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Awareness and Knowledge About the Impact of Artificial Intelligence on Ophthalmology among Ophthalmology Practitioners in Sudan

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Abstract | **Original Research Article**

The field of ophthalmology has witnessed a considerable expansion in the use of artificial intelligence or AI over the years that passed. Especially, deep learning algorithms are exhibiting particular promise with respect to examining complex data, especially medical images. Around the world, many AI tools have been developed for the diagnosis of ocular disease. However, there is limited evidence on the awareness and readiness of ophthalmology practitioners in a low-resource setting like Sudan toward the adoption of AI for clinical practice. This study was designed to assess the knowledge, attitudes and accessibility of AI technologies among the ophthalmologists and optometrists in Sudan, especially to find the technically acceptable barriers and capacity building areas. In a study with stratified sampling, a cross-sectional survey was undertaken between June and October 2024. There were residents, specialists, consultants, and optometrists working in hospitals and private clinics. Data was collected on demographics, AI knowledge, training, access to AI tools, and perceived clinical impact. ***Outcomes:*** A total of 142 practitioners participated, most of whom are aged 30-39 years (57%) and female (77.5%). 40.1% said they were somewhat familiar with AI while just 2.8% said experts. Most of the respondents (19.7%) went for formal AI training offered by international institutes. More than 80% of respondents do not have access to any AI tools. Among those who do have access, applications involving optical coherence tomography (OCT) were most common. Usage patterns differed, with 37.3% never using AI and 23.2% often using it in practice. Almost half (49.3%) feel that AI remarkably enhances workflow, with a third (33.1%) saying it moderately does so. In conclusion, ophthalmology practitioner of Sudan has a major gap in AI awareness, training, and accessibility. To ensure efficient delivery of eye care in low-resource settings, targeted educational initiatives, infrastructure development, and supportive policies would be required to optimize AI integration.

Keywords: Artificial intelligence, Ophthalmology, Deep learning, Sudan, Medical imaging.

1. BACKGROUND

Artificial intelligence (AI) has gained momentum in ophthalmology, and deep learning algorithms are enjoying popularity in analysing medical images. By analyzing retinal fundus photographs and optical coherence tomography (OCT) scans, AI has shown to achieve high accuracy in identifying eye diseases, including diabetic retinopathy, age-related macular degeneration (AMD), and glaucoma [1,2]. Apart from diagnostics, AI is also utilised in patient education using chatbots and in surgical assistance by offering real-time guidance [3,4]. While it promises much, calls into question the reliability of AI and the bias present in the AI learning datasets, and the explainability of decision making based on AI. Moreover, a widespread lack of awareness about AI among ophthalmologists has been noted, which poses a barrier to the successful incorporation of AI into routine clinical practice [5,6].

The widespread impact of AI in enhancing diagnostic accuracy, personalising treatment therapy for patients, and optimizing clinical operations has transformed the healthcare sector, especially in the visual imaging-specialties such as ophthalmology [7,8]. AI-

based diagnostic tools have demonstrated similar accuracy to human specialists in detecting disorders such as diabetic retinopathy, AMD, and glaucoma [8,9]. Chatbots powered by AI help triage patient concerns and AI-based guidance in surgery improves outcomes [10,11]. On the other hand, adoption is still limited due to issues such as biased training datasets and lack of algorithm transparency [12,13].

This is one of the greatest barriers to AI when it lacks knowledge within ophthalmologists, as they would not be able to provide useful insight for the tool. Research studies show that many practitioners do not feel prepared to utilize AI technologies [14]. In Sudan, where healthcare challenges are significant, this knowledge gap must be bridged to facilitate effective AI adoption. AI education should be integrated into ophthalmology training programs to orient future practitioners to AI-assisted clinical environments [15].

In the context of Sudan, AI is a very powerful opportunity for improving eye care by early disease detection, optimization of medical resources. About 50% of patients with diabetic retinopathy are undiagnosed when the disease has already progressed to the advanced stages, which highlights the necessity for improved screening strategies [16,17]. Moreover, AI-powered systems may be used to enhance the skills of current healthcare workers and add value to the underserved health systems [18].

