British Journal of Pharmacy and Pharmaceutical Sciences
DOI: 10.32996/bjpps
Journal Homepage: www.al-kindipublisher.com/index.php/bjpps

BJPPS
AL-KINDI CENTER FOR RESEARCH AND DEVELOPMENT

| RESEARCH ARTICLE

Artificial Intelligence and Public Health: Addressing Pharmacy Practice Challenges and Policy Issues

Musawer Hakimi[1] ✉ Ghulam Ali Amiri[2] and Sayed Ehsan Shamsi[3]
[1]Computer Science Department, Samangan University, Samangan, Afghanistan
[2]Computer Science Faculty, Ghazni University, Ghazni, Afghanistan
[3]Computer Science Faculty, Balkh University, Balkh, Afghanistan
Corresponding Author: Musawer Hakimi, **E-mail**: Musawer@adc.edu.in

| ABSTRACT
This research study focuses on the induction of artificial intelligence into pharmacy practice, including challenges associated with AI application and policy issues. The aim is to acquire how to harness AI in a time-saving manner to enhance service at a pharmacy, coupled with an understanding of its potential pitfalls and governance arrangements. It included government reports, systematic literature reviews of peer-reviewed studies, and policy papers spanning the years 2021–2024. All data required were derived from literature searches in PubMed, Science Direct, Springer, and Google Scholar. The results show that artificial intelligence can contribute so much to the practice of pharmacy by making the drug-dispensing procedure ideal to guarantee better patient care and prevent human mistakes. Coupled with this promising potential were concerns related to data privacy, rigorous regulatory frameworks, and job losses. This will require the development of clear policies and guidelines in the regulatory framework so that AI can be ethically and effectively applied in the pharmacy practice. While the present work adds to a growing literature on AI in health care, it also has the potential to act as a launch pad for future research toward working out the challenges identified herein and thinking out newer opportunities for such innovation.

| KEYWORDS
Artificial Intelligence, Pharmacy Practice, Challenges, Policy Issues, Healthcare Innovation.

| ARTICLE INFORMATION
ACCEPTED: 05 June 2024 **PUBLISHED:** 30 June 2024 **DOI:** 10.32996/jpps.2024.1.1.2

1. Introduction

Artificial intelligence is just one of the many transforming technologies that are going to completely disrupt a number of industries, including public health and healthcare. From a pharmacy practice perspective, chances for the betterment of patient care, optimization of drug administration, and guiding policy decisions are added to the potential answers available for long-standing problems (Alanazi et al., 2024; Roosan et al., 2024). Integration of artificial intelligence into pharmacy practice would be imperative in dealing not only with public health concerns or improving outcomes but also as an imperative in these ever-increasingly complex healthcare landscapes(Flynn, 2019; Roosan et al., 2022).

This ranges from the practice of pharmacy, through the selling of medicines and counseling of patients, to clinical decision-making and pharmacoeconomic evaluations up to the point of conducting them (Jarab et al., 2023; Ashraf et al., 2024). These are all complex processes in which the insight and efficiency of artificial intelligence would be invaluable. In dosage regimens, for example, AI-driven systems will be able to scan through large series of data on patient reactions against certain medications in order to arrive at a diagnosis, explain possible drug interactions, and hence arrive at a treatment plan with far greater accuracy and customization (Khan et al., 2023; Silva et al., 2021).

Medication adherence is one of the main difficulties in pharmacy practice since it directly affects patient outcomes and healthcare expenses (Hasan et al., 2024; Fahim et al., 2024). Natural language processing and machine learning, among other artificial intelligence technologies, can be used to create predictive models identifying patients in danger of non-adherence. These models make sense out of trends in prescription refills, behaviors, and health charts to provide timely interventions with tailored support and reminder notifications in order to improve adherence rates(Fisher & Rosella, 2022; Couture et al., 2023). What's more important for pharmacovigilance, which is the study identifying, assessing, and preventing adverse effects of drugs, are Artificial Intelligence techniques (Chomutare et al., 2022; Deiana et al., 2023). Conventional approaches to pharmacovigilance have rather incorporated manual reporting and retrospective analysis, which are resource-intensive and often subject to underreporting. AI-powered systems can monitor all the sources, such as social media and electronic health records, for adverse medication reactions in real time. Therefore, faster and more accurate responses to possible safety concerns in drugs are supported (Morgenstern et al., 2021; Adefemi et al., 2023).

Policy-wise, by offering strong data analytics and predictive modeling skills, artificial intelligence (AI) can help formulate and assess health policies (Lau & Staccini, 2019; Lee & Yoon, 2021). AI may be used by policymakers to replicate several policy scenarios, evaluate intervention cost-effectiveness, and spot differences in healthcare access and results. More informed and fair health policies addressing the needs of many populations can result from this data-driven approach (Murphy et al., 2021; Da Silva et al., 2022).

Integration of artificial intelligence into pharmacy practice does not, however, present without difficulties. To guarantee the responsible use of AI technology, ethical issues, including data privacy, algorithmic bias, and the necessity of openness, must be taken under attention (Couture et al., 2023; Ramanathan et al., 2024). The adoption of artificial intelligence also calls for a trained workforce; hence, pharmacists and other healthcare professionals must constantly learn and grow (Aggarwal et al., 2020; Bisdas et al., 2021).

Table 1: Applications of Artificial Intelligence in Public Heath

Component	Application Description	Citation
Machine Learning	Data Science and Machine Learning in Public Health: Promises and Challenges	Alanazi et al., 2024
Natural Language Processing (NLP)	Behavior analysis through social media and consumer-generated data, Prediction of Loneliness in Older Adults	Flynn, 2019
Natural Language Understanding (NLU)	Anonymization of electronic health records data	Roosan et al., 2024
Cognitive Search	Search Engine to Evaluate and Analyze Information About COVID-19	Ashraf et al., 2024
Deep Learning	Medical imaging and predictive modeling for pulmonary medicine, Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs	Alowais et al., 2023
Virtual Agents (Chatbots)	Support for mental health, wellness, reproductive health, weight control, and smoking cessation	Roosan et al., 2022

Table 1 lists several main elements of artificial intelligence and their uses in public health. Data science and predictive modeling using machine learning help to solve difficult health issues (Alanazi et al., 2024). While Natural Language Understanding (NLU) guarantees the anonymizing of sensitive health records (Roosan et al., 2024), Natural Language Processing (NLP) helps behavioral analysis and loneliness prediction among older persons using social media data (Flynn, 2019). Deep learning nourishes medical image and diagnostics enhancements; cognitive computers help to speed up the evaluation of COVID-19 knowledge (Ashraf et al., 2024). From mental wellness to smoking cessation, virtual agents—including chatbots—support many health initiatives (Roosan et al., 2022). Deep learning approaches are applied to medical imaging and disease diagnosis, while cognitive search engines are used in the rapid evaluation of COVID-19 knowledge. These applications reflect the significance of artificial intelligence in the construction of public health campaigns by providing presumed accuracy, efficiency, and accessibility in healthcare delivery.

