

APPLICATION OF ARTIFICIAL INTELLIGENCE IN PHARMACEUTICAL AND BIOTECHNOLOGIES: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Artificial intelligence (AI) has been increasingly applied in various fields of science and technology. In line with the current research, medicine involves an increasing number of artificial intelligence technologies. The introduction of rapid AI can lead to positive and negative effects. This is a multilateral analytical literature review aimed at identifying the main branches and trends in the use of using artificial intelligence in medical technologies. The total number of literature sources reviewed is $n = 89$, and they are analyzed based on the literature reporting evidence-based guideline PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) for a systematic review. As a result, from the initially selected 198 references, 155 references were obtained from the databases and the remaining 43 sources were found on open internet as direct links to publications. Finally, 89 literature sources were evaluated after exclusion of unsuitable references based on the duplicated and generalized information without focusing on the users. This article is identifying the current state of artificial intelligence in medicine and prospects for future use. The findings of this review will be useful for healthcare and AI professionals for improving the circulation and use of medical AI from design to implementation stage.

KEYWORDS: Artificial Intelligence, eHealth, Machine Learning, Medical Technologies, Medical Apps

INTRODUCTION

GENERAL STATE OF AI IN MEDICINE

Medical technologies play a vital role in the treatment and diagnosis of patients because of their direct contact with users (doctors, medical staff, and patients). According to the official site of Asia Pacific Medical Technology Association 'APACMed': 'Medical Technologies are technologies that diagnose, treat and/or improve a person's health and wellbeing'[1]. The introduction of artificial intelligence (AI) into medical technologies is becoming one of the important stages of their design and development. The main areas of medical AI application include imaging processing, physiological signal recognition, and neurological health issues [2]. Deep medicine (DM) is the definition of medicine involving AI applications to acquire, process, and analyze medical and clinical data. DM includes the development and use of machine learning algorithms, apps, and software, which are important medical AI elements [3]. The main issue with AI introduction in healthcare is users' trust in this type of technology because the medical function performance or the

processing of information by the device is invisible to doctors, medical staff, and patients. The importance of this trust is due to the fact that the user is passing a function to the AI that he cannot perform on his own, and therefore does not fully understand the process [4]. Moreover, most AI systems have the function of self-learning and modification of work algorithms. Accordingly, the process cannot be completely transparent and this interaction needs the trust of the users. This implies that the acceptance of AI medical devices by users is based mainly on trust. Lack of trust in users can interfere with the use of AI-based medical devices such as emotional discomfort, increased anxiety, reduced frequency or duration of AI device use, and, in some cases, device abandonment. Thus, participants in the development, production, and sales of the healthcare market are also interested in the implementation of AI technologies and solving the basic problem of mistrust [5].

In this study, we provide a systematic analytical literature review regarding the trends, benefits, and disadvantages of AI applications from the user point of view over the past three decades. In this study, we aim to assess different areas of AI application in healthcare such as big data, data mining, deep medicine, and clinical imaging. The findings will be useful for healthcare professionals, AI engineers, AI developers, AI providers, and medical and AI researchers to improve the circulation and use of medical AI at all stages of its life cycle from design to implementation [6].

RESEARCH NOVELTY

The presented article is a review dedicated to the summation of previous research on the application of AI in medicine based on PRISMA guidelines. The review of the literature on this topic was carried out by the authors for the first time and demonstrates their first study with the most complete inclusion of literary sources. Evaluation of previous literature allowed to detect the following gaps in presented research topic: lack of coverage of the general state of medical AI over the past decades, limited application of medical AI to a few areas, such as machine and deep learning, lack of overview of the prospects in the field of medical AI, and limited research methods [7]. Based on these research gaps, the study proposed the following novelty which addressing the posed scientific question:

