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ARTIFICIAL INTELLIGENCE IN OPHTHALMOLOGY: CHALLENGES AND READINESS IN INDONESIA

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Abstract

Artificial Intelligence (AI) has been increasingly used in various fields of medicine. It involves the development of algorithms and computer programs that can learn from and adapt to data, enabling machines to perform tasks without explicit human instructions. The ultimate goal of AI is to create machines that can think and reason like humans. AI has the potential to transform the field of ophthalmology, which leads to improved patient care. This study aims to examine the current state of AI in ophthalmology, the challenges facing its adoption in Indonesia, and the opportunities for growth and development in this field. A literature search was conducted using PubMed, Google Scholar, and Proquest to identify relevant studies and reports related to AI in ophthalmology. in ophthalmology has been studied extensively in the field of screening, diagnosis, management, and predicting outcomes. Some studies proved that AI has a relatively high accuracy in diagnosing certain eye diseases, as demonstrated by its high sensitivity and specificity. However, high accuracy does not necessarily mean that AI is ready for clinical practice, especially in Indonesia. Several challenges include the risk of bias, the absence of standard assessment methods for AI, inadequate infrastructure and regulation, ethics, and sociocultural aspects. AI has the potential to revolutionize the ophthalmology field in Indonesia, leading to better patient outcomes and more efficient healthcare systems.

Keywords : Artificial Intelligence, Challenges, Indonesia, Ophthalmology.

INTRODUCTION

Artificial intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to perform tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and natural language processing. AI involves the development of algorithms and computer programs that can analyze large amounts of data, learn from that data, and make predictions or decisions based on that learning.1,2

AI has been increasingly used in various fields of medicine, including ophthalmology, to improve diagnostic accuracy, treatment, and patient outcomes.3 In Indonesia, there has been a growing interest in applying AI in ophthalmology to address the increasing prevalence of eye diseases and the shortage of ophthalmologists in the country.

Indonesia is the fourth most populous country in the world with over 270 million people, and it has been experiencing rapid economic growth in recent years.4 However, Indonesia might face several challenges in adopting AI, such as the risk of bias, the absence of standardized assessment methods, the need for big data, the lack of regulation, inadequate infrastructure, and also bioethical and sociocultural aspects.

METHODS

PubMed, Google Scholar, and Proquest were used to conduct this narrative review. We searched for articles that investigate the current state of AI in ophthalmology, the

challenges facing its adoption in Indonesia, and the opportunities for growth and development in this field. The following were inclusion criteria: published in the last 5 years, available in full text, in English.

DISCUSSION

Diagnostic and Screening

AI has significantly altered the practice of ophthalmology. A wide range of diseases that can be diagnosed by machine learning (ML) and deep learning (DL) algorithms have seen rapid improvements in performance, imaging modalities, and detection accuracy.[5] The application of AI in ophthalmology has focused on important diseases such as diabetic retinopathy (DR), age-related macular degeneration (AMD), glaucoma, and cataract.[6]

According to Ahuja et al, AI has an overall sensitivity and specificity of 99.7% and 98.5% for any DR detection. [6] For screening DR, AI has area under the curve (AUC) of 0.980, a sensitivity of 96.8% and a specificity of 87.0%.[7] In AMD, AI can detect the disease with a sensitivity of 97.3%, specificity of 100%, and a positive predictive value (PPV) of 97.7%.[6] Another study reported that glaucoma screening has an estimated sensitivity of 83.2% and specificity of 79.0%, while DL algorithms have predicted glaucomatous changes through retinal nerve fiber layer analysis from wide-angle optical coherence tomography scans.[8] Finally, an AI-powered telemedicine platform has demonstrated strong diagnostic accuracy in diagnosing cataracts. AI agents have demonstrated good-to-excellent overall diagnostic performance in classifying different types of cataracts, with high AUC (0.86–1.0), accuracy (69.0%–99.5%), sensitivity (60.1%–99.5%), and specificity (63.2%–99.6%).[9]

Management and Prognosis

AI has a significant potential to improve the management and prognosis of ocular diseases. Several AI-based technologies have been created to help various aspects of cataract treatment. They cover everything from the detection and diagnosis of cataracts in both adults and children to optimizing biometry and calculating the power of intraocular lenses (IOLs), potential applications in cataract surgery workflows and training, and even the predicting of posterior capsule opacification (PCO) progression.[10]

