Cross-sectional Study

ANNALS OF MEDICINE & SURGERY

OPEN

Knowledge and attitude of medical students towards artificial intelligence in ophthalmology in Riyadh, Saudi Arabia: a cross-sectional study

Zainudheen Faroog, MD[a,*], Qais Saif Eldaula Dirar, MD[a], Abdul Rehman Zia Zaidi, MD[b], Mohammad Salman Khan, MD[a], Golam Mahamud, MD[a], Saad Rahman Ambia, MD[a], Selwa Al-Hazzaa, MD[c]

Background: The use of artificial intelligence (AI) in ophthalmology represents a transformative leap in healthcare. AI-powered technologies, such as machine learning and computer vision, enhance the accuracy and efficiency of ophthalmic diagnosis and treatment.

Objective: This study aimed to determine medical students' awareness and attitudes towards the use of artificial intelligence in ophthalmology.

Methods: This cross-sectional, questionnaire-based study was conducted between November 2022 and January 2023 using online questionnaires. Data collection was carried out using convenience sampling among medical students at the University. IBM SPSS version 23 was used to analyze the data.

Results: The current finding shows that most of the participants $N = 309$ (89.6%) had heard of the use of AI in medicine, and $N = 294$ (85.2%) heard of the use of AI in ophthalmology. 98.6% ($n = 340$) of respondents believed AI would be a helpful tool in ophthalmology. Along this line of questioning, a significant majority of respondents, 332 (96.2%) selected screening, 332 (96.2%) selected diagnosis, and 293 (84.9%) selected prevention as a usage of AI ophthalmology. However, the majority, 76.5%) of students had little understanding of the development of AI in ophthalmology. In addition, a significant relationship between sex, academic year, cumulative GPA (cGPA), and awareness of AI in ophthalmology ($P < 0.001$) was found in this study.

Conclusions: Overall, medical students in Saudi Arabia appear to have favorable thoughts about AI and positive perceptions towards AI in ophthalmology. However, the findings of this study emphasize the limited understanding and low confidence levels of medical students in Saudi Arabia regarding the use of AI in ophthalmology. As a result, early exposure to AI-related materials in medical curricula is crucial for addressing these challenges through comprehensive AI education and practical exposure to prepare future ophthalmologists.

Keywords: artificial intelligence, awareness, medical students, ophthalmology, perceptions, Saudi Arabia

Introduction

Artificial intelligence (AI) is the capacity of a computer to replicate a mental process that is exclusive to humans. The ability to generalize, link experiences to causes, and learn from experience are examples of this type of intelligence[1].

Recent developments in AI algorithms have led to the development of tools to solve problems in many medical fields[2]. For example, single nucleotide polymorphisms, the most prevalent genetic variations, were identified using a Google artificial intelligence framework called deep variant with 99.9587% accuracy and received an award from the FDA in 2016[3]. Moreover, the AI algorithm has been used to detect breast cancer lymph node metastasis by examining pathology slides, identifying suspected malignant melanoma based on skin lesion photographs, and diagnosing tuberculosis by analyzing chest X-rays[4–7]. These findings support the fact that AI systems are considered superior for locating and extracting visual features[8]. Furthermore, an AI radiology algorithm developed at Stanford University could diagnose pneumonia more accurately than radiologists[9]. This demonstrates that

HIGHLIGHTS

- Ophthalmology is an important medical field that uses artificial intelligence (AI) technology.
- Overall, medical students in Saudi Arabia appear to have favorable thoughts about AI and positive perceptions towards AI in ophthalmology.
- Early exposure to AI-related materials in medical curricula is crucial for addressing the challenges through comprehensive AI education and practical exposure to prepare future ophthalmologists.

[a]College of Medicine, Alfaisal University, Riyadh, Saudi Arabia, [b]Department of Family & Community Medicine, College of Medicine, Alfaisal University, Alfaisal University, Riyadh, Saudi Arabia and [c]King Abdulaziz City for Science & Technology (KACST), Riyadh, Saudi Arabia

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

*Corresponding author. Address: College of Medicine, Alfaisal University, Riyadh 11533, Saudi Arabia. Tel.: +966 11 215 7777. E-mail: zfaroog@alfaisal.edu (Z. Faroog).

