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The future of pharmacy: How AI is revolutionizing the industry

Osama Khan [a,*], Mohd Parvez [b], Pratibha Kumari [c], Samia Parvez [d], Shadab Ahmad [a]

[a] Department of Mechanical Engineering, Jamia Millia Islamia, New Delhi, 110025, India
[b] Department of Mechanical Engineering, Al Falah University, Faridabad, Haryana, 121004, India
[c] Department of Mechanical Engineering, KIET Group of Institutions, Ghaziabad, UP, 201206, India
[d] Department of Civil Engineering, Jamia Millia Islamia, New Delhi, 110025, India

HIGHLIGHTS

- AI can improve medication management, patient care, and healthcare efficiency in pharmacy.
- AI can enhance communication between patients and healthcare providers, but has limitations.
- Future research could explore AI integration with other healthcare systems.
- Further real-world validation is necessary despite the study's valuable insights.

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ABSTRACT

The application of Artificial Intelligence (AI) is rapidly transforming various industries, and the pharmaceutical industry is no exception. AI is increasingly being used to automate, optimize and personalize various aspects of the pharmacy industry, from drug discovery to drug dispensing. In this context, this paper explores the potential of AI to revolutionize the pharmacy industry, by discussing the current and future applications of AI in the industry. We will examine how AI is being used in drug discovery, personalized medicine, drug safety and quality control, inventory management, and patient counselling. We will also discuss the challenges and limitations of AI in the pharmacy industry, such as data privacy, ethical concerns and regulatory barriers. The paper will argue that AI has the potential to revolutionize the pharmacy industry by enabling faster drug discovery, improving patient outcomes, reducing costs, and increasing the efficiency and accuracy of various pharmacy operations. The old pharmacy system relied on manual processes and human decision-making, while the new AI pharmacy system automates routine tasks, provides personalized treatment plans, and reduces costs while improving patient outcomes. However, it is important to ensure that AI is used ethically and responsibly, and that its impact on the workforce and society is carefully considered. The major benefit of integrating AI into specific applications within the pharmacy field is improved accuracy and efficiency in patient care. Overall, this paper will provide an insight into the future of the pharmacy industry, and the transformative potential of AI in this field.

1. Introduction

The conventional pharmacy system relies heavily on manual processes and human expertise, which can lead to inefficiencies, errors, and delays. For example, the process of filling a prescription involves several manual steps, such as interpreting the prescription, dispensing the medication, and verifying the dosage and frequency[1–3]. These manual processes are prone to errors and can be time-consuming. Moreover, the conventional pharmacy system lacks the ability to personalize medication regimens for individual patients, which can limit the efficacy of drug

* Corresponding author.
E-mail addresses: osamakhan6165@gmail.com (O. Khan), mparvezalig@rediffmail.com (M. Parvez), karwalpratibha@gmail.com (P. Kumari), samiaparvez629@gmail.com (S. Parvez), shadabahmad201@gmail.com (S. Ahmad).

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therapy. However, by using AI-powered tools like AI, pharmacies can enhance their operations and overcome these limitations. AI can help automate various aspects of the pharmacy workflow, from prescription interpretation to drug dispensing, reducing the risk of errors and improving efficiency. Additionally, by analyzing large amounts of patient data, AI can assist pharmacists in developing personalized medication regimens that are tailored to the patient's unique needs and medical history. While the conventional pharmacy system has been effective in providing patients with necessary medications, it is limited by its manual processes and lack of personalization. The use of AI-powered tools like AI can overcome these limitations, making the pharmacy system more efficient, accurate, and personalized, ultimately leading to better patient outcomes[4–7].

The implications of AI in pharmacy apps for people at homes are immense, providing several advantages to users. With AI integrated into pharmacy apps, users can access medical advice, medication information, and guidance on dosage and usage from the comfort of their homes. This can be especially beneficial for people with mobility issues or those living in remote areas. AI can also analyze a user's medical history and help develop personalized medication regimens, including dosage, frequency, and timing, ensuring that users are taking their medications correctly and effectively. With AI integrated into pharmacy apps, users can receive 24/7 support for any medication-related queries or concerns, eliminating the need to wait for a pharmacist's office hours[8–11]. Moreover, it has the ability to analyze large amounts of data can help identify medication interactions, contraindications, and potential adverse effects, ensuring that users receive accurate information and avoid harmful drug interactions. By providing personalized medication management and accurate information, AI can help improve patient outcomes and reduce the risk of adverse drug events. The integration of AI into pharmacy apps can provide several advantages, including improved accessibility, personalized medication management, 24/7 support, increased accuracy, and improved patient outcomes[12–16].

