude human error and further supervision by trained healthcare professionals is needed to address complex clinical conditions.

3. Proposed Method

3.1 Overview of the Proposed IoT-Driven Medication Safety System

The medication safety system proposed based on the IoT is aimed at improving the accuracy and efficiency of medication administration in clinical pharmacy. The main aim is to minimize medication mistakes, maximize patient safety and also to make sure that the correct drug is provided to the correct patient at the correct time. The system conceptual model includes the combination of numerous interdependent IoT elements such as smart medication dispensers, wearable health sensors, environmental sensors, and data analytics platforms. These devices are linked to central cloud-based platform that aggregate and process the data, and give healthcare professionals real-time information of medication administration and patient conditions. The system is autonomous as it constantly monitors the use of medications and health indicators in patients and sends alerts in case of errors or non-adherence to the prescribed treatment regimen because of real-time data collection, monitoring, and communication. As an example, a smart medication dispenser is a device that checks the medication type, dosage, and patient identity by sensor technology and barcode scanning prior to dispensing the medication. At the same time, wearable health monitors measure vital signs of patients (heart rate, blood pressure, and body temperature) and send them to the central system to be analyzed. This data combined into a centralized system can enable healthcare providers to track patient safety in real-time, act proactively, and improve treatment regimens to attain improved outcomes.

3.2 System Architecture

The IoT-based medication safety system has several important elements, which are represented by its system architecture, and which operate together to guarantee the accuracy of medication and patient safety. The initial element is the smart medication dispenser that dispenses medications to patients according to the prescribed plan. The dispenser has sensors that confirm the type of medication, dosage and expiration date. Also, there is barcode scanning technology that makes sure that the right medication is dispensed to the right patient. The dispenser also gives feedback to the health provider and patient in case of missing doses or wrong medication. The second element is wearable health monitors, which the patient

is supposed to wear to monitor vital signs of heart rate, blood pressure, temperature, and respiratory rate.

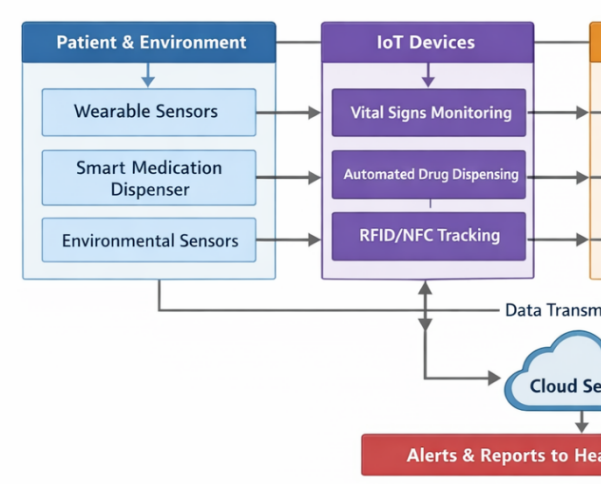

Figure 1: System Architecture of the IoT-Driven Medication Safety System

The architecture of the IoT-driven medication safety system is shown in Figure 1 and it incorporates multiple components that are interconnected in order to improve medication administration accuracy and patient safety. This system consists of four key parts: Patient & Environment, IoT Devices, Data Processing and Analysis and Clinical Interface and Alerts. Wearable sensors in the Patient and Environment section can measure vital signs like heart rate and blood pressure, and there are smart medication dispensers to be sure that the right medication is given to the right patient at the right time. The environmental sensors monitor the environment parameters like temperature and humidity which may influence the quality and stability of the medications. Such devices are synchronized to collect real-time information which is essential in keeping the patients safe.

In the IoT Devices section, the special attention is paid to such key technologies as automated drug dispensing, vital signs monitoring, and RFID/NFC tracking that are also used in the system. The smart medication dispenser is powered by the RFID/NFC technology, which will make sure that the dispensing medication is of the right prescription. The health of the patient and medication administration is constantly monitored by wearable sensors, and deviations in patient health or drug administration are highlighted. The Data Processing and Analysis section brings into focus the cloud-based platform on which all the information on the IoT devices is collected and analyzed. In this case, the machine learning algorithms and artificial intelligence (AI) are used to process the data obtained to identify the occurrence of errors and possible adverse drug reactions. The section will also handle prediction of errors using algorithms that will offer actionable information using real-time information. Lastly, there is Clinical Interface & Alerts section where providers are informed about the possible critical issues or medication errors. Patient alerts are sent to the dashboard of the healthcare provider in real time where the provider can watch patient data and intervene as necessary. EMR integration will make all the information available and up-to-date to make informed decisions.

