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ORIGINAL RESEARCH

Evaluation of Health Science Students' Knowledge, Attitudes, and Practices Toward Artificial Intelligence in Northern Saudi Arabia: Implications for Curriculum Refinement and Healthcare Delivery

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Background and Aim: As the integration of artificial intelligence (AI) in healthcare delivery becomes increasingly prevalent, understanding the knowledge, attitudes, and practices of health science students towards AI is crucial. However, limited evidence exists regarding the readiness of health science students, particularly in northern Saudi Arabia (KSA), to integrate AI into their future practices, highlighting the need for focused evaluation. We evaluated northern Saudi health science students' knowledge, attitude, practice, and associated factors toward AI.

Participants and Methods: The present cross-sectional study was conducted among 384 health science students aged 18 years and above from Jouf University, KSA. The study employed a validated data collection form with four sections: demographics, knowledge (AI principles and applications), attitudes (perceptions and ethical concerns), and practices (usage and confidence in AI tools). The three domains' scores were categorized as low (<60%), medium (60–80%) and high (>80%) based on their total scores. We utilized Spearman correlation test to ascertain the strength and direction of correlation among each subscale. Additionally, multivariate analysis was employed to identify associated factors.

Results: The present study demonstrated low knowledge, attitude, and practices among 55.7%, 37.0%, and 50.3% of health science students. We observed a positive correlation between knowledge and attitude (rho = 0.451, p = 0.001), knowledge and practice (rho = 0.353, p = 0.001), and attitude and practice (rho = 0.651, p = 0.001). Knowledge (p = 0.001) and practice (p = 0.002) were significantly higher among the students who participated in a formal AI training program. Females had a significantly higher level of attitude (p = 0.001) and practice (p = 0.030) than males.

Conclusion: In light of these findings, refining the curriculum to incorporate AI emerges as a critical strategy for addressing gaps in AI knowledge, attitudes, and practices among health science students. Therefore, formal and integrated training programs tailored to suit the local setting can effectively prepare health science students to adopt AI technologies in ways that enhance patient care.

Keywords: artificial intelligence, Vision 2030, curriculum refinement, AI training program, nursing, AI readiness

Introduction

Artificial Intelligence (AI) is a rapidly expanding field that has the potential to significantly transform healthcare.[1] AI has already been incorporated into various facets of our lives, with ongoing technological advancements driving its widespread adoption in healthcare.[2,3] In particular, the healthcare industry has embraced AI technologies, addressing long-

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standing challenges and enhancing the efficiency of healthcare professionals' practices.[4–6] In the dawn of the AI transformation era, this technology can be used in numerous ways in healthcare delivery, such as precision diagnosis, treatment, drug development, and administrative workflow.[7–9] Preparing a workforce that is technologically skilled and aware of the ethical, social, and clinical implications of AI has become essential as AI adoption in healthcare continues to grow.[10,11]

According to a study conducted in 2022 with doctors and medical students, about 74% of doctors and 68.8% of medical students had a basic knowledge of AI, but only 27.3% of doctors and 19.4% of students were aware of its medical application.[12] A study conducted in Riyadh, the Kingdom of Saudi Arabia (KSA), demonstrated that the current AI training initiatives encounter several obstacles to development and implementation at different levels of medical education.[13] Even though most health science students possess limited knowledge about AI applications, they exhibited a positive outlook towards AI in medicine and are ready to adopt it.[14,15]

The KSA looks to establish itself as a center of innovation and expertise in the healthcare field according to the health-sector transformation program of Vision 2030.[16,17] Among the program's components is the use of such advanced technologies as AI, and it will be involved in the care of patients. It supports a pool of competent and qualified health workforce with adequate training in technologies, including AI, to meet the ever-evolving health-sector system in the KSA. The opportunities that can be achieved through the adoption of AI in healthcare include screening, diagnosis, early intervention, and precision medicine in the KSA.[16] Recent education initiatives have begun to address the need for legislation, inter-faculty collaboration for curriculum improvement, competency-based education, and enhanced patient-physician communication to strengthen the healthcare system.[18–20] Therefore, understanding the readiness and attitudes of the future healthcare workforce toward AI is crucial in KSA. Furthermore, this scenario is not limited to KSA, as integration of AI in healthcare delivery is growing popular worldwide.[21]