The application of AI in the Sudanese context will allow us to create models for the integration of technology in low-resource settings. Educators, policymakers, and healthcare institutions should lay collaborative groundwork to improve the availability and ease of access to AI education. Partnerships with the international organizations may benefit AI adoption that leads to equitable health solutions [19].

There have been multiple international and regional studies that highlight the impact of AI on ophthalmology. Two months later, a landmark paper by Abràmoff *et al.,* (2016) showed that artificial intelligence (AI) can have diagnostic accuracy equivalent to expert ophthalmologists for screening of diabetic retinopathy, supporting the use of AI systems in resource-limited settings [9]. Lee *et al.,* (2020) confirmed AI performance in early AMD diagnosis using OCT scans [8]. Similarly, Ting *et al.,*[7], achieved successful glaucoma diagnosis from fundus images using AI (2020). AI has also been used for ophthalmic administrative functions, with Herfert *et al.,* (2019), which employs the use of natural language processing (NLP) as an aid to triaging and referral of patients [20].

Africa: A study in South Africa by Benjamin *et al.,* (2021) raised issues around AI and integration from the perspective of the ophthalmologist, ranging from data privacy to transparency [21]. A Kenyan study by Akinyi *et al.,* (2020) demonstrated that AI-assisted teleophthalmology was capable of increasing screening rates of diabetic retinopathy in a remote setting [22]. Similar research in the Middle East has demonstrated that although many ophthalmologists believed that AI has the potential to enhance patient care, they also recognized a need for more training to interpret AI effectively [23]. Hamade et al published a systematic review (2022) conducted research on AI adoption in the Arab world [24], emphasizing the applicability of AI even in regular eye-caring screenings.

This experience would have implications for AI implementation in LMIC education settings, with consideration of health equity, and would help inform the curricular decisions of the Sudan Medical Schools surrounding AI integration into their curricula. Medical education institutions need to incorporate education on AI into their curricula and residency programs to combat these challenges.

To provide a baseline, this survey is designed to evaluate the level of awareness and knowledge of ophthalmology practitioners in Sudan on the impact of AI in ophthalmology.

2. METHODOLOGY

2.1 Study Design

This research used a cross-sectional survey to check the knowledge and practice of eye doctors in Sudan about AI use in their work, from June 2024 to October 2024.

2.2 Study Area

The survey aimed at eye care professionals in hospitals and clinics in Sudan, including both city and village areas, to get different views.

2.3 Study Population

Participants were eye doctors, including residents, specialists, consultants, and optometrists, in public and private health sectors in Sudan.

2.4 Inclusion and Exclusion Criteria

2.4.1 Inclusion Criteria

- Practicing eye doctors (residents, specialists, and consultants) and optometrists.
- Agreeing to take part in the study.
- Working in diagnosing and treating eye diseases.

2.4.2 Exclusion Criteria

- Unfinished survey responses.
- Non-medical staff or those not involved in eye care.

2.5 Sample Size and Sampling Technique

The goal was to have at least 142 eye doctors to ensure enough data for study. Stratified random sampling was used to get a mix of different health settings and areas.

2.6 Data Collection and Analysis

Data was gathered with a set questionnaire to check the participants' knowledge, practice, and thoughts on AI in eye care. Focus group talks and semi-structured interviews gave extra insights.

Quantitative Analysis: Data was checked with SPSS and R software. Descriptive statistics summarized the data, while checks like chi-square saw links between data points.

2.7 Study Variables

2.7.1 Independent Variables

- Demographic details (age, gender, experience, and practice area).
- Levels of training in AI use.
- Access to AI tools and resources.

2.7.2 Dependent Variables:

- Knowledge and skills about AI.
- Views on AI use in their clinical practice.
- Seen effect of AI tools on eye care.

2.8 Outcome Measures:

- Skill with AI in eye care.
- Changes in work and diagnosis methods after using AI.
- Suggestions for adding AI to eye care study and rules.

2.9 Ethical Considerations

The study followed ethical rules set by the IRB of the Health Ministry and got approval from the Sudan Medical Board. All participants gave consent. Privacy was kept by making responses anonymous and storing data safely. Participants could leave the study at any time without any negative effects.