Several studies demonstrated the ability of AI to observe the progression and predict the outcome of patients diagnosed with AMD. Moreover, implementing machine learning can estimate the need for anti-VEGF injections in patients who have neovascular AMD. Another investigation revealed that deep learning can precisely predict the visual acuity of patients with retinal disease by analysing the baseline OCT characteristics and demographic data.[11]

The weaknesses of AI include: limited data availability for certain eye diseases, such as uveitis and scleritis, which can make it difficult to develop accurate AI algorithms for these conditions,[12] lack of clinical expertise such as diabetic retinopathy in macular edema, AI algorithm was not able to accurately detect because it did not take into account the presence of edema, which can affect the diagnosis.[13]

Challenges in Implementation of AI

a. Risk of bias

Despite its potential, the implementation of AI in ophthalmology faces various challenges. One of the biggest challenges of

using AI in ophthalmology is the issue of bias. The lack of a large, diverse, and representative dataset is the cause of this issue. Large datasets are required to develop accurate and reliable AI algorithms because AI algorithms are only as good as the data they are trained on. If the data used for training is not diverse and representative, the resulting algorithm will be in accurate and may lead to bias. Bias can lead to inaccurate diagnoses and may disproportionately affect certain patient groups, further exacerbating health disparities. This issue is particularly relevant to countries like Indonesia, where there is a high level of diversity among its population. Selection bias occurs when the distribution in the research population is unknowingly different from that of the general population.

Addressing these biases is important so that AI algorithms can be applied to different populations to provide accurate diagnoses. The study conducted by Baxter et al demonstrated that models developed with data from one population are not necessarily applicable to patients from another population.[14] Coyner et al discovered that the specificity ranged between population while studying an AI model to screen retinopathy of prematurity. It was 63,3% from India, 77,8% from Nepal, and 45,8% from Mongolia.[15]

External validation is an essential step in assessing the performance of an AI model and producing a robust AI algorithm. This is crucial to the translation of AI into clinical settings. To evaluate clinical efficacy in the real world, it is important to know how the algorithm performs using external datasets obtained from different sources than the development data used to train the algorithm.[16]

A meta-analysis of diagnostic accuracy of AI in Glaucoma screening and clinical practice conducted by Chaurasia et al only found 13% studies had external validation to assess model performance. They found that overall, AI diagnostics performed better when internal data was used for validation with AUC 96.7%, sensitivity 93.0%, and specificity 94.0%. However, when external data was used for validation, it revealed lower AUC of 89.4%, sensitivity of 83.0%, and specificity of 88.0%. This meta-analysis showed that most authors used internal data to validate their AI models and obtained unrealistically good diagnostic performance. This means the AI model may not be suitable for clinical implementation. To deploy AI models into clinical practice, they recommend evaluating them on unseen heterogeneous data (external data validation) and ensuring acceptable levels of diagnostic performance.[17,18]

b. Absence of standard assessment methods

The QUADAS tool is commonly used to assess the methodology of systematic reviews and meta-analyses, but it is unclear whether it is suitable for studies focused on AI. These studies differ methodologically from conventional trials and consist of details, techniques, and a different set of analytical challenges. Given the differences in study design and reporting of results, areas of potential bias can also vary significantly.[19] Moreover, there was no similar evaluation of new AI-centric quality assessment tools such as the Radiomics Quality Score (RQS), which was developed specifically for research reporting algorithm-based extraction of features from medical images.[20]

c. The need of big data

The quality and availability of medical data are often poor in developing countries like Indonesia. Without access to high-quality data, AI algorithms cannot be effectively

trained, limiting their potential impact on improving patient care. Finally, Indonesia has regulations on electronic medical records, which are laid down in Minister of Health Regulation No. 24 of 2022 on Medical Records. Through this policy, all health care facilities are required to run a patient medical history recording system electronically.[21] Based on a survey conducted by Indonesian Hospital Association (PERSI) on March 2022, in Indonesia only 50% of the 3.000 hospitals have implemented electronic medical record, with only 16% implementing them adequately.[22] Only 40% hospitals have the necessary infrastructure to support electronic medical record. Data resources must be standardized, connected, and uniformly formatted to optimize their usefulness in driving the application of AI forward in the healthcare.[23]

d. Lack of regulation

The lack of regulatory oversight and standardization poses an additional obstacle. requiring the establishment of clear regulations for the creation and implementation of AI in healthcare, particularly in ophthalmology. Currently, to the best of authors' knowledge, there are no specific regulations related to medical software or AI in Indonesia. Medical devices in Indonesia are regulated by government regulation No. 72 of 1988, which defines medical devices in its first article, but does not mention software.[24] Without proper regulations, there is a risk of using AI algorithms that have not been validated, dependable, or secure, which may cause harm to patients. The deficiency of regulations and guidelines governing the application of AI in medicine poses a threat to the safety of patients, confidentiality of data, and ethical matters. By contrast, in the United States, the application of AI in medicine is overseen by the FDA, whereas in the European Union, AI regulations fall under the regulation of medical devices and there is a proposal for further AI regulation in 2021.[25–27]