The advancement in AI technologies that have accelerated over the past few years and the integration of these technologies in the health sector calls for preparing future generations of health professionals to manage AI.[21–23] The day of integrating AI into healthcare education is no longer a future aspiration but a necessity as we equip future healthcare professionals with skills in the face of an increasingly technology-driven environment. For students to be ready to give efficient, accurate, and ethical patient care, they need to be trained in AI concepts like diagnostic algorithms, clinical decision-making tools, patient data analysis, etc.[6,24]

This study was motivated by the use of AI technologies in health care and the evident gap in the readiness of health science students in northern Saudi Arabia to adapt to the existing advancements. While Vision 2030 stresses advanced technology for driving transformation in our healthcare sector, there is insufficient evidence of the capacity of the current curricula to produce students who are fit to meet this expectation.[16] Assessing knowledge, attitude, and practice of AI among the students is essential to facilitate new curriculum generation or refining the existing curriculum and adequately equip these students to respond adequately to the opportunities and challenges of AI in healthcare delivery. However, there is a lack of information on the current AI readiness of health science students, especially given the northern KSA setting. Hence, the present study aimed to determine the knowledge, attitude, practice, and associated factors towards AI among the healthcare science students of northern KSA. Additionally, we aimed to identify the correlations between knowledge, attitude, and practice. Exploring these relationships is essential as it identifies key areas where targeted interventions, such as curriculum refinement or specialized training programs, can be most effective.

Materials and Methods

Study Design

The present survey is a quantitative and analytical cross-sectional study that was conducted from December 2023 to June 2024.

Setting

We conducted this survey among various health science college students from Jouf University, KSA. The Jouf University is in the Aljouf region, the northern part of KSA, bordering Jordan. Presently, it stands as the sole university catering to

this region. In the KSA, health science colleges typically consist of divisions for medicine, dentistry, pharmacy, nursing, and applied medical sciences. The education phases in health science colleges are divided into basic science, clinical science, and internship training programs (interns). Interns typically refer to students who are undergoing practical training or clinical rotations as part of their degree program.

Inclusion and Exclusion Criteria

The present study included male and female health science students aged between 18 and 25 years. Students who were enrolled, and actively registered for the academic year 2023–24 were included in the sampling frame. This covered the various phases of education, such as basic science, clinical science, and internship. We excluded those reluctant to participate in the study, postgraduate students, and students who had withdrawn from their courses. Postgraduate students were excluded to maintain the focus of the study only on undergraduate students. Furthermore, the authors excluded withdrawn students to ensure that only actively engaged students were represented in the data.

Sampling Description

The current study employed Cochran's sample size estimation equation ($n=z^2pq/e^2$) to determine the minimum-required number of health science students for the present research.[25] The authors used this formula, as this method is commonly used to estimate sample size due to its ability to calculate the required sample size in studies with large populations where the expected proportion is unknown or variable across the studies. This equation shows the n=minimum necessary number of students, p = expected proportion, q=1-p, z = 1.96 at a 95% confidence interval, and e = 5% (margin of error). Given the considerable variability in proportions reported in previous studies, we have used 50% as the anticipated proportion (a standard method used to obtain the maximum necessary number of participants). Applying all these values, we concluded that we require 384 health science students for this study. Regarding the sampling procedure, firstly, we calculated the required number of students from each type of health science college according to the registered number of students from each college; then, utilizing the Jouf University registration numbers, we employed a systematic random sampling procedure to select the students. Initially, 4100 undergraduate health science students were registered in the 2023–24 academic year, and 50 students were withdrawn. Hence, the sampling frame consisted of 4050 male and female students from different health science colleges of Jouf University.

Data Collection Steps

We performed this research following the principles of the Declaration of Helsinki. The present survey protocol was ethically cleared by the local committee of bioethics at Jouf University (Approval no: 3-06-45). Next, the research team contacted the health science colleges to get permission to collect data from their students. We coordinated with the class leaders and coordinators on the availability of students for data collection. Furthermore, the research team avoided data collection a week before the students' scheduled exams. After we got the informed consent from the chosen student, we requested the students to fill out the Google form on the data collector's personal electronic device. The data collection form was prepared based on open source published articles[12,26,27] and focused group discussions with the faculties from family medicine, medical education, and computer science departments. We performed a pilot study among 30 students before distributing it in the main study. All participants in the pilot study unanimously agreed that the data collection instrument was straightforward, clear, and easily understandable. During the pilot study data analysis, we encountered no instances of missing data, and on average, participants took approximately 10 minutes to complete the survey. The data collection instrument's subscales Cronbach's values ranged between 0.75 and 0.85 (knowledge = 0.83, attitude = 0.79, and practice = 0.76).