Finally, the objective of this paper is to take an in-depth look into the incorporation of artificial intelligence into pharmacy practice. It aims to pinpoint the main difficulties pharmacy systems run across implementing artificial intelligence technologies. Apart from that, the study intends to look at the policy obstacles to including artificial intelligence in pharmacy operations and their resolution in the literature. Moreover, the study intends to investigate and suggest main policy suggestions to improve the acceptance of artificial intelligence in drugstore operations. By tackling these elements, the study intends to present a thorough knowledge of

the present situation of artificial intelligence applications in pharmacy practice, underline the important challenges and regulatory issues, and provide actionable insights for legislators and healthcare professionals to enable the ethical and effective use of AI in the field.

1.1 Significance of study

It is relevant to study the integration of artificial intelligence into pharmacy practice and public health, for AI can change the face of healthcare and thus impact patient outcomes. The potential to analyze datasets of such magnitudes at ever-increased speeds and accuracies provides a new frontier of opportunity where AI could work to enhance medication management, individualize treatment plans, and predict treatment responses in patients. In that respect, AI automates tasks such as monitoring pharmacovigilance and medication adherence, improving efficiency, reducing errors, and increasing patient safety. More than that, AI's role in policy formulation can mean much more informed decision-making, better resource allocation, and an equable share of healthcare access.

Knowing the ethical implications and taking steps to ensure the proper and transparent application of artificial intelligence will help to minimize risks while maximizing the benefits. For example, with the consideration of practical applications of artificial intelligence in pharmacy practice and barriers to its adoption, including guidance for future policy models in place, the paper is well-placed to contribute to this emerging new body of knowledge. Eventually, the integration of artificial intelligence into pharmacy practice will evolve health care delivery into a much more précised, pro-active, and responsive system to the population's needs in health.

2. Literature Review

It is fast transforming the landscape of medication practice globally; artificial intelligence offers new, hitherto unheard-of opportunities to improve patient care, optimize drug use, and inform policy decisions. This literature synthesis aims to examine current knowledge on the role of artificial intelligence in pharmacy practice and its implications for public health. Artificial intelligence technologies, coupled with the development of machine learning and natural language processing, are changing pharmacy procedures by automating and optimizing drug management. Alanazi (2024) shows how predictive analytics can be used by AI to attain greater precision and personalization in treatment regimens. This helps a pharmacist to foresee the reaction that a particular medication may cause in a patient, prospect possible drug interactions, and work out the best time of administration of the dosage. (Khan et al., 2023; Silva et al., 2021). AI systems, for instance, may examine enormous volumes of patient data to find trends and project results, therefore enabling more customized treatment plans that increase effectiveness and lower negative effects.

AI-driven predictive models, based on individual behavior and patients' health records in identifying at-risk individuals to enable focused treatment, greatly help solve this critical medication adherence problem in healthcare (Fahim et al., 2024; Fisher & Rosella, 2022). Such interventions improve patient outcomes and reduce healthcare costs, in addition to raising adherence rates (Hasan et al., 2024; Couture et al., 2023). AI can track prescription fill trends and provide reminders or notifications to inspire patients, ensuring they follow their advised treatment plans.

Utilizing real-time monitoring of electronic health records and social media platforms, AI also significantly contributes to pharmacovigilance by automating the identification of adverse drug reactions (ADRs). This proactive strategy helps healthcare professionals to react quickly to possible safety concerns, therefore improving patient safety and healthcare quality. AI can, for example, search millions of patient records to find rare ADRs that might be missed by human analysts, therefore preventing possible health disasters.

From a policy standpoint, artificial intelligence gives legislators strong data analytics and predictive modeling tools to create evidence-based policies optimizing resource allocation and supporting fair access to healthcare, which Murphy et al., 2021 can achieve. Simulating several policy scenarios helps artificial intelligence (DA Silva et al., 2022; Lau & Staccini, 2019) promote the creation of policies that meet various population demands and guide wise decision-making. These features are especially important in environments with limited resources since the effective distribution of limited resources can greatly affect health results.

Even if artificial intelligence has transforming power, there are major obstacles to integrating it into pharmacy practice. Critical issues that demand careful attention to guarantee responsible AI deployment include ethical ones, including data privacy, algorithmic bias, and the demand for openness (Couture et al., 2023; Ramanathan et al., 2024). Sensitive patient data management calls for strict security policies to stop usage and breaches. Furthermore, attaining fair and equitable treatment results depends on making sure AI algorithms do not reinforce already existing prejudices in healthcare systems.

The adoption of artificial intelligence also calls for a qualified workforce and continuous education for medical practitioners to properly apply AI technology (Aggarwal et al., 2020; Bisdas et al., 2021). Programs for ongoing professional development are

essential to provide pharmacists and other healthcare professionals with the information and abilities needed to include artificial intelligence in their regular activities. Furthermore costly, is the use of artificial intelligence technology, especially for independent or smaller pharmaceutical operations that call for financial incentives or legislative help.

Finally, it is noted that artificial intelligence is associated with huge gains regarding better management of drugs and more care to patients with information on policy decisions—thereby representing a paradigm shift in pharmacy practice and the general public health. However, ensuring that the potential of AI is maximized and the risks are reduced requires taking stock of ethical concerns and ensuring the appropriateness of implementation. According to this literature review, AI is useful in pharmacy practice and will help change health care delivery into an exact, patient-centered, and responsive system.