Annals of Medicine & Surgery (2024) 86:4377–4383

Received 18 March 2024; Accepted 23 May 2024

Published online 10 June 2024

http://dx.doi.org/10.1097/MS9.0000000000002238

AI models can diagnose diseases based on indications or morphologies, just as well as or better than human doctors.

Ophthalmology is another important medical field that uses AI technology. This is due to digital diagnosis techniques, such as color fundus photography, optical coherence tomography (OCT), and computerized visual field (VF) testing. Currently, numerous ophthalmology AI researchers have built deep learning models using medical pictures to perform high-dimensional analysis. For example, an AI software called IDX-DR, approved by the FDA in 2016, was used to classify patients according to the level of diabetic retinopathy[10]. Furthermore, researchers from Sun Yat-sen University in China developed a deep learning model called CC-Cruiser to recognize congenital cataracts[11]. With expert-level accuracy, these technologies have been used to automate screening and diagnose common vision-threatening disorders, such as diabetic retinopathy (DR)[12], glaucoma[13], age-related macular degeneration (AMD)[14], cataract, and other anterior segment diseases[15].

The widespread adoption and commercialization of AI software in ophthalmology has prompted speculation that AI could potentially supplement ophthalmologists in the future[10]. Several studies have been conducted to understand the perceptions of medical undergraduates regarding AI applications in radiology and general medicine[16] as well as the attitudes of healthcare professionals toward AI in ophthalmology[17]. Additionally, researchers have addressed the ethical challenges associated with the integration of AI into medical practice[18].

Despite the rapid advancements in healthcare technology and the increasing adoption of AI solutions in Saudi Arabia, to the best of our knowledge, there is a lack of studies examining medical students' perceptions and attitudes towards AI in ophthalmology. Although a great deal of research has been done on similar topics in other specialties such as dermatology and radiology. A similar study on AI carried out among radiologists in Saudi Arabia, which reported an awareness of 61.2%[18]. Likewise, another study was done regarding AI among dentists in Saudi Arabia, had an awareness of 90.7%[19] Moreover, a study conducted among pharmacy medical students in the country showed 73.9% awareness of AI[20]. The lack of studies specific towards ophthalmology constitutes a significant knowledge gap that impedes the establishment of customized educational programs and healthcare regulations that support the integration of AI in the nation's ophthalmology practices.

Therefore, understanding the status of awareness and attitude toward AI in the field of ophthalmology is important for developing strategies to raise awareness and discuss its challenges in the field. The findings of the study will benefit stakeholders such as educators, healthcare administrators, and legislators in addition to adding to the body of knowledge on AI and medical education. Moreover, the study endeavors to foster a deeper understanding of the opportunities and challenges associated with AI integration in ophthalmology, thereby facilitating informed decision-making and promoting the delivery of high-quality eye care services in Saudi Arabia

Methods

Study design and sample size estimation

A cross-sectional questionnaire-based study was conducted among undergraduate medical students in College of Medicine between November 2022 and January 2023. The required sample size was determined using a computerized sample size calculator (http://www.raosoft.com/samplesize.html) accessed on 1 October 2022. During the sample size calculation, there were approximately 1812 students in the College of Medicine, for whom the required sample size was obtained at a 95% CI and a 5% margin of error (ME). To calculate the sample size, we used a 5% nonresponse rate, which led to a sample size of 318. Nevertheless, we ultimately included 345 students in our study to account for potential non-responses or incomplete surveys. By keeping the sample size at 345, the study's findings were guaranteed to be valid and reliable as it provided sufficient statistical power to detect meaningful differences and relationships between variables.

Questionnaire design and data collection

The questionnaire was developed based on previous reports to allow for generalizability and comparison with other studies. The self-administered questionnaire consisted of three sections, with a total of 18 questions. The first section included demographic questions, such as age, sex, and medical year. The second section comprises awareness and knowledge questions related to artificial intelligence. The third section consisted of questions related to attitudes toward artificial intelligence in ophthalmology and the source of information.

The questionnaire was initially created in English and reviewed by a biostatistician and expert faculty from the College of Medicine and by an Ophthalmologist to ensure content and face validity. In addition, a pilot study was conducted among a randomly selected small sample of students ($n = 40$) to ensure readability. The results of the pilot study were excluded from the final data analysis. Feedback from this preliminary phase led to the refinement of the questionnaire, including the provision of an Arabic version to accommodate language preferences. The questionnaire's reliability was evaluated using Cronbach's alpha, and the result was 0.76, indicating that the questionnaire was reliable for use in the study.