These devices send real-time health information to the cloud-based platform where the healthcare providers can evaluate the patient response to the treatment and identify possible adverse drug reactions (ADRs) at the early stages. The third element is the environmental sensors which are used to check the environment of the patient to identify any type of conditions that might interfere with medication safety like temperature changes or humidity that might interfere with the integrity of some medications. The fourth element is the data collection platform, which is a cloud-based platform that centralizes all transaction data of all the devices and processes and gives real-time analysis. The platform relies on state-of-the-art data analytics and machine learning algorithms to identify patterns, anticipate possible medication errors and produce notifications to care providers. Lastly, the healthcare provider interface enables the medical professionals to engage with the system and access real-time information, have notifications, and make rational decisions about medication and patient care.

4. Results and Discussion

Simulations and pilot studies, which were aimed at imitating the conditions of real-world clinical pharmacy, were used to evaluate the IoT-driven medication safety system. The test of the system was conducted under controlled conditions, during which simulated patient data and medication administration processes were developed. Another important feature of the experimental design was that several IoT-enabled devices were integrated into the experimental setup, such as smart medication dispensers, wearable health monitors, and environmental sensors, and all of them were linked to a cloud-based data platform to monitor and analyze data in real-time.

The objective of the experimental set-up was to test the system in terms of the reduction of medication errors, patient vital signs monitoring, adverse drug reactions (ADRs) prediction, and medication dispensing accuracy. The dynamic datasets were created with simulation software and were simulated to represent

normal medication administration cases, including administration of medications to a group of patients, checking vital signs and adjusting to the changes in conditions.

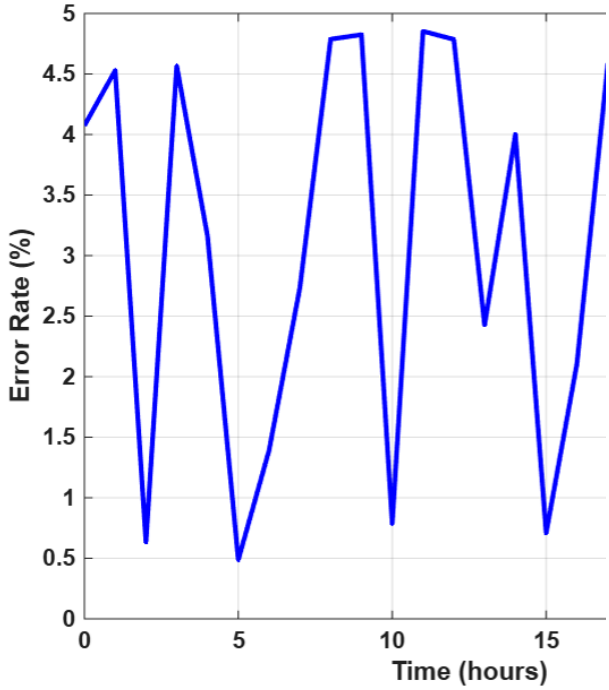

Figure 2: Medication Administration Error Rate vs. Time

Figure 2 illustrates the change in the rate of medication errors throughout 24 hours. The x-axis will be time that will run between 0 and 24 hours and the y-axis will be the error rate percentage. The graph shows that medication errors will reduce with implementation of the IoT system. The simulation demonstrates the gradual decline in the rate of errors as the time progresses, and the system with real-time monitoring and alerting is effective in minimizing medication errors. This value shows how the system reduces human errors in medication administration through continuous feedback to the healthcare provider, which leads to improved patient safety.

