MEDICAL EDUCATORS' PERSPECTIVE REGARDING THE INTEGRATION OF ARTIFICIAL INTELLIGENCE AND ROBOTICS IN UNDERGRADUATE CURRICULA AND HEALTHCARE SYSTEMS, MAKKAH PROVINCE, SAUDI ARABIA

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Abstract:
Background: The fourth industrial revolution has brought Artificial Intelligence (AI) and Robotics into sharp focus, particularly in healthcare. AI, defined as the capacity of digital systems to perform tasks requiring human-like intelligence, has achieved significant advancements in medical applications.

Aim: This study explores the perspectives of medical educators in Makkah Province, Saudi Arabia, on integrating AI and Robotics into medical education and healthcare system.
Methods: A cross-sectional study was conducted to evaluate the perspectives and attitudes of health profession educators in Makkah Province, Saudi Arabia, regarding the integration of AI and Robotics into undergraduate curricula. A voluntary response, convenience-based non-probability sampling method was employed, with sample size determination using G*Power software. A total of 220 participants responded to the online questionnaire. The study utilized a validated online questionnaire, adapted with written consent from the corresponding author of a previously conducted study at Cyprus Medical School. The questionnaire items were rated by medical educators on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Ethical approval for the study was obtained from the Ibn Sina National College Research and Ethics Committee.

Results: Female respondents represented 57.27% of participants, with lecturers comprising the largest professional group (27.73%). Notable findings include significant gender-based differences in perceptions of AI's diagnostic capabilities, with females showing greater acceptance of AI's potential. Most educators supported AI's application in Surgery, Cardiology, and Biopharmaceutical research, emphasizing supervised integration in healthcare systems. Concerns about AI's judgment compared to physicians revealed statistically significant differences (p = 0.049).
Conclusion: Educators demonstrated moderate familiarity with AI and Robotics, with strong support for its supervised adoption in medical practice. They acknowledged AI's potential to enhance diagnostic accuracy and surgical precision but expressed reservations about legal, ethical, and privacy challenges. AI is viewed as a complementary tool rather than a replacement for human expertise.

Keywords: Artificial intelligence, Robotics , Medical education, Healthcare system, Saudi Arabia

Introduction:

 In the midst of the fourth industrial revolution, Artificial Intelligence (AI) has seized unprecedented attention across diverse aspects of our lives, notably within the medical field [1]. AI, characterized as the capacity of digital machines to execute tasks associated with intelligent entities, has made remarkable strides. John McCarthy introduced AI in 1956 and defined it as "the science and engineering of making intelligent machines" [2]. The early 1970s saw the emergence of the concept of employing AI in medicine to improve medical diagnosis and treatment. Recent progress in AI, particularly within medical AI systems, has empowered expert-level disease diagnosis, ushering in a transformative era for healthcare. This revolution has not only elevated healthcare services but has also significantly improved human health outcomes [1]. AI has found substantial applications across varied medical specialties, encompassing radiology, neurology, pathology, dermatology. Ophthalmology, gastrointestinal, cardiology, surgery, molecular medicine, and genetics [2]. With the continuous expansion of AI adoption in healthcare such as customized treatment plans, medication formulation, and virtual healthcare assistants, its integration into medical education holds substantial promise for the future of medical practice [1].

The future of healthcare is set to be shaped by the integration of Robotics and AI in medicine, a development that has generated varying opinions. Many believe that Robotics and AI will bring significant benefits to healthcare [3]. Recent studies indicate that health profession educators share a consensus that artificial intelligence will propel advancements in medicine. Notably, there exists a gender disparity, with males exhibiting greater confidence and interest in AI compared to females; however, both genders disagree with the notion that AI will imminently replace human physicians [4]. Concurrently, a prevailing belief suggests that the implementation of AI and fully autonomous robotic systems could potentially marginalize doctors in various healthcare settings, thereby giving rise to ethical and legal dilemmas [3][5]. Furthermore, research indicated that medical students face discouragement from pursuing specializations as a career because of the developments in artificial intelligence and worry about the replacement of different AI specialties [2]. A number of medical AI have also

been used in China's everyday clinic operations, including disease screening and diagnosis, biobank information management, and medical record management [1].