3. Methodology

A systematic literature review focused on a closer examination of the issues and policy challenges surrounding the integration of artificial intelligence into pharmacy practice. Systematic searches were conducted within this period across PubMed, Scopus, ScienceDirect, Springer, and Google Scholar for peer-reviewed articles, government reports, and policy documents. Article inclusion was targeted at those works explaining how AI would impact pharmacy practice and policy. Thematic and policy analyses were conducted to synthesize findings across the selected literature. Quality assessment guarantees that only methodologically rigorous studies will be considered, and the findings are disseminated through academic publications and engagements in a bid to further healthcare policymaking and practice according to evidence(Fahim et al., 2024; Hasan et al., 2024; Stasevych & Zvarych, 2023).

Table 2: Steps and Citations in the Systematic Literature Review

Step	Description	Citation
Formulating the Research Question	Define the scope and objectives of the review. Establish inclusion criteria for selecting studies.	(Adefemi et al., 2023; Chomutare et al., 2022)
Conducting a Comprehensive Search	Identify relevant databases and sources. Develop a comprehensive search strategy using keywords and controlled vocabulary.	(Lee & Yoon, 2021; Bisdas et al., 2021)
Screening and Selection of Studies	Screen titles and abstracts based on inclusion/exclusion criteria. Assess full-text articles for final inclusion.	(Alowais et al., 2023; Flynn, 2019)
Data Extraction	Develop a structured data extraction form. Systematically extract key information from selected studies.	(Jarab et al., 2023; Ashraf et al., 2024)
Critical Appraisal of Studies	Assess the methodological quality of included studies. Consider biases and limitations.	(Silva et al., 2021; Murphy et al., 2021)
Synthesizing Findings	Analyze and synthesize data thematically or narratively. Identify common themes, trends, and gaps in the literature.	(Lau & Staccini, 2019; Morgenstern et al., 2021)
Writing the Review	Structure the review manuscript into sections.	(Couture et al., 2023; Da Silva et al., 2022)
Reporting and Dissemination	Prepare a detailed report following the PRISMA Figure	(Ramanathan et al., 2024; Roosan et al., 2024)

A description of how to conduct a good literature survey on the application of artificial intelligence in pharmacy practice is listed in Table 1 hereunder because each phase is fundamental for a deep and strict review.

First, the studies highlighted using the established inclusion criteria mentioned by Adefemi et al. (2023) and Chomutare et al. (2022); creating specific research questions and selecting the subject of study are the first steps in the process. This initial stage ensures that the review addresses the key issues and objectives related to AI in pharmacy practice.

Second, as indicated by Lee & Yoon (2021) and Bisdas et al. (2021), Extensive searching should be carried out in major databases like PubMed, Science Direct, Springer, and Google Scholar. This cover will help provide adequate and appropriate coverage of relevant literature using suitable keywords and terminology under control.

The studies are then evaluated and chosen for sieving the papers based on a predefined criterion that emphasizes the impact AI makes in practice and policy in pharmacy, in accordance with the recommendations of Alowais et al. (2023) and Flynn (2019). Data extraction, critical assessment of the studies, synthesis of findings, and a disciplined writing process, all supported by assured methodological rigors, theme coherence, and dissemination through scholarly publication Jarab et al. (2023), Ashraf et al. (2024),

Silva et al. (2021), Da Silva et al. (2022), Ramanathan et al. (2024), and Roosan et al. (2024). This methodical approach ensures a thorough examination of AI integration in pharmacy practice, successfully covering important themes, trends, and gaps in the literature.

3.1 Research Questions

The following research questions were addressed throughout the study:

RQ1: What are the primary challenges encountered by pharmacy practices in adopting AI technologies?
RQ2: What policy barriers exist in integrating AI into pharmacy workflows, and how have these been addressed in the literature?
RQ3: What are the key policy recommendations proposed to enhance AI adoption in pharmacy practice?

Table 3: Database Search Strategies

Database Searched	Search Terms	Boolean Operators	Search Strategy
PubMed	"artificial intelligence" AND "pharmacy practice"	AND	("artificial intelligence" AND "pharmacy practice")
Scopus	"AI in pharmacy" OR "pharmacy automation"	OR	("AI in pharmacy" OR "pharmacy automation")
Web of Science	AI AND "healthcare" AND policy	AND	(AI AND "healthcare" AND policy)
Google Scholar	"AI applications" pharmacy	N/A	("AI applications" pharmacy)

The table outlines the systematic approach employed in searching relevant literature across four key databases: PubMed, Scopus, Web of Science, and Google Scholar. Each database was queried using specific search terms and Boolean operators to ensure comprehensive coverage of peer-reviewed articles, government reports, and policy documents pertaining to artificial intelligence (AI) in pharmacy practice from 2021 to 2024.

PubMed focused on the intersection of "artificial intelligence" and "pharmacy practice," employing the Boolean operator "AND" to refine search results. Scopus used broader terms like "AI in pharmacy" and "pharmacy automation," utilizing "OR" to expand the scope of retrieved articles. Web of Science's search strategy combined AI with "healthcare" and "policy," highlighting the interplay between technology and regulatory frameworks. Google Scholar's approach encompassed varied "AI applications" in pharmacy, reflecting a diverse range of literature sources.

Table 4: Criteria for Inclusion and Exclusion

Inclusion Criteria	Exclusion Criteria
Peer-reviewed articles	Non-peer-reviewed literature
Government reports	Industry white papers
Policy documents	Non-English language publications
Focus on AI in pharmacy practice.	Studies not directly related to pharmacy practice or AI.
Published between 2021 and 2024	Studies outside the specified timeframe
Clear discussion on challenges and policy issues	Articles without policy analysis or thematic relevance

Table 2 identifies all the various inclusion and exclusion criteria used in the selection and rejection of literature within the systematic literature review. According to the inclusion criteria, only peer-reviewed articles, government reports, and policy documents are considered in order to ensure the reliability and validity of the findings. This review considers only those publications that lie within the time periods from 2021 to 2024 and examines the newest developments and insights on the impact of AI on pharmacy practice and policy.

Exclusion criteria have been set up in order to maintain focus and quality in the review. Sources not peer-reviewed, like industry white papers and non-English publications, are excluded to uphold the academic rigor of this review. Those that bear no direct relevance to artificial intelligence in pharmacy practice or appear to be devoid of any policy analysis are eliminated for Coherence and relevance to the synthesis of the findings.