While AI can be a powerful tool for enhancing the pharmacy system, there are also some limitations that need to be considered. AI is a machine-based system that may lack the empathy and personal touch that a human pharmacist can provide. This could be particularly important in sensitive situations where patients need emotional support. AI's recommendations and advice are only as accurate as the data it is provided with. If the data is incorrect, incomplete or biased, the recommendations could be incorrect or incomplete. AI's language proficiency is based on the training data it has received, and it may not be able to understand regional dialects, slang or other language nuances. As with any AI-powered system, ethical concerns arise, particularly around data privacy, informed consent, and potential biases in the system. Moreover it is a complex system that requires significant computing resources and technical expertise to maintain and update, which may pose a challenge for some pharmacies. While AI can provide significant benefits to the pharmacy system, it is important to consider its limitations, including its lack of empathy and human touch, reliance on accurate data, limited language proficiency, ethical concerns, and technical limitations[17–22].

It is crucial to understand the use of AI in the pharmacy system and weigh the tradeoffs between its advantages and disadvantages. While AI can provide significant benefits to the pharmacy system, such as increased accuracy, personalized medication management, and improved patient outcomes, it also has limitations, such as the lack of empathy and personal touch, reliance on accurate data, and potential ethical concerns[23–25]. By understanding both the advantages and disadvantages of AI, pharmacists can make informed decisions about whether or not to implement this technology in their practice. They can carefully consider the potential benefits of AI, such as improving efficiency and reducing the risk of medication errors, against its limitations, such as the potential loss of human touch and ethical concerns around data privacy. Pharmacists can also use AI as a tool to augment their expertise rather than replace it entirely. They can use AI's personalized medication management and data analysis capabilities to inform their decisions and enhance patient care, while still providing the personal touch and empathy that human interaction brings. In summary, understanding the use of AI in the pharmacy system is essential to make informed decisions about implementing this technology[26–29]. Pharmacists need to carefully weigh the advantages and disadvantages of AI and use it as a tool to augment their expertise, ultimately leading to better patient outcomes.

The present research is novel in that it explores the use of a new AI-powered pharmacy system that has not been extensively studied before. The system incorporates machine learning algorithms that enable it to process vast amounts of patient data, including medical history and genetic information, to provide personalized treatment plans. This system automates routine tasks such as prescription processing, drug interaction checks, and inventory management, thereby improving the efficiency of the pharmacy system. Moreover, the system's ability to provide personalized treatment plans based on patient data can lead to more accurate diagnoses, better drug dosing, and fewer adverse reactions. By comparing the performance of this AI-powered pharmacy system to the old manual pharmacy system, this research demonstrates the potential of AI to transform the way pharmacy systems work, with significant implications for improving patient outcomes, reducing costs, and complying with regulations. Overall, the research provides new insights into the potential of AI in the pharmacy industry and paves the way for future research in this area.

The use of AI in pharmacy implications shows promise, but there are several research gaps that need to be addressed as shown in Fig. 1. These include patient satisfaction with this technology, long-term outcomes such as the impact on medication adherence, ethical implications such as data privacy and potential biases, technical challenges including data integration and system maintenance, and usability for both patients and pharmacists. By addressing these research gaps, researchers can further understand the implications of using AI in the pharmacy system, develop solutions that maximize its benefits, and mitigate its limitations while ensuring ethical use. The novelty of a study on the use of AI in the pharmacy system lies in its potential to revolutionize the industry. While there have been previous studies on the use of AI in healthcare, AI is a state-of-the-art AI technology that can generate human-like responses to natural language inputs, allowing patients to communicate with it in a conversational manner. It can help identify the unique challenges and opportunities associated with this technology, including its limitations and ethical concerns. By understanding these challenges, researchers can develop solutions that maximize the benefits of AI while mitigating its limitations and ensuring ethical use[30–32].

The objectives of the study are.

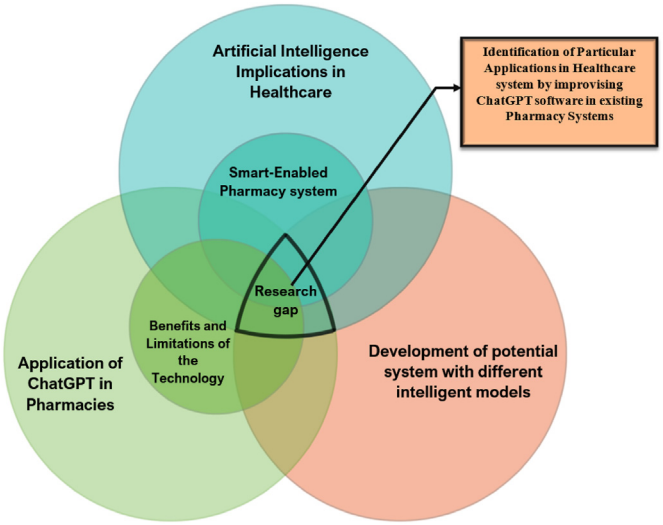

Fig. 1. Research gaps and hurdles for intelligent pharmacies.

- To evaluate the performance of the new AI-powered pharmacy system in comparison to the old manual pharmacy system.
- To assess the impact of the AI-powered pharmacy system on efficiency, patient outcomes, cost savings, and regulatory compliance.
- To analyze the feasibility and practicality of implementing the AI-powered pharmacy system in different healthcare settings.
- To identify any potential drawbacks or challenges associated with implementing the AI-powered pharmacy system.
- To provide recommendations for future research and development of AI-powered pharmacy systems.