The remarkable developments in AI have not kept medical education up to date, despite the growing interest in this technology. The integration of AI training into medical education has been slow, despite calls to action. Since medical education can reach the largest group of medical trainees early in their careers, its integration with AI could offer significant benefits for future practice as the technology's adoption in healthcare continues to grow as the foreseeable future will see intersections between the paths of present undergraduate medical students and AI and Robotics [1][2]. Understanding the perspectives of health professional educators in Makkah Province, Saudi Arabia, regarding AI and Robotics in healthcare is essential for ensuring successful implementation. These technologies offer opportunities for interactive learning in medical education and have transformative implications for patient care. Despite the potential benefits in healthcare outcomes, cost reduction, and improved patient experiences, there is a research gap in Saudi Arabia. Limited studies have explored the perception of Saudi Arabian health professional educators. Therefore, it is crucial to identify acceptance factors, address challenges, and consider ethical dimension for the effective integration of AI and Robotics . By exploring the expectations and concerns of faculty, strategies can be developed to seamlessly integrate AI and Robotics into medical education and healthcare systems within Makkah Province. The objectives of this study were to assess the familiarity level of medical educators with AI and Robotics in medical education and healthcare systems, to explore medical educators' beliefs, perspectives, and expectations regarding the present and future integration of AI and Robotics in diverse medical disciplines, and to explore the legal liability issues which could arise from the use of AI and Robotics in medical education and healthcare systems.

Methodology:
Study Area/Setting:

The study was conducted by medical students from Ibn Sina National College (ISNC) for Medical Studies in Jeddah, Saudi Arabia, targeting medical educators in the Makkah Province, Saudi Arabia, during the 2023–2024 academic year.

Study Design:

A cross-sectional study design was employed to assess the perspectives and attitudes of medical educators regarding the integration of AI and Robotics into medical education and healthcare systems.

Subjects and Sample Size:

The study population included all medical educators from universities and colleges in the health sector within Makkah Province. Inclusion criteria encompassed all medical educators working within this region, while exclusion criteria excluded other healthcare professionals.

Sampling Size and Technique:

A voluntary response convenient nonprobability sampling technique was used. Using G power software, the minimum sample size was calculated based on an alpha level of 0.05, a power of 0.95, an effect size of 0.3, and 5 degrees of freedom. Accordingly, the study sample size was 220 medical educators.

Data Collection:

Familiarity with AI and Robotics, their impact on healthcare, potential legal and ethical challenges, and the advantages and disadvantages of their integration into health-related fields and undergraduate curricula were assessed using a validated online questionnaire. This questionnaire was adapted based on the research objectives, with written consent obtained from the corresponding author of a previously conducted study at the Medical School of Cyprus to utilize their data collection tool for the current study [2]. The questionnaire items were completed by medical educators using a five-point frequency scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Data Management and Analysis:

The statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS, version 23). Nominal variables were reported as frequencies and percentages. Chi-square tests were used for comparing variables, with a 95% confidence interval and a significance threshold set at $p < 0.05$. Appropriate statistical tests were applied based on the variable types, and results were presented using tables and figures when necessary.

Ethical Considerations:

Ethical clearance for the study was obtained from the Ibn Sina National College Research and Ethics Committee **(IRRB-01-19052024).** Study participants were informed about the purpose of the research and their right to refuse participation. Ethical conduct was maintained throughout data collection and the research process, adhering to the Declaration of Helsinki (2008). Participation was voluntary, and confidentiality was ensured by providing anonymous online questionnaires. Participants retained the right to withdraw from the study at any time without consequences.

<u>Results:</u>

The result of this study is presented in the below tables and figures. **Figure 1** illustrates the distribution of academic ranks among the study participants (n = 220) with consideration of their gender distribution. Lecturers made up the largest proportion, with 61 participants (27.7%). Both Assistant Professors and Demonstrators accounted for 53 participants each (24.1%). Associate Professors comprised 33 participants (15.00%), while Professors represented 20 participants (9.1%).
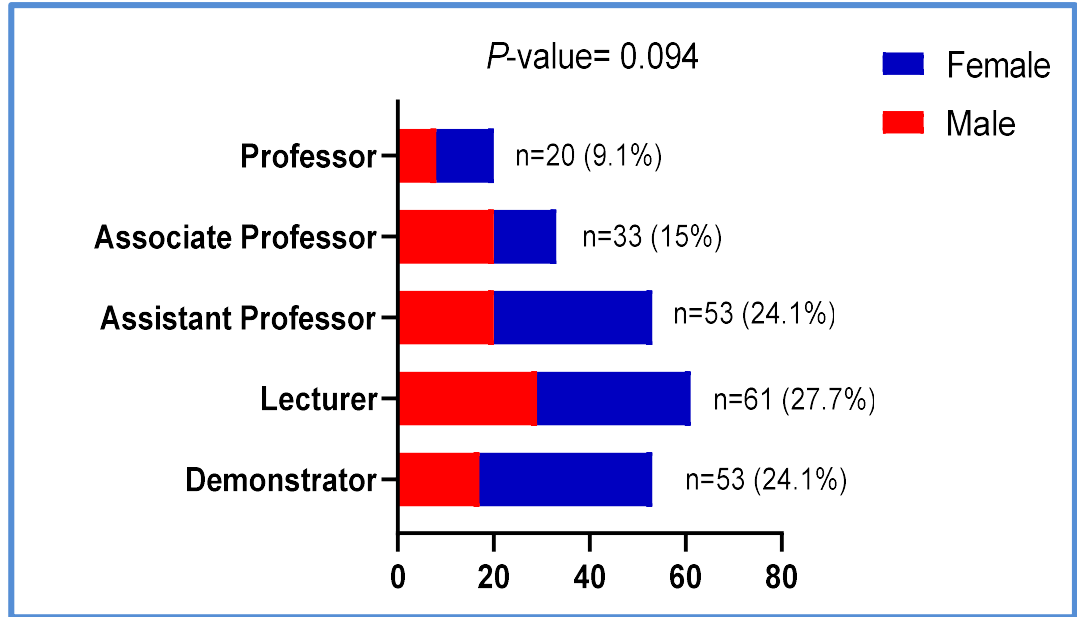
Figure 1: Show the Academic Rank Distribution among the Study Participants' Gender (n=220)