A self-administered questionnaire was created using Google Forms. The survey was distributed electronically to medical students via e-mail and various social media platforms, followed by a convenience sampling strategy. Eligible participants in this study included adults over 18 years of age enrolled as students in the undergraduate College of Medicine during data collection. The study excluded anyone who was under 18 years of age and any student from a different college or graduate program in the college.

Ethical approval and considerations

A brief paragraph emphasizing the confidentiality of their responses and the option to withdraw from the survey at any time was written online. They were also informed of their right to withdraw from the study, without incurring any negative consequences. Written informed consent was obtained from the study participants prior to the study's commencement. This manuscript has been reported in line with the STROCSS criteria[21].

Statistical analysis

The data collected for this study were analyzed using IBM SPSS version 23 (IBM Corp.). Descriptive statistics were used to define the socio-demographic characteristics as frequencies and percentages, whereas the numerical variables were presented as mean ± standard deviation. The association of awareness about artificial with age, sex, medical year, and cumulative GPA (cGPA) was assessed using independent *t*-tests and One-way ANOVA tests to compare means for two groups and more than two groups, respectively, assuming a normal distribution. A *P* value less than 0.05 was used to report any statistically significant result.

Results

Of a total of 1812 medical students in the College of Medicine, 346 responses were collected. 1 response was excluded due to the exclusion criteria. Eventually, 345 (response rate = 21.2%) respondents were included in the study, as they fulfilled the inclusion criteria. Table 1 shows the demographic information of the participants, with a gender distribution of 201 (58.3%) females and 144 (41.7%) males, with a mean age of 22.17 ± 2.25. Most of the respondents in their pre-clinical years of 103 (29.9%) were first-year medical students, 62 (18%) were second-year medical students, and 63 (18.3%) were third-year medical students. The majority of the students *N* = 113 (32.8%) had academic standing (GPA) of 3–3.49.

Table 2 shows medical students' awareness and perception of the application of AI in ophthalmology in Riyadh, Saudi Arabia.

Overall, most of the participants *N* = 309, (89.6%) had heard of the use of AI in medicine, and *N* = 294 (85.2%) heard of the use of AI in ophthalmology. The majority of the students chose the Internet as their primary source of information (42.9%), followed by medical school curriculum coursework (31.6%), social media (11%), and friends/family members (2.9%).

Regarding the potential AI application in ophthalmology, most students 318 (92.8%) chose diabetic retinopathy, 313 (90.7%) chose glaucoma, 308 (89.3%) chose age-related macular degeneration, 110 (31.9%) chose age-related/congenital cataract and 100 (29%) chose retinopathy of prematurity.

Table 1

Socio-demographic characteristics of study participants.

Characteristics of participants	
Variable	***N* = 345, *N* (%)**
Age	
Mean ± SD	22.17 ± 2.25
Range	18–29
Sex	
Female	201 (58.3)
Male	144 (41.7)
Academic year	
Year 1	103 (29.9)
Year 2	62 (18)
Year 3	63 (18.3)
Year 4	60 (17.4)
Year 5	22 (6.4)
Internship	35 (10.1)
cGPA	
Freshman no cGPA	53 (15.4)
< 3.0	108 (31.3)
3.0–3.49	113 (32.8)
3.5–3.74	31 (9)
3.75–4.0	14 (4.1)
Do not prefer to answer	26 (7.5)

cGPA, cumulative GPA.

Table 2

Awareness and perception of the application of artificial intelligence in ophthalmology among study participants