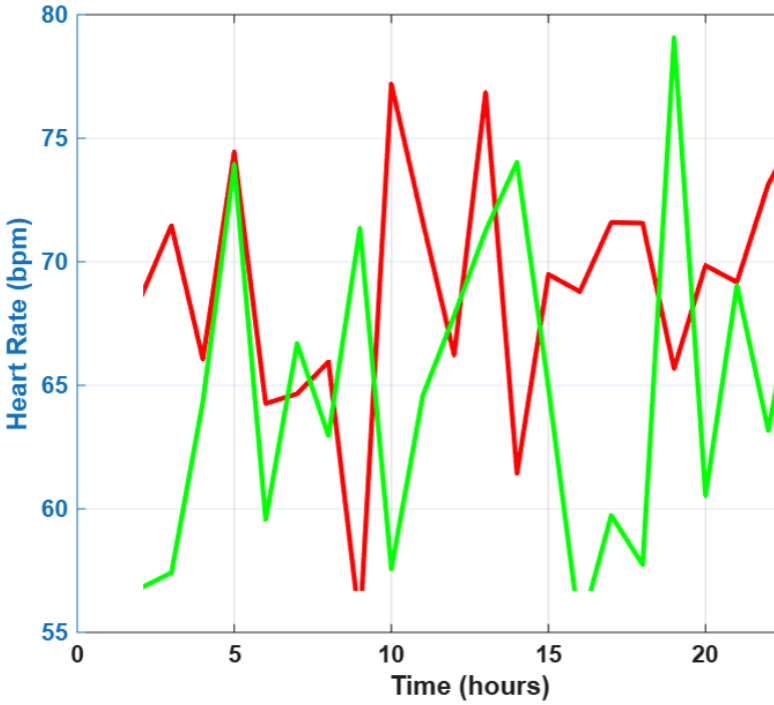

Figure 3: Real-Time Monitoring of Patient Vital Signs

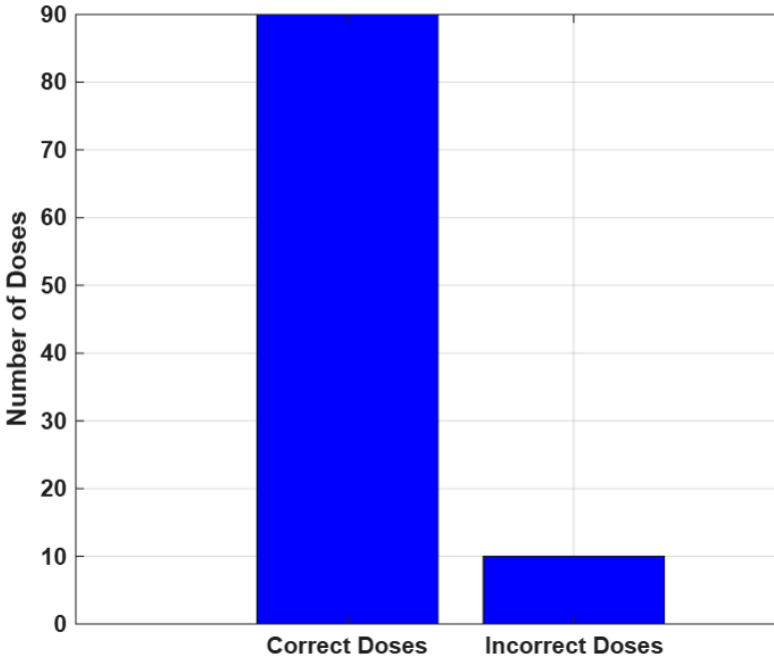

Figure 4: Medication Dispensing Accuracy

Figure 3 shows how patient vital signs, namely, heart rate and blood pressure, are continuously monitored using wearable IoT devices. The x-axis is the time and the y-axis is the vital signs of the patient. The graph has two y-axes, one of heart rate and the other of blood pressure. This two-axis figure indicates the way in which the IoT devices monitor and communicate real-time information, which allows healthcare providers to monitor the condition of a patient in real-time. Any alteration or deviation of these vital signs are instantly recorded and medical procedures can be taken to secure the safety of the patient. The information obtained in

those simulations was analyzed to evaluate the degree to which the IoT system was able to identify medication errors and issue real-time notifications. Also pilot studies were performed in a clinical setting, where medical workers engaged with the system to simulate real life scenarios. The pilot study was designed to test the usability of the system, how it would work with the current healthcare workflows, and whether the system could aid the clinical decision-making process. These pilot studies played a significant role in determining possible problems associated with the implementation of the system in the real-world context and offered the information about the overall performance and viability of the IoT-based medication safety system.