- The article focuses on the general state of artificial intelligence in medicine and paints a broad picture of the problems.
- The main medical applications of artificial intelligence have been identified and gives an understanding of which of them require more implementation of AI technologies;
- The problems and challenges of using AI in medicine have been fully described. The study also focused on issues that are rare in the current literature, such as the ethical and legal regulation of the use of AI in medicine. And this question is scientifically sensitive and important, since it is directly related to the health and life of patients.
- Based on the described novelty of the study, it can be concluded that the literature review reflects the research question posed about assessing the general state and trends in the application of AI in medicine

COMPREHENSIVE LITERATURE REVIEW

REVIEW METHOD

The present study is a systematic analytical review of the literature concerning the advantages, disadvantages, and dangers of AI medical devices for users [8]. A literature review was performed to evaluate problems arising during the use of AI medical devices from the viewpoint of user perception based on the most current data. Literature analysis was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. According to the official PRISMA website, PRISMA proposes a minimal set of requirements for systematic reviews and meta-analyses for conducting a literature review of higher quality. PRISMA is universal and can evaluate innovations, contributions, and, sometimes, impact of the reviewed publications [9]. The main principles and sequence of the analysis applied in this study are shown in Figure 1.

International and interdisciplinary literature was selected from 198 sources, without bias, from different databases. The following keywords in different combinations were used during searching process: artificial intelligence, AI, medicine, medical, machine learning, deep learning, medical device, future, challenge, trends, robots, and treatment. From the selected 198 references, 155 references were obtained from the following databases: Science Direct, Scopus, PubMed, Google Scholar, SAGE, and PsycINFO [10-31]. The remaining 43 sources were found on open internet as direct links to publications. Among all the literature sources, 34 sources were duplicates or had similar information. Hence, they were removed, and a subsequent initial abstract review was conducted on 164 publications. After evaluating abstracts and selecting relevant content, 122 literature sources were selected for a full-text review. Next,

33 references were excluded based on the following reasons: generalized information about new AI technologies without focusing on the users, a description of the AI technology design process without considering the impact on the potential user, and the study of non-medical AI devices. The aforementioned literature source evaluation was based on research topics, publication period, theoretical background, findings, and conclusions. During screening, the following keywords and their combinations were used: artificial intelligence, AI, medicine, healthcare, medical devices, user experience, ergonomics, human factors, AI technologies, and AI applications. This literature review approach has been used in different studies on the application of AI technologies, including healthcare. An affirmative answer to the following questions was the main factor that led to the inclusion of the literature sources in the review.

Does the study provide information or findings related to AI in medicine and its impact on users? Does the study discuss the dangers, advantages, and disadvantages of AI applications in medicine? Does this study present methods for the development of AI applications in medicine and healthcare? Does the study provide topics for discussion regarding the dangers, advantages, and disadvantages of AI in medicine and healthcare, considering user experience?

BASIC STATISTICS OF SELECTED LITERATURE

Selected literature sources, using the PRISMA method (published from January 2011

to June 2021), analyzed statistically and showed that the majority of research in the examined field was performed in the USA, Canada, and the UK (Figure 2). In general, active studies connecting AI applications, healthcare, and ergonomics have been performed in a small number of countries. Furthermore, given that only studies till the middle of 2021 were considered, the number of articles has rapidly increased since 2011 (Figure 3).

Statistical analysis of the selected literature sources presented above shows that AI in medical devices and technologies is relatively undeveloped. Accelerated growth in the number of studies on these topics started approximately five years ago. The USA, Canada, and the UK are leaders in this research topic. In developing countries, attention to medical AI is much lower than in developed countries [32-49].

OVERVIEW OF ARTIFICIAL INTELLIGENCE APPLICATION IN MEDICAL TECHNOLOGIES

In the above sections, it was found that the main branches of medicine using AI are oncology, pulmonology, cardiovascular medicine, orthopedics, hepatology, and neurology. Therefore, it is necessary to analyze and determine the application of AI in these medical areas.