The data collection form consisted of four sections. The first section inquired about the student's background characteristics, including age, gender, phase of education (basic science, clinical, and internship), college type, and previous training in AI. The second division asked about knowledge aspects, including principles, definition, and scope of AI in healthcare science (7 questions through multiple choice with a single best answer). Correct responses were awarded 1 point, while incorrect answers received 0 points. The third part consisted of attitude aspects such as intention to incorporate into the curriculum, ethical concerns, and concerns related to future job scarcity that may be contributed

due to the widespread use of AI (10 questions). Regarding practice aspects (final component), we asked students about their confidence in their ability to use, frequency, comfort in using for their studies, and idea generation related to the health science field (7 questions). In the attitude and practice section, the students responded on a 5-point Likert scale ranging from strongly agree (5 marks) to strongly disagree (1 mark). At the end, we computed the total score in each category and grouped them into low (less than 60% of total score), medium (60 to 80% of total score), and high (more than 80% of total score). This categorization was made according to Bloom's criteria and widely used in previous studies.[28–30]

Data Analysis

We utilized Statistical Package for Social Sciences (SPSS) version 24 for converting data, coding, and further analysis. We displayed the descriptive data by expressing the frequency and proportion for categorical information, the mean, and the standard deviation for quantitative data. We applied a normality assumption test (Shapiro–Wilk test) to our data, and the results did not meet the normality assumption ($P<0.05$). Therefore, the survey team performed Spearman correlation tests to find the correlation (strength and direction) between the subscales (knowledge, attitude, and practice) of the instrument. Finally, we carried out binomial logistic regression (enter method) analyses to find the factors linked with knowledge, attitudes, and practice. The research team combined medium and high as a single category to be used as a binary outcome. This was done to identify the factors associated with the low category and plan for tailored intervention for them. In our study, a *P*-value below 0.05 was deemed statistically significant.

Results

During the data collection process, we contacted 456 health science students to get the minimum required sample size with a response rate of 84.2%. The study included a total of 384 health science students aged 18–25 years, with a mean age of 21.76 ± 1.84 years. Of these, 54.7% of them were above 21 years of age, males (57.3%), the highest proportion of participants was medical college (23.4%), single (93.0%), and only 10.7% participated a formal AI training course (Table 1).

Table 1 Background Characteristics of the Health Science University Students (n = 384)

Parameters	Frequency	Proportion
Age (years) mean ± SD	21.76 ± 1.84	
Age group (years)		
Up to 21	174	45.3
Above 21	210	54.7
Gender		
Male	220	57.3
Female	184	42.7
College type		
Medical	90	23.4
Dental	71	18.5
Pharmacy	85	22.1
Nursing	54	14.1
Applied medical sciences	84	21.9
Education phase		
Basic sciences	206	53.7
Clinical sciences	126	32.8
Interns	52	13.5

(*Continued*)

Table 1 (Continued).

Parameters	Frequency	Proportion
Marital status		
Single	357	93.0
Married	27	7.0
Living status		
Hosteler/living alone	87	22.7
Living with family	297	77.3
Artificial course (AI) participation		
No	343	89.3
Yes	41	10.7

The findings related to knowledge revealed that the highest (69.0%) correct answers for the item related to the question "How AI can contribute to personalized medicine in healthcare, followed by AI requirements of labelled data (63.5%), AI in diagnostic role (62.0%), and meaning of natural language processing (NLP) in the context of healthcare (58.9%)" (Table 2).

Turning to attitude, the highest level of agreement (53.1%) was observed for the statement "AI should be used as a complementary, with human judgment remaining a critical factor", followed by "AI will make a revolution in changing health science education curriculum (51.3%)" and "I am open to embracing new AI-based tools and technologies in my future healthcare practice (46.4%)". Furthermore, 33.9% of them agreed for the statement inquired on their concerns about "Widespread use of AI in healthcare may lead to job scarcity for health science students" and 37.5% had concerns about the "ethical implications of using AI in healthcare" (Please see Supplementary Table 1 for each item's detailed responses).

Regarding practice towards AI, the present survey demonstrated that 42.7% agreed with the statement "I am comfortable collaborating with AI systems as part of a healthcare team", and 45.8% agreed with the statement "I am confident in my ability to use AI-based tools in my health science studies". Furthermore, 39.8% frequently use AI for personality development and other skills, and 39.6% regularly check AI for spelling and grammar (Please see Supplementary Table 2 for each item's detailed responses).