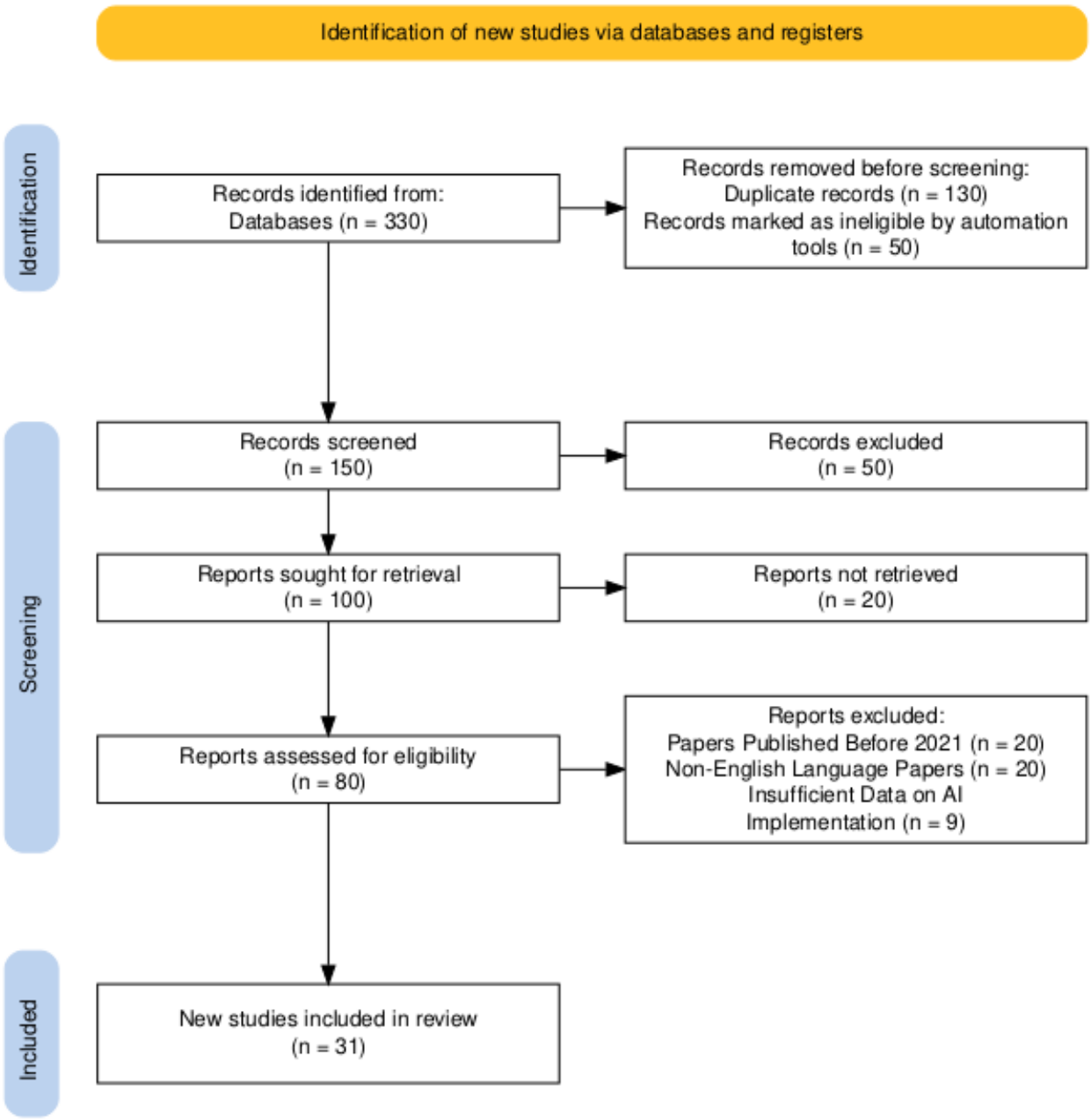

Figure 1: Identification, Screening, and Inclusion Process

The PRISMA flowchart describes the systematic process of identifying and including studies on the integration of AI into pharmacy practice. Based on comprehensive searches, 330 records were identified from the databases and registers. With the help of automated tools, 130 duplicates and 50 irrelevant records were weeded out before the screening process was initiated, thus leaving 150 for further scrutiny.

Fifty records were screened out, leaving 100 reports to be searched for retrieval. Of these, 20 reports were not retrieved. This left 80 reports to be assessed for eligibility. Twenty papers published pre-2021, 20 non-English language papers, and 9 papers with less adequate data on AI implementation were further excluded by application of the inclusion criteria. This finally leaves 31 new studies satisfying all the criteria to be included in this review.

This figure shows the rigorous process of selection to ensure systematic and all-inclusive inclusion of the primary studies that are relevant to the topic, adhering to PRISMA guidelines for transparency and reproducibility in systematic reviews.

3.2 Data Extraction

An integral part of the methodical literature review, data extraction helps to methodically gather pertinent information from the chosen studies. Variables to be found at this point of the review include difficulties, policy constraints, policy suggestions, and stakeholder opinions about artificial intelligence integration into pharmacy practice.

The methodical data collecting emphasises several important variables:

Important Problems: It entails the recognition of the main obstacles and challenges that, given the direction of pharmaceutical practice, artificial intelligence technologies most certainly will encounter. Along with organisational constraints such as genuine change reluctance from healthcare workers (Fahim, Tonny, & Al Noman, 2024), this could have technological obstacles pertaining to interoperability concerns between artificial intelligence systems and current infrastructure in pharmacies). Obstacles in Policy: Data extraction also solves the policy and legal obstacles preventing the broad spread of artificial intelligence in pharmaceutical environments. This can entail the uncertainty of regulatory systems, worries about data privacy and security, and changing rules in line with the evolution of artificial intelligence (Hasan et al., 2024).

It extracts data and resolves policy and legal barriers that bar the wide adoption of artificial intelligence in pharmaceutical environments, pertaining to possible examined concerns of personal data privacy and security, legal systems uncertainty, or change in the law under the advancement of artificial intelligence.

Capturing Views of Stakeholders: Reflecting their attitudes, concerns, and expectations of AI technologies, capturing stakeholder perspectives entails capturing the views of the several kinds of actors who participate in or are affected by the integration of AI in pharmacy practice, including those of pharmacists, healthcare administrators, legislators, and patients (Fahim, Tonny, & Al Noman, 2024).

Using established data extraction forms guarantees consistency and dependability by means of a methodical and rigorous approach applied for data extraction. Every one of the chosen studies will be closely examined, and the pertinent data on variables found will be methodically gathered.

