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Artificial intelligence in ophthalmology – threat or aid?

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HIGHLIGHTS

The introduction of artificial intelligence into ophthalmology opens up new diagnostic possibilities, but at the same time presents challenges related to patient data protection, diagnostic inequalities, costs, and trust, necessitating the development of appropriate norms and guidelines for the safe and ethical use of AI in medical practice.

ABSTRACT

Objective: This review seeks to identify and analyze the drawbacks and advantages associated with the integration of artificial intelligence (AI) into the field of ophthalmology.

Methods: A comprehensive review of scientific literature, articles, and publications on PubMed was undertaken. Various aspects, including the effectiveness and diagnostic speed of diabetic retinopathy, as well as ethical considerations and data security, were evaluated. Results were meticulously checked, compared, and summarized. In total, 98 articles were scrutinized using keywords in both Polish and English, including "artificial intelligence," "ethics," "diabetic retinopathy," and "machine learning."

Results and discussion: The application of AI in ophthalmology demonstrates significant potential in improving the diagnosis of diabetic retinopathy. AI-based systems not only contribute to facilitating and streamlining the diagnostic and therapeutic processes but also enhance therapy efficiency. However, issues related to patient data protection, physician responsibility, the cost of training adequately skilled personnel, trust in the accuracy of diagnoses, and the long-term consequences of replacing human intervention with AI necessitate careful consideration.

Conclusions: AI presents substantial opportunities in ophthalmology but simultaneously poses challenges that demand diligence and attention. It is imperative to develop norms and guidelines for the responsible use of AI in ophthalmic practice, ensuring benefits for patients while minimizing potential risks and maintaining high ethical standards. This proactive approach is crucial for harnessing the full potential of AI in healthcare.

Key words: artificial intelligence, medical ethics, public health, diabetic retinopathy, legal regulation, machine learning

INTRODUCTION

Artificial intelligence (AI) has become an integral part of progress in various fields, and medicine, including ophthalmology, is no exception. Introducing AI into the diagnosis and treatment of eye disorders holds promises for improving effectiveness, reducing diagnosis time, and tailoring therapy to individual patient needs. However, along with these benefits, ethical issues, data security concerns, and challenges related to understanding decisions made by algorithms arise.

HOW DOES AI WORK?

AI employs diverse methods and techniques, including Case-Based Reasoning (CBR) and Machine Learning (ML), to make decisions, infer, and learn from data. Here's a brief characterization of these two methods [1].

CBR, or reasoning based on clinical cases, is a method that solves problems by referring to past experiences. The CBR algorithm analyzes the similarity between the current case and previously solved cases. If there is similarity and the solution was effective, the algorithm applies the same strategy in the current situation. In practice, the CBR system compares features and symptoms of the current case with recorded cases and draws conclusions or proposes solutions based on the best-matched cases [2, 3].

ML is an area of AI that enables machines to learn and adapt to data without explicitly defining rules [5]. In ML the machine (computer) is trained using data to independently identify patterns and create models that can predict, classify, or make decisions. Various ML techniques include:

Supervised Learning: the algorithm is trained using a dataset that includes both inputs and their corresponding expected outputs. The model is fitted to the training data and then tested on new, unknown data.

Unsupervised Learning: the algorithm is trained on data without assigning labels. The machine must find patterns and structures in the data.

Reinforcement Learning: the learning machine is rewarded or penalized based on the correctness of its decisions in a given environment. The algorithm learns through trial and error.

In medicine, both CBR and ML can be used for analyzing clinical cases, diagnostics, developing treatment plans, and predicting therapeutic outcomes. The integration of these methods allows AI systems to flexibly and effectively approach problem-solving in the healthcare domain [6–8].

DISCUSSION

Advantages of AI in ophthalmology

1. Fast and early diagnosis. Using deep learning techniques, intelligent systems have been developed to precisely identify diabetic retinopathy by analyzing eye fundus images [9]. AI enables rapid analysis of these eye images, allowing for early detection of diseases such as diabetic retinopathy [4].

