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The Impact of Artificial Intelligence and Machine Learning on Pharmacy Practice

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ABSTRACT

This paper explores the transformative potential of artificial intelligence (AI) and machine learning (ML) within the field of pharmacy. It discusses the definitions, basics, and advancements of AI and ML, and explores their specific applications in healthcare, particularly in pharmacy practice. The integration of these technologies can enhance clinical decision-making, optimize medication management, and improve patient outcomes. However, this paper also highlights the challenges and limitations, including data privacy and security concerns. Future directions and opportunities, such as personalized medicine and pharmacovigilance, are examined to understand the evolving role of AI and ML in pharmacy. This review concludes by emphasizing the promise of these technologies to revolutionize pharmacy practice, despite the hurdles that must be overcome.

Keywords: Artificial Intelligence (AI), Machine Learning (ML), Pharmacy Practice, Healthcare Technology and Clinical Decision Support

INTRODUCTION

In the realms of medicine and technology, the term 'innovate' often signifies incremental advancements within a new context [1-2]. At the dawn of the 21st century, pharmaceutical care practitioners are encountering groundbreaking technologies that could significantly impact their professional activities. Some of these technologies promise to enhance service capabilities and outcomes, while others may inadvertently hinder practitioners' abilities to add value and secure compensation for their activities [3-4]. The potential for these technologies to either benefit or harm underscores both the excitement and the risk associated with innovation. Healthcare is increasingly driven by new technologies that have the potential to transform system efficiency and patient experience. Among these, artificial intelligence (AI) and machine learning (ML) are at the forefront [5-7]. Pharmacy, too, stands to benefit from these advancements, with the possibility of delivering better patient outcomes and adding value for employers and commissioning bodies. However, these tools come with limitations and challenges regarding their application and the analysis of the products they generate. This paper provides an introduction and perspective on AI and ML, exploring their potential applications within pharmacy, defense strategies for employers, practical considerations, and the limitations of these innovative technologies [8-9].

Artificial Intelligence and Machine Learning

A laudable term in the medical and technological world is the word 'innovate'. This, however, is often used to describe incremental change, perhaps in a new context. At the beginning of the 21st century, pharmaceutical care practitioners find themselves facing innovative new technology for use in a range of professional activities [10]. Some of these technologies will have a significant positive impact, while others may ultimately reduce their ability to add value and provide compensation for their activities. These new technologies, when used well, could be used to improve service capabilities and outcomes. However, when used poorly, they may develop into a substantial barrier to the practitioners' ability to change. The range of possibilities to afford harm or benefit provides both the grounds for excitement and the possible risk to the innovation [11-12]. Healthcare is increasingly being driven by new technologies that have the potential to transform both system efficiency and patient experience. Of these, at the forefront, are artificial intelligence (AI) and machine learning (ML). Pharmacy is no exception, and the pharmacy practitioner can potentially deliver a better outcome or experience for the patient and, at the same time, provide value for the employer or commissioning body. However, these tools are not without limitations or challenges, both to their application and use, and the analysis of the products they generate. This chapter introduces and provides a perspective on AI and ML, the potential applications within pharmacy, defense strategies for employers, practical considerations, and the limitations of these innovative new technologies [13-14].

Definition and Basics

Artificial Intelligence, originally unstructured around the field of rules, was introduced and developed before the start of Machine Learning [15]. It was massively democratized with the advent of ML. The preeminence of this sub-field resonates in Redmon and Farhadi's remarks: "In the first few decades of AI, as we learned to bring computers to areas where humans excel, we tended to use rules to solve specific tasks. Machine Learning enables the same results but is based on statistical predictions. It is significant because, despite its older age, AI has only gained traction with practical successes in the last ten years thanks to these approaches, which encourage congruence between humans and the capabilities of algorithms [15-16]." Deep learning is a sub-field of ML that tries to imitate the way a human brain works. It uses artificial neural networks to interpret data in an unsupervised manner. It is based on representation learning, in which higher levels of the task's hierarchy are defined with automated inspiration, and abstraction is extracted from raw data rather than handcrafted data [4]. Machine Learning (ML) is a research area that deals with the analysis of the ability of machines to improve their performance through new experiences. This improvement is achieved through the development of algorithms that enable the machines to learn for themselves based on previous data, to meet some objective, evaluate their results, and eventually adopt appropriate decisions in the presence of new conditions [5]. Artificial Intelligence (AI) is a branch of computer science that deals with the simulation of intelligent behavior in computers, the development of intelligent computer programs to perform specific tasks, expert systems, and the building of robotics capable of human-like decision-making and running intelligent machines [6].