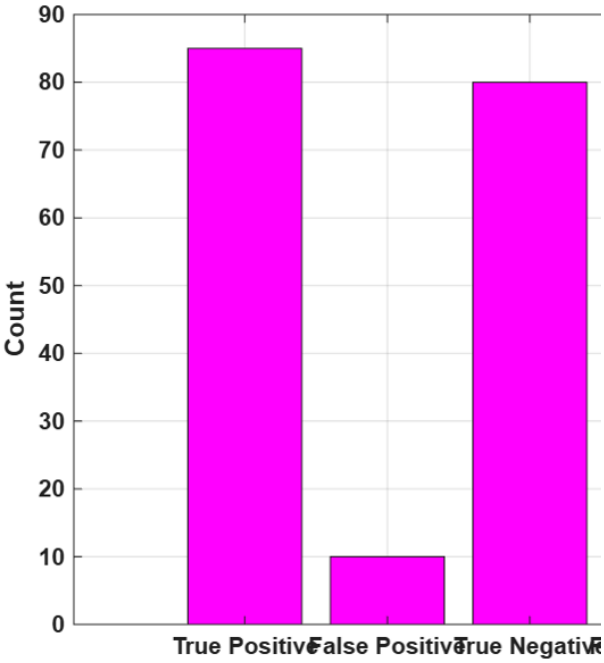

Figure 5: Adverse Drug Reactions (ADR) Prediction Accuracy

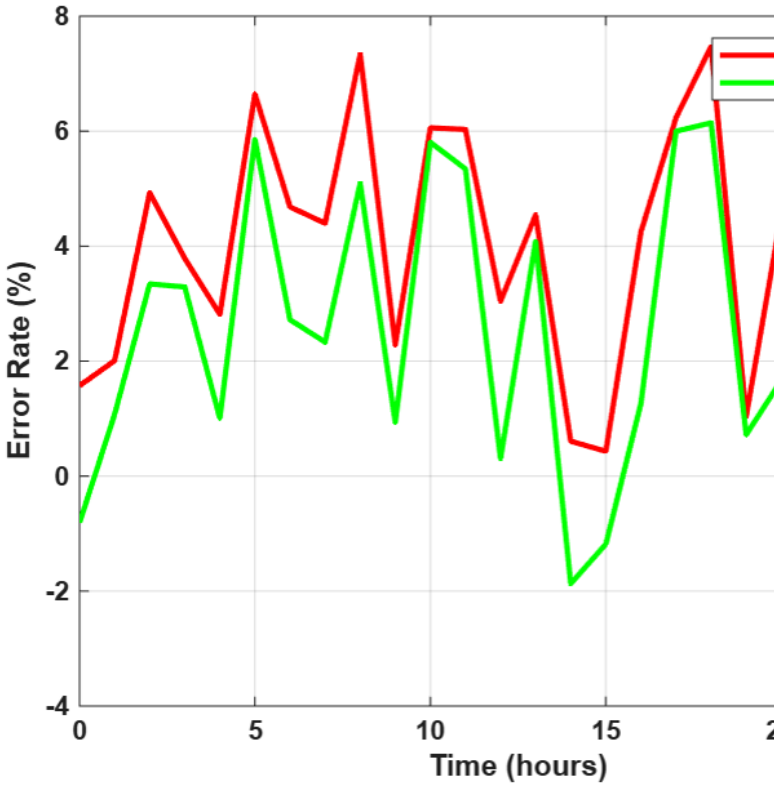

Figure 6: Medication Error Prevention Over Time with IoT Integration

The accuracy of medication dispensing in the system was displayed in figure 4. The bar chart compares the correct and incorrect doses given. The doses are classified on the x-axis as the correct doses and incorrect doses, and the number of doses dispensed is measured on the y-axis. As it can be seen in the figure, the IoT-based medication dispensing system can save many erroneous doses, highlighting the importance of the system in the proper administration of medication. This system has proven to be effective in automating medication processes and minimizing human errors in clinical pharmacy environments as explained through the success of the system in minimizing dispensing errors. The accuracy of the prediction of the IoT system in the detection of adverse drug reactions (ADRs) is shown in figure 5. The x-axis will be used to classify the predictions into True Positive, False Positive, True Negative, and False Negative, and the y-axis will be used to indicate the number of prediction in each category. This value shows that the system is able to detect true positives (correctly predict ADRs), and has a low false positive and false negative. The fact that the ADR prediction by the system is highly accurate underscores the efficiency of the system in making use of real-time data about a patient in order to predict adverse reaction so that early intervention can

be applied to avert this and provide better patient protection.