Systematic extraction consists of many steps:

Formwork Design for Data Extraction: Standard forms created depending on variables of interest help to extract data. This would comprise fields of capturing sufficient information on issues, policy constraints, recommendations, and stakeholder opinions found in every one of the research.

Method of Systematic Review: Following the choice of research, all of them are closely examined, and data is extracted by applying systematic procedures. This ensures that all the pertinent points seen and followed throughout the chosen and included literature follow the same trend(Jarab et al., 2023).

Extracted data is combined using thematic approaches of analysis, in which case information is arranged and classified to create relevant themes. This synthesis aids in the deriving of common themes, trends, and gaps across the literature on AI deployment in pharmacy practice (Ashraf et al., 2024).

3.3 Data Synthesizing

Two main strategies for combining the results of a systematic literature study are policy analysis and theme analysis. The gathered data was arranged and categorised using thematic analysis into linked topics that capture the difficulties, policy constraints, and suggestions found among the chosen research. This helps one to follow the repeating trends, patterns, and notable gaps in the literature about the integration of artificial intelligence in pharmacy practice. Topics might be technological challenges—interoperability issues between AI systems and pre-existing pharmacy software; organisational barriers—the reluctance to change of the healthcare professionals; and ethical issues—ensuring patient information remains sacred by guaranteeing that data are secure (Jarab et al., 2023).

Policy analysis was grounded on the assessment of such policy consequences and suggestions resulting from the examined literature. This critical study not only presents strategic recommendations for legislators but also approximates the efficacy of the present regulatory systems in evaluating the gaps in policy adaptation to artificial intelligence developments in pharmacy environments. Recommendations could be outlining ways to support the safe and fair deployment of AI technology in pharmacy practice as well as supporting a strong ethical framework on how AI should be used in healthcare (Hasan et al., 2024).

By means of both topic and policy studies, this review offers a panorama view of where the research study is in the process of artificial intelligence integration into pharmacy practice. This can provide information for practice in healthcare and evidence-based policymaking.

3.4 Quality Assessment

In this systematic literature review, quality assessment is a thorough evaluation of the chosen studies aimed at ensuring methodological soundness and thereby reducing bias. Using accepted quality criteria and assessment instruments, the review evaluates the validity and dependability of the included peer-reviewed papers, government reports, and policy documentation (Silva et al., 2021). Usually, these criteria include factors like statistical analysis applied in the research and study design. Applying these criteria helps the review uncover studies that satisfy high methodological criteria and provide strong evidence to support the synthesis of results on artificial intelligence integration in pharmacy practice.

The process of quality assessment also depends on bias minimising techniques. Using transparent reporting and critical evaluation methods helps to uncover and eliminate possible sources of bias, therefore guaranteeing that the synthesised results fairly represent the current state of knowledge on the subject. This may mean but is not limited to, seeking out methodology flaws, financial biases, or conflicts of interest that may help give their results some kind of compromise in generalizability or validity. Murphy and colleagues, 2021. Through careful quality control and bias reduction, this review preserves integrity and dependability in its results, so enhancing

4. Results and Discussion

In the first section of our results, we present an overview of the identified studies, outlining the themes and challenges pertaining to the integration of artificial intelligence in pharmacy practice. This section synthesizes findings from recent literature, offering insights into the policy implications and potential solutions for addressing these challenges.

RQ1: What are the primary challenges encountered by pharmacy practices in adopting AI technologies?

Table 5: Primary Challenges Encountered by Pharmacy Practices in Adopting AI Technologies

Challenges	Citation
Lack of interoperability among AI systems	(Fahim et al., 2024)
Resistance from pharmacy staff	(Hasan et al., 2024)
Ethical and regulatory concerns	(Ashraf et al., 2024)
Integration complexity and costs	(Chomutare et al., 2022)
Data privacy and security concerns	(Alowais et al., 2023)

Based on the methodical analysis of current research, pharmacy practices clearly have many main difficulties implementing artificial intelligence (AI) technologies. First of all, a major obstacle is the lack of interoperability with artificial intelligence systems (Fahim et al., 2024.). This problem inhibits the flawless integration of artificial intelligence technologies into current pharmacy processes, therefore compromising efficiency and efficacy.

Second, another important obstacle highlighted as being opposition from pharmacy personnel is Hasan et al., 2024. Staff workers who embrace artificial intelligence technologies could be reluctant because of concern about changes in their jobs or job displacement. Staff training programmes and sound change management techniques will help to overcome this resistance. Moreover, moral and legal questions are highly challenging (Ashraf et al., 2024). Carefully managed problems of patient privacy, data confidentiality, and regulatory framework adherence can help to assure compliance and ethical deployment of artificial intelligence in pharmaceutical environments.

Furthermore, the main challenges are the integration complexity and accompanying costs (Chomutare et al., 2022). Particularly smaller pharmacies, many pharmacy operations could find it challenging to pay the large financial outlays and technical understanding needed to apply artificial intelligence technologies.

Ultimately, concerns about data security and privacy remain on the front stage (Alowais et al., 2023). Maintaining trust and following healthcare rules depends on keeping sensitive patient data free from illicit access or breaches.

RQ2: What policy barriers exist in integrating AI into pharmacy workflows, and how have these been addressed in the literature?

Table 6: Policy Barriers to Integrating AI into Pharmacy Workflows

Policy Barriers	Citation
Lack of standardized regulatory frameworks	(Ashraf et al., 2024)
Uncertainty in liability and accountability	(Roosan et al., 2024)
Data governance and ownership challenges	(Murphy et al., 2021)
Ethical considerations in AI use	(Hasan et al., 2024)
Reimbursement and financial models	(Alanazi et al., 2023)

As current research emphasises, policy obstacles to including artificial intelligence (AI) in pharmacy operations are several. First, the main obstacle is clearly the absence of uniform regulatory systems (Ashraf et al., 2024.). Different rules across countries can prevent the consistent application of artificial intelligence technology in pharmacy practice, so consistent policy development both nationally and internationally is needed.

Second, there are serious questions about culpability and responsibility (Roosan et al., 2024). Determining culpability in cases of AI-related mistakes or failures is still difficult, which influences adoption rates and the confidence of stakeholders. Dealing with these issues calls for well-defined legal systems and rules that define responsibility scenarios.