Awareness and perception questions	*N* (%)
Heard about AI in medicine	
Yes	309 (89.6)
No	36 (10.4)
Heard about AI in ophthalmology	
Yes	294 (85.2)
No	51 (14.8)
Source of information regarding AI in ophthalmology	
Conference	1 (0.3)
Course work	109 (31.6)
Friends/family members	10 (2.9)
Internet	148 (42.9)
Social media	38 (11)
Magazine	1 (0.3)
Tv	1 (0.3)
Potential AI application in ophthalmology	
Diabetic retinopathy	318 (92.8)
Glaucoma	313 (90.7)
Age-related/congenital cataract	110 (31.9)
Macular degeneration	308 (89.3)
Retinopathy of prematurity	100 (29)
AI is a helpful tool in the field of Ophthalmology	
Agree	340 (98.6)
Neutral	5 (1.4)
Usage of AI in ophthalmology	
Screening	332 (96.2)
Diagnosis	332 (96.2)
Prevention	293 (84.9)
Treatment	74 (21.4)
AI technology is effective in screening ophthalmic disease	
Agree	334 (96.8)
Neutral	12 (3.45)
Disagree	4 (1.16)
AI technology is effective in the clinical diagnosis of ophthalmic disease.	
Agree	331 (95.94)
Neutral	12 (3.45)
AI technology is effective in treating ophthalmic disease	
Agree	321 (93)
Neutral	14 (4.06)
Disagree	13 (3.77)
AI in ophthalmology will replace ophthalmologists	
Agree	49 (14.2)
Neutral	17 (4.9)
Disagree	279 (80.9)
AI should be integrated into ophthalmology residency/fellowship training	
Agree	332 (96.2)
Neutral	9 (2.6)
Disagree	4 (1.2)
AI technology in ophthalmology practice is dangerous/harmful to patients	
Agree	8 (2.3)
Neutral	17 (4.9)
Disagree	320 (92.8)

AI, artificial intelligence.

Whether AI will be a helpful tool in the field of ophthalmology, more than half the respondents selected responses indicating it will be a helpful tool; 98.6% ($n = 340$) of respondents selected agreed, while 1.4% ($n = 5$) were neutral.

Along this line of questioning, a significant majority of respondents, 332 (96.2%) selected screening, 332 (96.2%) selected diagnosis, and 293 (84.9%) selected prevention as a usage of AI ophthalmology. Only 74 (21.4%) believed AI could be used during/for treatment in ophthalmology.

96.8% ($n = 334$) of participants agreed that AI technology is effective in the screening of ophthalmic diseases, while 3.45% ($n = 12$) were neutral and 1.16% ($n = 4$) disagreed. Similarly, 95.9% ($n = 331$) of participants agreed that AI technology was effective in clinical diagnosis, and 3.45% ($n = 12$) were neutral. Also, 93% ($n = 321$) agreed, 4.06% ($n = 14$) were neutral, and 3.77% ($n = 13$) disagreed that AI technology was effective in treating ophthalmic diseases.

Two hundred seventy-nine (80.9%) participants disagreed, 17 (4.9%) were neutral, and 49 (14.2%) agreed that AI in ophthalmology would replace ophthalmologists in the future.

Likewise, 96.2% ($n = 332$) of participants agreed AI should be integrated into ophthalmology residency/fellowship training. Whereas 2.6% ($n = 9$) were neutral and 1.2% ($n = 4$) disagreed. Also, 92.8% ($n = 320$) of students disagreed that AI technology in ophthalmology practice is dangerous/harmful to patients. While 4.9% ($n = 17$) of students were neutral, 2.3% ($n = 8$) agreed.

Table 3 shows the participants' confidence levels in using and having a basic understanding of the development of AI in ophthalmology.

The percentage of respondents who completely understood and almost understood the basics of the current development of ophthalmic artificial intelligence was 23.5%. However, the majority (76.5%) of students had little understanding. (Table 3)

Among the respondents in Table 3, 55.9% of them are not unconfident in using artificial intelligence technology in ophthalmology. Approximately 37.4% of respondents had little confidence. Only 6.7% of respondents had complete confidence in using artificial intelligence in ophthalmology.

Certain factors have been found to be related to the level of awareness of AI in ophthalmology. There was a significant relationship between gender and awareness of AI in ophthalmology ($P < 0.001$), indicating that females had higher awareness than males. Second, a significant relationship was found between the students' academic years ($P < 0.001$). First-year students had higher awareness than both second- and fifth-year students. Moreover, cGPA was found to be associated with awareness ($P < 0.001$), as participants with a cGPA of 3–3.49 had a higher awareness than participants with less than (<) 3 cGPA and freshmen with no cGPA. (Table 4)

Table 3

Participants' confidence level in using and having a basic understanding of the development of AI in ophthalmology.

Question	*N* (%)
Do you have a basic understanding of the development of AI in ophthalmology?	
A little	264 (76.5)
Almost	77 (22.3)
Completely	4 (1.2)
How confident are you in using artificial intelligence technology in ophthalmology?	
Do not understand.	193 (55.9)
A little	129 (37.4)
Completely	23 (6.7)

AI, artificial intelligence.