The present study demonstrated low knowledge, attitude, and practices among 55.7%, 37.0%, and 50.3% of health science students. In comparison, high knowledge, attitude, and practices were observed among 19.8%, 14.8%, and 21.9%, respectively (Figure 1).

Table 2 Participants' Responses to Knowledge Items Towards AI (n = 384)

Items	Correct answer	
	Frequency	Proportion
AI in healthcare purpose	217	56.5
In the healthcare field, what does "EMR" stand for	193	50.3
AI in diagnostic role	238	62.0
AI contribution in personalized medicine	265	69.0
Natural language processing (NLP) in healthcare	226	58.9
AI requires a lot of data already processed by humans (labeled data)	244	63.5
AI Healthcare Supervised Learning Example	217	56.5

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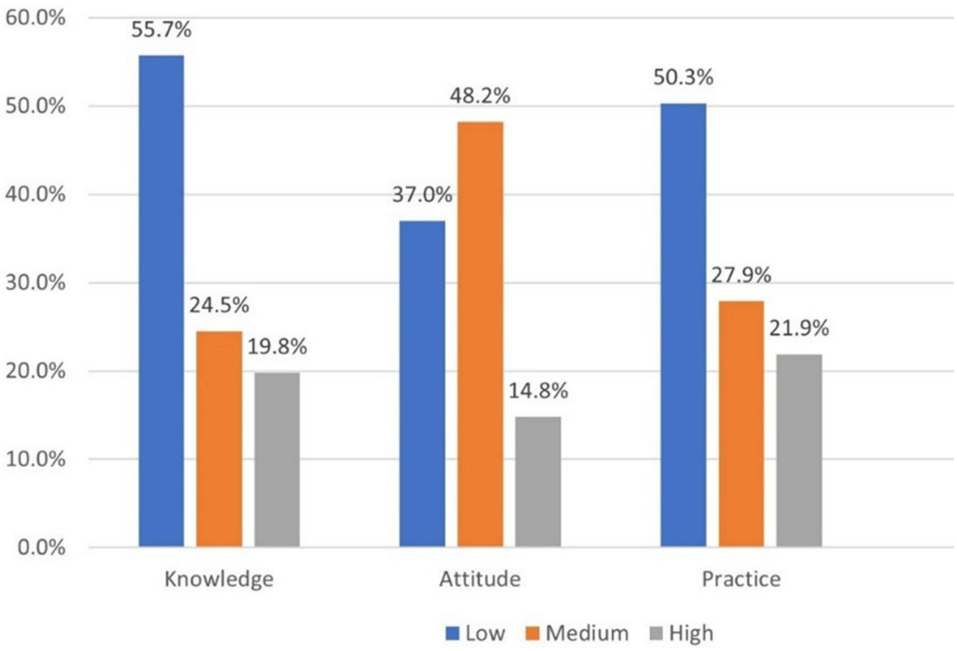

Figure 1 Knowledge, Attitude, and Practice Categories (n = 384).

When examining correlations among the three domains, we observed a positive correlation between knowledge and attitude (rho = 0.451), knowledge and practice (rho = 0.353), and attitude and practice (rho = 0.651). All the correlations were significant at the 0.01 level (2-tailed) (Table 3).

Binomial logistic regression revealed several factors associated with knowledge levels toward AI. In the univariate analysis, the students who participated in an AI training program had a higher knowledge (crude odds ratio [COR] = 2.13, 95% confidence interval [CI] = 1.09–4.14, p = 0.025), and the interns had a lower knowledge (COR = 0.22, 95% CI = 0.17–0.39, p = 0.001). The multivariate analysis revealed that the students who participated in an AI training program (adjusted odds ratio [AOR] = 2.23, 95% CI = 1.10–4.50, p = 0.001) and nursing students (AOR = 2.39, 95% CI = 1.20–3.75, p = 0.044) had a significantly higher level of knowledge than others. Multivariate analysis also revealed that the interns had a lower level of knowledge than other categories (AOR = 0.57, 95% CI = 0.36–0.74, p = 0.001) (Table 4).