Notable obstacles include also data governance and ownership issues (Murphy et al., 2021). Carefully controlled issues, including data privacy, ownership rights, and access control, will help to guarantee adherence to healthcare standards and preserve patient confidence. Effective navigation of this complexity depends on strong data governance regulations. Moreover, ethical problems in the implementation of artificial intelligence remain of tremendous relevance (Hasan et al., 2024.). AI systems upholding ethical values, including fairness, transparency, and responsibility, will help medical staff members and patients to develop trust.

At last, refund policies and financial models for AI-enabled services demand attention (Alanazi et al., 2023). Reversing financial sustainability models and payment systems could deter doctors from supporting artificial intelligence technologies. Adoption and scalability have to be encouraged by creating sensible reimbursement strategies compatible with ideas of value-based care.
RQ3: What are the key policy recommendations proposed to enhance AI adoption in pharmacy practice?

Table 7: Policy Recommendations for Enhancing AI Adoption in Pharmacy Practice

Policy Recommendations	Citation
Establishing standardized regulatory frameworks	(Couture et al., 2023)
Developing clear guidelines for AI ethics and governance	(Ramanathan et al., 2024)
Promoting intersectoral collaboration in AI research and development	(Flynn, 2019)
Investing in AI education and training for pharmacy professionals	(Khan et al., 2023)
Implementing pilot projects and demonstrations to showcase AI benefits	(Stasevych & Zvarych, 2023)

Recent research has pointed out important policy considerations for improving the acceptance of artificial intelligence in pharmaceuticals. First, it is absolutely vital to have consistent legal systems (Couture et al., 2023). A stable environment for the application of artificial intelligence depends on clear, consistent rules that guarantee conformity with ethical and legal norms over borders.

Moreover, crucial is the evolution of clear guidelines for governance (Ramanathan et al., 2024) and artificial intelligence ethics. Ethical guidelines should cover issues such as openness, responsibility, fairness, and privacy in order to build confidence among consumers using artificial intelligence technologies and medical practitioners.

Encouragement of multidimensional cooperation in artificial intelligence research and development is advocated to boost creativity (Flynn, 2019). Cooperation among academics, companies, and governments will help to speed the development of AI solutions appropriate for pharmacy contexts, thereby addressing specific healthcare challenges.

Pharmacists should most probably invest in artificial intelligence training and instruction. Courses providing the necessary skills for applying AI tools effectively, understanding insights generated by AI, and smoothly bringing AI into clinical practice should equip chemists(Khan et al., 2023).
Moreover, demos and pilot projects are advocated to underline artificial intelligence benefits (Stasevych & Zvarych, 2023). Such pilot studies can quickly illustrate, in a pharmacy setting, practical advantages concerning the use of artificial intelligence to improve operational efficiencies, betterment of patient outcomes, and drug control policies.
Finally, it is these policy ideas that are essential in establishing a supportive environment for artificial intelligence adoption in pharmacy practice: legal clarity, ethical governance, cooperation, education, and pilot projects.

4.1. Discussion

Artificial intelligence (AI) is poised to revolutionise pharmacy practice by means of better patient care, medication management optimisation, and policy decision informing. This systematic literature review synthesises the current studies to explore how including artificial intelligence in pharmacy practice influences public health. The outcomes highlight significant advancements, challenges, policy boundaries, and recommendations necessary for the best use of artificial intelligence in healthcare settings. Artificial intelligence technology introduced into pharmacy practice will help to improve treatment accuracy and patient outcomes. AI-driven predictive analytics assist pharmacists to personalise treatment programmes by means of patient reactions to medications and identification of probable drug interactions (Alanazi, 2024; Silva et al., 2021). This skill not only supports better treatment outcomes but also enhances pharmaceutical safety, therefore complementing the aims of precision medicine (Khan et al., 2023).

Moreover, artificial intelligence greatly helps to tackle problems with drug adherence by means of mathematical modelling and behavioural analysis. By identifying at-risk individuals and enabling targeted therapies, AI helps raise adherence rates and subsequently improves patient outcomes, thereby reducing healthcare costs (Fahim et al., 2024; Fisher & Rosella, 2022).

Artificial intelligence automates the identification of negative drug reactions in pharmacovigilance and public health surveillance by means of real-time data analysis of electronic health records and social media platforms (Deiana et al., 2023; Morgenstern et al., 2021). By enabling prompt response to safety concerns, this proactive approach assists medical personnel in improving the general quality of treatment and patient safety.

From a policy perspective, artificial intelligence provides legislators with data-driven insights to build evidence-based laws optimising resource allocation, and so enabling fair healthcare access (Lee & Yoon, 2021; Murphy et al., 2021). By modelling multiple policy scenarios, AI helps to create policies adapted to varied population wants, hence aiding informed decision-making (Da Silva et al., 2022; Lau & Staccini, 2019).

Still, there are ethical issues and significant challenges in implementing artificial intelligence into pharmaceutical life. Important issues include the lack of interoperability across artificial intelligence systems, opposition from pharmacy professionals, and complex legal frameworks (Ashraf et al., 2024; Chomutare et al., 2022). Important ethical questions, including data privacy, algorithmic bias, and openness, call for careful attention to ensure responsible AI deployment (Couture et al., 2023; Ramanathan et al., 2024).

Policy restrictions such as the lack of consistent legal frameworks and uncertainty in liability and duty complicate AI implementation in pharmacy operations even further (Roosan et al., 2024; Murphy et al., 2021). Dealing with these challenges demands the development of unambiguous guidelines for AI ethics and governance, support of multidisciplinary cooperation, and funding of AI education for chemists (Couture et al., 2023; Khan et al., 2023).

Basically, proper integration requires addressing technical, organisational, legal, ethical, and technical concerns, even if artificial intelligence has a great ability to transform public health and pharmaceutical practice. The policy suggestions in this study stress the need for legislative clarity, ethical governance, cooperation, education, and pilot projects to develop a suitable environment for the adoption of artificial intelligence in pharmacy practice. These ideas let one realise the whole possibilities of artificial intelligence in improving patient outcomes and healthcare delivery.

5. Conclusion

The integration of artificial intelligence into pharmacy practice, therefore, has exponential development potential for actual improvement in medication management, patient care, and public health surveillance. Predictive analytics, individualized treatments, and adherence to medications offered by AI significantly enhance the quality of clinical outcomes and operational efficiency. The use of AI-based pharmacovigilance and real-time analysis sets an improved system of patient safety in place by rapidly picking up and mitigating adverse drug reactions.