Discussion

As the world approaches modernization and globalization, the digitalization of various fields has become a common phenomenon in this contemporary era. A wide array of medical specialties already uses AI for daily tasks, although some specialties are still lacking in this regard. One of the biggest sectors that is highly influenced by AI is ophthalmology, which is second only to radiology, as these specialties use the largest number of scans and imaging for screening, diagnosing, etc., while also having to handle and utilize large amounts of data's[4,9,12,14].

Not much literature has been identified nationally about the awareness and attitude of artificial intelligence in ophthalmology; however, most of the literature reported was among practicing healthcare professionals in certain specialties such as radiology, dermatology, and dentistry and among healthcare students about general artificial intelligence.

Our study is particularly important in fortifying the field of AI in ophthalmology and increasing its knowledge and awareness among the Saudi population and the worldwide audience. Based on our extensive literature search, no study within the country was found regarding the awareness and knowledge of AI in ophthalmology. Thus, to the best of our knowledge, this is the first study in Saudi Arabia to assess awareness of AI in the ophthalmology specialty among medical students in Saudi Arabia.

When looking at the awareness of medical students in Saudi Arabia regarding the topic, it has been seen in our study that among the 345 students who filled out the questionnaire, 89.6% of the respondents heard about the usage of AI in medicine in general, while 85.2% of them heard about the use of AI in ophthalmology specifically. These numbers indicate significant awareness among medical students in Saudi Arabia in general,

Table 4

Association between socio-demographic characteristics and awareness of artificial intelligence in ophthalmology.

Variable	Factor	Ophthalmology awareness (*M*)		*P*
Sex		Yes	No	< 0.001
	Female	187	14	
	Male	107	37	
		Mean (M) ophthalmology awareness	SD	
Academic year	Year 1	1.26	0.442	< 0.001
	Year 2	1.03	0.178	
	Year 3	1.22	0.419	
	Year 4	1.08	0.279	
	Year 5	1.00	0.000	
	Internship	1.09	0.284	
cGPA	Freshman no cGPA	1.01	0.096	< 0.001
	< 3.0	1.08	0.272	
	3.0–3.49	1.51	0.505	
	3.5–3.74	1.16	0.374	
	3.75–4.0	1.29	0.469	
	Do not prefer to answer	1.19	0.402	

cGPA, cumulative GPA.

particularly when considering our sample size.

These findings are like, a study on AI carried out among radiologists in Saudi Arabia, which reported an awareness of 61.2%[18]. Likewise, another study was done regarding AI among dentists in Saudi Arabia, had an awareness of 90.7%[19] Moreover, a study conducted among pharmacy medical students in the country showed 73.9% awareness of AI[20]. This finding aligns with the broader trend of increasing awareness regarding AI technologies in the healthcare sector worldwide. However, it is noteworthy that awareness levels may vary among different cohorts of medical students, as prior exposure to AI-related topics may influence their knowledge and perceptions.

The study revealed that the majority of medical students recognized the potential of AI applications in ophthalmology, with diabetic retinopathy, glaucoma, and age-related macular degeneration being the top three conditions for which they believed AI could be used. This supports the current trends in AI research and development, where significant advancements have been made in AI-based diagnostic and predictive models[10,13,14].

The results of this study suggest that medical students have favorable perceptions and attitudes about AI and its advantages in ophthalmology. The majority of the respondents (98.6%) agreed AI is a helpful tool for ophthalmologists, with an overwhelming majority agreeing that AI can be effective in screening, diagnosis, and prevention of ophthalmic diseases 96%, 95.9%, and 93%, respectively). These findings reflect a positive attitude among medical students regarding AI's potential of AI to enhance ophthalmological care. Similarly, a study reported 69.4% of pharmacy students in Saudi Arabia believed AI is a tool that helps healthcare professionals[20]. The strong agreement regarding AI's effectiveness in screening and diagnosis suggests that students recognize the potential of AI to improve early disease detection and patient outcomes.

A notable fraction or about 21.4%) remained skeptical about its potential in treatment, which suggests that while medical students acknowledge AI's capabilities in diagnosis, screening, and prevention, they may have reservations regarding its role in treatment decisions. Similarly, this has been seen in a study among radiologists in Saudi Arabia, where approximately 50% of participants believed that most patients would not accept a report from AI applications without the supervision of a physician and would require their approval[22]. Also, it has been proven that many situations require a physician's knowledge, examination skills, and experience for interpretation and discussion of the diagnosis with the patient following the treatment plan[23].

