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The impact of various artificial intelligence applications in pharmacy practice: A narrative review

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Abstract

Introduction: Artificial Intelligence (AI) in pharmacy practice is refers to the application of AI technologies and techniques in various aspects of the pharmacy field and it has the potential to improve the efficiency, accuracy, and patient care. This study presents a narrative literature review of the present applications of AI in hospital pharmacy practice.

Method: We conducted a narrative review on relevant published articles about AI applications in pharmacy practice in Saudi Arabia and other country and included five relevant studies based on our inclusion criteria.

Results: Our search methodology yielded a total of 2646 studies, but only five of them met our inclusion criteria. These studies were published within a span of four years from 2018 to 2022. In terms of geography, two studies originated from the Middle East, specifically the Kingdom of Saudi Arabia. One study was from Northeast Asia (Japan), while the remaining two were from Southwestern Europe (Spain).

Conclusion: Given the widespread use of AI in pharmacy practice, pharmacists should consider its potential benefits. This narrative review suggests that pharmacy automation improves patient care safety and efficiency in various areas and enhances patient satisfaction. Therefore, it is crucial to broaden the use of pharmacy automation in hospital pharmacies.

1. Introduction and background

1.1. Rationale

The healthcare industry, among others, is evolving rapidly due to advancements in artificial intelligence (AI). AI, a scientific field centered around intelligent machine

learning and sophisticated computer programs, is transforming various sectors by delivering results on par with human performance.[1] This includes data collection, efficient data usage systems, accurate or estimated decision-making, and ongoing self-improvement. AI has already led to notable advancements like Big Data analysis, machine learning, robotics, and the Internet of Things (IoT), and promises to continue driving innovation in the future.[2]

The concept of AI originated from a conference proposal by Dartmouth College in 1955. By the 1970s, AI had made its way into the healthcare industry with the creation of MYCIN, a program designed to detect treatments for blood infections. Pharmacy computers, aiding in tasks such as data collection, analysis, management, and drug storage, have become integral to pharmacy operations. More recently, AI has attracted significant interest in the pharmacy sector, leading to a surge of programs centered on drug therapy. As a result, AI-driven applications now oversee activities such as drug interaction checks, drug therapy monitoring, and drug formulary selection.[3] These developments contribute to improved health outcomes and enhanced patient experiences.

Advanced AI applications like Electronic Health Records (EHRs) and robotic dispensing systems are now in place in hospital pharmacies.[4] These aim to free pharmacists to focus on a wider array of patient care services rather than just dispensing medication. Thus, it allows them to operate at their highest professional level and improve patient care.[5] AI integration also enhances collaboration between pharmacies and other patient care entities. However, seamless AI integration with existing software systems is vital to fully exploit the benefits of pharmacy automation.[6]

AI technologies are now a key part of hospital pharmacies in many countries, including Saudi Arabia. They are central to the developmental plans for the Kingdom's Vision 2030.[7] The importance of innovation and AI in clinical pharmacy was a major focus at the 2nd Saudi Society of Clinical Pharmacy (SSCP) Annual International Conference in 2022. The goal is to boost workflow productivity, cut operational costs, and improve safety and accuracy in the pharmacy environment.[8]

The growing use of advanced AI applications, notably the implementation of EHRs and robotic dispensing systems, is revolutionizing the healthcare industry, especially in pharmacy areas.[9] These technologies enable pharmacists to deliver better care, enhance patient results, and promote cooperation among healthcare organizations, thereby advancing the objectives of the healthcare sector.[10]

1.2. Objective

The purpose of this study is to offer a comprehensive review of the present applications of AI in hospital pharmacy practice. We strive to equip hospital pharmacists with a deep understanding of the significant developments brought about by the global implementation of AI in our field.

1.3. Research question

What are the outcomes of using AI applications extensively in hospital pharmacies?

2. Methods

2.1. Study design

After conducting an initial literature search, we found a variety of study designs, suggesting a wide range of research available. As a result, we chose to conduct a narrative review instead of a meta-analysis. The inclusion criteria for our review are outlined below.

2.2. Systematic review protocol

We carried out an exhaustive narrative review, scouring databases such as PubMed, Embase, ScienceDirect, KAU DeepKnowledge, Google Scholar, and the Saudi Medical Journal. Our search focused on AI applications in pharmacy practice, spanning articles published from 2000 to December 2022. Of the 2646 studies initially found, only five met the inclusion criteria and were selected for our review.

2.3. Search strategy

Search engines were used with specific keywords: "artificial intelligence in pharmacy practice," "pharmacy automation," "robotic dispensing system," and "electronic health records in hospital pharmacy."

2.4. Data sources and data extraction

First, we assessed the relevance of articles by examining their titles and abstracts. We restricted our search to English-written studies focusing on the use of AI in pharmacy practice. We found a total of 2646 articles. However, we excluded some due to their irrelevance or inadequate information.

2.5. Data analysis

We used a narrative synthesis of the studies.