Regarding attitudes, both univariate and multivariate analyses revealed that gender, educational phase, and marital status were the significant associated factors, however, with the differences in odds ratio and significant level (p-value). In binomial regression analysis, after adjusting with other variables, we found that female students (AOR = 2.16, 95% CI = 1.36–3.44, p = 0.001) had significantly higher levels of attitude than males. In comparison, interns (AOR = 0.39, 95% CI = 0.26–0.58, p = 0.001) and married students (AOR = 0.47, 95% CI = 0.31–0.69, p = 0.001) had a lower level of attitude (Table 5).

Regarding health science students' practices towards AI, the univariate analysis found that females (COR = 1.63, 95% CI = 1.09–2.45, p = 0.019) and those who participated in an AI training program (COR = 3.55, 95% CI

Table 3 Spearman Correlation Results Knowledge, Attitude, and Practice Towards AI

	Spearman correlation (rho)	**Significant (2-tailed)***
Knowledge - Attitude	0.451	0.001
Knowledge - Practice	0.353	0.001
Attitude - Practice	0.651	0.001

Note: *Significant at the 0.01 level (2-tailed).

Table 4 Factors Associated With Knowledge of Health Science Students Towards AI. Results of Univariate and Multivariate Analysis (Binomial Logistic Regression)

Characteristics	Total Participants (n= 384)	Knowledge Categories		Univariate Analysis No vs Yes		Regression Analysis No vs Yes	
		Low n= 214	Medium/High n=170	Crude Odds Ratio (COR) (95% CI)	p value	Adjusted Odds Ratio (AOR) (95% CI)	p value
Age group (years)							
Up to 21	174	88	86	Ref			
Above 21	210	126	84	0.68 (0.46–1.02)	0.065	1.02 (0.57–1.84)	0.948
Gender							
Male	220	121	99	Ref			
Female	164	93	71	0.93 (0.62–1.40)	0.739	0.88 (0.57–1.37)	0.583
College type							
Medical	90	55	35	Ref			
Dental	71	41	30	1.15 (0.61–2.17)	0.666	Ref	0.410
Pharmacy	85	45	40	1.40 (0.77–2.55)	0.276	1.81 (0.79–2.23)	0.123
Nursing	54	24	30	1.96 (0.99–3.89)	0.053	2.39 (1.20–3.75)	0.044
Applied medical sciences	84	49	35	1.12 (0.61–2.06)	0.709	1.17 (0.59–2.30)	0.652
Education phase							
Basic sciences	206	106	100	Ref		Ref	
Clinical sciences	126	65	61	0.99 (0.63–1.55)	0.982	0.95 (0.51–1.79)	0.877
Interns	52	43	9	0.22 (0.17–0.39)	0.001	0.57 (0.36–0.74)	0.001
Marital status							
Single	357	195	162	Ref		Ref	
Married	27	19	8	0.51 (0.32–1.19)	0.118	0.81 (0.31–2.14)	0.671
Living status							
Hosteler/living alone	87	51	36	Ref		Ref	
Living with family	297	163	134	1.17 (0.72–1.89)	0.537	1.19 (0.71–4.15)	0.519
AI participation							
No	41	16	25	Ref		Ref	
Yes	343	198	145	2.13 (1.09–4.14)	0.025	2.23 (1.10–4.50)	0.036

Table 5 Factors Associated With Attitude of Health Science Students Towards AI. Results of Univariate and Multivariate Analysis (Binomial Logistic Regression)

Characteristics	Total Participants (n= 384)	Attitude Categories		Univariate Analysis No vs Yes		Regression Analysis No vs Yes	
		Low n=142	Medium/High n= 242	Crude Odds Ratio (COR) (95% CI)	p value	Adjusted Odds Ratio (AOR) (95% CI)	p value
Age group (years)							
Up to 21	174	56	118	Ref		Ref	
Above 21	210	86	124	0.68 (0.45–1.04)	0.077	1.49 (0.79–2.84)	0.221
Gender							
Male	220	98	122	Ref		Ref	
Female	164	44	120	2.91 (1.42–3.39)	0.001	2.16 (1.36–3.44)	0.001
College type							
Medical	90	33	57	Ref		Ref	
Dental	71	30	41	0.79 (0.42–1.49)	0.471	1.14 (0.56–2.32)	0.710
Pharmacy	85	32	53	0.96 (0.52–1.77)	0.893	1.27 (0.65–2.50)	0.483
Nursing	54	23	31	0.78 (0.39–1.54)	0.480	1.04 (0.49–2.21)	0.925
Applied medical sciences	84	24	60	1.45 (0.76–2.74)	0.256	1.71 (0.83–3.54)	0.147

(*Continued*)

Table 5 (Continued).