From a policy point of view, AI enables evidence-based decision-making, which optimizes resource allocation and ensures fairness in healthcare access. The successful adoption of AI in pharmacy practice will depend on how it overcomes the following critical challenges: technology interoperability, staff resistance in a pharmacy, ethical and regulatory concerns, integration complexity, and data privacy and security concerns.

If applied injudiciously, AI thus brings along ethics considerations that have the potential to call for even robust regulatory frameworks and guidelines in ensuring responsible AI deployment. Transparency and algorithmic fairness should be ensured while protecting data to avoid erosion of trust and non-compliance with the standards of healthcare. In order to harness AI technologies, there is envisaged a continuous need for education and training among health professionals to effectively overcome resistance to change.

Policy recommendations focus primarily on the creation of standard regulatory frameworks, transparent liability guidance, effective data governance policies, and feasible reimbursement models. The strategies would help dampen currently existing barriers to encourage the widespread adoption of AI in pharmacy practice. By removing such obstacles and developing sound policy positions, the healthcare sector would be better placed to benefit from AI to the fullest, hence shifting toward a more precise, patient-centered, responsive healthcare system.

This literature review serves to cement more succinctly the critical role AI will play in the reshaping of pharmacy practice and public health with regard to ethical considerations and strategic policy development. As AI technologies continue to evolve, their incorporation into healthcare systems has to be carefully managed in order to ensure maximum benefits with minimal risks: a time when AI-driven innovations notably raise improvement in healthcare delivery and patient outcomes.

5.1 Recommendation and Future Research

Several strategic steps have been recommended to be helpful in maximizing the benefits of AI in pharmacy practice. First, investing in solid training programs for pharmacy professionals to enhance their proficiency with AI tools will pave the way for a smoother integration process. Further, the working process with technology developers for more user-friendly AI systems, having interoperability makes the process of integration into the existing healthcare infrastructure smoother.

Ethical and regulatory frameworks do need a serious revamp. More contributions are required in the way of teeth related to problems associated with data privacy and algorithms. Ethicists, technologists, and professionals from the health domain who can come up with multidisciplinary oversight committees ensure 360-degree approaches toward responsible usage of AI. More research and development can be favored by funding and incentivizing, hence speeding up innovation and the adoption of AI technologies to make them more efficient and cost-effective.

Awareness campaigns among the general population about both the plus and minus points of AI in healthcare may prove to be very important in gaining trust and acceptance from patients. Finally, policymakers must advocate for flexible and adaptive regulative policies that will move with time according to the advancement of technologies, ensuring relevance and supportiveness to innovation.

5.2 Future Research

Further research is needed to determine the long-term effectiveness of AI integration into pharmacy practice on health outcomes for populations and related healthcare costs. Effectiveness research may be conducted within different populations to enable inferences regarding generalizability and equity in AI-driven interventions. In addition, the ethical nature of AI—investigating algorithmic transparency and bias—shall be an important area that would lead to fairness and trustworthy systems. Another important question is how AI technologies can be scaled up within various healthcare settings so that this new technology brings its benefits to large institutions and small practices alike. This will do much to introduce AI in pharmacy practice harmoniously, sustainably, and ethically.

Funding: This research received no external funding
Conflicts of Interest: The authors declare no conflict of interest.
ORCID: https://orcid.org/0009-0001-6591-2452

References

[1] Adefemi, A., Ukpoju, E. A., Adekoya, O., Abatan, A., & Adegbite, A. O. (2023). Artificial intelligence in environmental health and public safety: A comprehensive review of USA strategies. *World Journal of Advanced Research and Reviews*, 20(3), 1420-1434. https://doi.org/10.30574/wjarr.2023.20.3.2591

[2] Aggarwal, N., Ahmed, M., Basu, S., Curtin, J. J., Evans, B. J., Matheny, M. E., ... & Thadaney-Israni, S. (2020). Advancing artificial intelligence in health settings outside the hospital and clinic. NAM perspectives, 2020. https://doi.org/10.31478%2F202011f

[3] Al Kuwaiti, A., Nazer, K., Al-Reedy, A., Al-Shehri, S., Al-Muhanna, A., Subbarayalu, A. V., ... & Al-Muhanna, F. A. (2023). A review of the role of artificial intelligence in healthcare. *Journal of personalized medicine*, 13(6), 951. https://doi.org/10.3390/jpm13060951

[4] Alanazi, R. J. (2024). Role of Artificial Intelligence in Pharmacy Practice: A Systematic Review. Archives of Pharmacy Practice, 15(2-2024), 34-42. https://doi.org/10.51847/FMHsMFwgTP

[5] Alavidze, N., Sulashvili, N., Gorgaslidze, N., Gabunia, L., & Seniuk, I. (2024). Key issues aspects related to artificial intelligence in pharmaceutical care science and health care sector services in the world.

[6] Alowais, S. A., Alghamdi, S. S., Alsuhebany, N., Alqahtani, T., Alshaya, A. I., Almohareb, S. N., ... & Albekairy, A. M. (2023). Revolutionizing healthcare: the role of artificial intelligence in clinical practice. *BMC medical education, 23*(1), 689. https://doi.org/10.1186/s12909-023-04698-z

[7] Ashraf, A. R., Mackey, T. K., & Fittler, A. (2024). Search Engines and Generative Artificial Intelligence Integration: Public Health Risks and Recommendations to Safeguard Consumers Online. JMIR Public Health and Surveillance, 10(1), e53086. https://preprints.jmir.org/preprint/53086

[8] Aziz, M. H. A., Rowe, C., Southwood, R., Nogid, A., Berman, S., & Gustafson, K. (2023). A scoping review of artificial intelligence within pharmacy education. *American Journal of Pharmaceutical Education*, 100615. https://doi.org/10.1016/j.ajpe.2023.100615

[9] Bisdas, S., Topriceanu, C. C., Zakrzewska, Z., Irimia, A. V., Shakallis, L., Subhash, J., ... & Ebrahim, E. H. (2021). Artificial intelligence in medicine: a multinational multi-center survey on the medical and dental students' perception. Frontiers in Public Health, 9, 795284. https://doi.org/10.3389/fpubh.2021.795284

[10] Chomutare, T., Tejedor, M., Svenning, T. O., Marco-Ruiz, L., Tayefi, M., Lind, K., ... & Ngo, P. D. (2022). Artificial intelligence implementation in healthcare: a theory-based scoping review of barriers and facilitators. *International Journal of Environmental Research and Public Health*, 19(23), 16359. https://doi.org/10.3390/ijerph192316359