Despite the widespread optimism about AI's role in ophthalmology, the majority of participants (80.9%) disagreed with the idea that AI would replace ophthalmologists in the future. Similarly, the majority ($n = 21$, 39.6%) of dermatologists working in Saudi Arabia disagreed that AI would replace doctors. Only 3.8% strongly agreed, while 5.7% agreed with this hypothesis[24]. This sentiment aligns with the broader understanding that AI technologies are tools for enhancing and not replacing human expertise in healthcare.

However, a study conducted among radiographers on the emergence of artificial intelligence in diagnostic imaging in Saudi Arabia showed 50% of the respondents believed that the integration of AI would limit their work in the units, and a large proportion were concerned about displacement from their jobs. In addition, they believed that radiologists' jobs were affected by the introduction of AI into diagnostic image interpretation[25]. These varying attitudes in different specialties suggest that there is a need for educational interventions that not only enhance awareness, but also address misconceptions and concerns regarding AI in healthcare. Therefore, it is essential for the ophthalmological community to actively engage in AI developments and integrate them into practice to maintain relevance and provide the best possible care.

A significant proportion of the surveyed medical students, ~76.5%, reported having little understanding of the basics of current ophthalmic AI development. This result suggests that a substantial majority of participants lacked fundamental knowledge of the current state of AI applications in ophthalmology. Also, the study revealed that a considerable percentage of respondents (55.9%) expressed a lack of confidence in using AI technology in ophthalmology. Additionally, approximately 37.4% of participants reported having only a limited level of confidence. However, a study done among medical workers in China toward artificial intelligence in ophthalmology reported that the proportion of medical workers whose understanding level was "completely understand" or "almost understand" was 42.6% for AI in ophthalmology[17].

The low confidence levels might be attributed to the fact that, when considering ophthalmology as a whole, students are seldom exposed to the specialty in depth during their medical school career, and those who decide to pursue it often have to undertake separate training in the field for a specific period after finishing medical school. In the medical schools' curriculums in general, apart from a '2 credit hour block,' and a '1 month outpatient clinical elective in fifth year,' there is not much exposure to the specialty. A study aimed at evaluating the ophthalmology courses taught in medical schools in Saudi Arabia, carried out among ophthalmology residents in the country, showed that more than 80% of the participants thought that the ophthalmology courses taught in medical schools required improvement in all its aspects, especially the duration for the exposure of the specialty[26]. To promote greater confidence in using AI in ophthalmology, efforts should be made to create an environment in which students have hands-on experiences with AI tools and technologies. This can include incorporating AI into clinical rotations, research projects, and internships, allowing students to witness firsthand the benefits and limitations of AI in clinical settings.

The study highlights that a significant percentage of participants (96.2%) believed that AI should be integrated into ophthalmology residency and fellowship training. This underscores the importance of adapting medical education programs to include AI-related content, ensuring that future ophthalmologists are well prepared for lever-age AI tools effectively in their clinical practice. There is a pressing need to integrate AI education into medical curricula. Medical schools and institutions should consider revising their curricula to include AI-related coursework, practical training, and exposure to AI tools and ophthalmology applications.

One of the notable findings of the study is that there was a significant relationship between sex, cumulative grade point average (GPA) academic year, and awareness of AI in ophthalmology. Females exhibited higher awareness than males. This gender disparity might be attributed to various factors, including differences in certainty regarding AI-related content, individual interests, and engagement with healthcare technology. Participants with a cGPA in the range of 3–3.49 exhibited higher

awareness compared to those with a cGPA below 3 or freshmen without a recorded cGPA. This association between academic performance and awareness may indicate that students with stronger academic records are more proactive in seeking out and engaging in AI-related educational resources and information. Lastly, first-year students exhibited higher awareness than both second- and fifth-year students. On the other hand, a study conducted among pharmacy medical students in Saudi Arabia showed that senior undergraduates consistently demonstrated a higher level of awareness or knowledge than juniors and others, as well as the fact that the older an individual is, the higher the level of knowledge and awareness. as Prior exposure to AI during the graduation process (via a course, congress, seminar, etc.) may have influenced this situation[20]. In our study, the opposite trend occurred due to the skew in the data where more first-year participants participated in the study compared to the seniors.