Figure 2. The gender distribution of the study participants (n = 220) revealed that the majority were females, comprising 57.27% (126 out of 220). Regarding familiarity with AI, 63.9% of females reported being familiar compared to 36.1% of males. Neutral knowledge about AI was observed in 47.6% of females and 52.4% of males. Conversely, non-familiarity with AI was reported by 56.9% of females and 43.1% of males.
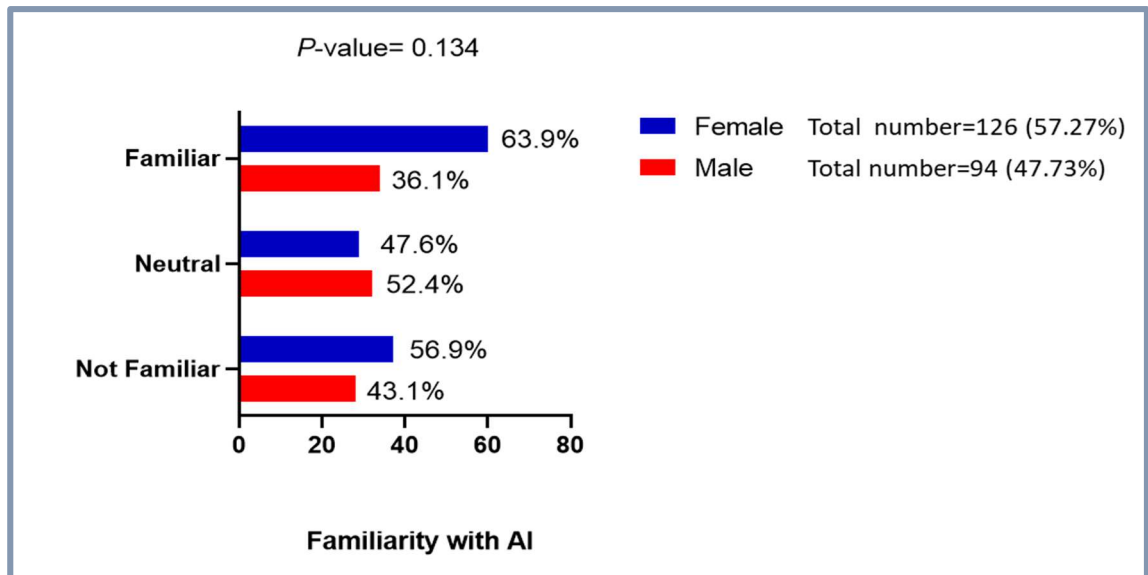

Figure 2: The Familiarity about AI according to the Study Participants' Gender Distribution (n=220)

Table 1 presents data comparing male and female participants (n = 220) regarding their prior educational experience in AI, views on AI advancements within medical specialties, and opinions on whether AI's diagnostic ability surpasses that of a doctor. While most categories show no statistically significant differences between genders, 60.9% of all participants expressed disagreement with the idea that AI's diagnostic ability is superior to a doctor. Conversely, 70.5% of participants agreed on the importance of introducing AI into the medical school curriculum.