Applications in Healthcare

Clinical decision support provides pharmacists with real-time and evidence-based information to facilitate patient care. It involves interpreting knowledge obtained from large healthcare data and databases to develop algorithms or rules that are used to guide clinical decision-making, reduce system errors, and ultimately optimize patient outcomes [7]. The system can anticipate adverse drug effects or contraindications by querying genetics, allergies, and the medications the patient is currently taking, and help stratify patients who might benefit from closer monitoring of their pharmacotherapy. In addition, it can provide drug-specific information ranging from enhancing blood pressure control to inhaler and drug compatibility, and suggest evidence-based modifications for a drug therapy regimen rapidly [11]. Today's AI and machine learning technologies hold great promise for improving the quality of patient care, better health outcomes, reducing treatment costs, and addressing the problem of the increasing shortage of pharmacists. Some typical AI/ML applications in healthcare include clinical decision support, patient management, predictive analytics, population health management, precision medicine, image recognition, medical diagnoses, AI DIY (Do-It-Yourself), personalized health monitoring, drug discovery and development, robot-assisted surgery, virtual assistants, and automated external defibrillators. Drug discovery, drug repurposing, personalized medicine, outcome prediction, patient safety, dosage errors and treatment plans, optimization of drug combinations, prediction of patient wait time, and drug interactions are among the forefront prominent areas in pharmaceutical practice. AI/ML can and does have a great impact on the industry now and is expected to play a significant role in the future [4].

Current Applications in Pharmacy Practice

Telepharmacy has evolved from a videophone and asynchronous messaging technology that enabled non-pharmacists to prepare, check off prescriptions and compound medicine in the general vicinity but unpersoned pharmacy premise, while pharmacists worked remotely [2]. Promoted as a means of ensuring and perhaps expanding access to the benefits of medication management for patients in rural areas without access to local pharmacist services, use was initially low. In recent months, the heightened awareness of the impact of the COVID-19 pandemic on work and lifestyle has sparked a keen interest and rapid amplification in the number of retail and community pharmacies that have begun to implement Telepharmacy as the shifts to remote work for customer service functions became a backstop for continuity of business [3]. Not unexpectedly, informatics is playing an increasingly significant role in pharmacy practice across all practice settings. Within retail practice, utilization (albeit still limited) of artificial intelligence tools for analyzing images of prescription medication taking to determine pill information, artificially intelligent operational systems that can solve problems that are typically performed by pharmacists, and the development and utilization of chatbots for medication adherence are all worthy and innovative AI/ML interventions that augment pharmacist activities [1]. These new developments complement the burgeoning use (and acceptance) of robotic automation for repetitive (e.g., centralized prescription filling, inventory management) and even higher level process tasks. But, with the advent of AI/ML capabilities that can and are "thinking" like humans, what are the possibilities to expand and redefine the roles and responsibilities of the pharmacist?

Medication Management

Currently, the majority of successful pharmacists function in hospitals. While most hospital representatives brief patients on medications and use machines to dispense medications, they do not actually care for medications in any meaningful manner [4]. By using technology, pharmacists in this area can become even more successful in moving away from basic counseling and drug distribution and into an area that offers basic medication clarification, management, and medication reconciliation. This could result in a large decrease in the burden of disease related to medication errors. Simply put, pharmacists may provide the same services and significantly boost the number of patients they serve by getting the aid of computer systems and gadgets. Additionally, their guidance can aid in the reduction of healthcare costs [8]. As healthcare professionals, pharmacists have extensive knowledge of medications and how they work. They perform their duties by meeting with patients to determine their prescription and over-the-counter needs, suggesting products that will aid in the treatment or prevention of a condition, and providing details about drug interactions, side effects, and proper usage [9]. Pharmacists educate patients on the best and most cost-effective strategies to treat various health problems. By using technology, AI, and machine learning, pharmacists can learn more about clients to help them get the most out of their drugs and make better decisions to fit their individual needs and budgets. Pharmacists have tremendous potential to assist patients with their drugs by acting as mediators between patients and their myriad medications. Patients frequently grow disappointed by their medications as a result of their inability to manage them. Individuals regularly fail to adhere to long-term medication schedules, which leads to a variety of health and economic problems. Pharmacists can help by advising patients on which drugs are most beneficial and by offering them advice on successful medication doses and forms, as well as packaging [11].