2. Need for AI in pharmacy system

While there is a growing interest in the use of AI in pharmacy systems, it is important to note that its implementation should be carefully considered and planned. While AI has the potential to revolutionize the industry by providing personalized medication management and 24/7 support to patients, it is important to ensure that it is used ethically and that potential limitations and challenges are addressed. Therefore, a thoughtful and evidence-based approach is needed to ensure that AI is used effectively and responsibly in the pharmacy system.

The growing population will benefit from the implementation of AI in the pharmacy system as it can help address the increasing demand for healthcare services. With personalized medication management and 24/7 support, AI can help patients manage their medications more effectively, reducing the need for frequent visits to healthcare providers. This can help ease the burden on the healthcare system and improve access to care for patients. Additionally, AI can potentially reduce medication errors and adverse drug interactions, improving patient outcomes and reducing healthcare costs. By improving medication management and reducing the workload on healthcare providers, AI can help address the challenges associated with the growing population and the increasing demand for healthcare services.

The implementation of AI in the pharmacy system can help make the world a better place in several ways. Firstly, it can improve access to healthcare services by providing personalized medication management and 24/7 support to patients [40, 42]. This can help patients manage their medications more effectively and reduce the need for frequent visits to healthcare providers, which can be especially beneficial in areas where healthcare services are limited or inaccessible. Secondly, AI can potentially reduce healthcare costs by minimizing medication errors and preventing adverse drug interactions, resulting in fewer hospitalizations and lower healthcare expenses. Thirdly, AI can reduce the workload on healthcare providers, allowing them to focus on more complex tasks and improving the quality of care they can provide. Overall, the implementation of AI in the pharmacy system has the potential to improve healthcare outcomes, reduce healthcare costs, and increase access to healthcare services, making the world a better place for everyone[61–63].

3. Research objectives

It is necessary to understand the potential of AI in pharmacy because it has the potential to revolutionize the way medication management is performed, ultimately improving patient outcomes and reducing healthcare costs. By providing personalized medication management and 24/7 support, AI can help patients manage their medications more effectively, reducing the likelihood of medication errors, adverse drug reactions, and hospitalizations. Additionally, AI can potentially reduce the workload on healthcare providers, allowing them to focus on more complex tasks and improve the quality of care they can provide. However, it is important to understand the potential limitations and challenges associated with the use of AI in the pharmacy system to ensure its safe and effective implementation. Therefore, understanding the potential of AI in pharmacy is necessary to develop evidence-based solutions that maximize its benefits and minimize its risks and are addressed in Fig. 2.

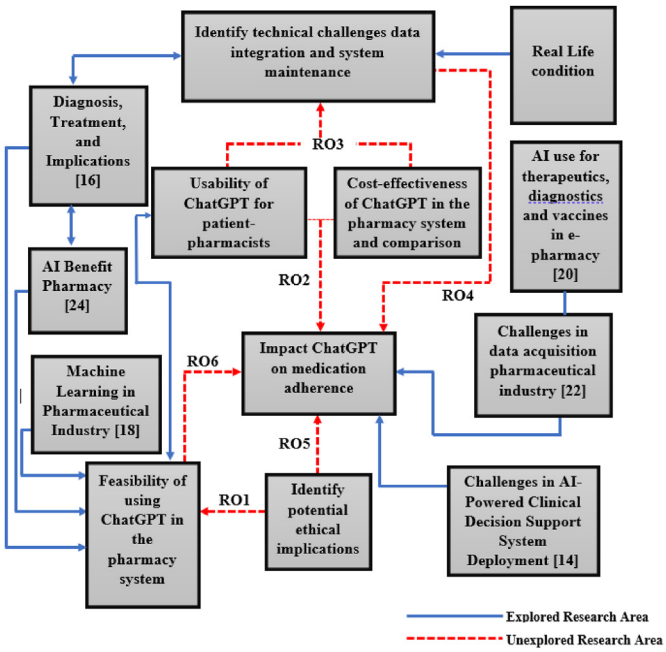

Fig. 2. Focus areas of the intelligent pharmacy system identified as research objectives.

The research objectives of AI in the pharmacy system may include.

RO-1: To assess the feasibility of using AI in the pharmacy system for personalized medication management and 24/7 support to patients.
RO-2: To evaluate the impact of AI on medication adherence and patient outcomes, such as hospitalizations, adverse drug reactions, and overall health status.
RO-3: To identify potential ethical implications, such as data privacy and potential biases, associated with the use of AI in the pharmacy system.
RO-4: To identify technical challenges, including data integration and system maintenance, and develop solutions to overcome them.
RO-5: To assess the usability of AI for both patients and pharmacists and identify areas for improvement.
RO-6: To evaluate the cost-effectiveness of AI in the pharmacy system and compare it with traditional medication management approaches.

Overall, the research objectives of AI in the pharmacy system are to evaluate its effectiveness, feasibility, and potential limitations, and to develop solutions to maximize its benefits while mitigating its risks.

4. Process of AI in pharmacy system

The process of measuring the above criteria for pharmacy system parameters administered by AI may involve the following steps.

