



Assessment of the knowledge and the application of Artificial Intelligence in Pharmacy practice by Community Pharmacists in the city of Tripoli/Libya and Suburbs

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ABSTRACT

Artificial intelligence (AI) rapidly transforms various industries, including healthcare. Community pharmacies play a crucial role in providing healthcare services to patients, and the integration of AI tools and AI systems into these pharmacies has the potential to enhance the quality of care and improve efficiency significantly.

Objectives: This research aims to explore the use of artificial intelligence tools and systems in community pharmacy in Libya, focusing on the city of Tripoli.

Methods: A cross-sectional study involved 97 pharmacists in Tripoli district, Libya community pharmacies. Data was collected using a questionnaire. The questionnaire included questions about pharmacists' use of AI tools and AI systems, the benefits and challenges they experience, and their expectations for the future of AI in community pharmacies.

Results: The study found that AI tools and AI systems are becoming increasingly common in community pharmacies in Tripoli, Libya. 74.23% of pharmacists are aware of AI tools and 60.82% utilize them in their pharmacies. The benefits of AI use were improved patient care quality, increased customer satisfaction, and reduced costs by 31.96%, 37.11%, and 21.65%. respectively, however, challenges of AI adoption were Integration difficulties with existing systems 28.87%, high cost 43.30%, lack of training 37.11% and security and privacy concerns 36.08%, although expectations for the future of AI 59.79% believed that AI use will become more prevalent in the coming years.

Conclusion: The findings of this study suggest that AI tools and AI systems are gaining traction in community pharmacies in Tripoli, Libya. Pharmacists recognize the diverse advantages of AI adoption, including improved patient care, enhanced efficiency, and cost reduction. While challenges such as high costs, training gaps, and integration issues exist, pharmacists remain optimistic about the future of AI in their practice.

1. Introduction

The world is witnessing a massive technological revolution thanks to the rapid development in the field of artificial intelligence (AI), which opens new horizons in various fields, including the healthcare sector. (1).

Artificial intelligence is defined as the ability for machines to mimic human cognitive abilities, such as learning, thinking, and problem-solving. (1).

The use of artificial intelligence in pharmacy began decades ago in areas such as drug analysis and development. (2). Artificial intelligence is being used in hospital pharmacy to improve patient safety and process efficiency. Applications of AI in healthcare include medical diagnosis, drug development, and personalized patient care. Artificial intelligence is being used in community pharmacies to improve services provided to patients, such as medication counseling and medication management (5).

ChatGPT, a large language model, is used to provide virtual customer service in community pharmacies (7).



Artificial intelligence is used to accelerate the drug discovery and development process.

Artificial intelligence is being used to assist pharmacists with their daily tasks, such as checking prescriptions and providing medication advice. Applications of AI in drug development include identifying new drug targets, designing drugs, and predicting drug efficacy.

Artificial intelligence is used to study how drugs interact with each other and identify potential drug interactions.

1.1. Aims of the study:

This study aimed to:

- Understanding the concept of artificial intelligence and its applications in pharmacy.
- Explore the history of the use of artificial intelligence in pharmacy.
- Study the role of artificial intelligence in hospital and community pharmacy.
- Identify potential applications of artificial intelligence in community pharmacies in Libya.
- Evaluating the opinions and attitudes of community pharmacists in Tripoli regarding the use of artificial intelligence.
- It seeks to understand the benefits, challenges, and expectations of pharmacists regarding AI adoption in their practice.

1.2. Research contribution:

- This research contributes to understanding the role of artificial intelligence in community pharmacy in Libya.
- The research findings provide useful information to community pharmacists in Libya on how to use artificial intelligence to improve their practice.
- The research helps develop strategies to implement the use of artificial intelligence in community pharmacies in Libya.

2. Literature Review

2.1. The concept of artificial intelligence

Artificial Intelligence (AI) is the field of computer science that specializes in the creation of intelligent machines, developed with the ability to perform tasks that will ordinarily be associated with a human being. Artificial Intelligence is a stream of science related to intelligent machine learning, mainly intelligent computer programs, which provides results in a similar way to the human attention process. Simply terms, AI refers to the ability of machines and computers to think, act, behave and function as human beings.[1]

Artificial intelligence is the capacity of machines to carry Out tasks that ordinarily require human intelligence, including Sensing, thinking, learning, and decision-making".[2]

Artificial Intelligence is a stream of science related to intelligent machine learning, mainly intelligent computer programs, which provides results in the similar way to human attention process." [3]

The core of AI can be Knowledge Engineering, in which machines are assembled with access to abundant data and information relating to the human world, which enables them to be able to mimic human behavior .[1]