Table 1: The importance of AI in Healthcare among the study participants' gender distribution (n=220)

Items of Evaluation		Gender		Total	P-value
		Male	Female		
Past Educational Skills in AI	No experience	**34 (36.2%)**	**38 (30.2%)**	72 (32.7%)	**0.579**
	Attended seminars and presentation	33 (35.1%)	**55 (43.7%)**	**88 (40%)**	
	Received training over the internet	18 (19.1%)	24 (19%)	42 (19.1%)	
	Received training in medicine	9 (9.6%)	9 (7.1%)	18 (8.2%)	
Advancements of AI being involved in a specialty	Not familiar	30 (31.9%)	42 (33.3%)	72 (32.7%)	**0.111**
	Neutral	24 (25.5%)	46 (36.5%)	70 (31.8%)	
	Familiar	40 (42.6%)	38 (30.2%)	**78 (35.5%)**	
Diagnostic ability of AI is superior to the doctor	Disagree	66 (70.2%)	68 (54%)	**134 (60.9%)**	**0.030**
	Neutral	16 (17%)	26 (20.6%)	42 (19.1%)	
	Agree	12 (12.8%)	32 (25.4%)	44 (20%)	
Introduction of AI in medical school curriculum	Disagree	19 (20.2%)	14 (11.1%)	33 15%)	**0.121**
	Neutral	15 (16%)	17 (13.5%)	32 (14.5%)	
	Agree	**60 (63.8%)**	**95 (75.4%)**	**155 (70.5%)**	
Total		94 (100%)	126 (100%)	220 (100%)	

Table 2 highlights the attitudes of medical educators regarding the influence of AI and Robotics on medical practice. The majority of participants (54%) disagreed with the notion that AI will devalue the medical profession. Most respondents (63%) agreed that AI will reduce errors

in medical practice, while 78.2% believed AI will facilitate patients' access to healthcare services. Additionally, 76.4% agreed that AI will enhance physicians' access to information, and 74.1% supported the idea that AI will improve patient education. Overall, these opinions were statistically insignificant when analyzed by gender.

Table 2: The Medical Educators' Attitude towards the Influence of AI and Robotics on Medical Practice in Relation to Gender distribution (n=220)

Items of Evaluation		Gender		Total	P-value
		Male	Female		
AI devalues the medical profession	Disagree	57 (60.60%)	63 (50.00%)	**120 (54.50%)**	0.097
	Neutral	13 (13.80%)	32 (25.40%)	45 (20.50%)	
	Agree	24 (25.50%)	31 (24.60%)	55 (25.00%)	
AI reduces errors in medical practice	Disagree	15 (16.00%)	26 (20.60%)	41 (18.60%)	0.602
	Neutral	19 (20.20%)	21 (16.70%)	40 (18.20%)	
	Agree	60 (63.80%)	79 (62.70%)	**139 (63.20%)**	
Facilitation of patients' access to healthcare services by AI	Disagree	11 (11.70%)	13 (10.30%)	24 (10.90%)	0.832
	Neutral	9 (9.60%)	15 (11.90%)	24 (10.90%)	
	Agree	74 (78.70%)	98 (77.80%)	**172 (78.20%)**	
AI facilities physicians' access to information	Disagree	13 (13.80%)	12 (9.50%)	25 (11.40%)	0.308
	Neutral	14 (14.90%)	13 (10.30%)	27 (12.30%)	
	Agree	67 (71.30%)	101 (80.20%)	**168 (76.40%)**	
AI increases patients' confidence in medicine	Disagree	21 (22.30%)	20 (15.90%)	41 (18.60%)	0.353
	Neutral	21 (22.30%)	25 (19.80%)	46 (20.90%)	
	Agree	52 (55.30%)	81 (64.30%)	**133 (60.50%)**	
AI facilitates patient education	Disagree	14 (14.90%)	15 (11.90%)	29 (13.20%)	0.628

	Neutral	10 (10.60%)	18 (14.30%)	28 (12.70%)	
	Agree	70 (74.50%)	93 (73.80%)	**163 (74.10%)**	
Negative patient-physician relationship due to AI's use	Disagree	42 (44.70%)	41 (32.50%	83 (37.70%)	0.177
	Neutral	19 (20.20%)	29 (23.00%)	48 (21.80%)	
	Agree	33 (35.10%)	56 (44.40%)	89 (40.50%)	
AI damages that trust which is the basis of the patient-physician relationship	Disagree	49 (52.10%)	60 (47.60%)	109 (49.50%)	0.534
	Neutral	12 (12.80%)	23 (18.30%)	35 (15.90%)	
	Agree	33 (35.10%)	43 (34.10%)	76 (34.50%)	
Violations of professional confidentiality due to AI	Disagree	40 (42.60%)	42 (33.30%)	82 (37.30%)	0.209
	Neutral	27 (28.70%)	34 (27.00%)	61 (27.70%)	
	Agree	27 (28.70%)	50 (39.70%)	77 (35.00%)	
Enhance patient's control over his own health with AI	Disagree	20 (21.30%)	20 (15.90%)	40 (18.20%)	0.588
	Neutral	15 (16.00%)	22 (17.50%)	37 (16.80%)	
	Agree	59 (62.80%)	84 (66.70%	**143 (65.00%)**	

Table 3 shows that the majority of male medical educators (165, 75%) support the incorporation of artificial intelligence (AI) into standard medical practice. The fields most anticipated to be influenced by AI include surgery, cardiology, and biopharmaceutical research. Regarding the future, over 80% of respondents believe that AI will be integrated into healthcare, though under the supervision of specialist staff. These opinions were found to be statistically insignificant when analyzed by gender.