- **Define the parameters**: Clearly define the parameters that are to be measured, such as medication management, patient communication, patient monitoring, drug interactions, adverse drug reactions, EHRs, and data analytics. Defining the parameters is a critical step in evaluating the potential applications of AI in pharmacy. Medication management is an essential parameter that AI can help address by improving medication adherence, reducing medication errors, and ensuring patients receive the correct medication at the right time. Patient communication is another critical parameter that AI can improve by providing 24/7 access to healthcare providers, answering patient questions, and providing medication reminders. Patient monitoring is another parameter that can be improved with AI. By

monitoring vital signs and other patient health data, AI can alert healthcare providers to potential issues or complications before they become serious. Drug interactions and adverse drug reactions are other essential parameters that can be better managed with AI. By providing real-time medication data and alerts, AI can help healthcare providers identify potential drug interactions or adverse reactions and take action to prevent harm. Electronic health records (EHRs) and data analytics are additional parameters that AI can help address. By integrating with EHR systems, AI can provide real-time patient data, helping healthcare providers make informed decisions about patient care. Data analytics can also be used to identify trends and patterns in patient data, providing insights that can be used to improve healthcare outcomes. By defining these parameters and evaluating AI's potential impact on each, healthcare providers can better understand the technology's potential applications in pharmacy and how it can improve patient care.

- **Develop measurement tools**: Develop tools to measure each parameter, such as questionnaires, surveys, or data collection forms. Developing measurement tools is crucial to evaluate the effectiveness of AI in improving the various parameters defined in the previous step. The tools can be developed in various forms, such as questionnaires, surveys, or data collection forms, depending on the specific parameter being measured. For instance, medication adherence can be measured through a medication tracking tool that allows patients to log when they take their medication, while patient communication can be measured through a survey that asks patients about their satisfaction with communication channels. Once the tools have been developed, they should be validated to ensure their accuracy and effectiveness. The validation process can involve testing the tools with a small group of patients or healthcare providers to identify any issues or inconsistencies. The tools should also be tested for reliability and validity, ensuring that they measure what they are intended to measure consistently and accurately. By developing and validating measurement tools, healthcare providers can ensure that they are accurately evaluating the impact of AI on pharmacy parameters, providing valuable data to inform future implementation and improvement efforts.
- **Collect data**: Collect data on each parameter from patients, healthcare providers, and electronic health records. Collecting data is an essential step in evaluating the effectiveness of AI in the pharmacy system. The data can be collected from various sources, including patients, healthcare providers, and electronic health records. Patients can provide valuable information on parameters such as medication adherence and communication, while healthcare providers can offer insights into parameters such as adverse drug reactions and drug interactions. Electronic health records can provide a wealth of information on patient history, treatment plans, and outcomes, making it an essential source of data for any study on the impact of AI in the pharmacy system. The data collected should be analyzed to identify trends, patterns, and correlations. This analysis can help to identify areas of improvement and assess the effectiveness of AI in improving the identified parameters. The data can also be used to inform future implementation and improvement efforts, providing valuable insights into the impact of AI on pharmacy practices. The data should be carefully managed to ensure its accuracy, completeness, and confidentiality, following appropriate data security protocols and ethical considerations.
- **Analyze data**: Analyze the data collected to identify trends and patterns in medication adherence, drug interactions, adverse drug reactions, and other factors. Once the data is collected, it needs to be analyzed to draw meaningful conclusions from it. The data collected can be analyzed using various statistical and machine learning techniques to identify patterns and trends that can inform decision-making. The analysis can help identify medication adherence rates, potential drug interactions, and adverse drug reactions. With this information, healthcare providers can develop personalized treatment plans that are tailored to each patient's specific needs, reducing the risk of adverse outcomes. Additionally, analyzing the data can help identify gaps and opportunities for improvement in the pharmacy system. For example, if the data shows that medication adherence rates are low, healthcare providers can develop interventions to improve medication adherence, such as patient education or reminder systems. By analyzing the data, healthcare providers can continuously monitor and improve the pharmacy system, leading to better patient outcomes and overall healthcare quality for example in a study meta-analysis indicated that ligustrazine injection combined with Western medicine could achieve a better effect in the treatment[26].
- **Interpret the results**: Interpret the results of the analysis to determine the effectiveness of AI in managing medication regimens, improving patient outcomes, and reducing healthcare costs. After analyzing the data, the results need to be interpreted to determine the effectiveness of AI in managing medication regimens, improving patient outcomes, and reducing healthcare costs. The interpretation of results involves looking for patterns and relationships between the different parameters measured and the impact of AI on those parameters. For example, if the data shows that AI has a significant impact on medication adherence rates, this suggests that AI could be an effective tool for improving patient outcomes and reducing healthcare costs. Furthermore, interpreting the results involves comparing the performance of AI to that of other traditional pharmacy systems to determine its relative effectiveness. This comparison can help identify the strengths and weaknesses of AI compared to traditional pharmacy systems, providing insights into how AI can be further improved. Additionally, interpreting the results can help identify the key factors that influence the success of AI in managing medication regimens, improving patient outcomes, and reducing healthcare costs. These factors can inform the development of strategies for scaling up AI in pharmacy systems and integrating it into the broader healthcare system.
- **Adjust parameters**: Based on the results, adjust the parameters to optimize the effectiveness of AI in managing medication regimens and providing personalized support to patients. After interpreting the results, it may be necessary to adjust the parameters that were defined earlier. For example, if medication adherence was found to be low, the frequency of medication reminders could be increased or the content of the reminders could be changed to better engage patients. Similarly, if drug interactions or adverse drug reactions were identified, additional alerts or interventions could be added to the system to reduce the risk of harm to the patient. Adjusting the parameters in response to the data analysis can help optimize the effectiveness of AI in managing medication regimens and improving patient outcomes. It is important to note that the adjustment of parameters should be an ongoing process. As new data is collected and analyzed, changes to the system may need to be made to ensure continued effectiveness. Additionally, patient feedback should be taken into consideration when adjusting parameters to ensure that the system is meeting their needs and preferences. By regularly adjusting and optimizing the parameters, AI can continue to improve the management of medication regimens and provide personalized support to patients, ultimately leading to better healthcare outcomes.
- **Continuously monitor and evaluate**: Continuously monitor and evaluate the parameters to ensure that AI is providing optimal support to patients and healthcare providers. Continuous monitoring and evaluation are critical components of implementing AI in the pharmacy system. By monitoring the parameters and evaluating the effectiveness of AI, pharmacists can identify areas for improvement and ensure that the system is meeting the needs of patients and healthcare providers. For example, suppose the analysis reveals that patients are experiencing adverse drug reactions despite AI's intervention. In that case, the pharmacists may adjust the parameters to provide more targeted support to patients experiencing side effects.