3. RESULTS

3.1 Participant Demographics

- **Age Distribution**: The majority (57%) of participants are aged 30-39. Smaller groups include those aged 40-49 (19.7%), under 30 (17.6%), 50-59 (4.9%), and 60+ (0.7%).
- **Gender**: A significant gender imbalance exists, with 77.5% identifying as female and 22.5% as male.
- **Nationality**: Nearly all participants (99.3%) are Sudanese, with only 0.7% identifying as non-Sudanese.

3.2 Professional Backgrounds

- **Dominant Profession**: The majority (31.7%) are ophthalmology residents (R3-R4). Other significant groups include optometrists (20.4%) and ophthalmology residents (R1-R2) (9.2%).
- **Underrepresented Professions**: Fewer ophthalmology consultants (6.3%) and general practitioners in primary health care (5.6%).

3.3 Years of Experience

- **Experience**: Most participants (46.5%) have 3-5 years of experience. A smaller portion has less than 2 years (19%), while those with 16-20 (4.2%) and more than 20 years (4.9%) of experience are the least represented.

3.4 Practice Settings

- **Work Locations**: Many (45.8%) works in both public hospitals and private clinics, with 41.5% working exclusively in public hospitals. Fewer work in private clinics (10.6%) or primary health care centres (1.4%).

3.5 Familiarity and Training in AI

- **Familiarity with AI**: Most participants (40.1%) are somewhat familiar with AI, while 29.6% are familiar and 17.6% are not familiar at all. A small portion (2.8%) are experts.
- **Training**: A majority (80.3%) have not received formal AI training, while only 19.7% have had some form of training.

3.6 Confidence in AI Tasks

- **Confidence Levels**: Participants are most confident in trusting AI results (63.4%). Confidence in identifying AI applications (39.4%), explaining AI principles (45.1%), and evaluating AI screening (32.4%) varies, with the lowest confidence in identifying AI applications (29.6%).

3.7 Access and Usage of AI Tools

- **Access to AI Tools**: The majority (81.7%) do not have access to AI tools. Among those with access, the most common tools are OCT-related (31.58%), perimetry tools (21.05%), Pentacam (10.53%), and others (36.84%).
- **Usage Frequency**: Most participants rarely (37.3%) or sometimes (21.8%) use AI tools, with 23.2% using them frequently, 11.3% rarely, and 6.3% always.

3.8 Perceived Impact of AI Tools

- **Workflow Impact**: Half of the participants (49.3%) perceive a significant improvement in clinical workflows due to AI, while 33.1% report moderate improvement. A small percentage (9.2%) report no change, and 8.4% believe AI hinders their workflow.

3.9 Opinions on AI Integration

- **Positive Attitudes**:
  - 78% believe AI can enhance diagnostic accuracy.
  - 77.4% think AI aids in early detection of eye diseases, especially in remote areas.
  - 80.8% support integrating AI into ophthalmology education.
  - 79.6% are in favor of incorporating AI into ophthalmology residency training in Sudan.

4. DISCUSSION

This study provides valuable insights into the awareness, knowledge, and attitudes of ophthalmology practitioners in Sudan regarding the impact of artificial intelligence (AI) in eye care. While there is a generally positive outlook on AI's potential to improve diagnostic accuracy, enable early disease detection, and enhance education, there are significant gaps in AI familiarity, training, access, and usage.

Awareness and Knowledge: Many practitioners lack familiarity with AI, with 40.1% reporting moderate awareness and 80.3% having no formal AI training. This aligns with findings from a study by Wong *et al.,*(2021), which reported a similar gap in awareness among eye care professionals in Southeast Asia, highlighting the urgent need for targeted educational initiatives. This lack of familiarity is concerning, given that AI technologies are rapidly evolving and becoming vital tools in clinical settings, underlining the critical nature of incorporating AI training into ophthalmology curricula and continuous professional development programs (Wong et al., 2021). The challenge of insufficient awareness and the variability in training underscore a broader trend observed across many healthcare disciplines. A systematic review by Hamet and Tremblay (2017) emphasized that despite the growing prevalence of AI technologies in healthcare, many practitioners remain uninformed, which can hinder the adoption of these innovations and ultimately impact patient care (Hamet & Tremblay, 2017). Additionally, the results of our study align with findings from a study conducted in the UK by Topol (2019), who noted that clinicians often feel unprepared to understand and leverage AI technologies due to longstanding educational gaps in medical training (Topol, 2019).