3. Results

3.1. Study selection and characteristics

Our search methodology yielded a total of 2646 studies, but only five of them met our inclusion criteria. These studies were published within a span of four years - from 2018 to 2022. In terms of geography, two studies originated from the Middle East, specifically the Kingdom of Saudi Arabia. One study was from Northeast Asia (Japan), while the remaining two were from Southwestern Europe (Spain). These studies explored various applications of AI, such as EHRs and a range of robotic dispensing systems. The central theme of all these studies was the evaluation of pharmacy automation's impact within hospital pharmacy settings. The details of these studies are illustrated in Table 1.

Table 1. Study characteristics and outcomes of implantation of AI applications in pharmacy practices.

Author	Year	Location	Study design	Type of AI	Outcomes	Limitations
Meshaal Mohammed Eisa Hamad, et al.[11]	2022	Saudi Arabia	Quasi-experimental time-series design	Electronic health records (EHRs)	In contrast to the significant reduction in the number of medication orders from 22.76 to 18.76 ($p<0.001$), they found that the medication error rate had increased nearly twofold after the implementation of EHRs.	-
Tomoki Takase, et al.[12]	2022	Japan	Experimental and statistical analysis	Various robotic dispensing systems, such as; 1. Automated dispensing robot. 2. Dispensing robot for powdered drugs. 3. Bar-coded medication dispensing systems.	It was remarkable to see the reduction in both preventable (0.204% to 0.044%, $p<0.001$) and unpreventable (0.015% to 0.002%, $p<0.001$) dispensing errors. In addition, none of the cases in which drug selection and/or drug strength were chosen incorrectly. There was a significant reduction in the median time pharmacists spent per medication order, from one minute to less than 30 seconds, $p<0.001$.	-
Hisham Momattin, et al.[13]	2021	Saudi Arabia	Data collection	Robotic Pharmacy	The mean waiting time was reduced by half, resulting in increased patient satisfaction and pharmacist productivity. The dispensing process was error-free.	In order to reap the full benefits of robotic pharmacy, the facility's software systems must be integrated with this technology.
Carlos Del Rio-Bermudez, et al.[14]	2020	Spain	-	Electronic health records (EHRs)	Pharmacists can use the daily data collected while practicing to enhance the delivery of healthcare rather than only using the data as a byproduct of their work. Hospital pharmacists will be better recognized and more visible, and above all, promoting better patient care.	What to document, how, and when. Privacy and security. Data availability and data sharing.

Carmen Guadalupe Rodriguez-Gonzalez, et al.[15]	2018	Spain	Disguised observation technique	Robotic depending system	Following the implementation of a robotic dispensing system, the dispensing error rate was reduced by half, and there was a five-fold reduction in stock-out ratios. Previously, it took an hour and a half for staff to manage stock on a daily basis. Now it takes less than 40 minutes.	-

3.2 Synthesized findings

Meshaal Mohammed Eisa Hamad et al. (2022)[11] used a quasi-experimental time-series design to investigate the impact of introducing EHRs on medication errors. Data from 1.5-year periods before and after EHR implementation were retrospectively examined. The data for analysis was sourced from various units within the study setting. Medication error data was provided by the risk management section of the quality department. The process of medication management was studied qualitatively. Descriptive and inferential statistics were used to analyze the numerical data. The findings revealed a notable drop in the median number of medication orders per patient, from 22.76 pre-EHR implementation to 18.76 post-implementation ($p < 0.001$). In contrast, there was a significant rise in the median number of incidents per patient, from 0.029 before to 0.040 post-implementation ($p = 0.004$). The qualitative analysis of the medication management process offered insight into these observed alterations.

The effect of automated dispensing robots on medication dispensing in Japan is currently under review. Tomoki Takase et al. (2022)[12] sought to evaluate their impact and that of coordinated work with pharmacy support staff. Our findings revealed a significant decrease in the overall rate of forestalled dispensing errors from 0.204% to 0.044% upon the integration of the robotic dispensing system ($p < 0.001$). Moreover, the total rate of non-forestalled dispensing errors considerably lessened from 0.015% to 0.002% ($p < 0.001$). The instances of incorrect medication dosage and wrong drug, both of which severely affect patient health, were nearly eradicated. Further, the median time pharmacists spend on dispensing per prescription notably dropped from 60 to 23 seconds ($p < 0.001$).

Hisham Momattin et al. (2021)[13] conducted ongoing data collection in the field, accumulating pre-implementation data over an 11-month period to evaluate aspects such as patient wait time for medication dispensing, pharmacist productivity, and the rate of dispensing errors per 1000 prescriptions. After implementing changes, the authors tracked these metrics every month. By the tenth month, there was a noticeable enhancement in all aspects. Patient wait time was down by 53%. Patient satisfaction, in relation to pharmacy wait time, rose by 20%. Overall, patient satisfaction with pharmacy services increased by 22%. Our pharmacist productivity

showed a 33% increase. Furthermore, no dispensing errors were reported, signifying an error rate of zero.