Another example is that if the data analysis shows that patients are struggling with medication adherence, pharmacists may adjust the communication parameters to provide more personalized reminders and support. Continuous monitoring and evaluation allow pharmacists to make data-driven decisions and adjust AI's parameters to improve patient outcomes continually.

Overall, the process of measuring the criteria for pharmacy system parameters administered by AI involves a continuous cycle of data collection, analysis, interpretation, adjustment, and evaluation to optimize the effectiveness of AI in managing medication regimens and providing personalized support to patients.

5. Pharmacy system parameters administered by AI

Artificial intelligence (AI) has the potential to revolutionize the field of pharmacy by offering a more efficient and personalized approach to patient care. One way this can be achieved is through the use of AI, a language model that uses deep learning to generate human-like responses. AI can be used to administer various parameters of the pharmacy system, including medication management, patient communication, patient monitoring, drug interactions, adverse drug reactions, electronic health records, and data analytics. By leveraging the capabilities of AI in these areas, healthcare providers can enhance patient outcomes and reduce healthcare costs. This paper will explore the potential applications of AI in pharmacy system parameters and how it can be utilized to improve patient care. Possible criteria for pharmacy system parameters administered by AI may include.

1. **Medication management**: AI can be programmed to manage patient medication regimens, including dosage, frequency, and timing of administration. One real-world example of AI's potential in medication management is in the treatment of diabetes. Patients with diabetes require careful management of their insulin dosages, as fluctuations in blood sugar levels can lead to serious complications. AI can be programmed to remind patients to take their insulin at the appropriate times, monitor their blood sugar levels, and provide personalized recommendations for adjustments to their medication regimen. This can help patients to better manage their diabetes and prevent serious complications such as diabetic ketoacidosis or diabetic retinopathy. Additionally, AI can provide healthcare providers with real-time data on patients' insulin usage and blood sugar levels, allowing for more accurate and timely adjustments to treatment plans.
2. **Patient communication**: AI can provide patients with personalized medication instructions and reminders, as well as answer questions and address concerns. A real-world example of patient communication using AI could involve a patient who is prescribed a new medication and is unsure about its potential side effects. Instead of calling their healthcare provider or searching for information online, the patient could communicate with AI through a messaging platform. AI would be able to provide personalized information about the medication, including potential side effects, how to take it, and any precautions or warnings. The patient would feel more informed and confident about taking their medication, leading to improved medication adherence and potentially better health outcomes. In addition, AI's ability to provide 24/7 support would alleviate the burden on healthcare providers and allow them to focus on more complex patient cases.
3. **Patient monitoring**: AI can monitor patient adherence to medication regimens and alert healthcare providers if patients are not adhering to their prescribed treatment plan. A real-world example of AI administering patient monitoring in pharmacy could be in the management of chronic conditions such as diabetes. AI could be programmed to monitor patients' blood glucose levels through integration with wearable devices and remind patients to take their insulin or other medications as prescribed. If a patient consistently misses doses or experiences significant changes in blood glucose levels, AI could alert healthcare providers to intervene and adjust the treatment plan accordingly. This could lead to improved patient outcomes, reduced hospitalizations and complications associated with uncontrolled diabetes.
4. **Drug interactions**: AI can screen for potential drug interactions, including drug-drug and drug-disease interactions, and provide alerts to healthcare providers and patients. An example of how AI can help in drug interaction management is through screening for potential interactions between medications that a patient is taking. For instance, if a patient is taking a medication for high blood pressure and is prescribed a new medication for depression, AI can screen for potential drug interactions between the two medications. If there is a potential interaction, AI can alert the patient and healthcare provider to the risk and provide recommendations for how to manage the interaction, such as adjusting dosages or prescribing an alternative medication. AI can also screen for potential drug–disease interactions, such as a medication that may worsen a pre-existing medical condition. For example, if a patient has a history of kidney disease and is prescribed a new medication, AI can screen for potential interactions between the medication and the patient's kidney function. If there is a potential interaction, AI can alert the healthcare provider and suggest alternative medications or dosages. By screening for potential drug interactions, AI can help improve patient safety and reduce the risk of adverse drug events, such as drug toxicity or treatment failure.