Table 3: The Medical Educators Perspectives Regarding the Present and Future integration of AI and Robotics in different medical fields in Relation to Gender distribution (n=220)

Items of Evaluation		Gender		Total	P-value
		Male	**Female**		
Integration of AI in medical practice nowadays	**Yes**	**67 (71.3%)**	**98 (77.8%)**	**165 (75%)**	**0.271**
	No	27 (28.7%)	28 (22.2%)	55 (25%)	
Advancements of AI being involved in a specialty	**Biopharmaceutical research and development**	**25 (26.6%)**	**21 (16.7%)**	**46 (20.9%)**	**0.173**
	Cardiology	11 (11.7%)	15 (11.9%)	26 (11.8%)	
	Dermatology	2 (2.1%)	7 (5.6%)	9 (4.1%)	
	Endocrinology	3 (3.2%)	14 (11.1%)	17 (7.7%)	
	Histology	4 (4.3%)	8 (6.3%)	12 (5.5%)	
	Internal medicine	2 (2.1%)	6 (4.8%)	8 (3.6%)	
	Nephrology	3 (3.2%)	5 (4%)	8 (3.6%)	
	Oncology	3 (3.2%)	9 (7.1%)	12 (5.5%)	
	Ophthalmology	10 (10.6%)	7 (5.6%)	17 (7.7%)	
	Radiology	7 (7.4%)	8 (6.3%)	15 (6.8%)	
	Surgery	**24 (25.5%)**	**26 (20.6%)**	**50 (22.7%)**	
In your opinion, in the future	**Physicians will be replaced by AI and Robotics**	10 (10.7%)	14 (11.1%)	23 (10.5%)	**0.661**
	AI and Robotics will be integrated into medical care and supervised/operated by specialized personnel	**77 (81.9%)**	**101 (80.2%)**	**178 (80.9%)**	
	AI and Robotics will have the same role in medical care as they have today	7 (7.4%)	11 (8.7%)	18 (8.2%)	
Application of AI in medical fields in future	**Biopharmaceutical research and development**	**12 (12.8%)**	**20 (15.9%)**	**32 (14.5%)**	**0.980**
	Cardiology	**26 (27.7%)**	**35 (27.8%)**	**61 (27.7%)**	
	Dermatology	4 (4.3%)	3 (2.4%)	7 (3.2%)	
	Endocrinology	5 (5.3%)	10 (7.9%)	15 (6.8%)	
	Histology	3 (3.2%)	4 (3.2%)	7 (3.2%)	
	Internal medicine	1 (1.1%)	1 (1.1%)	2 (9%)	
	Nephrology	5 (5.3%)	4 (3.2%)	9 (4.1%)	
	Oncology	2 (2.1%)	4 (3.2%)	6 (2.7%)	
	Ophthalmology	4 (4.3%)	7 (5.6%	11 (5%)	

	Radiology	3 (3.2%)	5 (4%)	8 (3.6%)	
	Surgery	**29 (30.9%)**	**33 (26.2%)**	**62 (28.2%)**	
Total		94 (100%)	126 (100%)	220 (100%)	

Table 4 shows gender-based insights into the legal liability issues, benefits, and drawbacks of AI and Robotics in medicine. There is a statistically significant difference (p-value = 0.049) in the opinions about physicians' judgment compared to AI's judgment. A higher percentage of males (68.1%) support the physician's opinion, while females show a slightly lower support (64.3%). No significant difference in opinion regarding responsibility for AI errors, suggesting a consensus or lack of strong opinions on this issue. Assisting physicians (44.5%) and surgeons (43.6%) was viewed favorably, indicating a strong belief in AI's potential to enhance diagnostic and surgical accuracy. However, the perceived benefit in reducing physician burnout (11.8%) is considerably lower. The p-value of 0.689 indicates no significant difference in opinions about the drawbacks of AI, with the majority (66.8%) expressing concerns about dehumanization in medicine.