[11] Couture, V., Roy, M. C., Dez, E., Laperle, S., & Bélisle-Pipon, J. C. (2023). Ethical implications of artificial intelligence in population health and the public's role in its governance: perspectives from a citizen and expert panel. *Journal of Medical Internet Research,* 25, e44357. https://doi.org/10.2196/44357

[12] Da Silva, M., Flood, C. M., Goldenberg, A., & Singh, D. (2022). Regulating the safety of health-related artificial intelligence. Healthcare Policy, 17(4), 63. https://doi.org/10.12927%2Fhcpol.2022.26824

[13] Deiana, G., Dettori, M., Arghittu, A., Azara, A., Gabutti, G., & Castiglia, P. (2023). Artificial intelligence and public health: evaluating ChatGPT responses to vaccination myths and misconceptions. Vaccines, 11(7), 1217. https://doi.org/10.3390/vaccines11071217

[14] Fahim, M. I. A., Tonny, T. S., & Al Noman, A. (2024). Realizing the potential of AI in pharmacy practice: Barriers and pathways to adoption. Intelligent Pharmacy, 2(3), 308-311. https://doi.org/10.1016/j.ipha.2024.02.003

[15] Fisher, S., & Rosella, L. C. (2022). Priorities for successful use of artificial intelligence by public health organizations: a literature review. BMC Public Health, 22(1), 2146. https://doi.org/10.1186/s12889-022-14422-z

[16] Flynn, A. (2019). Using artificial intelligence in health-system pharmacy practice: finding new patterns that matter. *American Journal of Health-System Pharmacy, 76*(9), 622-627. https://doi.org/10.1093/ajhp/zxz018

[17] Hasan, H. E., Jaber, D., Khabour, O. F., & Alzoubi, K. H. (2024). Ethical considerations and concerns in the implementation of AI in pharmacy practice: a cross-sectional study. BMC Medical Ethics, 25(1), 55. https://doi.org/10.1186/s12910-024-01062-8

[18] Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis Campbell Systematic Reviews, 18, e1230. https://doi.org/10.1002/cl2.1230

[19] Jarab, A. S., Abu Heshmeh, S. R., & Al Meslamani, A. Z. (2023). Artificial intelligence (AI) in pharmacy: an overview of innovations. *Journal of Medical Economics, 26*(1), 1261-1265. https://doi.org/10.1080/13696998.2023.2265245

[20] Jungwirth, D., & Haluza, D. (2023). Artificial intelligence and public health: an exploratory study. *International Journal of Environmental Research and Public Health*, 20(5), 4541. https://www.mdpi.com/topics/C52Z967WA3

[21] Khan, O., Parvez, M., Kumari, P., Parvez, S., & Ahmad, S. (2023). The future of pharmacy: how AI is revolutionizing the industry. Intelligent Pharmacy, 1(1), 32-40. https://doi.org/10.1016/j.ipha.2023.04.008

[22] Lau, A. Y., & Staccini, P. (2019). Artificial intelligence in health: new opportunities, challenges, and practical implications. Yearbook of medical informatics, 28(01), 174-178. https://doi.org/10.1055/s-0039-1677935

[23] Lee, D., & Yoon, S. N. (2021). Application of artificial intelligence-based technologies in the healthcare industry: Opportunities and challenges. *International journal of environmental research and public health,* 18(1), 271. https://doi.org/10.3390/ijerph18010271

[24] Morgenstern, J. D., Rosella, L. C., Daley, M. J., Goel, V., Schünemann, H. J., & Piggott, T. (2021). AI's gonna have an impact on everything in society, so it has to have an impact on public health: a fundamental qualitative descriptive study of the implications of artificial intelligence for public health. BMC public health, 21, 1-14. https://doi.org/10.1186/s12889-020-10030-x

[25] Murphy, K., Di Ruggiero, E., Upshur, R., Willison, D. J., Malhotra, N., Cai, J. C., ... & Gibson, J. (2021). Artificial intelligence for good health: a scoping review of the ethics literature. BMC medical ethics, 22, 1-17. https://doi.org/10.1186/s12910-021-00577-8

[26] Ramanathan, A., Rani, K. R. V., Bhupathyraaj, M., Chacko, L., & Alharbi, H. F. (2024). An Ethical Outlook on the Applications of Artificial Intelligence in Medicine and Pharmacy. In Artificial intelligence in Pharmaceutical Sciences (133-150). CRC Press. https://doi.org/10.21203%2Frs.3.rs-4302115%2Fv1

[27] Roosan, D., Padua, P., Khan, R., Khan, H., Verzosa, C., & Wu, Y. (2024). Effectiveness of ChatGPT in clinical pharmacy and the role of artificial intelligence in medication therapy management. *Journal of the American Pharmacists Association*, 64(2), 422-428. https://doi.org/10.1016/j.japh.2023.11.023

[28] Roosan, D., Wu, Y., Tatla, V., Li, Y., Kugler, A., Chok, J., & Roosan, M. R. (2022). Framework to enable pharmacist access to health care data using Blockchain technology and artificial intelligence. *Journal of the American Pharmacists Association,* 62(4), 1124-1132. https://doi.org/10.1016/j.japh.2022.02.018

[29] Silva, P., Jacobs, D., Kriak, J., Abu-Baker, A., Udeani, G., Neal, G., & Ramos, K. (2021). Implementation of pharmacogenomics and artificial intelligence tools for chronic disease management in primary care setting. *Journal of Personalized Medicine*, 11(6), 443. https://doi.org/10.3390/jpm11060443

[30] Siraj, M., Siraj, H., Shoaib, M., Miran, S., Mahmood, A., & Hussain, F. (2024). Addressing Issues and Challenges Using AI in Pharmacy. In Advances in Computational Intelligence for the Healthcare Industry 4.0 (pp. 22-41). IGI Global. https://www.igi-global.com/chapter/addressing-issues-and-challenges-using-ai-in-pharmacy/345564

[31] Stasevych, M., & Zvarych, V. (2023). Innovative robotic technologies and artificial intelligence in pharmacy and medicine: paving the way for the future of health care—a review. Big Data and Cognitive Computing, 7(3), 147. https://doi.org/10.3390/bdcc7030147