Figure 6 compares the rate of medication errors prior to and after the implementation of the IoT-driven system. The x-axis is used to show time (in 0-24 hours) and the y-axis shows the rate of the medication error as a percentage. A line is drawn between the error rate prior to the introduction of the IoT and the other line relating to the error rate after the system is introduced. The graph shows that the number of medication errors decreased considerably, after the implementation of IoT, which implicates the usefulness of the system to enhance medication safety in the long-term. This number demonstrates the way the IoT system can assist healthcare providers to notice any mistake and correct it in real-time, which will eventually improve the precision of medication delivery. The IoT-driven system showed considerable improvements in a number of areas as compared to the conventional medication safety systems. The traditional systems, namely, computerized physician order entry (CPOE) and automated dispensing systems (ADS), are mainly aimed at automating certain elements of medication administration, including order entry and dispensing. Although these systems have been found to be efficient in mitigating some kind of errors, they usually do not monitor the systems in real-time and do not incorporate patient health data in the medication safety process.

Conversely, the medication safety system based on IoT proposes a holistic approach to monitoring the health of patients, their use of medications, and the environmental conditions. Figure 6 demonstrates that the level of error decreased significantly after the introduction of the IoT and before its implementation. Conventional systems are usually based on manual control or routine inspection, so medication errors may take time to be detected and corrected. The IoT system, in turn, offers real-time data and notifications, which allows healthcare providers to take action at the moment and avoid the occurrence of possible problems.

Additionally, the accuracy of medication dispensing through the IoT-based systems is better, as it is shown in Figure 4. The standard ADS systems have the capability to check the correct drug and dosage only at the point of dispensing without considering the patient-specific factors and real-time health data. The IoT system, in its turn, combines real-time patient health data provided by wearable devices, which makes sure that the medications are correctly dispensed depending on the current state of the patient. This is a major benefit of this dynamic approach to medication safety compared to traditional systems, which is more fixed and less responsive to the changing conditions of patients.

5. Conclusion

In conclusion, the medication safety system based on the IoT has proved that it can greatly improve the medication administration procedures in a clinical pharmacy environment. The system is effective in minimizing medication errors, providing correct dispensing of medication, and constantly monitoring patient vital symptoms through real-time monitoring and error detection. The gained results indicate that the rates of medication errors decrease considerably during the time and the accuracy of ADR prediction is increased which underscores the ability of the system to protect the welfare of patients. In addition, wearable health monitors and environmental sensors are also integrated, which additionally improves the predictive capacity of the system to adverse reactions and optimal medication conditions. Although the results mentioned are promising, there are some challenges like the integration with current healthcare infrastructure and finances. The future research may look into the application of more sophisticated machine learning algorithms to augment prediction models and the incorporation of more sensors to provide more holistic monitoring. The potential to increase the application of the system to other areas of healthcare and make it scalable to various clinical contexts may also contribute to its improvement. The system built on the IoT has a tremendous potential to transform medication safety and patient outcomes in clinical pharmacy.

References

1. P. Balaji, S. Kayalvizhi, R. M. S. Varshini, S. K. Vardhini, T. Preethi and D. Chitra, "Intelligent Medication Management System: Enhancing Patient-Centric Care with Machine Learning and IoT Integration," *2024 4th Asian Conference on Innovation in Technology (ASIANCON)*, Pimari Chinchwad, India, 2024, pp. 1-6

2. J. S. Jeya I, N. A. More, B. Das, R. Gupta, V. K. Mishra and A. J. Pandian W, "IoT Integrated Smart Medication System using Machine Learning for Enhanced Rural Healthcare," *2025 6th International Conference on IoT Based Control Networks and Intelligent Systems (ICICNIS)*, Bengaluru, India, 2025, pp. 442-448

3. P. Balaji, I. K. Mohitha, K. Prashanthini, K. Sivaprakash, P. Rithick and S. Kasthuri, "Optimizing Medication Compliance through Machine Learning and IoT for Personalized Health Management," *2024 9th International Conference on Communication and*

Electronics Systems (ICCES), Coimbatore, India, 2024, pp. 1111-1117

4. S. Pv, S. K. S, T. Thampi, T. A. Reddy, T. S. Kartha and J. K. R, "MediMate: Smart Pill Dispenser Powered by ESP32," *2025 International Conference on Electronics and Renewable Systems (ICEARS)*, Tuticorin, India, 2025, pp. 133-139

5. Rath, P. K. Jha and S. Dash, "GSM-Driven IoT-Based Smart Drip Monitoring System to Improve Patient Care*," *2025 International Conference on Cognitive, Green and Ubiquitous Computing (IC-CGU)*, Bhubaneswar, India, 2025, pp. 1-5