Table 4: The legal liability issues which could arise from AI And Robotics in relation to gender (n=220)

Items of Evaluation		Gender		Total	P value
		Male	**Female**		
Physician's Judgement vs AI's Judgement	**Physician's opinion**	**64 (68.1%)**	**81 (64.3%)**	**145 (65.9%)**	0.049*
	AI's opinion	17 (18.1%)	13 (10.3%)	45 (20.5%)	
	Patient's choice	13 (13.8%)	32 (25.4%)	45 (20.5%)	
Responsibility of AI's Mistakes	**Doctor in charge of patient care**	**26 (27.7%)**	**41 (32.5%)**	**67 (30.5%)**	0.385
	Company that created the AI	47 (50%)	52 (41.3%)	99 (45%)	
	Patient who consented to follow AI's input	15 (16%)	28 (22.2%)	43 (19.5%)	
	Independent AI agency	06 (6.4%)	05 (4%)	11 (5%)	
Benefits of AI in Medicine	**Assist physicians for more accurate diagnosis**	**42 (44.7%)**	**56 (44.4%)**	**98 (44.5%)**	0.189
	Assist surgeons for more precise surgical interventions	45 (47.9%)	51 (40.5%)	96 (43.6%)	
	Reduction of physician burnout	07 (7.4%)	19 (15.1%)	26 (11.8%)	
	Dehumanization of medicine	**60 (63.8%)**	**87 (69%)**	**147 (66.8%)**	0.689

Drawbacks of AI in Medicine	Privacy violations of sensitive medical data	27 (28.7%)	32 (25.4%)	59 (26.8%)	
	No standardized evaluation of the effect of artificial intelligence and Robotics on healthcare	07 (7.4%)	07 (5.6%)	14 (6.4%)	

Table 5 presents the distribution of perspectives regarding the integration and application of AI in medical practice across different academic degrees, a large proportion of respondents believe that AI is integrated into medical practice today, with higher percentages among Lecturers (20.9%) and Assistant Professors (19.5%). The distribution across various medical fields suggests that AI is perceived to be most commonly used in Biopharmaceutical Research (highest for Lecturers at 7.3%) and Surgery (with a notable 5.9% of Lecturers and 5% of Demonstrators agreeing). When asked about the future, most respondents across all academic levels believe that AI and Robotics will be integrated into medical care and supervised by specialized personnel. This view is the strongest among Lecturers (22.3%) and Assistant Professors (20.9%). Cardiology shows a notable increase in agreement, particularly among Assistant Professors (9.1%) and Lecturers (6.8%), indicating a strong expectation that AI will become more prevalent in this field.

Table 5: The Medical Educators Perspectives regarding the Present and Future integration of AI and Robotics in different Medical Fields in relation to Academic Degree (n=220)

Items of Evaluation		Academic Degree					P-value
		Demon strator	Lecturer	Assistant Professor	Associate Professor	Professor	
Integration of AI in medical practice nowadays	Yes	39 (17.7%)	**46 (20.9%)**	**43 (19.5%)**	23 (10.5%)	14 (6.4%)	**0.757**
	No	14 (6.4%)	15 (6.8%)	10 (4.5%)	10 (4.5%)	6 (2.7%)	
Total		53 (24.1%)	61 (27.7%)	53 (24.1%)	33 (15.0%)	20 (9.1%)	
Application of AI in medical fields nowadays	Biopharmaceutical research and development	**8 (3.6%)**	**16 (7.3%)**	**12 (5.5%)**	7 (3.2%)	3 (1.4%)	**0.440**
	Cardiology	**6 (2.7%)**	**6 (2.7%)**	**6 (2.7%)**	**4 (1.8%)**	**4 (1.8%)**	
	Dermatology	3 (1.4%)	4 (1.8%)	4 (1.8%)	1 (0.5%)	0 (0.0%)	
	Endocrinology	6 (2.7%)	3 (1.4%)	3 (1.4%)	1 (0.5%)	1 (0.5%)	
	Histology	2 (0.9%)	2 (0.9%)	4 (1.8%)	2 (0.9%)	2 (0.9%)	

	Internal medicine	4 (1.8%)	1 (0.5%)	3 (1.4%)	0 (0.0%)	0 (0.0%)
	Nephrology	4 (1.8%)	1 (0.5%)	3 (1.4%)	0 (0.0%)	0 (0.0%)
	Oncology	2 (0.9%)	8 (3.6%)	2 (0.9%)	0 (0.0%)	0 (0.0%)
	Ophthalmology	2 (0.9%)	5 (2.3%)	3 (1.4%)	4 (1.8%)	3 (1.4%)
	Radiology	5 (2.3%)	2 (0.9%)	3 (1.4%)	3 (1.4%)	2 (0.9%)
	Surgery	**11 (5.0%)**	**13 (5.9%)**	**10 (4.5%)**	**5 (2.3%)**	**5 (2.3%)**
Total		53 (24.1%)	61 (27.7%)	53 (24.1%)	33 (15.0%)	20 (9.1%)
In your opinion, use of AI in the future	Physicians will be replaced by AI and Robotics	9 (4.1%)	6 (2.7%)	4 (1.8%)	3 (1.4%)	1 (0.5%)	
	AI and Robotics will be integrated into medical care and supervised/ope rated by specialized personnel	38 (17.3%)	49 (22.3%)	46 (20.9%)	27 (12.3%)	**18 (8.2%)**	**0.480**
	AI and Robotics will have the same role in medical care as they have today	6 (2.7%)	6 (2.7%)	3 (1.4%)	2 (0.9%)	1 (0.5%)	
Total		53 (24.1%)	61 (27.7%)	53 (24.1%)	33 (15%)	20 (9.1%)	
Application of AI in medical fields in future	Biopharmaceutical research and development	12 (5.5%)	10 (4.5%)	5 (2.3%)	5 (2.3%)	0 (0.0%)	
	Cardiology	**10 (4.5%)**	**15 (6.8%)**	**20 (9.1%)**	**8 (3.6%)**	**8 (3.6%)**	**0.027 ***
	Dermatology	0 (0.0%)	1 (0.5%)	3 (1.4%)	2 (0.9%)	1 (0.5%)	
	Endocrinology	5 (2.3%)	2 (0.9%)	5 (2.3%)	3 (1.4%)	0 (0.0%)	
	Histology	4 (1.8%)	1 (0.5%)	1 (0.5%)	0 (0.0%)	1 (0.5%)	