2.2. History of artificial intelligence in pharmacy

The first application of a computer in a pharmacy presumably dates back to the 1980s and since then. Dartmouth Summer Research Project on AI, which began in the middle of the twentieth century, is where the history of AI as a scientific field may be explored. Following this, machine Learning (ML) algorithms were created, enabling the creation of predictions or decisions based on the patterns seen in sizable data sets. Genetic algorithms were subsequently developed using evolutionary principles to identify the best solutions to complicated problems, neural networks, and other cutting-edge methodologies. Chatbots, powered by AI, have become increasingly Popular in recent years as a tool to improve patient care and medication management.[20]

2.3. Artificial Intelligence in hospital pharmacy

The advanced technologies of AI hold enormous transformative potential that is set to revolutionize clinical pharmacy practice by integrating their duties in a seamless and synergistic manner. It offers pharmacists an unparalleled opportunity to enhance their collaboration with clinicians, especially in hospital settings. AI-driven platforms streamline communication between pharmacists and clinicians by delivering real-time updates on patient medications, potential drug interactions, and dosage recommendations derived from integrated patient data. Such



seamless integrations position pharmacists as essential members of healthcare teams, ensuring both patient safety and therapeutic effectiveness. AI's capacity to interpret vast amounts of patient data and clinical guidelines enables it to recommend appropriate drug therapies, dosages, and combination medications. For example, IBM Watson for Oncology is an AI-driven tool that aids oncologists in pinpointing potential cancer drug treatments tailored to individual patient profiles. By analyzing a patient's medical history in conjunction with extensive medical literature and clinical trial data, Watson suggests therapies that could be most effective for particular cancer types⁹. AI also plays a pivotal role in quality improvement. By identifying patterns in medication errors and adverse drug reactions, AI can offer insights into potential systemic issues, thus informing quality improvement strategies. For example, Google's AI has demonstrated its ability to predict adverse events in hospitals and formulate preventative measures, leading to enhanced patient safety and overall care quality¹⁰. For example, in 2018, Google unveiled a significant advancement in cardiovascular disease (CVD) studies. Their researchers, harnessing machine learning techniques, crafted an AI model capable of estimating an individual's heart disease risk by examining the retina¹¹. Another example is the Chemical Substructure Representation (CASTER), an AI tool that can conduct an extensive assessment of hidden features depicts drugs or pairs of drugs based on these common structures. It then uses deep learning techniques to create a universal representation of these drugs. This can help in anticipating possible drug-drug interactions and adverse drug reactions, enhancing the safety and efficacy of pharmaceutical treatments.

AI's predictive analytics capabilities also have the potential to streamline patient care by predicting health trajectories based on current treatment plans and patient health histories. Tools like Google DeepMind have shown the ability to accurately forecast hospital readmission rates for heart failure patients, providing pharmacists with a more precise tool for customizing care strategies.

In patient education, AI plays a vital role, translating sophisticated medical advice into more digestible and comprehensible formats. Interactive chatbots, such as Buoy Health, offer personalized advice about medication usage, diet changes, lifestyle modifications, and treatment plans, fostering increased understanding and compliance. In consultations, AI's ability to swiftly analyze new research findings, guidelines, and patient-specific information enables pharmacists, equipped with tools like PathAI, to rapidly generate evidence-based treatment recommendations, thereby strengthening collaborative healthcare processes.

AI algorithms have proven themselves to be invaluable tools in therapeutic drug monitoring, continuously analyzing patient data, including biomarkers, to assess the efficacy and safety of medication therapies. Platforms like Dosis Personalized Dosing use real-time patient data to suggest optimal medication dosages based on individual responses for better therapeutic outcomes.

Overall, AI can enable clinical pharmacists to concentrate their efforts on delivering superior, patient-centric care rather than on administrative duties, leading to improved patient outcomes and increased job satisfaction and professional fulfillment for pharmacists.[5]

2.4. Applications of Artificial Intelligence in health care:

The role of Artificial Intelligence is rapidly expanding in the field of medicine. AI's capability of large-scale data interpretation Can help in better clinical decision-making. It can revolutionize the healthcare system via more personalized measures according to the Individual needs of the patients. Currently, AI is used to diagnose and recommend appropriate disease management Steps. AI could be more autonomous in the future to perform complicated tasks such as patient triage. However, AI-associated Potential risk factors should be carefully handled to ensure optimal healthcare delivery".[28]

There are several applications of AI in hospital pharmacy based health care system in organizing dosage forms for individualized patients, selection of the suitable or available administration routes or treatment policies.

Maintaining of medical records: Maintenance of the medical records of patients is complicated task. The collection, storage normalizing, tracing of data are made easy by implementing the AI system. Google Deep Mind health project (developed by Google) assists to excavate the medical records in short span of time. Hence, this project is a useful one for better and faster health care. The Moor fields Eye hospital NHS is assisted by this project for improvement of eye treatment.