These three groups are united in the general process of AI application in medicine and treatment, but include different medical activities. The above studies showed that the collection stage includes medical data detection and extraction, which is related to the preparation for disease diagnosis. The analysis stage includes the classification and identification of information obtained from the collection stage, which is related to disease/disorder diagnostic activity. The active treatment stage refers to all therapeutic measures considered by the doctor after the diagnosis of the disease/disorder, such as physiotherapy, radiotherapy, surgery, chemotherapy with medication prescription, and prediction and prognosis of the patient state tomography to predict lung cancer. This method shows high accuracy and supports the hypothesis that optimization of the cancer screening process can be performed via introduction of AI. Deep learning methods play an important role in lung cancer screening and increase the accuracy and effectiveness of treatment. Deep convolutional neural network (DCNN) models to improve the ultrasound detection process for thyroid cancer. A highly accurate DCNN model was developed using ultrasound images of patients with cancer. The effectiveness of the model for cancer detection was similar to that of an experienced radiologist. These findings support the ability of medical AI applications to improve the treatment processes. Tuberculosis detection during chest radiography can be improved using deep convolutional neural networks.⁴⁵ Specifically, a model was developed to classify images, which demonstrated the presence/absence of tuberculosis.

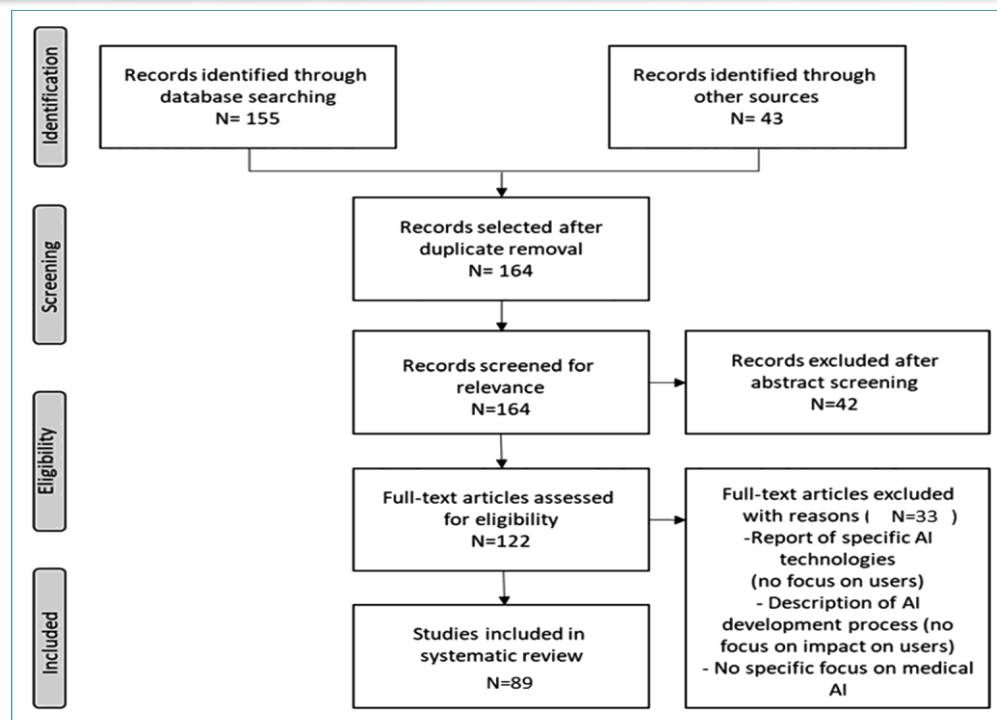


Figure 1. Literature selection for review process according to PRISMA guideline

The authors discuss the application and future of imaging methods in radiology [50-62]. A gastrointestinal AI diagnostic system for patients with upper gastrointestinal cancer. Clinical endoscopy imaging data were used to develop this method with high diagnostic accuracy. The basis of this method corresponds to deep learning for medical imaging. The developed AI model is comparable to that of experienced medical professionals in terms of the effectiveness of cancer detection. These studies show that in cancer treatment processes, AI approaches can be equal to those of experienced professionals in data processing and imaging stages. Deep learning approaches have been found to be the most promising and have been implemented in image recognition. Methods, such as convolutional neural networks or variational autoencoders, present a promising future in radiology and oncology.