Limitations

The results of this study may have been predisposed to some limitations. First, the study may have been subject to sampling bias, as the participants were recruited from one medical university in Saudi Arabia. This limited geographic scope may not fully represent the diversity of medical students across the country, and the results may not apply to students from other regions. Second, the study relied on self-reported data, which could introduce response bias. Participants may have provided socially desirable responses, leading to an overestimation of their awareness of or attitudes toward AI in ophthalmology. Additionally, non-response bias may have influenced the results if those who did not participate had different levels of awareness. Finally, the cross-sectional nature of this study prohibits inferring causality. This does not allow for the assessment of changes in awareness over time or causal relationships. Longitudinal studies are needed to explore these trends and changes in awareness. Despite these limitations, this study provides valuable insights into the awareness of AI in ophthalmology among medical students in Saudi Arabia. As a result, we believe that the results can offer additional direction to policymakers in the fields of education and healthcare.

Conclusions

In conclusion, the current study shows that medical students in Riyadh appear to have favorable thoughts about AI and positive perceptions towards AI in ophthalmology. However, the findings of this study emphasize the limited understanding and low confidence levels of medical students in Saudi Arabia regarding the use of AI in ophthalmology. Addressing these challenges through comprehensive AI education and practical exposure is essential to prepare future ophthalmologists to effectively lever-age AI technologies and to contribute to the advancement of ophthalmological practice. Moreover, as AI continues to transform healthcare, medical education must keep pace with these advancements to ensure that future healthcare professionals are equipped with the necessary skills and knowledge to provide the best possible care for patients.

Ethical approval

Ethical approval for this study (IRB-20166) was provided by the Institutional Review Board of the Alfaisal University, Riyadh, Saudi Arabia on 13 October 2022.

Consent

Written informed consent was obtained from the patient for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Source of funding

This research did not receive any specific grant from any funding agency in the public, commercial or not-for-profit sector.

Author contributions

Conceptualization: Z.F. and Q.S.E.D.; methodology: Z.F. and Q.S.E.D.; software: Q.S.E.D.; validation: Q.S.E.D. and A.R.Z.Z.; formal analysis: Q.S.E.D.; investigation: Z.F., Q.S.E.D., A.R.Z.Z.; resources: Z.F., Q.S.E.D., A.R.Z.Z.; data curation: Z.F., Q.S.E.D., A.R.Z.Z.; writing—original draft preparation: Z.F., Q.S.E.D., A.R.Z.Z., M.S.K., G.M., S.R.A.; writing—review and editing: Z.F., Q.S.E.D., A.R.Z.Z., M.S.K., G.M., S.R.A.; visualization: Z.F., Q.S.E.D., A.R.Z.Z.; supervision: Q.S.E.D. and A.R.Z.Z.; project administration: Z.F., Q.S.E.D., A.R.Z.Z.; funding acquisition: nil. All the authors have read and agreed to the published version of the manuscript.

Conflicts of interest disclosure

The authors declare that there are no conflicts of interest.

Research registration unique identifying number (UIN)

Registry Used: Researchregistry.com
Research Registry Unique Identifying Number: researchregistry10068
Hyperlink: researchregistry10068

Guarantor

Qais Saif Eldaula Dirar.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. Access to the data is subject to a data use agreement and restrictions on reuse of the data.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Acknowledgement

The authors acknowledge the support of the College of Medicine at Alfaisal University. The authors thank the participants for their willingness to participate in the study.