Treatment plan designing: the designing of effective treatment plans is possible with the help of AI technology. When any critical condition of patient arises and selection of suitable treatment plan becomes difficult, then the AI system



is necessary to control the situation. All the previous data and reports, clinical expertise, etc., are considered in the designing of treatment plan as suggested by this technology. A program is launched by IBM Watson to help oncologists. Assisting in repetitive tasks: AI technology also assists in some repetitive tasks, such as examining the X-ray imaging, radiology, ECHO, ECG, etc., for the detection and identification of the diseases or disorders. Medical Sieve (an algorithm launched by the IBM) is “cognitive assistant” having good analytical and reasoning ability. A medical start-up is necessary for the improvement of patient condition by combining deep learning with medical data. A specialized computer program is available for each body part and used in specific of disease conditions. Deep learning can be employed for almost all types imaging analyses, such as X-ray, CT scan, ECHO, ECG, etc.

Health support and medication assistance: Recent years, the uses of AI technology are recognized efficient in health support services and also, for the medication assistances. Molly (a start-up designed virtual nurse) receives a pleasant voice along with a cordial face. Its aim of it is for helping patients to guide the treatment of patients as well as supporting them with chronic condition between the doctor’s visits. Ai Cure, is an app existing in Smartphone’s webcam, monitors patients and assists them to control their conditions.

AI helps to people in health care system: It is capable of collecting and comparing the data from social awareness algorithms.⁶ The vast information recorded in healthcare system involves the medical history of the patients along with the treatment history profile from the birth, habits as well as life-styles of the patients.

Healthcare system analysis: In the healthcare system, if all the data is computerized then retrieval of data is easy. Netherland maintains 97% of invoices in digital format, which contain treatment data, physician names, and hospital names. Hence, these can be retrieved easily. Zorgprisma Publiek, a local company analyses the invoices with the help of IBM Watson cloud technology. If any mishap occurs, it recognizes it immediately and takes the correct action. Because of this, it improves and avoids patient hospitalization.

2.5. Artificial Intelligence in community pharmacies

AI promises to revolutionize community pharmacy practice, extending its impact beyond pharmacists’ primary responsibilities. Firstly, AI enhances supply chain management. AI algorithms can analyze a vast amount of data, including past sales, seasonality, local health trends, promotional activities, and even external factors like weather patterns or disease outbreaks, to predict demand for various medications. This helps pharmacies maintain an optimal inventory, minimizing stockouts (when high-demand items run out) and overstock (where items remain unsold, potentially expiring before being sold). Furthermore, AI automates the reordering processes to maintain optimal inventory levels. By monitoring stock levels in real-time and automatically generating purchase orders to replenish stocks when levels fall below certain thresholds, this technology can save staff time and help ensure essential medications are always readily available for purchase. AI tools can also evaluate suppliers based on factors like reliability, cost, delivery speed, and product quality. For instance, this technology could analyze historical delivery time, cost, and quality data from each provider before suggesting the ideal supplier for each product, helping pharmacies maintain high-quality inventory while minimizing costs.

Secondly, AI can improve Automated Dispensing Systems (ADSs). AI can significantly increase accuracy and precision in dispensing, learn from past errors, and employ machine learning algorithms for continuous system optimization.

AI’s capability to swiftly sort and label medications, anticipate maintenance needs, and tailor dispensing according to each patient’s specifications will not only maximize operational efficiency but also foster personalized patient care. By integrating automated dispensing with other aspects of pharmacy management, such as inventory control and electronic health records, AI can further streamline medication processes from prescription generation to billing. AI’s ability to cross-reference dispensed medication against patients’ health records provides an extra safeguard, promptly alerting pharmacists of potential drug interactions or patient allergies, thus greatly enhancing patient safety. Thirdly, AI assists in advancing public health monitoring. AI systems can analyze large-scale health data sets to detect trends in disease outbreaks, drug usage patterns, and other public health issues that may require a response by pharmacists or public health organizations. For instance, AI could detect an upsurge in reported flu symptoms from certain regions through data parsing¹⁹, subsequently notifying pharmacists in those regions about potential outbreaks. This will prompt them to stockpile antiviral medications, flu shots, and over-the-counter remedies in anticipation of increased demand. Furthermore, AI can aid pharmacists in tackling health equity challenges by analyzing data such as zip codes, demographics, and medical histories. By correlating zip codes with socioeconomic indicators and health outcomes, AI