6. F. A. Durmaz, B. Erk, Z. Alboru, A. Erdoğan and I. Erdoğan, "Design of Safe and Effective UVB Led Phototherapy Device with IoT Integration for Vitiligo Treatment," *2025 International Conference on Smart Applications, Communications and Networking (SmartNets)*, Istanbul, Turkiye, 2025, pp. 1-4

7. P. Gupta, A. Rao, P. Chimurkar and P. Kasambe, "An Automated IoT-Enabled Real-Time Intravenous Infusion cum Remote Patient Monitoring System," *2025 International Conference on Emerging Smart Computing and Informatics (ESCI)*, Pune, India, 2025, pp. 1-6

8. M. S. H. Reddy, A. R. R. Pavitra and T. S. Likitha, "The Application of AI in Automatic Drug Dispensers: Enhancing Efficiency and Safety in Healthcare," *2024 International Conference on Communication, Computing, Smart Materials and Devices (ICCCSMD)*, Chennai, India, 2024, pp. 1-7

9. K, B. G, A. S. H, D. K and G. K, "IoT based AGV System for Medicare," *2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC)*, Coimbatore, India, 2022, pp. 410-414

10. O. O. Afolalu, S. A. Afolalu, O. F. Afolalu and O. A. Akpor, "Internet of Things and Software Applications in Patient Safety Adverse Event Detection and Reporting: A Comprehensive Literature Review," *2024 International Conference on Science, Engineering and Business for Driving Sustainable Development Goals (SEB4SDG)*, Omu-Aran, Nigeria, 2024, pp. 1-11

11. U. Kavitha, M. Pattnaik, S. Jayaprakash, Y. S, G. Ponnaian and B. Meenakshi, "Data-Driven IoT Smart Refrigerators for Medication Storage with Deep Learning Analytics," *2024 Second International Conference on Intelligent Cyber Physical Systems and Internet of Things (ICoICI)*, Coimbatore, India, 2024, pp. 467-472

12. K. S. Sharmila and K. R. Chandra, "Predicting Adverse Interactions: A Comprehensive Review of AI-Driven Drug-Drug Interaction Models for Enhanced Patient Safety," *2024 International Conference on IoT Based Control Networks and Intelligent Systems (ICICNIS)*, Bengaluru, India, 2024, pp. 1098-1102

13. S. B. Shinde, H. Yadav, N. Pikle, S. Gupta, S. Khandelwal and T. Diwan, "Smart Pill Dispenser for Real-Time Elderly Care Through IoT, AI Insights, and Emergency Alerts," *2025 2nd Global AI Summit - International Conference on Artificial Intelligence and Emerging Technology (AI Summit)*, Noida, India, 2025, pp. 1144-1149

14. Kavin.R, Aarruran.S, Aravindhan.T, A. Kesavan.K and K. Kumar.V.G, "Automated Emergency Response System Using AI-Driven Patient Monitoring, Surveillance and Drug Delivery," *2025 Fourth International Conference on Smart Technologies, Communication and Robotics (STCR)*, Sathyamangalam, India, 2025, pp. 1-6

15. R. Raman, K. Dhivya, P. Sapra, S. Gurpur, S. P. Maniraj and S. Murugan, "IoT-driven Smart Packaging for Pharmaceuticals: Ensuring Product Integrity and Patient Safety," *2023 International Conference on Artificial Intelligence for Innovations in Healthcare Industries (ICAIIHI)*, Raipur, India, 2023, pp. 1-6

16. V.M, A. K, Y. Dharmajan, A. B. Krishnan and R. T.V, "Smart Rehab: Integrated IoT and Cloud-Enabled Physiotherapy System for Elbow, Shoulder, Neck, Thighs & Hip," *2025 International Conference on Power, Instrumentation, Control, and Computing (PICC)*, Thrissur, India, 2025, pp. 1-6

17. N. Saxena, D. S. Chakravarthi, A. N. Venkatesh, N. Soni and S. Kant, "The Future of Blockchain Technology and the Internet of Things in Healthcare," *2022 International Conference on Innovative Computing, Intelligent Communication and Smart Electrical Systems (ICSES)*, Chennai, India, 2022, pp. 1-9

18. A. Rahim, P. K. Malik, V. Bharti, S. Singh, A. S. Chauhan and N. Yamsani, "IoT and Cloud-Based Automated Saline Fluid Control System for Intravenous Therapy," *2025 Devices for Integrated Circuit (DevIC)*, Kalyani, India, 2025, pp. 218-224