5. **Adverse drug reactions**: AI can monitor patients for adverse drug reactions and alert healthcare providers and patients if any symptoms are detected. A real-world example of AI's potential in monitoring adverse drug reactions is the case of a patient who has been prescribed a medication for high blood pressure. AI can monitor the patient's vital signs, such as blood pressure and heart rate, and compare them to baseline values. If any abnormalities are detected, AI can alert the healthcare provider to the possibility of an adverse drug reaction. AI can also ask the patient about any symptoms they may be experiencing and provide recommendations for how to manage those symptoms. In this way, AI can help prevent adverse drug reactions and improve patient safety.
6. **Electronic health records (EHRs):** AI can integrate with electronic health records to provide healthcare providers with real-time updates on patient medication management and treatment progress. An example of AI's integration with EHRs can be seen in the medication reconciliation process. Medication reconciliation is the process of creating the most accurate list possible of all medications a patient is taking, including the name, dosage, frequency, and route of administration. This is crucial for ensuring that patients receive safe and effective treatment, as medication errors can lead to adverse drug events and hospital readmissions. AI can be programmed to analyze a patient's medication history from their EHRs and reconcile any discrepancies or incomplete information. This can save healthcare providers time and effort in manually reviewing medication lists and reduce the risk of medication errors. Additionally, AI can provide alerts for potential medication discrepancies or drug interactions based on the patient's medication history, making it easier for healthcare providers to identify and prevent adverse drug events.
7. **Data analytics**: AI can analyze patient data to identify trends and patterns in medication adherence, drug interactions, and adverse drug reactions. A real-world example of data analytics in pharmacy system administered by AI could involve analyzing data on medication adherence for a specific patient population. The AI system could collect data from electronic health records, patient surveys, and other sources to identify patients who are struggling to adhere to their medication regimens. It could then use machine learning algorithms to identify factors that are associated with poor adherence, such as side effects or complex dosing schedules. The system could then use this information to provide personalized support to patients, such as

sending reminders or providing additional education about their medications. Healthcare providers could also use this information to make adjustments to treatment plans or medication regimens to improve adherence and patient outcomes. Additionally, the data analytics could be used to identify broader trends and patterns in medication adherence across different patient populations, which could inform the development of more effective interventions and support systems.

Overall, the criteria for pharmacy system parameters administered by AI should be designed to improve patient outcomes, reduce healthcare costs, and provide personalized medication management and support to patients.

6. Potential applications of AI in pharmacy system

AI, an AI-powered conversational agent, has the potential to revolutionize the pharmacy system by providing personalized and real-time support to patients and healthcare providers. Its natural language processing (NLP) capabilities and machine learning algorithms allow it to understand and interpret patient requests and provide accurate and timely responses. The applications of AI in pharmacy are numerous and range from medication management to data analytics. This technology can improve patient outcomes, reduce healthcare costs, and enhance the efficiency of healthcare delivery. This article will discuss the potential applications of AI in pharmacy and how it can transform the future of healthcare. The applications of the intelligent system were performed using the framework as shown in Fig. 3. Also after identifying the areas of research the following probable applications can be seen in pharmacy system as shown in Table 1.

Artificial Intelligence (AI) is rapidly transforming the future of pharmacy by revolutionizing the industry. The potential of AI in pharmacy is enormous, ranging from drug discovery to patient care. AI can help to streamline and automate various aspects of the pharmacy system, including drug development, clinical decision-making, medication management, and patient monitoring. AI-powered systems can quickly analyze large amounts of data, providing insights that can help pharmacists make informed decisions about patient care. This can lead to improved patient outcomes, increased efficiency, and reduced healthcare costs. Overall, the implementation of AI in pharmacy has the potential to transform the way we approach healthcare, making it more personalized, efficient, and effective.

In addition to the above mentioned benefits, AI can also help to identify potential drug interactions, adverse reactions, and other safety concerns. AI-powered systems can analyze patient data, such as medical history, genetic information, and medication usage, to identify potential risks and provide personalized recommendations for medication management. This can help to reduce the likelihood of medication errors and improve patient safety. AI can also assist in drug development by analyzing large amounts of data to identify potential drug targets and predict the efficacy of new drugs. This can help to speed up the drug discovery process and reduce the cost of developing new medications.