can pinpoint areas with pronounced health disparities, offer tailored patient recommendations, and provide insights for specific policy actions. Such understanding can pave the way for more strategic and effective healthcare initiatives. For example, AI might pinpoint areas with high adult diabetes rates, which can inform the creation of educational programs, provision of complimentary medications, or enhanced access to care for affected individuals. Lastly, AI tools can boost pharmacies' profitability. By analyzing data such as past sales and local health trends, AI algorithms can predict medication demand. This ensures optimal inventory management, minimizing stockouts or overstocks that could negatively impact profits. Moreover, operational efficiency improvements, a direct result of AI integration, contribute significantly to profitability. Automating tasks like dispensing medication and managing inventory allows pharmacy staff to focus on higher-value services like patient counseling and care. This not only enhances service quality but may also open new revenue streams. AI tools such as chatbots or automated reminders can increase patient engagement. For instance, an AI chatbot could provide personalized medication advice, promoting better adherence among patients. This can improve patient health outcomes and foster loyalty, as customers are more likely to return when offered personalized and attentive service. In terms of cost savings, AI can reduce dispensing errors that lead to costly reimbursements or reputational damage, patient harm, and prevent equipment breakdowns, thus saving on unexpected repair costs. AI also facilitates data-driven decision-making. For example, AI could analyze sales data to identify high-margin products, allowing a pharmacy to concentrate its marketing efforts on these items for increased sales. AI can identify trends suggesting new revenue opportunities, such as an unmet need in local communities for certain health products or services. Efficient staffing through AI not only enhances patient satisfaction but directly links to the profitability of pharmacists. Optimizing staffing levels means pharmacists can attend to a greater number of patients without compromising on the quality of service, thereby increasing revenue. Moreover, satisfied customers often lead to repeat business and word-of-mouth referrals, further boosting profitability. Reducing overheads by avoiding overstaffing, combined with the increased revenue from efficient service, enhances the overall financial health of the pharmacy.[5]

2.6. ChatGPT in community pharmacy

One of the most promising chatbot models is ChatGPT, a conversational agent built using the GPT (Generative Pre-trained Transformer) language model. ChatGPT is designed to assist patients in answering health-related questions and providing personalized advice. However, the success of this technology depends on the knowledge and experience of the pharmacists who use it. Chat GPT has attracted a range of reactions from the academic and scientific communities, reflecting the long debate about the advantages and disadvantages of cutting-edge AI technologies. On one hand, Chat GPT, along with other Large Language Models (LLMs), can be useful for conversational and writing jobs, helping to improve the effectiveness and correctness of the required output. On the other hand, questions have been raised about potential bias based on the data sets used in ChatGPT training, which may limit its capabilities and lead to factual inaccuracies but alarmingly appear to be academically reasonable (a phenomenon known as hallucination). In addition, security issues and the potential for breaches with the dissemination of misleading data through LLMs should be considered. This research aims to investigate pharmacists' current knowledge and experience regarding using ChatGPT in their practice. Through a survey, we explored the benefits and drawbacks of using ChatGPT in a pharmacy setting, the level of training required to use it effectively, and the impact on patient care. This research will provide valuable insights into the pharmacists' perceived challenges and opportunities of implementing AI-powered chatbots in pharmacy practice, and inform strategies to optimize their use." [20]

"This study evaluates ChatGPT, an AI-based language model, in addressing common pharmacist inquiries in community pharmacies. The assessment encompasses Drug-Drug Interactions, Adverse Drug Effects, Drug Dosage, and Alternative Therapies, each comprising 20 questions, totaling 80 questions. Responses from ChatGPT were compared against standard answers, generating textual and chart scores. Textual score was computed by relating correct answers to the total questions within each category, while chart score involved the total correct answers multiplied by the chart-type questions. ChatGPT exhibited distinct performance rates: 30% for Drug-Drug Interactions, 65% for Adverse Drug Effects, 35% for Drug Dosage, and an impressive 85% for Alternative Therapies. While Alternative Therapies displayed high accuracy, challenges arose in accurately addressing Drug Dosage and Drug-Drug Interactions [7]9

2.7. Artificial Intelligence in pharmaceuticals development



Pharmaceutical companies are collaborating with AI vendors and leveraging AI technology in their manufacturing processes for research and development and overall drug discovery. Reports show nearly 62 percent of healthcare organizations are thinking of investing in AI shortly, and 72 percent of companies believe AI will be crucial to how they do business in the future. To get a better sense of the future of AI in the sector, Pharma News Intelligence dives into current AI use cases, the best uses for the technology, and the future of AI and machine learning. The McKinsey Global Institute estimates that AI and machine learning in the pharmaceutical industry could generate nearly \$100B annually across the US healthcare system. According to researchers, the use of these technologies improves decision-making, optimizes innovation, improves the efficiency of research/clinical trials, and creates beneficial new tools for physicians, consumers, insurers, and regulators. Top pharmaceutical companies, including Roche, Pfizer, Merck, AstraZeneca, GSK, Sanofi, AbbVie, Bristol-Myers Squibb, and Johnson & Johnson have already collaborated with or acquired AI technologies. In 2018, the Massachusetts Institute of Technology (MIT) partnered with Novartis and Pfizer to transform the process of drug design and manufacturing with its Machine Learning for Pharmaceutical Discovery and Synthesis Consortium.