Internal medicine	1 (0.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.5%)
Nephrology	6 (2.7%)	3 (1.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Oncology	1 (0.5%)	2 (0.9%)	0 (0.0%)	3 (1.4%)	0 (0.0%)
Ophthalmology	0 (0.0%)	5 (2.3%)	3 (1.4%)	1 (0.5%)	2 (0.9%)
Radiology	0 (0.0%)	4 (1.8%)	3 (1.4%)	1 (0.5%)	0 (0.0%)
Surgery	14(6.4%)	18(8.2%)	13(5.9%)	10(4.5%)	7(3.2%)

Discussion:

The current study was designed to assess perspectives of medical educators regarding the integration of Artificial Intelligence (AI) and Robotics in medical education and healthcare systems. The study found that many of the participants were familiar with Artificial Intelligence (AI) and Robotics. Moreover, few of the participants received training in AI over the internet and in medicine. The findings of the study are consistent with previous studies conducted by Sassis et al. (2021) which showed that most of the faculty were moderately familiar with the concept of AI and Robotics [2]. However, this finding is not in agreement with other previous studies. For example, two cross-sectional online studies conducted in Pakistan and Syria found that doctors are not fully aware of the applications of AI in medicine where only 23% and 27% of them, respectively were aware with the use of AI in medicine, thus showing a poor level of knowledge [7,8]. Similarly, another study conducted by Kansal et al. (2022) showed that about 80% of clinicians responded that they were unfamiliar with AI applications, while 83% did not know the limitations of AI in medicine [9]. A possible explanation for these findings might be due to that many medical universities do not include AI in their educational programs until now. There are also few resources and training opportunities for AI in some countries and many teachers may not have the background to use it well in the educational process.

Furthermore, the present study showed that females were more familiar with AI and Robotics than males. Surprisingly, they also had a more positive attitude regarding the current integration of AI in medical practice. These results differ from some published studies. A study conducted by European Commission (2017) found that males are more interested in AI and Robotics with a percentage of 67% compared to only 54% for females [10]. Similarly, another study conducted in USA (2017) showed that 30% of males and 44% of females were more skeptical about new technologies and considered AI as probably unsafe [11]. The reason for this is not clear but this inconsistency may be due to those female educators received past educational skills in AI where our study showed that more females attended training or seminars regarding the use of AI.

The current study found that most participants believed that AI is expected to play a key role in fields like Surgery, Cardiology, and Biopharmaceutical research and would be integrated into medical fields in the future. These results agree with the findings of other studies, for instance, a study conducted in Germany among clinical specialists found that 90% of physicians emphasized that in the near future, AI would play an important part in Surgery and Pathology, mainly in record-

keeping tasks such as maintaining the health records and case history of the patients [12]. Our results are also in agreement with those from previous research findings where 14% of radiologists agreed to the importance role of AI within the radiology field and practices [13]. This is supported by a report published by Goldman Sachs in Nexford university (2024) which estimated that AI might replace approximately 300 million full-time jobs worldwide by 2030, while affecting about 25% of tasks within the U.S. and Europe [14].

Regarding legal liability issues arising from AI and robotics in healthcare, this study found a strong consensus among participants (including both male and female respondents with diverse academic backgrounds) that physician judgment should take precedence when physician and AI case assessments differ. Similarly, participants largely agreed that in cases of AI-related errors, the primary responsibility lies with the physician overseeing patient care, followed by the AI's developing company. These findings align with previous research indicating that all faculty participants in a prior study believed the attending physician should bear legal liability for AI-driven mistakes. The study showed that a significant part of faculty reported that physician's opinion should be followed in case of physician's and AI's judgment diverges [2]. This presupposes that physician decision-making has a higher priority, echoing the caution against using AI alone in situations with legal and ethical implications and a requirement for operation within the strict guidelines defining its place in clinical settings.