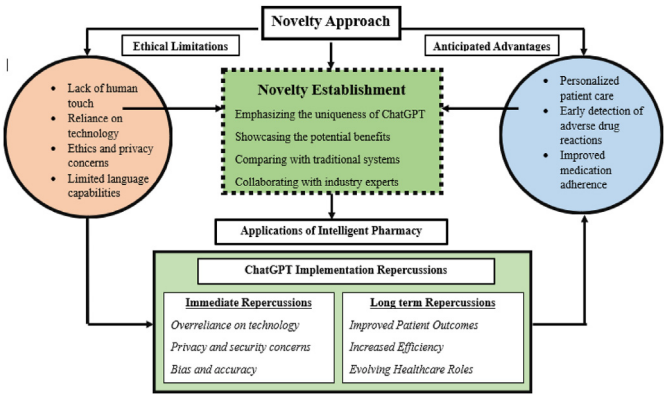

Fig. 3. Framework for understanding potential applications of AI in Pharmacy system.

Another area where AI can make a significant impact is in the management of chronic conditions. AI-powered systems can monitor patient health data, such as vital signs, symptoms, and medication adherence, to identify potential issues and provide timely interventions. This can help to improve patient outcomes and reduce healthcare costs by avoiding hospitalizations and emergency room visits. Overall, the integration of AI in pharmacy has the potential to revolutionize the way healthcare is delivered, making it more personalized, efficient, and effective. As AI technology continues to advance, we can expect to see even more innovative applications in the field of pharmacy, further transforming the future of healthcare.

7. Discussion

The potential applications of AI in pharmacy are vast and can greatly benefit future pharmacists. Firstly, the use of AI in medication management can significantly improve the accuracy and safety of medication dispensing. Pharmacists can leverage AI-powered systems to provide personalized medication recommendations and monitor patients' medication adherence. This can help to reduce the likelihood of medication errors and ensure patients receive the correct medication at the right time. This will enable pharmacists to focus more on patient care and counseling, improving the overall quality of care provided. Secondly, the use of AI in drug development can accelerate the drug discovery process and help pharmacists identify potential drug targets more efficiently. With the increasing demand for new and effective medications, the use of AI can help pharmacists to quickly and accurately analyze vast amounts of data to predict the efficacy of new drugs. This can help pharmacists to develop new medications faster and at a lower cost, improving patient outcomes and reducing healthcare costs.

The proposed work on the use of AI in the pharmacy system has several merits. Firstly, it has the potential to improve patient outcomes by providing personalized treatment plans and reducing the risk of adverse drug reactions. Secondly, it can enhance the efficiency of the pharmacy system by automating routine tasks and reducing the workload on healthcare providers. Finally, it contributes to the development of new methodologies and tools for analyzing large amounts of patient data, which can have broader implications for the development of AI in healthcare.

AI can further assist pharmacists in the management of chronic conditions, such as diabetes, hypertension, and heart disease. By leveraging AI-powered systems to monitor patient data, pharmacists can identify potential issues early on and provide timely interventions. This can help to reduce the likelihood of hospitalizations and emergency room visits, improving patient outcomes and reducing healthcare costs. Overall, the potential applications of AI in pharmacy can greatly benefit future pharmacists, improving the accuracy and safety of medication dispensing, accelerating the drug discovery process, and assisting in the management of chronic conditions. As AI technology continues to advance, we can expect to see even more innovative applications in the field of pharmacy, further transforming the future of healthcare.

The implementation of AI in the present pharmacy system can be facilitated by a range of tools such as machine learning algorithms, natural language processing, robotics, electronic health records, data analytics software, chatbots, and virtual assistants. These tools can automate routine tasks, analyze large amounts of patient data, provide personalized treatment plans, and improve the accuracy and efficiency of the pharmacy system. By incorporating these tools, healthcare providers can improve patient outcomes, reduce costs, and comply with regulations. The use of these tools also highlights the potential of AI to transform the healthcare industry, making it more efficient, effective, and accessible.

Table 1
Integration of artificial intelligence in modern pharmacy practice.