Diabetic retinopathy is a major complication affecting the eyes of individuals with diabetes, occurring in approximately 35% of patients with this disease [10]. Globally, over 100 million people struggle with diabetic retinopathy, which is a major source of vision problems [11]. Fortunately, many cases of vision loss associated with diabetic retinopathy can be effectively prevented. In recent decades, there has been a steady decline in the frequency of vision loss related to this disease [12]. Improving visual outcomes in diabetic retinopathy depends on various factors and is mainly a result of improving the control of systemic risk factors, supported by advances in diagnosing eye diseases, conducting screening tests, using modern imaging techniques, and developing effective treatment methods in recent years. Diabetic retinopathy, being the leading cause of secondary blindness, can be prevented through regular eye fundus examinations [11]. However, there are limitations to such examinations as they require an experienced specialist and the necessity of dilating the pupil, often restricting the patient's activities on the day of the examination, such as driving immediately after using drops containing the active substance – tropicamide. Nowadays, modern solutions exist, such as automated diabetic retinopathy diagnostics and monitoring of cardiovascular risk factors, which use extensive image data of the eye fundus [4]. These modern approaches achieve high sensitivity and specificity, exceeding 90% [4, 13]. Recently, the Food and Drug Administration (FDA) approved a medical device called IDx-DR (IDx LLC, Coralville, IA). This device uses AI algorithm-based software, analyzing images taken with the Topocan NW400 fundus camera. As a result, it can classify retinopathy as "more severe than mild" or "not more severe than mild" [15]. Another promising solution is the AI algorithm developed by Medios Technologies in Singapore. This screening software for diabetic retinopathy uses a fundoscope built into a smartphone, eliminating the need for a fundus examination device. The sensitivity and specificity of this solution are 83.3% and 95.5%, respectively [15].

2. Efficient Data Management. AI assists in the efficient collection, analysis, and management of medical data, contributing to the improvement of patient care quality. Time is an extremely valuable resource for both patients and ophthalmologists. Patients often experience a lack of sufficient contact with the doctor, and doctors are increasingly exhausted, as most of their time is spent on administrative tasks rather than patient care.

Here, AI like ChatGPT can come to the rescue – created by Open AI in San Francisco, it has gained tremendous popularity since its debut in November 2022 [14, 16]. It is an AI-based chatbot trained on internet data, including human conversations. ChatGPT has broad capabilities, including composing poetry, writing essays, solving programming problems, and explaining complex concepts. Some believe that it takes online searching to a new level, offering quick and easy understanding of complex issues [17]. Although still in the research phase, ChatGPT impresses with its performance in various application areas. One potential application could be generating medical summaries. The process of creating high-quality summaries can be time-consuming, and ChatGPT can help doctors by allowing them to input information that the doctor can develop, and then generate a ready-made summary in a few seconds [18, 19]. Despite promising prospects, implementing ChatGPT in clinical practice requires overcoming many challenges. It depends on the data it receives, necessitating the manual input of relevant information. Issues related to data management and patient acceptance of this technology also pose challenges. Research is essential to gather opinions from doctors and demonstrate the improvement in the efficiency and quality of processes, such as medical documentation management [20].

ChatGPT illustrates the power of AI in a tangible way. Although health care chatbots are not new, they have the potential to significantly advance this area due to their generative and analytical capabilities. The ultimate introduction of this technology will require addressing data-related issues, patient acceptance, and appropriate quality control procedures. However, it is worth considering, as this type of AI can significantly streamline hospital documentation management and facilitate data management in the ward.

3. Detectability of the disease in its early stage. In the publication from *Ophthalmology science* in March 2023, the effectiveness of ophthalmologists and the AI system EyeArt [21] in detecting diabetic retinopathy more than mild (mtmDME) in nature was compared. The study involved 521 participants (999 eyes), including 406 non-retina specialists and 115 retina specialists. In the sample of participants, there were 2077 positive eyes and 792 negative eyes for mtmDME. Out of 999 eyes, 26 could not be assessed by EyeArt. Retina specialists correctly identified 22 out of 37 eyes as positive (sensitivity 59.5%) and 182 out of 184 eyes as negative (specificity 98.9%) for mtmDME compared to the EyeArt AI system, which identified 36 out of 37 as positive (sensitivity 97%) and 162 out of 184 eyes as negative (specificity 88%) for mtmDME. General ophthalmologists correctly identified 35 out of 170 eyes as positive (sensitivity 20.6%) and 607 out of 608 eyes as negative (specificity 99.8%) for mtmDME compared to the EyeArt AI system, which identified 164 out of 170 as positive (sensitivity 96.5%) and 525 out of 608 eyes received a negative result (specificity 86%) for mtmDME. The AI system distinguished itself with a greater ability to detect issues related to mtmDME compared to ordinary ophthalmologists or retina specialists when compared with the clinical reference standard [22]. This system has the potential to be a cost-effective and practical tool for detecting diabetic retinopathy, which can be helpful in early detection and treatment of changes in the eye associated with diabetes in its early stage [21, 21].

THREATS OF AI IN OPHTHALMOLOGY

1. Patient Privacy. The introduction of AI raises concerns related to the privacy of patient data awaiting treatment. How to ensure the security and confidentiality of this information?