In terms of the benefits and drawbacks of AI in medicine, our study showed that participants selected assistance of physicians for more accurate diagnosis and surgeons for more precise surgical interventions as the main benefits of AI. On the other hand, they chose dehumanization of medicine as the main drawback followed by privacy violations of sensitive medical data. There are similarities between these findings in our study and those described in earlier literature. For instance, a study showed that the main benefit of integrating AI and Robotics in medical care was the assistance they provide to the surgeon during the performance of more accurate interventions while the main disadvantage was the dehumanization of medicine [2]. These findings highlight the ethical challenges posed by AI in healthcare, particularly the risk of reducing the human element in patient care and the potential for data breaches.

Regarding academic degrees and their relationship to AI familiarity, this study revealed that participants holding professorships demonstrated the lowest levels of familiarity with AI, attitudes toward AI and robotics, and knowledge of AI's applications and integration in medical fields and practices. This finding is consistent with previous research. For instance, a survey of academic library employees found that those with higher academic qualifications reported only modest self-rated understanding of AI, suggesting a gap in hands-on experience and ethical discourse surrounding AI applications [10]. Similarly, a systematic review indicated that familiarity with AI tools significantly influences attitudes toward their adoption in educational settings, with individuals holding advanced degrees often exhibiting greater skepticism compared to those with lower qualifications [11].

Several factors may explain this observation. Professors, who tend to be older, may have had less exposure to AI technologies compared to younger individuals who encountered AI during their education. Furthermore, professors may prioritize teaching over engaging with cutting-edge research areas involving technologies like AI. Finally, their demanding schedules may limit the time available for learning new technologies. These combined factors likely contribute to their lower awareness and acceptance of AI in medical domains.

The strengths of this study include its in-depth analysis of medical educators' perspectives on AI and Robotics in medical education, providing valuable insights into both benefits and ethical

concerns. By comparing the findings to similar studies, the research situates itself within the broader context of global trends, making its contributions more meaningful. Additionally, the study is among the few that address both the advantages and ethical implications of AI in medical education. However, the study's limitations include a relatively small sample size, which may affect the generalizability of the findings. Furthermore, participants' self-reported "familiarity" with AI might not reflect actual experiential knowledge, potentially introducing response bias. Future research could benefit from implementing pre- and post-intervention studies following AI-focused educational sessions to track changes in understanding. Expanding the scope to include multi-cultures studies would further enhance generalizability and provide a more comprehensive view across diverse educational contexts.

Conclusion:

This study concludes a moderate level of familiarity with AI and robotics among medical educators in Makkah Province, with only a minority having received formal training in these technologies. Notably, female educators demonstrated higher familiarity and more positive attitudes toward AI integration than their male counterparts. Strong support exists for incorporating AI in specialized fields such as surgery, cardiology, and biopharmaceutical research, contingent upon appropriate oversight. Concerns regarding legal accountability remain significant, underscoring the need for clear protocols that prioritize physician judgment in AI-related clinical decisions. While apprehensions about potential dehumanization of care and data privacy persist, educators generally view AI as a valuable tool for enhancing diagnostic accuracy, surgical precision, and patient access to healthcare. This reinforces the prevailing belief that AI should serve as a complement to, rather than a replacement for, human medical expertise.

Recommendation:

➢ Establish mandatory AI training programs for all medical educators, with special attention to senior faculty members to address the identified knowledge gap.
➢ Develop clear legal and ethical guidelines for AI use in healthcare practice, including protocols for managing AI-related errors and protecting patient privacy.
➢ Create a comprehensive support system including technical infrastructure, resources, and continuous professional development opportunities for all medical educators.
➢ Implement regular evaluation mechanisms to assess the effectiveness of AI integration in medical education and its impact on learning outcomes.

Authors' contributions:

This study was conceptualized and overseen by Asmaa Abdelnasser, who also played a crucial role in drafting the final manuscript. Wasan Aleqbali, Yara Abu Bakr Jarfan, Renad Al Ansari, Jannatun Nayem, and Lina Sultan Alhazmi were responsible for developing, administering, and collecting data from the online survey, as well as contributing to the initial manuscript draft. Noha M. Abd El-Fadeal supervised all statistical analyses. Throughout the research process, Asmaa Abdelnasser provided overall supervision to all authors, offering critical reviews and ensuring the

cohesiveness of the various components. Finally, Asmaa Abdelnasser and Noha M. Abd El-Fadeal played a pivotal role in the final review, editing, and approval of the manuscript.

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