Research works are carried out daily to find new active principles for the currently incurable diseases and conditions; increase the safety profile of already existing drugs; combat drug resistance and minimize therapeutic failure. Hence, there is an increase in the size and variety of biomedical data sets involved in drug design and discovery. This factor and many more contributed to the advancement of AI in the pharmaceutical industry. Today, some companies offer software with much relevance in drug design and data processing, as well as in predicting treatment outcomes. GNS healthcare uses AI machine software known as Reverse Engineering and Forward Simulation (REFS). REFS determines the cause and effect relationships between various types of data, that are unforeseen ordinarily by direct data evaluation. GNS claims that REFS can transfer millions of data points ranging from clinical to genetics, laboratory, imaging, drug, consumer, geographic, pharmacy, mobile, proteomic, and so on. In drug design, a company known as Atomwise developed the first deep learning neural network for structure-based drug design and discovery that they called AtomNet. AtomNet makes use of a statistical approach to extract information from millions of experimental affinity measurements and thousands of protein structures to predict the binding properties of small molecules with proteins. By presenting 3-dimensional images of the protein and ligand pair showing channels for carbon, oxygen, nitrogen, and other types of atoms, AtomNet technology enables the pharmaceutical chemists to perform core processes of drug discovery and design like hit discovery, lead optimization, and prediction of toxicity with high precision and accuracy in weeks as against years. Insilico Medicine announced an AI project by the company called Pharm AI. Insilico Medicine claims they applied Generative Adversarial Networks (GAN) and reinforcement learning algorithms. The GAN is a type of generative model that can generate samples and also learn from training samples. They are made up of two neural networks, the generator, and the discriminator. The relationship between the generator and the discriminator is referred to as “adversarial”. The generator tries to create and learns to create new samples and sends them to the discriminator, which classifies the sample as real or fake where real denotes the examples that belong to the data set, and the examples generated by the generator are denoted “fake”. Through continuous training, the generator begins to create samples that are similar to the real ones while the discriminator gets better at the identification process. With Pharm AI, through GAN and reinforcement learning, Insilico Medicine claims that it can generate new molecular structures and ideate the biological origin of a disease.

2.8. Artificial Intelligence in pharmacy practice, hospital and community Pharmacies:

Chatbots are capable of mimicking interactions between customers and customer care of sale staffs. Chatbots are capable of automatically resolving customer complaints and queries and the difficult questions are transferred to human staff. In retail pharmacy, this principle can be applied. The chatbots can be programmed to mimic pharmacist-patient interaction. Walgreen made a partnership with Medline, a telehealth firm to create an avenue to help patients interact with healthcare professionals through video chat. AI can also be useful in inventory management. As a retail pharmacist, imagine being able to predict what your patients will need in the nearest future, stocking them, and using personalized software to deliver e-mails to remind the patient of drug needs. With the use of AI-powered data analytics, a patient’s future drug purchase can be predicted. Predicting the patient’s drug purchase through AI will help the pharmacist to make proper stock procurement decisions. Although, there are existing inventory management software and application that are used in retail pharmacy stock management like Mckessons; Liberty; Winpharm;



PrimeRx; and WinRx, not all of them utilize AI or machine learning. For example, an AI company, Blue Yonder developed software for Otto group, a German online and catalog retailer. This software can predict with 90% accuracy what will be sold by Otto in 30 days. This reduced the delivery schedule for purchased products from one week or more to one of two days by enabling direct delivery of the product from the supplier to the consumer without having to pass through the warehouse. Intending to improve the safety of patients, the University of California San Francisco (UCSF) Medical Center uses robotic technology for the preparation and tracking of medications. According to them, the technology has prepared 3, 50, 000 medication doses without any error. The robot has proved to be far better than humans both in size as well as its ability to deliver accurate medications. The abilities of the robotic technology include the preparation of oral as well as injectable medicines which include toxic chemotherapy drugs. This has given the freedom to the pharmacists and nurses of UCSF so that they can utilize their expertise by focusing on direct patient care and working with the physicians. Within the automated system of the pharmacy, the computers first receive medication orders electronically from the physicians and pharmacists of UCSF. After this, individual doses of pills are picked, packaged, and dispensed by the robotics. This is followed by machines assembling the doses onto a bar-coded plastic ring. The thin plastic ring contains all medications that have to take by a patient within a period of 12h. Adding to the capabilities of the automated system is their ability to prepare sterile preparations that are meant for chemotherapy along with filling intravascular syringes with the right medications.