e. Bioethical aspects

Bioethical challenges of AI implementation in medicine are machine training ethics, machine accuracy ethics, patient-related ethics, and physician-related ethics. Ethical concerns in machine training is related to the use of medical data. The collection and use of medical data raises concerns about privacy and confidentiality of patient information. Patients' confidentiality is exposed twice during the process. First, exposed when the data is entered into an electronic medical record, and second, exposed when the electronic medical record is connected to an AI system.

Problems including insurance discrimination, emotional distress, mental health impact, and loss of trust might arise when data privacy is violated.[23] In Indonesia, the confidentiality of medical data is protected by Law No. 29 of 2004 and Law No. 27 of 2022 on Personal Data Protection.[28,29] Informed consent is based on the principle of autonomy.[68] Patients who opt out should have their electronic health record data excluded from AI algorithms connected by any means to the electronic health record.[23]

When using AI, responsibility for clinical decision-making still applies. Physicians must fully understand the capabilities of the machines they use. AI companies have a responsibility to provide complete information about the functions and limitations of their products, as well as training on the use of these machines, but standards for this are currently limited.[30]

f. Inadequate infrastructure

Investment in technology, infrastructure, and training is crucial for the implementation of AI in medicine, including ophthalmology. This investment can be a significant barrier, especially in developing countries like Indonesia where resources are scarce, and there are competing priorities for limited resources. Indonesia's access to electricity stands at 96.9%, and internet access is at 62%.[31,32] Despite this, the availability of 5G technology in the country is very limited, covering only nine cities.[33] Indonesia still lags behind many of its regional peers on key metrics such as median download speed and the penetration of more advanced routers supporting 5 GHz Wi-Fi, and this disparity is growing.[34]

Additionally, the cost of implementing AI in clinical practice can be prohibitively expensive, making it difficult for developing countries to adopt these technologies. Therefore, it is essential to develop AI algorithms that are affordable and accessible to these countries to ensure that everyone can benefit from these technological advancements. Without the necessary investment, AI cannot reach its full potential to improve patient outcomes and reduce healthcare costs. The lack of resources, expertise, and infrastructure required to develop and implement AI algorithms makes it difficult for developing countries to reap the benefits of AI in healthcare.

g. Sociocultural aspects

The use of AI in medicine may face cultural and social resistance in some countries, leading to resistance of adoption. Almost any new technology leads to a degree of dependence.[35] Doctors' dependence on AI can be misleading them by making them vulnerable to inflicting harm and subject to lawsuits.[36,37] As a result, the use of AI can lead to less efficient decision making.[38,39] Overdependence on AI, also known as "automation bias," is a short-term symptom while loss of skill might happen in long-term. Doctors' skills can be completely or partially superseded by technology, leading to possible loss of confidence or competence.[40–42]

The competition between machines and doctors could have a detrimental effect on the relationship between doctors and patients, as well as on job security for doctors.[43] Although AI may be able to perform certain clinical tasks more effectively and with greater safety than doctors,[44] it is not expected to fully replace doctors in their decision-making capacities. It is important to remember that the purpose of introducing AI into healthcare is to support and enhance the work of doctors, not to replace them entirely.[45]

The public's trust in doctors is founded on their ability to emotionally connect with their patients. While trust in intelligent machines may not take as much time to establish, it still requires time and effort to build in people's minds.[46] Interaction between patient and machine should be based on trust, similar to the trust built between patients and human doctors.[23] Medical education and training programs must include the development of empathetic skills and knowledge. AI can assist doctors in utilizing empathy by performing certain tasks, allowing doctors to have more time to interact with patients.[47] Patients expect doctors to exhibit more empathy than machines and desire a greater involvement of doctors in their care.[48]

CONCLUSION

AI in ophthalmology has been studied extensively in the field of screening, diagnosis, management, and predicting outcomes. Several challenges include the risk of bias, the absence of standard assessment methods for AI, inadequate infrastructure and regulation, ethics, and sociocultural aspects. With enough preparation, AI has the potential to revolutionize the ophthalmology field in Indonesia, leading to better patient outcomes and more efficient healthcare systems.

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