Characteristics	Total Participants (n= 384)	Attitude Categories		Univariate Analysis No vs Yes		Regression Analysis No vs Yes	
		Low n=142	Medium/High n= 242	Crude Odds Ratio (COR) (95% CI)	p value	Adjusted Odds Ratio (AOR) (95% CI)	p value
Education phase							
Basic sciences	206	64	142	Ref		Ref	
Clinical sciences	126	44	82	0.84 (0.53–1.34)	0.467	0.65 (0.33–1.72)	0.092
Interns	52	34	18	0.24 (0.13–0.45)	0.001	0.39 (0.26–0.58)	0.001
Marital status							
Single	27	18	9	Ref		Ref	
Married	357	124	233	0.27 (0.12–0.61)	0.001	0.47 (0.31–0.69)	0.004
Living status							
Hosteler/living alone	87	37	50			Ref	
Living with family	297	105	192	1.35 (0.83–2.20)	0.224	1.38 (0.81–2.34)	0.239
AI participation							
No	41	11	30	Ref		Ref	
Yes	343	131	212	1.67 (0.82–3.48)	0.158	1.67 (0.77–3.60)	0.194

= 1.68–7.46, p = 0.001) had significantly higher level of practice. Similarly, multivariate analysis also explored that practice towards AI was significantly higher among females (AOR = 1.51, 95% CI = 1.15–2.47, p = 0.030) and those who participated in AI training program (AOR = 2.42, 95% CI = 1.59–4.12, p = 0.002). The lower level of practice identified among interns in both univariate (COR = 0.44, 95% CI = 0.24–0.84, p = 0.012) and multivariate (AOR = 0.39, 95% CI = 0.17–0.61, p = 0.029) (Table 6).

Table 6 Factors Associated With Practice of Health Science Students Towards AI. Results of Univariate and Multivariate Analysis (Binomial Logistic Regression)

Characteristics	Total Participants (n= 384)	Practice Categories		Univariate Analysis No vs Yes		Regression Analysis No vs Yes	
		Low n=193	Medium/High n=191	Crude Odds Ratio (COR) (95% CI)	p value	Adjusted Odds Ratio (AOR) (95% CI)	p value
Age group (years)							
Up to 21	174	79	95	Ref		Ref	
Above 21	210	114	96	0.70 (0.47–1.05)	0.083	1.14 (0.63–2.06)	0.668
Gender							
Male	220	122	98	Ref			
Female	164	71	93	1.63 (1.09–2.45)	0.019	1.51 (1.15–2.47)	0.030
College type							
Medical	90	49	41	Ref			
Dental	71	38	33	1.04 (0.56–1.94)	0.907	Ref	0.450
Pharmacy	85	41	44	1.28 (0.71–2.32)	0.412	1.52 (0.80–2.88)	0.200
Nursing	54	26	28	1.29 (0.65–2.53)	0.464	1.55 (0.74–3.22)	0.236
Applied medical sciences	84	39	45	1.38 (0.76–2.50)	0.291	1.73 (0.81–3.07)	0.185
Education phase							
Basic sciences	206	94	112	Ref		Ref	
Clinical sciences	126	65	61	0.79 (0.51–1.23)	0.292	0.67 (0.35–1.25)	0.207
Interns	52	34	18	0.44 (0.24–0.84)	0.012	0.39 (0.17–0.61)	0.029

(*Continued*)

Table 6 (Continued).

Characteristics	Total Participants (n= 384)	Practice Categories		Univariate Analysis No vs Yes		Regression Analysis No vs Yes	
		Low n=193	Medium/High n=191	Crude Odds Ratio (COR) (95% CI)	p value	Adjusted Odds Ratio (AOR) (95% CI)	p value
Marital status							
Married	357	176	181	Ref		Ref	
Single	27	17	10	0.57 (0.26–1.28)	0.175	0.71 (0.59–2.44)	0.431
Living status							
Hosteler/living alone	87	45	42	Ref		Ref	
Living with family	297	148	149	1.08 (0.67–1.74)	0.756	0.89 (0.69–1.56)	0.987
AI participation							
No	41	10	31	Ref			
Yes	343	183	160	3.55 (1.68–7.46)	0.001	2.42 (1.59–4.12)	0.002

Discussion

The World Health Organization (WHO), in their first global report on AI in health, stated that AI possesses tremendous potential to improve the health and well-being of millions of people worldwide. Nonetheless, there is a potential for misuse of AI, leading to harm if not used properly.[31] This statement reinstates the necessity of the present study as our findings serve the dual purpose of identifying the gaps in knowledge and giving insights for curriculum refinement. Therefore, health science students are appropriately trained to optimize the advantages of AI in healthcare delivery while mitigating its risks and avoiding its drawbacks. The present study evaluated health science students' knowledge, attitude, practice, and associated factors toward AI.