2.9. Implications for pharmacists and their practice

AI can strongly influence and shift pharmacists' focus from the dispensing of medications toward providing a broader range of patient-care services. The pharmacist can leverage AI to help people get the most from their medicines and keep them healthier. Most importantly, AI provides pharmacy an opportunity for more collaboration across many different entities serving the same patient. For the patient, in addition to potentially better healthcare services offered by their professionals, AI may be a useful tool for providing guidance on how and where to obtain the most cost-effective healthcare and how best to communicate with healthcare professionals; optimizing the value of data from wearable; providing everyday lifestyle guidance; integrating diet and exercise; and supporting treatment compliance and adherence.

2.10. Applications of AI in drug development

The tasks of finding successful new drugs is daunting and predom-inantly the most difficult part of drug development. This is caused by the vast size of what is known as chemical space, which is estimated to be in the order of 1060 molecules . The technolo- gies that incorporate AI have become versatile tools that can be applied ubiquitously in various stages of drug development, such as identification and validation of drug targets, designing of new drugs, drug repurposing, improving the R&D efficiency, aggregating and analysing biomedicine information and refining the decision-making process to recruit patients for clinical trials. These potential uses of AI provide the opportunity to counter the inefficiencies and uncertainties that arise in the classical drug development methods while minimising bias and human intervention in the process .The other uses of AI in drug development include the prediction of feasible synthetic routes for drug-like molecules , pharma-cological properties , protein characteristics as well as efficacy, drug combination and drug–target association and drug repurposing. Also, the identification of new pathways and targets using omics analysis becomes possible via the generation of novel biomarkers and therapeutic targets, personalised medicine based on omics markers and discovering the connections between drugs and diseases. DL has demonstrated outstanding success in proposing potent drug candidates and accurately predicting their properties and the possible toxicity risks . Circumventing past problems in drug development – such as analysis of large datasets, laborious screening of compounds while minimising standard error, requiring large amounts of R&D cost and time of over US\$2.5 billion and a more than a decade – are now possible using AI methods. With AI technology, new studies can be carried out in assisting the identification of new drug targets, rational drug designing and drug repurposing .

2.11. Artificial Intelligence in polypharmacology

The concept of polypharmacy is often studied as a static exposure to medications without considering past medication use or subsequent changes, Which may limit the conclusions about the consequences of polypharmacy. Identifying what combinations of medications or trajectories of treatment are associated with health outcomes would allow the development of specific polypharmacy indicators for public health surveillance . Such indicators would be useful to guide clinical practice, to implement interventions or policies and would allow For their evaluation thereafter.



Determining health outcomes associated with polypharmacy requires considering concurrent and sequential use of multiple medications, duration of treatment, medical and sociodemographic characteristics of individuals. This type of analysis of large amount of complex data is difficult to perform with traditional statistics, but it can be accomplished with artificial intelligence (AI) methods. However, using AI in large health administrative data may pose ethical challenges, such as those related to re-identifying individuals or using the data sparingly, that is to restrict attention only to the variables necessary to answer the research question. Moreover, the polypharmacy indicators that are created must neither marginalize nor discriminate against any specific population. Taking into consideration the ethical and social aspects involved will be beneficial for researchers, clinicians, decision-makers, and for the population in general".[28]

AI-developed systems can predict potential drug interactions by effectively analyzing major databases based on patient-related factors such as genetics, age, allergies, and ethnicity. These predisposing factors can facilitate the analysis of existing health status, prescribed medications, and medical history to prevent the occurrence of certain diseases. Collectively, the information could improve the decision-making regarding medication combinations to alleviate polypharmacy-linked adverse reactions, particularly in older individuals under multiple treatments for different diseases. Sema4 signal is a patient health-centered transformative product of a Healthcare intelligence development company, Sema4. It employs AI, digital tools, and innovative exome-based genetic testing to reveal the genetic profile and clinical history of the Patient. The information helps to evaluate and predict adverse risks of medications and enables healthcare practitioners, particularly oncologists, to vigilantly evaluate multiple treatment options for better patient care. Elsevier's Pinpoint suite provides evidence-based literature by utilizing machine learning and AI, which assist healthcare providers in considering contraindications and adverse drug interactions during treatment. Moreover, it facilitates making inclusive decisions to ensure patient safety in complicated cases." [28]

Currently, the 'one-disease-multiple-targets' paradigm dominates over the 'one-disease-one-target' paradigm because of deeper understanding of pathological processes in diseases at the molecular level. One-disease-multiple-targets is termed poly-pharmacology. Many databases, such as ZINC, PubChem, Ligand Expo, KEGG, ChEMBL, DrugBank, STITCH, BindingDB, Supertarget, PDB, among others, are available to integrate diverse information of molecular pathways, crystal structures, binding affinities, drug targets, disease relevance, chemical properties and biological activities. AI could be used to probe these databases to design polypharmacological agents. A success story of an AI application in designing polypharmacological agents was recently published in the literature – the authors developed a computational platform, DeepDDI, for better understanding of drug – drug interactions and associated mechanisms and prediction of alternative drugs for intended clinical use without negative health effects.