Access and Usage of AI Tools: A large portion (81.7%) of participants lack access to AI tools, which is consistent with the findings of Khan *et al.,* (2022), who indicated that healthcare providers face significant barriers in accessing advanced technology, especially in developing countries (Khan et al., 2022). This lack of access can be attributed to several factors, including financial constraints, inadequate infrastructure, and insufficient policies to promote AI integration into healthcare. This finding emphasizes the need for concerted efforts among policymakers and stakeholders to address these barriers by providing the necessary resources, training, and infrastructure that could support the adoption of AI tools in ophthalmology. Moreover, the low frequency of AI tool usage—37.3% reporting they never use AI tools—suggests that even when tools are available, they may not be utilized effectively due to a lack of training or integration into clinical workflows. This aligns with research by Raj *et al.,* (2020), which found that underutilization of technology often stems from a lack of confidence in its application (Raj et al., 2020). The challenge lies not only in access but also in ensuring that practitioners are adequately trained to utilize these tools effectively, translating into better patient outcomes.

Impacts on Clinical Workflow: The study found that a significant majority (49.3%) believed AI tools have significantly improved clinical workflow, reflecting the findings from Zhang *et al.,* (2018), where the integration of AI in clinical settings led to enhanced efficiency and lower workloads for clinicians (Zhang et al., 2018). The perceived benefits of AI in streamlining workflows and improving diagnostic accuracy potentially correlate with the widespread adoption of AI tools in high-resource settings, where studies have shown improvements in productivity and decision-making processes. However, as noted in our research, there is also a notable minority (9.2%) who reported no change or a hindrance in workflow due to AI integration. This hesitance may reflect a lack of trust or familiarity with AI tools, a factor identified by Denecke and Nussberger (2019), who found that skepticism towards AI stems from an insufficient understanding of its applications and limitations (Denecke & Nussberger, 2019). This underlines the importance of fostering a culture of continuous learning and adaptation among practitioners, promoting a better understanding of how AI can be a tool for enhancing rather than complicating clinical practice.

Clinical Applications of AI: A significant portion of participants (50%) strongly agree that integrating AI can improve diagnostic accuracy. This is supported by numerous studies demonstrating that AI algorithms can outperform human experts in specific diagnostic assessments. For example, Gulshan *et al.,* (2016) reported that an AI system achieved sensitivity and specificity comparable to ophthalmologists in detecting diabetic retinopathy (Gulshan et al., 2016). This notable correlation between AI capabilities and diagnostic accuracy offers a promising avenue for enhancing patient care, particularly in regions with limited access to trained specialists. Furthermore, the perception that AI tools are beneficial for early detection, especially in underserved areas, resonates with findings from a study by Kader *et al.,* (2020), where AI tools were found to effectively aid in the diagnosis of ocular diseases in remote communities, bridging the gap in healthcare access (Kader et al., 2020). This aspect of AI holds particular relevance for Sudan, where rural areas may have limited access to qualified ophthalmologists,

making AI an essential ally in improving healthcare delivery.

Education and Training Needs: The prevailing sentiment among respondents (40.8%) regarding the necessity of integrating AI into ophthalmology education aligns with calls from several experts in the field. Naeem *et al.,* (2022) argued for the urgent need for structured educational programs designed to prepare medical students and residents for the integration of AI technologies into their future practices (Naeem et al., 2022). This is particularly crucial in Sudan, where the study findings indicate a current gap in the knowledge and skills essential for applying AI in clinical settings. The findings suggest that there is a shared understanding among practitioners of the need to incorporate AI into the curriculum of residency programs. This approach has been emphasized in multiple studies as a means to ensure that future healthcare professionals are equipped with the requisite skills to utilize these technologies effectively. A comprehensive curriculum that includes AI training would not only enhance knowledge but also boost confidence levels among practitioners, as evidenced by the study's finding that only 28.9% felt confident explaining AI's basic principles (Naeem et al., 2022).

In conclusion, while there is optimism about AI’s role in ophthalmology in Sudan, targeted efforts to improve access, training, and integration are essential for maximizing its potential in the healthcare

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