Health science is always a knowledge-driven field, and sufficient knowledge is critical in academics and clinical settings. The present study demonstrated that about 56% of the health science students had low knowledge of AI's concepts, scope, and principles in healthcare. In contrast to our findings, a study conducted in Vietnam among health science students by Truong et al in 2023 reported that more than 90% of their participants lacked comprehension regarding the role of AI in healthcare.[32] Similar to the current research, Al-Qerem et al found a moderate level of knowledge among their study participants.[33] Other researchers also found a varying range of knowledge among their study participants.[10,12,34,35] These contrasting results could be attributed to diversity in study settings, data collection instruments, the type of colleges included in their study, and previous participation in AI training. For example, the present study participants belonged to all health science colleges, and Truong et al included only pharmacy and medicine program students. This variation across the studies underscores the need to consider diverse educational contexts when planning AI curriculum integration, rather than a one-size-fits-all approach.[4,34] With AI becoming increasingly prevalent in healthcare settings, students must have a strong understanding of its concepts and applications to ensure they are prepared for the future of healthcare practice.[19,36] This can be achieved by refining the existing curriculum to enhance the health science students' opportunities to learn about AI in a formal method. Some of these differences, such as gender and educational phases, were identified in the present study, which required further curriculum adjustment based on the subgroup analysis of the study's findings concerning AI knowledge among the students. For example, a lower level of knowledge identified among interns indicates the need to increase AI training in the later phases of education. Similarly, the present study's findings on variations in knowledge between participants' genders indicate that stakeholders should consider the importance of sociocultural factors in education settings.

The emerged low rate of the participants who reported having ever experienced any form of formal training in AI from our research study implies that there might be a gap in training health science students on AI. In this case, the result of the study showed that participants of the study who received some form of training in AI and nursing students possess a high level of knowledge as compared to their counterparts. This observation can be a result of the fact that nursing programs may pay more attention to the application of technology and being influenced by the Vision of 2030 of KSA,

which seeks to empower women as well as enhanced training.[16,37,38] Similarly, Perrier et al found that those who participated in an AI formal training program had significantly higher knowledge than those who did not attend ($P < 0.05$).[11] The higher AI knowledge among participants in formal training programs suggests that structured educational initiatives effectively enhance understanding and proficiency in AI concepts. Our findings and implications are supported by Catalina et al. In their study, the mean value of AI's professional impact among respondents was significantly higher among those who had prior knowledge of AI and nursing professionals.[39] Our study found that the interns had a substantially lower level of knowledge than in the basic and clinical science phases. This could be due to several factors, such as the change in the learning environment, time constraints, and limited exposure to formal education, as the interns will be primarily involved in learning bedside patient care.

Regarding participant's responses in the attitude section, we found that more than half of the students agreed that AI should be a complement while the human factor is critical for patient care. However, less than half (46.3%) were ready to embrace the new AI technologies and tools in academics and patient care. Two crucial concerns are ethical and job scarcity due to the widespread use of AI. Therefore, the psychological impacts of these concerns among health science students need to be kept in focus, as they may also indirectly impact patients' care. Integrating AI means that healthcare providers, including our study's students interviewed, have apprehensions about job security, role changes, and reliance on AI more than ever in clinical decision-making.[40–42] We observed that our findings were concomitant with these worries, where a large number of students expressed uncertainties regarding job scarcity and ethical issues inherent in the adoption of AI. These findings are critical to the stakeholders to increase the attitude of the students to embrace, as AI will inevitably be incorporated into many facets of healthcare delivery. Our study findings are supported by Busch et al[43] and Al-Qerem et al.[33] However, these results must be considered with some degree of caution, and it must be acknowledged that they are just an initial attempt to study this problem. Further studies should include a wider range of questions that will allow for the exploration of negative concerns in greater detail and, thereby, provide a better understanding of AI with respect to different concerns, including those linked with job security and ethical issues in the healthcare field. The present study findings explored that nearly two-thirds (63%) of the health science students had medium to positive attitudes. Similar to variation in knowledge towards AI among different studies, attitude varies across various studies conducted in several regions.[10,33,44,45] Our study found that female students had more favorable attitudes than male students. This finding contrasts Swed et al[10] and Syed et al conducted a study among medical students and doctors and found a favorable attitude among the males ($P<0.001$), and Syed et al[13] surveyed undergraduate PharmD students. The lower level of attitude explored by the present study among the interns than students in earlier phases of their health science education may be influenced by support systems and organizational culture. It is worth noting that organizational culture is a proven factor in influencing healthcare providers' attitudes and innovative behaviors.[46,47] Interestingly, Lukić et al stated that first-year students of their study had a positive attitude towards AI.[45] Where the component attitude towards AI is concerned, its sub-group analysis yielded a significantly higher value for female students than for male students. These differences might be due to changes in gender-specific policies that have been implemented in the KSA as a country that wants women to embrace technology and take up careers. Similarly, interns have lower scores in attitude as compared to students of previous phases, which indicates fewer trained interns on AI. This scenario could lead to less usage of AI during their clinical practice.