In "*Towards a symbiotic relationship between Big Data, artificial intelligence, and hospital pharmacy*", Carlos Del Rio-Bermudez et al. (2020)[16] present the potential of employing Big Data, AI, and natural language processing (NLP) within hospital pharmacy settings. The authors underscore how using NLP and machine learning to scrutinize unstructured data from EHRs can offer valuable insight into medication safety, therapeutic results, and pharmacokinetic consultations. They propose that these approaches could enhance patient care, aid decision-making in pharmacy and therapeutics committees, and facilitate real-time assessments of drug efficacy and safety. Additionally, the authors stress the need to access and analyze the large volume of clinical data produced in hospital pharmacy settings to uncover new research queries and boost patient management and drug safety.

Carmen Guadalupe Rodriguez-Gonzalez et al. (2018)[15] carried out a study to evaluate medication errors through a covert observation technique, contrasting the phases before and after implementation. The research also tracked stock management indicators and staff satisfaction.

During the pre-implementation phase, drugs were manually dispensed by technicians using a barcode-controlled system, while in the post-implementation phase, the ROWA Vmax (ARX) dispensing robot was employed. However, due to certain limitations, manual dispensing was still performed for some drugs.

The results showed a reduction in the dispensing error rate from 1.31% of prescriptions to 0.63% (relative risk reduction [RRR] of 51.7%; 95% CI, 17.3% to 71.8%). When errors were excluded during residual manual dispensing, the error rate further decreased to 0.12% (RRR, 90.8%; 95% CI, 70.4% to 97.1%). The stock-out ratio also decreased from 0.85% to 0.17% (RRR, 80.5%; 95% CI, 49.5% to 92.5%). Furthermore, there was a significant reduction of 59.3% in daily staff time (median) dedicated to stock management (from 1 hour 36 minutes to 39 minutes). The technology received a high level of staff satisfaction, with slightly higher satisfaction reported among pharmacists compared to technicians (8.63 ± 0.7 vs 7.78 ± 0.7, $P = .046$).

4. Discussion

This study aimed to assess the performance of popular AI applications in pharmacy practice. These include EHR, a digital system that compiles patient medical data in a computerized database accessible only to authorized healthcare professionals. The EHR system contains various information about a patient's medical history, such as their health condition, laboratory results, current medications, vaccines, allergies, and treatment plans.

The study also looked at robotic dispensing systems. These systems automate all steps of drug dispensing, from storage to distribution, under machine control, eliminating the need for manual prescription filling. It is important to note that all dispensing processes are closely supervised by pharmacy staff.

Meshaal Hamad et al. (2022) detected[13] a significant reduction in medication orders following the implementation of EHRs (from 22.76 to 18.76, $p < 0.001$). This decrease can be attributed to several factors: Patient orders are canceled when the requested medication is not listed on the hospital's drug formulary. The new EHR system allows multiple prescriptions to be included in a single order - known as the "order setting" feature - which reduces the total number of medication orders. Furthermore, the EHR system automatically recommends the most suitable dosage for a specific medication, leading to another reduction in total orders.

However, despite the decrease in medication orders, medication errors saw an increase, rising from 0.029 to 0.040 ($p = 0.004$). Qualitative analyses suggested that the rising rate of medication error reporting is linked to improved detection capabilities resulting from enhancements in medication management.

Although not originally included in our review, the Clemens et al. (2016)[16] study identified several obstacles to the implementation of EHR. These challenges primarily include initial cost, technical support, and adjustment of work habits. The study also recognized issues related to maintenance costs, training, privacy concerns, workflow disruptions, perceived value, the difficulty of entering medical history data, hospital location, system complexity, limitations, and potential for medical errors.

The installation of robotic dispensing systems has greatly improved the safety and efficiency of medication dispensation by pharmacists. There has been a significant reduction in median dispensing time per prescription, dropping from 60 to 23 seconds ($p<0.001$) (Clemens Scott Kruse et al., 2016).[16] Furthermore, there has been a marked decrease in both prevented (from 0.204% to 0.044%, $p<0.001$) and unprevented (from 0.015% to 0.002%, $p<0.001$) dispensing errors (Tomoki Takase et al., 2022).[12] Another study demonstrates that the rate of medication dispensing errors fell to zero (Hisham Momattin et al., 2021).[13] Moreover, these systems contribute to a decrease in patient wait time and stock management time, substantially increasing pharmacist productivity. This improvement has notably augmented patient satisfaction levels with pharmacy services.

4. Limitations

In our research, we faced several limitations. Notably, most articles did not discuss the financial aspects of incorporating AI into hospitals and how it might affect budgets. While many articles focused on patient satisfaction and reduced medication errors, they overlooked the perspectives of pharmacists and other hospital staff.

5. Conclusion

Given the widespread use of AI in pharmacy practice, pharmacists should consider its potential benefits. This narrative review suggests that pharmacy automation improves patient care safety and efficiency in various areas and enhances patient satisfaction. Therefore, it is crucial to broaden the use of pharmacy automation in hospital pharmacies.

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