Pharmacovigilance

The successful application of AI techniques on pharmacovigilance predictions widens the resource capacity of traditional PV systems and also creates new tasks that were impossible to do before. Currently, the pre-marketing tests, the post-marketing tests, the animal studies results, and the clinical studies results of the European Medicines Agency (EMA) are the common resources accessed by firms and regulators to determine which products are suitable for revenue [13]. The EudraVigilance system that provides data describing suspected CVs (both desirable and unwanted) associated with medicinal items available in the European Economic Area is the fundamental continuum of effect identification. However, the benefit–risk ratio of EMA- and Food and Drug Administration (FDA)-approved drugs must be assessed continuously [14]. The huge quantity of data, both structured and unstructured, implicates a big effect flow both in patients who regularly use these items and from pharmacovigilance structure inputs. In spontaneous reporting databases, Web and online forums, blogs, social media, and anonymous self-assessment panels receive a significant amount of adverse reports. Moreover, the Electronic Health Records and the Truven MarketScan claim data represent an obligatory level of AE data reliability of pharmaco-epidemiology studies [15, 16]. Collecting such an amount of dissimilar data necessitates not only real-time algorithms but also ones developed to tackle type I and Type II error problems in big data sets. Furthermore, the time lag makes these AE signals unsuitable for year-in-review signaling. Pharmacovigilance is the science and activities relating to the detection, assessment, understanding, and prevention of adverse effects or any other drug-related problem [5]. Adverse drug reactions (ADRs) are a significant cause of hospital admissions and represent elementary unintentional medical errors. Using spontaneous reporting databases records, different kinds of methods and systems have been developed to detect these ADRs, facilitating the flow of information, existing both in structured and unstructured databases. These systems vary remarkably in accuracy. To make DB records available for AE report data, the pharmaceutical companies must assess their benefit–risk ratio continuously and monitor the safety of their product once they are on the market. It is mandatory to tackle these challenges through the flawless execution of pharmacovigilance (PV) activities.

Challenges and Limitations

The current strategies and challenges when building and/or implementing clinical-based devices and applications can be classified into three branches: physiological, medical-image related, and statistical predictions [2]. As it stands now, there are no methods able to model the human physiological components in a clinical-based pipeline, including heart dynamics at different scales. A second challenge in clinically model building is processing large dimension data like medical images to extract information to be fed to existing standard models, whether they are predictive of statistical or physiological nature. Inversely, there is also the challenge of predicting back the state of the patient. A third issue of clinical-based predictive models is the presence of a low number of patient records to learn the intrinsic structure of the data, thus limiting the generalization capabilities of the model in real-world applications and when different existing conditions are present in patients [8].

Data Privacy and Security

Since the UK Health and Care Data Security Protection tool kit has published various requirements that need to be met so that sensitive patient data can be recorded. These security criteria for data recording are emphasized because Electronic Medical Records are likely to be found at risk of breaches. These breaches could occur due to the lack of investment required to protect patient records, as suggested in the many white papers [7]. Therefore, the authors suggest that, in order to maintain respect for patient privacy in the pharmacy, it is important to abide by these criteria before considering data collection. The patient privacy model proposed in this chapter suggests a concept called 'Data Protection Tools' as defined by Adigun aimed at creating contextual data at the time of data entry. This ensures that relevant patients' semi-structured privacy is adhered to when a patient data collection is attempted to be automated in a retail setting [9]. With the digitization of healthcare, the processing of personal data is becoming more and more vital. Today, artificial intelligence continuously learns through the process of learning and decision-making from specific data. However, the challenges associated with artificial intelligence are due to the vast amount of data that is required to work with it. This enormous data collection could lead to inaccuracies which can be based on gender, race, and even religion. In pharmacy, sensitive data may be collected to help the business grow and is used specifically to help patients. The collection of patient data is a topic of considerable sensitivity, as well as being traditionally regulated by various acts. There are, therefore, countervailing measures to be taken into account by organizations such as retail pharmacies, which want to adopt machine learning systems in their operations [11-14].