Similar to the attitude, we found that females had a higher practice towards AI than males, and interns had a lower level of practice than students in earlier phases of education. Some studies found contrasting results to our findings.[10,33] Similar to Hamedani et al, another positive factor identified by the present study was participation in an AI training program.[48] The gender disparity in higher levels of practice could be due to sociocultural and prevailing policies in the country. The possible higher level of attitude and practice of females in the present study could be due to the recent remarkable transition happening in KSA under Vision 2030, where women's empowerment was given top priority.[16] Furthermore, addressing gender disparities in AI practice requires recognizing and challenging underlying sociocultural factors. Lower-level practice among interns is a serious concern, and further understanding of contributing factors can support interns' professional development, enhance their attitude and practice toward AI, and incorporate it into their healthcare delivery practice.

We observed a positive correlation between each subscale (knowledge, attitude, and practice) of the present study. Our study findings are similar to those of Labrague et al[44] and Al-Qerem et al.[33] The observed positive correlation between knowledge, attitude, and practice toward AI among health science students provides valuable insights into shaping education strategies and curriculum development plans. This study's findings provide comprehensive support for the urgent need to revise the health science colleges curriculum to close gaps in AI knowledge, attitudes, and practices among health science students. The AI-focused modules that cover theoretical knowledge, hands-on training, and its ethical implications can prepare students to use AI technologies optimally in clinical practice. These enhancements are in accordance with the Vision 2030 of Saudi Arabia to create a technologically efficient healthcare workforce to deliver technology-enhanced healthcare, enhance patient outcomes, and improve the overall delivery of healthcare.

Limitations and Future Directions

The readers of the present research must consider some restrictions of the present study. Firstly, the cross-sectional design used in the survey may not give the trend; rather, it can provide a snapshot of current knowledge, attitudes, and practices. Secondly, the study was performed on northern Saudi health science students from a single institution and may have limited generalizability beyond the specific context and population studied. Thirdly, self-reported data introduces the potential for response bias, as participants may overestimate or underestimate their knowledge, attitude, and practice. Next, the potential for bias in relying on self-reported data cannot be excluded. Finally, this study identified only association, not causation.

Limitations identified in this research should be addressed in future research, as should additional avenues explored to leverage AI to expand the use of AI in health science education. Longitudinal studies can show how KAP levels evolve over time and how effective AI-focused curriculum interventions become over a long period of time.

Conclusion

The present study found low knowledge and practice levels in more than half of the health science students. We also observed different associated factors for the knowledge, attitude, and practices towards AI among the students. Notably, students who had undergone formal AI training and female students showed significantly higher levels of knowledge, attitude, and practice. Moreover, the authors identified a positive correlation between all three domains. The present study findings suggest that the need for tailored curriculum refinement is a critical strategy for addressing gaps in AI knowledge, attitudes, and practices among health science students of Jouf University. Therefore, formal and integrated training programs can effectively prepare health science students to adopt AI technologies in ways that enhance patient care to align with the Vision 2030 framework. Furthermore, we suggest in-depth exploration related to students' concerns about job security and ethical aspects of AI. Finally, we recommend prospective and mixed-method studies at the national level that evaluate the qualitative components in this area to explore how AI-related topics are currently addressed and perceived within the curriculum.

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