3. Materials and Methods

3.1. Study design:

For the theoretical study and then adopt the descriptive method in the study of the methodology through references, books, publications and reports through the information network.

For the field study then rely in order to investigate the validity of information and results on some of the tools, including (questionnaires, personal interviews, and personal observations) after the moral approval by relevant pharmacists to conduct a special questionnaire.

3.2. Study community and Temporal boundaries :

The present study was conducted on a sample of pharmacists in community pharmacies in the city of Tripoli during the period from 1/5/2025 to 1/7/2025.

3.3. Tools to collect data and samples:

This cross-sectional study was conducted among community pharmacists in Tripoli-Libya using a questionnaire. The total sample consisted of (97) pharmacists working in community pharmacies, and this study was taken from existing cases.

In addition to socio-demographics, the survey assessed pharmacists' willingness, attitudes, and barriers to AI adoption in pharmacy.

3.4. Methods of data analysis :



The researchers relied on the descriptive and analytical statistical methods suitable for the nature of the data collected through the field study and used the following statistical methods :

- Frequency distribution table .
- Percentages .

4. Result and Discussions

4.1. Results:

The total number of participants was 97 pharmacist from various localities in Tripoli area with both sexes different and ages and qualifications. These results are introduced in the following frequency tables in respect to percentages.

Table (1): shows ages of total participants

Age (years)	Frequency	Percent
20-24	33	34.02 %
25-34	55	56.70 %
34-44	7	07.21 %
45-54	2	02.06 %

Most

participants (34.02%) fall within the 20-24 age group, followed by the 25-34 age group (56.70%).

Table (2): shows the gender of the participants

Gender	Frequency	Percent
Male	50	51.55 %
Female	47	46.39 %

The distribution of participants is relatively even between males and females were 51.55% and 46.39 ; respectively.

Table (3): shows educational qualification the pharmacists

Qualification	Frequency	Percent
Intermediate diplom	1	01.03 %
Higher diplom	46	47.42 %
Bachelor's Degree	48	49.48 %
Master's Degree	2	02.06 %

Table (3)
the most

figure out
common

educational qualification among participants, although a great proportion of pharmacists included in study samples have a bachelor's degree were and, a higher diploma in pharmacy were 49.48% and 47.42%; respectively, however



those have Master's Degree or Intermediate diplom were in a more less proportion by 02.06 % and 01.03 %; respectively.

Table (4): shows Number of years of experience in pharmacy.

Years of experience	Frequency	Percent
Less than 5 year	53	54.64 %
5-10 years	36	37.11 %
11-15 years	4	04.12 %
More than 15 year	4	04.12 %

The majority of participants (54.64%) have less than 5 years of experience in pharmacy, followed by those with 5-10 years of experience (37.11%). There are no participants with more than 15 years of experience were found out of results in table (4).

Table (5): shows prcentages of familiar with AI tools.

Familiarity with AI tools	Frequency	Percent
Yes	72	74.23 %
No	25	25.77 %

The result (5) in Table revealed that most pharmacists in Tripoli, Libya (74.23%) are familiar with AI tools. However (25.77%) pharmacists were not familiar with AI tools

Table (6): shows the uses of AI in pharmacy settings:

AI use	Frequency	Percent
In providing drug advice to patients (AI consultation system)	26	26.80 %
Select the appropriate medication for the patient	21	21.65 %
To choose the best pharmaceutical preparation	26	26.80 %
control the quantity of medicines in the pharmacy (inventory management system)	34	35.05 %
Monitoring the expiration date of medicines	41	42.27 %
To order medicines from suppliers (sales management system)	32	32.99 %

Other tasks	3	03.09 %
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According to the results in table (6) it was found out that AI is used for a variety of tasks, where the most commonly use of AI and smart systems was in monitoring the stocks, inventory management systems and sales management system accordingly by 42.27%, 35.05 % and 32.99 %; respectively, however less commonly in consultation system, Select the appropriate medication and best pharmaceutical preparation by different proportions at 26.80 %, 26.80 % and 21.65 % ; respectively.

Table (7): shows average concentration of Which AI tools do you use for medical consultations.

AI tool used for medical consultations.	Frequency	Percent
Bard or Gimni	10	10.37 %
ChatGPT	40	40.03 %
Bing or Coplet	17	17.52 %
I don't use any of them	30	32.98 %

It has resulted in Table (7) that the AI tool used in medical consultation settings was ChatGPT (41.24%). However, others like Bing or Coplet and Bard or Gimni were among the AI tools used in medical consultation settings in lower percentages (17.53 % and 12.37 %; respectively, some other pharmacists (32.98%) do not know any of the listed AI tools. Some pharmacists know and use all the listed AI tools.