Future Directions and Opportunities

Over time, as the pace of technological change continues to grow and the scalability and usability of AI and ML tools improve, the sophistication and importance of pharmacy practice opportunities will also rise [2]. AI and ML have the potential to transform some areas of pharmacy practice, creating new opportunities for pharmacists and other stakeholders to improve patient care and demonstrate their value by leveraging new knowledge and technology to get the right medicine to the right patient at the right time. In the prior pages, we have attempted to describe two technologies from the rapidly expanding field of AI in an intuitive way, and we offered practical examples of how these tools can be used to improve the practice of pharmacy [5]. In closing, opportunities for AI and ML in pharmacy practice include, but are not limited to: customizing medication therapy according to personal genetic or other biological factors; tracking infectious diseases in real time to create accurate visual representations or maps of current outbreaks and the spread of the disease; mapping patterns and networks of patient-level prescription opioid misuse in defined areas (needles in a haystack problem) and identifying or predicting patient or prescriber level behaviors just before the onset of opioid use disorder; using wearable biopatches that contain all necessary medication components for drug delivery; using machine learning for pharmacokinetics and pharmacodynamics modeling; predicting disease phenotype from hundreds of clinical variables and genotypes, and so forth [9].

Personalized Medicine

Although some clinical routines use these tools to initiate therapies, individual responses have been shown to be variable in real-world clinical settings. It is in these groups that digital technologies have enormous potential due to their capacity for mathematical modeling with the ability to handle a large amount of data representing parameters with high complexity [8]. Medicine 2.0 envisions a future with virtual patients and a health system based on predictive, preventive, personalized, and participatory medicine. These objectives of medicine 2.0 can involve costs that could be significantly reduced given an intelligent management of the available resources, naturally respecting the limits and ethical precepts associated with decisions related to the risks, challenges and opportunities of this trend [9]. The use of computational machine learning techniques as the most important tool for handling the massive amount of data is essential. It is at this entrance of efficient data handling that big data, with sound usage of artificial intelligence and its subgroup of machine learning algorithms, become essential to filter and classify large-scale molecular features with the greatest possibility of biological significance [7]. Personalized medicine aims to better characterize patients in order to tailor their specific requirements. This is a mix of more specific maps of the human genome and definitive advances in technology with the use of specific parameters to predict individual responses. In order to achieve personalized medicine, it is necessary to collect, integrate, and analyze different sources of information [5]. The obtained knowledge will be fundamental to give each patient the most appropriate treatment, favoring the effectiveness and safety of the treatments and minimizing unwanted side effects. Among the main sources of information in health are: information collected during interactions between patients and caregivers; information from imaging and refraction labs; and information from laboratories, noting that analysis from high-dimensional technologies, such as genomics, transcriptomics, proteomics or metabolomics, are those that add the largest number of parameters [8].

CONCLUSION

There is still much work to be done to ensure that the potential value of AI and ML interventions is met. The possible pitfalls of these technologies should not distract away from the promise that these areas offer. While AI can be employed to define automated rules that enable machines to respond in particular circumstances (simple automation), ML can be employed to produce data-specific rules for human programmers to implement. The current literature suggests that ML can play a pertinent role in the similar tasks of identifying patterns and making predictions, with comprehensible ML models being potentially more appropriate for explaining the characteristics of a model or attributes significant to a solution. Here, examples of how AI and ML are beginning to infiltrate pharmacy practice are described. The world of pharmacy is only beginning to experience the potential of AI, and the future of AI and ML in pharmacy practice can be expected to have significant positive impacts. Through automation and process improvement, organizations that have adopted these technologies demonstrate increased efficiencies and cost savings. AI/ML could play an integral role in boosting staff problem-solving activities, and therefore translate to more time for communication and better therapeutic outcomes.

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