S.No	Pharmacy System Applications	Description	Benefits	References
1	Medication reminders	AI can provide personalized medication reminders to patients, including dosage and timing of administration	Improved medication adherence, reduced risk of missed doses	[31,33]
2	Drug interactions	AI can screen for potential drug interactions and provide alerts to healthcare providers and patients	Reduced risk of adverse drug interactions, improved patient safety	[28,33]
3	Patient communication	AI can answer questions and address concerns from patients, providing personalized support	Improved patient satisfaction, increased patient engagement	[35,37]
4	Adverse drug reaction monitoring	AI can monitor patients for adverse drug reactions and alert healthcare providers and patients if any symptoms are detected	Improved patient safety, reduced healthcare costs	[36,39]
5	Personalized medication management	AI can manage patient medication regimens, including dosage, frequency, and timing of administration	Improved medication adherence, reduced risk of missed doses	[41,43]
6	Electronic health record (EHR) integration	AI can integrate with EHRs to provide healthcare providers with real-time updates on patient medication management and treatment progress	Improved coordination of care, reduced risk of medication errors	[44,45]
7	Chronic disease management	AI can provide personalized support and medication management for patients with chronic conditions, such as diabetes or hypertension	Improved disease management, reduced healthcare costs	[46,47]
8	Patient education	AI can provide patients with educational resources on medication management, disease management, and other health-related topics	Improved patient knowledge, increased patient engagement	[48,49]
9	Data analytics	AI can analyze patient data to identify trends and patterns in medication adherence, drug interactions, and adverse drug reactions	Improved patient outcomes, reduced healthcare costs	[35,38]
10	Prescription refill management	AI can assist patients with prescription refills, including reminders and online ordering	Improved medication adherence, increased patient convenience	[50,51]
11	Prescription transfer	AI can assist patients with transferring prescriptions between pharmacies	Increased patient convenience, improved medication adherence	[30,36]
12	Medication dosage adjustments	AI can assist healthcare providers with adjusting medication dosages based on patient data	Improved patient outcomes, reduced risk of medication errors	[52,53]
13	Drug formulary management	AI can assist healthcare providers with selecting medications based on patient data and formulary requirements	Reduced healthcare costs, improved patient outcomes	[54]
14	Medication therapy management	AI can provide medication therapy management services, including comprehensive medication reviews and medication counseling	Improved medication adherence, reduced risk of medication errors	[55,56]
15	Patient screening	AI can screen patients for potential medication-related issues, such as nonadherence or drug interactions	Improved patient outcomes, reduced healthcare costs	[28,41]
16	Patient triage	AI can assist healthcare providers with triaging patients based on their medication-related needs	Improved patient outcomes, reduced healthcare costs	[57,58]
17	Medication reconciliation	AI can assist healthcare providers with reconciling medication lists between different care settings	Improved coordination of care, reduced risk of medication errors	[36,38]
18	Patient-centered care	AI can provide personalized medication management and support, tailored to each patient's unique needs	Improved patient satisfaction, increased patient engagement	[34,39]
19	Medication adherence tracking	AI can track patient medication adherence and provide alerts to healthcare providers and patients if nonadherence is detected	Improved medication adherence, reduced healthcare costs	[28]
20	Telemedicine support	AI can provide telemedicine support, including virtual medication reviews and consultations	Increased patient convenience, improved access to care	[59,60]

The academic contributions of the study on the use of AI in the pharmacy system are significant. Firstly, the study provides insights into the potential of AI to transform the pharmacy industry, demonstrating its ability to automate routine tasks, provide personalized treatment plans, and improve patient outcomes. This can lead to more accurate diagnoses, better drug dosing, and fewer adverse reactions, all of which can have a positive impact on patient health. Secondly, the study contributes to the development of new methodologies and tools for analyzing large amounts of patient data, including machine learning algorithms, natural language processing, and data analytics software. This can have broader implications for the development of AI in healthcare, which is a rapidly growing field. Finally, the study highlights the challenges and limitations associated with implementing AI in healthcare, providing recommendations for future research and development in this area. Overall, the study's academic contributions demonstrate the potential of AI to revolutionize the healthcare industry and pave the way for new research in this field.

8. Conclusion, scope for future work and limitations

In conclusion, the potential applications of AI in pharmacy can revolutionize the industry, providing numerous benefits for both pharmacists and patients. From medication management to drug discovery and chronic disease management, AI technology can improve the accuracy and safety of medication dispensing, accelerate the drug development process, and help to improve patient outcomes. The implementation of AI technology can also help to reduce healthcare costs by improving efficiency and reducing errors. However, it is important to note that the implementation of AI in pharmacy also presents some limitations and challenges that need to be addressed. For example, there may be concerns around patient privacy and security when using AI-powered systems to monitor patient data. Additionally, there may be a need for pharmacists to undergo additional training to effectively use and integrate AI technology into their practice. Nonetheless, with proper implementation and management, the benefits of AI in pharmacy far outweigh the potential limitations and challenges, paving the way for a brighter future in healthcare.

While the potential applications of AI in pharmacy are vast, there is still much work that needs to be done in terms of research and development. One potential area for future study could be the integration of AI technology with other healthcare systems, such as electronic health records (EHRs) or telemedicine platforms. This could allow for a more comprehensive and coordinated approach to healthcare delivery, improving patient outcomes and reducing healthcare costs. Another area for future research could be the ethical considerations around the use of AI technology in pharmacy. As the technology continues to evolve, it is important to consider issues such as data privacy and security, algorithmic bias, and the potential for AI systems to replace human jobs. Addressing these issues in a thoughtful and proactive manner can help to ensure that the implementation of AI in pharmacy is both effective and

ethical. By continuing to explore these areas of study, we can further unlock the potential of AI technology in pharmacy and pave the way for a more efficient and effective healthcare system.

The study has limitations as it lacks real-world implementation and validation, and primarily focuses on the benefits of AI in pharmacy without exploring potential challenges. Further research is needed to validate findings in real-world settings and to explore potential challenges and negative implications of AI in pharmacy.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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