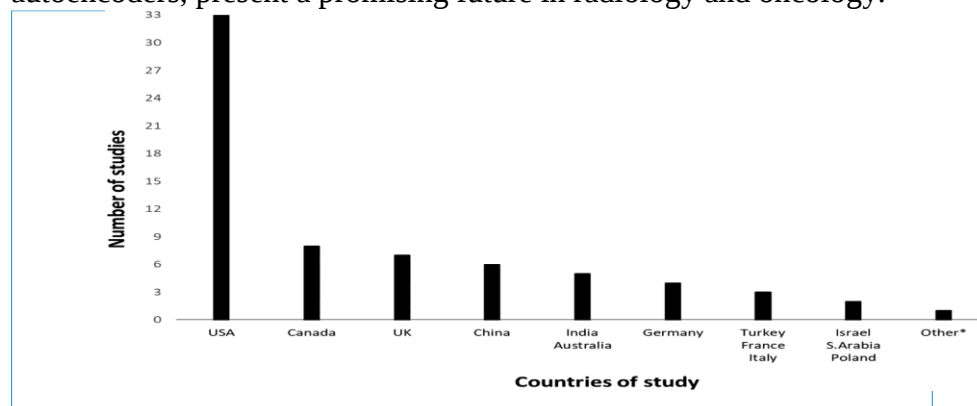


Figure 2. Trend of studies on AI in healthcare and medical devices by country (January

2011–June 2021). * Brazil, Indonesia, Taiwan, Switzerland, New Zealand, Ukraine, Russia, Denmark, Belgium, Portugal, Finland, Malta, and Singapore.

Hence, the accuracy of the method exceeds 97%, and the analysis of medical data together with experts reduces the error in disease diagnosis [63-78]. The diagnosis of fibrotic lung disease is based on accurate high-resolution computed tomography. Deep learning applications show accurate results, and thus, disease detection shows human accuracy. The proposed algorithm can aid in optimizing the cost- effective management of clinics or research centers that lack medical personnel and other specialists. The Systolic Blood Pressure Intervention Trial method was developed to test the effectiveness and usability of medical programs for patients with ischemic cardiovascular disease for reducing blood pressure and limit it to recommended values. The combination of the inference and electronic methods shows the effectiveness of blood pressure treatment. Machine learning methods can be used to treat heart failure. The proposed method is based on tensor factorization with the integration of deep phenotypic and transomics and accounts for the interactions between patient genetic factors. A statistical learning approach to high-dimensional biomolecular data for heart disease treatment. The study provides evidence of the importance of using multiscale modeling for the connection of organs and provision of anatomical shapes. Han et al.⁵⁰ discussed the issue of using AI in orthopedic medicine. The authors claimed three main limitations. First, the use of AI is a time- and finance-consuming process. Second, when AI is applied to big data management, it can lead to spread of confidential medical information [79-90]. The third problem is that separate AI use in orthopedic surgery is still impossible without human intervention. All of these limitations complicate the AI introduction process. Machine learning with AI elements can be applied for the prediction and classification of hepatology diseases with large patient datasets. The authors summarized previous studies and concluded that the growth of AI and machine learning applications in hepatology can significantly improve the treatment process. Kochanski et al.⁵² applied a deep convolutional neural network and 3D methods to increase the knee treatment efficiency.