References

[1] Artificial intelligence | Definition, Examples, Types, Applications, Companies, & Facts | Britannica. Accessed 22 September 2022. https://www.britannica.com/technology/artificial-intelligence.
[2] Jordan MI, Mitchell TM. Machine learning: trends, perspectives, and prospects. Science 2015;349:255–60.
[3] PrecisionFDA Truth Challenge — Google Genomics v1 documentation. Accessed 22 September 2022. https://googlegenomics.readthedocs.io/en/staging-2/use_cases/discover_public_data/precision_fda.html
[4] Lakhani P, Sundaram B. Deep learning at chest radiography: automated classification of pulmonary tuberculosis by using convolutional neural networks. Radiology 2017;284:574–82.
[5] Ting DSW, Yi PH, Hui F. Clinical applicability of deep learning system in detecting tuberculosis with chest radiography. Radiology 2018;286:729–31.
[6] Esteva A, Kuprel B, Novoa RA, *et al*. Dermatologist-level classification of skin cancer with deep neural networks. Nature 2017;542:115–8.
[7] Ehteshami Bejnordi B, Veta M, Johannes van Diest P, *et al*. Diagnostic assessment of deep learning algorithms for detection of lymph node metastases in women with breast cancer. JAMA 2017;318:2199.
[8] Litjens G, Kooi T, Bejnordi BE, *et al*. A survey on deep learning in medical image analysis. Med Image Anal 2017;42:60–88.
[9] Algorithm better at diagnosing pneumonia than radiologists | News Center | Stanford Medicine. Accessed 22 September 2022. https://med.stanford.edu/news/all-news/2017/11/algorithm-can-diagnose-pneumonia-better-than-radiologists.html
[10] Abràmoff MD, Lavin PT, Birch M, *et al*. Pivotal trial of an autonomous AI-based diagnostic system for detection of diabetic retinopathy in primary care offices. Yearbook Paediatr Endocrinol 2018;1:39.
[11] Long E, Lin H, Liu Z, *et al*. An artificial intelligence platform for the multihospital collaborative management of congenital cataracts. Nat Biomed Eng 2017;1:0024.
[12] Gulshan V, Peng L, Coram M, *et al*. Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs. JAMA 2016;316:2402.
[13] Li Z, He Y, Keel S, *et al*. Efficacy of a deep learning system for detecting glaucomatous optic neuropathy based on color fundus photographs. Ophthalmology 2018;125:1199–206.
[14] Grassmann F, Mengelkamp J, Brandl C, *et al*. A deep learning algorithm for prediction of age-related eye disease study severity scale for age-related macular degeneration from color fundus photography. Ophthalmology 2018;125:1410–20.
[15] Li W, Yang Y, Zhang K, *et al*. Dense anatomical annotation of slit-lamp images improves the performance of deep learning for the diagnosis of ophthalmic disorders. Nat Biomed Eng 2020;4:767–77.
[16] Pinto dos Santos D, Giese D, Brodehl S, *et al*. Medical students' attitude towards artificial intelligence: a multicentre survey. Eur Radiol 2019;29:1640–6.
[17] Zheng B, Wu Mn, Zhu Sj, *et al*. Attitudes of medical workers in China toward artificial intelligence in ophthalmology: a comparative survey. BMC Health Serv Res 2021;21:1067.
[18] Alelyani M, Alamri S, Alqahtani MS, *et al*. Radiology community attitude in saudi arabia about the applications of artificial intelligence in radiology. Healthcare (Switzerland) 2021;9:834.
[19] Abouzeid HL, Chaturvedi S, Abdelaziz KM, *et al*. Role of robotics and artificial intelligence in oral health and preventive dentistry—knowledge, perception and attitude of dentists. Oral Health Prev Dent 2021;19:353–63.
[20] Syed W, Basil A. Al-Rawi M. Assessment of awareness, perceptions, and opinions towards artificial intelligence among healthcare students in Riyadh, Saudi Arabia. Medicina (Lithuania) 2023;59:828.
[21] Mathew G, Agha R. STROCSS 2021: Strengthening the reporting of cohort, cross-sectional and case-control studies in surgery. Int JSurg 2021;96:106165.
[22] Khafaji MA, Safhi MA, Albadawi RH, *et al*. Artificial intelligence in radiology Are Saudi residents ready, prepared, and knowledgeable? Saudi Med J 2022;43:53–60.
[23] Krittanawong C. The rise of artificial intelligence and the uncertain future for physicians. Eur J Intern Med 2018;48:e13–4.
[24] Al-Ali F, Polesie S, Paoli J, *et al*. Attitudes towards artificial intelligence among dermatologists working in Saudi Arabia. Dermatol Pract Concept 2023;13:e2023035.
[25] Aldhafeeri FM. Perspectives of radiographers on the emergence of artificial intelligence in diagnostic imaging in Saudi Arabia. Insights Imaging 2022;13:178.
[26] Al-Najmi YA, Subki AH, Alzaidi NS, *et al*. Medical schools' ophthalmology course: an appraisal by ophthalmology residents. Int J Gen Med 2021;14:8365–72.