Table (8): shows percentages of benefits that have been noticed from using AI tools or smart systems in your pharmacy.

Benefits of using AI tools in pharmacy practice	Frequency	Percent
Improved patient care quality	34	31.96 %
Improved customer satisfaction	38	37.11 %
Improved pharmacy efficiency	61	60.82 %
Reduced medication costs	23	21.65 %

Results in Table (8) revealed that there were a lot of benefits of using AI tools or smart systems in pharmacies It was found out that improved pharmacy efficiency in 60.82% of tested pharmacies by improving patient care quality in (31.96%), improved customer satisfaction (37.11%) and reduced costs (21.65%).

Table (9): shows percentages of challenges in using AI tools in pharmacy practice.

Of What challenges do you face in using AI tools in your pharmacy.	Frequency	Percent
High cost	42	43.30 %
Lack of training	36	37.11 %
Difficulty integrating with other systems	28	28.87 %

Security and privacy concerns	35	36.08 %
Other challenges (please specify	10	10.31 %

The most common challenge faced by pharmacists in using AI tools or smart systems is high cost (43.30%). Others frequently reported challenges include lack of training (37.11%), difficulty integrating with other systems (28.87%), and security and privacy concerns (36.08%). A variety of other challenges were also mentioned by participants (10.31%).

Table (10): shows percentages of the future expectations for the use of AI tools and pharmacy systems in libya.

Future expectations of AI tools and pharmacy systems in libya	Frequency	Percent
will become more common	63	64.94%
They will become more complex	12	12.37 %
They will become more expensive	21	21.65 %
They will become easier to use	45	46.39%

The most common expectation for the future use of AI tools and pharmacy systems in Libya is that they will become more common (64.94%) was found out in results of Table (10). Other frequently reported expectations included that they will become easier to use, more complex, and more expensive (46.39%, 12.37% and 21.65% respectively).

4.2. Discussion:

The present study explored the willingness and attitudes of pharmacists in Tripoli, Libya, towards AI integration in community pharmacies. The findings revealed a generally positive outlook on AI, with pharmacists recognizing its potential to improve efficiency and patient care.

The high willingness and positive attitudes resonate with prior studies on AI adoption in healthcare settings [1, 2, 3]. This alignment strengthens the generalizability of the findings and suggests a global trend of healthcare professionals embracing AI technology.

However, the present study also identifies significant barriers, including the lack of AI-specific software and hardware, high costs, and the perceived need for constant human supervision. These hurdles mirror those reported in other studies [4, 5, 6]. To address these challenges in Tripoli's context, policymakers and healthcare organizations should consider:

Subsidies or grants to make AI solutions more affordable for pharmacies.

Developing partnerships with AI technology providers to facilitate access and integration.

Enhancing collaboration between pharmacists and IT professionals to ensure smooth implementation and ongoing support.

Promoting AI Education is Crucial finding that pharmacists with a better understanding of AI technology exhibited greater willingness to adopt it underscores the importance of education.

Here are some recommendations:

* Integrating AI-related modules into the pharmacy curriculum at universities in Tripoli.

* Organizing workshops and training programs for practicing pharmacists to equip them with the necessary knowledge and skills to leverage AI effectively.



Addressing Study Limitations

The present study contributed valuable insights into the potential and challenges of AI adoption in community pharmacies in Tripoli. By addressing the identified barriers and promoting AI education, stakeholders can empower pharmacists to harness the potential of AI, ultimately leading to improved patient care and pharmacy practice in Tripoli.

5. Conclusions and recommendations

5.1. Conclusions

- AI tools and smart systems are becoming increasingly common in pharmacies in Tripoli, Libya.
- Pharmacists perceive a variety of benefits associated with using AI, including improved patient care, increased efficiency, and reduced costs.
However, there are also challenges associated with AI adoption, such as high cost, lack of training, and integration difficulties.
- Pharmacists have positive expectations for the future of AI in Libyan pharmacies, believing that it will become more common, easier to use, and more complex.

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5.1. Recommendations

- Continue to invest in the development and implementation of AI tools and smart systems for pharmacies. AI has the potential to significantly improve the quality of patient care, pharmacy efficiency, and cost-effectiveness.
- Provide training and support to pharmacists on the use of AI tools and smart systems. This will help to ensure that pharmacists are able to get the most out of these technologies and minimize the risk of adoption challenges.
- Develop standards and guidelines for the use of AI in pharmacies. This will help to ensure that AI is used in a safe, ethical, and effective manner.
- Conduct further research on the impact of AI on pharmacies. This research can help to identify the potential benefits and risks of AI adoption and inform future policy and practice decisions.

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