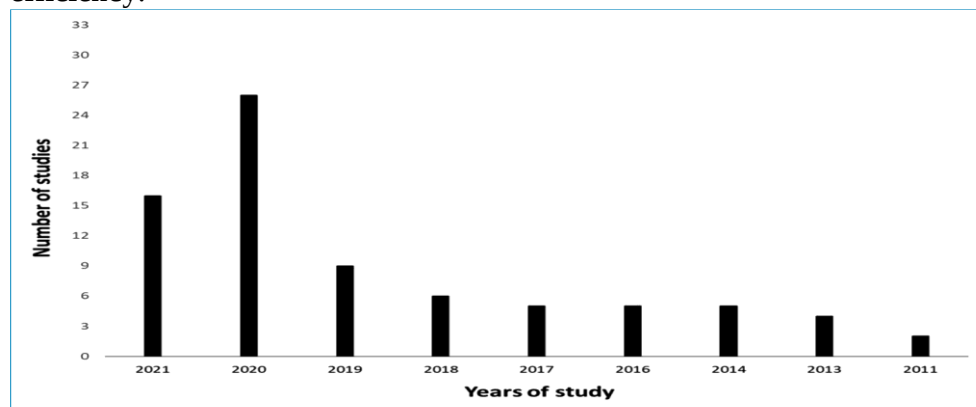


Figure 3. Trend of studies on AI in medical devices and healthcare (January 2011–June 2021).

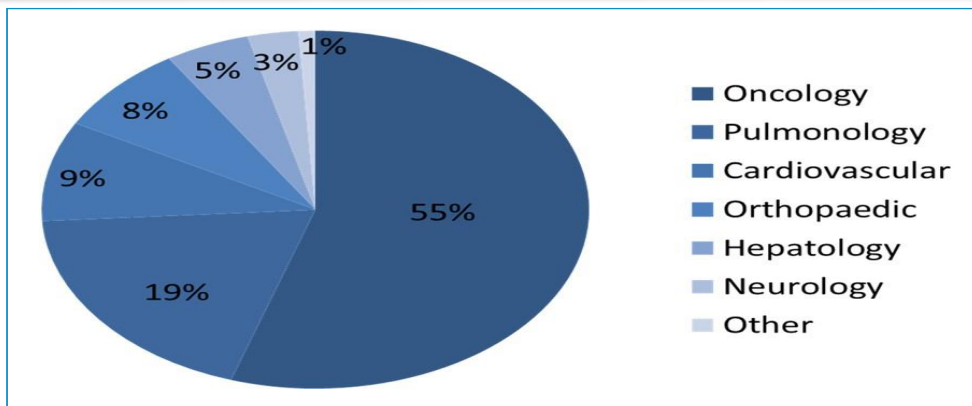


Figure 4. Main areas of AI application in medicine.

CONCLUSION

This article provides an overview of the current state of artificial intelligence in the field of medical technologies. Over 100 published and gray literature sources were reviewed and evaluated, and major trends in medical AI were identified. Statistical analysis of previous literature shows that the leaders in medical AI research are the USA, Canada, UK, and China. Furthermore, the number of published AI studies started rapidly increasing from 2005 to 2006. The main branches of medicine that use AI are oncology, pulmonology, cardiovascular medicine, orthopedics, hepatology, and neurology. The main applications of AI in medical devices can be classified into three major groups: collection of medical data, medical data analysis, and active treatment processes. Special attention to the use of AI is focused on clinical imaging, data exchange, big data processing, and machine-learning algorithm development to predict and classify diseases. Problems and challenges in AI use include the high cost of devices with AI elements, lack of user trust in AI, long-term research plans for AI development, ethical issues of AI use, ease of use of AI equipment or devices by doctors, and responsibility for medical errors due to AI use. The solutions to these problems are associated with the legislative consolidation of principles for the development and use of AI in medicine as well as the creation of AI products with user-centered design and clear future development plans. Despite all the difficulties of AI use, previous research has shown that this is the most promising area in the medical sector.

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