Despite numerous benefits, such as the automation of diagnostics, personalized treatment, and improved healthcare efficiency, there is a significant threat to patient privacy. According to the regulation of the legislative body of the European Union, the GDPR (General Data Protection Regulation), known as RODO in Poland [22], as well as the WHO frameworks from 2019 regarding the implementation of innovations and digital technologies in healthcare, which state that collected data should be transparent and interpretable, and evaluated based on "benefits and harms" [23], which is crucial in the context of medicine. However, the automation of processes, such as automated interviews or patient selection, raises concerns about the incorrect interpretation of data and possible consequences for the patient. The entity collecting data has an obligation to inform the patient about the type of data being collected, how it will be processed, and for how long. The patient should also be informed whether automatic profiling or intelligent algorithm systems are used [22, 24]. It should also be noted that the introduction of electronic medical records and their connection to AI systems carries a double risk to the privacy of patient data. Electronic medical records represent a potential source of data leaks, and integration with AI increases this risk. Violations of data privacy lead to serious consequences, such as discrimination in insurance or employment, emotional stress related to the disclosure of sensitive health data, or even harm to the mental health of patients [1].

2. Lack of understanding of AI decisions. Often, AI algorithms operate as a "black box", making it difficult to fully understand the decisions made by AI systems [25]. In the case of diabetic retinopathy, the use of a "bad" algorithm by AI can lead to the misclassification of a patient into the wrong ethnic group. Diabetic retinopathy is a serious complication of diabetes, making it a significant challenge for healthcare [10, 26]. However, the phenomenon of diagnostic inequalities between social groups, especially in the context of racial classification, is becoming increasingly apparent [27, 28]. In recent years, there have been concerns about the improper assessment of the risk and diagnosis of diabetic retinopathy, which can lead to delays in treatment and worsen the health of patients. Studies have shown that individuals belonging to the black racial group are often incorrectly classified by AI in terms of the risk of diabetic retinopathy. This can lead to delays in diagnosis and treatment, negatively impacting health outcomes. Inequalities in access to healthcare for different social groups mean that some people are more vulnerable to developing advanced diabetic retinopathy [29, 30].

3. Costs, trust, and trained staff. Evaluating modern medical solutions in practice poses challenges. The digital health sector is large, diverse, and dynamic, making it difficult to assess whether new tools meet real medical needs [31]. Therefore, we need rigorous evaluation criteria tailored to different technologies. Although some AI algorithms demonstrate higher accuracy than human doctors in certain tasks, it is challenging to choose between a doctor's decision and an AI decision, especially when the decision-making process of AI is incomprehensible. This, in turn, poses important ethical and decision-making challenges about when and to what extent to trust algorithms [32].

Technical assessment checks whether new technologies work as expected. The next step is a clinical evaluation, adapted to the specifics of digital technologies. Attention should also be paid to usability and ease of use for doctors and patients. The introduction of AI into clinical practice also requires educating doctors about the use and evaluation of AI systems. Practicing clinicians will need specialized training to effectively adapt to using this technology when it reaches a sufficient level of maturity. It is also essential to recognize the need to employ qualified personnel who will collaborate with clinicians to effectively implement AI in medical practice [33].

As mentioned above [22, 23], regulatory organizations are trying to develop rules for users and payers, treating AI as a medical product subject to specific standards [34]. This poses challenges for regulatory bodies as they must adapt to dynamically developing technologies.

4. Lack of clear clinical features in AI algorithms. AI in the field of medicine, especially in ophthalmology, is still a relatively limited tool and is rarely practically utilized. There are several challenges that affect its effective implementation. One of the main problems is the difficulty in unambiguously identifying clinical features that lead to a specific diagnosis. The inability to explain the decisions of AI is an obstacle to the complete trust of doctors and patients in these systems [35, 36].

An important issue is also the question of the responsibility of programmers in the event of a system failure or incorrect AI diagnosis. However, there are currently no clear regulations in this regard [37]. Currently, AI serves as a supporting tool, operating under the strict supervision of doctors, and full autonomy of machines is still ahead of us. The final diagnostic decisions and treatment plans remain in the hands of the doctor who analyzes the information obtained from the algorithms.

Final challenges also include data security and cybersecurity issues, especially in the context of information transfer between countries. Patient acceptance, trust in AI, and legal issues related to the responsibility of programmers in case of errors or data leaks are also significant. As technology continues to advance in medicine, taking measures to ensure data integrity, patient privacy, and the security of medical information will be crucial [38, 39].

CONCLUSIONS

The implementation of AI in ophthalmology brings both promising benefits and significant challenges. AI in ophthalmology offers significant opportunities to improve the diagnosis and treatment of diabetic retinopathy. It also enables easy data analysis and facilitates medical documentation, streamlining the diagnostic and therapeutic process. However, at the same time, it poses challenges related to data security, diagnostic inequalities, costs, trust, and the need for appropriate training of medical staff. It is necessary to develop norms and guidelines for the responsible use of AI in ophthalmic practice to ensure benefits to patients while minimizing potential threats and maintaining high ethical standards.

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