Afghan Medical Journal

Afghan Medical Journal. 2026; 3(2):38–44. | E-ISSN: 3007-0805

DOI: https://doi.org/10.70194/6ty9z150

Knowledge, Attitudes, and Practices Regarding Artificial Intelligence among Medical Students in Jalalabad, Nangarhar Province, Afghanistan

Dr. Nasratullah Akbari[1], Teaching Assistant. Dr. Faheemullah Behsoodwal [2], Safiullah Muhabat[3]

[1] Department of Public Health, Spinghar Medical University, Nangarhar, Afghanistan
[2] Department of Ophthalmology, Nangarhar Medical Faculty, Nangarhar, Afghanistan
[3] Department of Basic Sciences, Spinghar Medical University, Nangarhar, Afghanistan

Email: Nasratullahakbari143@gmail.com

ABSTRACT

Background

Artificial intelligence (AI) is playing an increasingly important role in reshaping the delivery and practice of healthcare and medical education through its use in areas such as disease diagnosis, clinical decision support, medical image interpretation, and personalized learning. Future physicians require adequate knowledge, appropriate attitudes, and practical competencies to use AI effectively and ethically. However, evidence regarding medical students' preparedness for AI in Afghanistan remains limited.

Objective

To assess knowledge, attitudes, and practices regarding artificial intelligence (AI) among medical students in Jalalabad, Nangarhar Province, Afghanistan, and to identify educational factors associated with AI knowledge and utilization.

Methods

A cross-sectional study was conducted between November 2025 and February 2026 among 386 undergraduate medical students enrolled in government and private medical faculties in Jalalabad, Nangarhar Province, Afghanistan. Participants were recruited using a non-probability self-selection sampling approach. Data were collected through a pre-tested, structured questionnaire administered via Google Forms. The questionnaire assessed participants' knowledge, attitudes, and practices regarding artificial intelligence (AI). Data were analysed using IBM SPSS Statistics version 23. Descriptive statistics were used to summarize participants' characteristics and study variables. Associations between categorical variables were examined using the Pearson chi-square test of independence, while correlation analysis was performed to assess relationships between continuous variables. Multiple linear regression analysis was conducted to identify factors associated with AI-related knowledge, attitudes, and practices. A p-value of <0.05 was considered statistically significant.

Results

The majority of participants were between 18 and 22 years of age (60.1%), and 65.0% were enrolled in General Medicine. General Medicine students demonstrated significantly higher knowledge of AI concepts and applications compared with other faculties ($P < 0.001$). Positive correlations were observed among AI knowledge domains, while greater knowledge of AI limitations and ethical concerns was associated with lower use of AI for some academic activities. AI utilization differed by academic year for assignments and research activities ($P < 0.05$), with no consistent junior–senior pattern. Attitude-related variables were not significant independent predictors of AI utilization.

Conclusion

Although medical students generally expressed favorable views toward AI, opportunities for formal education in this area were limited. Integrating structured AI education, ethical training, and practical learning opportunities into medical curricula is needed to strengthen AI readiness among future healthcare professionals in Afghanistan.

Keywords: Artificial Intelligence; Medical Students, Knowledge; Attitudes; Medical Education

Introduction

Artificial intelligence (AI) has emerged as one of the defining technologies of the Fourth Industrial Revolution and is increasingly transforming healthcare delivery, biomedical research, and medical education worldwide. AI refers to computational systems capable of performing tasks that traditionally require human intelligence, including learning, reasoning, problem-solving, pattern recognition, and decision-making [1]. In healthcare, AI has demonstrated substantial potential through its ability to analyze large and complex datasets, support clinical decision-making, improve diagnostic accuracy, and enhance healthcare delivery [2]. Machine learning (ML), a major branch of AI, enables computer systems to learn from data and improve performance without explicit programming, while deep learning (DL), a subset of ML, uses artificial neural networks to analyze complex datasets and has shown significant applications in medical imaging, disease diagnosis, and other healthcare domains [3–5].

The rapid advancement of AI has expanded its applications across multiple healthcare disciplines. AI technologies are increasingly used in oncology for cancer detection, classification, and treatment planning [6], gastroenterology for assisting endoscopic diagnosis and

improving lesion detection [7], and radiology for image interpretation, workflow optimization, and clinical decision support [3]. Furthermore, the increasing availability of healthcare-related big data has created opportunities for AI-based approaches to improve clinical decision-making and personalized healthcare [2,8]. Beyond clinical practice, AI has become an important educational tool through applications such as adaptive learning platforms, virtual patient simulations, automated assessment systems, and research support tools, which may enhance students' learning experiences, clinical reasoning, and decision-making abilities [9,10]. Consequently, competence in artificial intelligence is increasingly regarded as a key skill for healthcare professionals of the future.

Globally, medical schools have increasingly recognized the need to prepare students for AI-supported healthcare environments. Studies conducted among medical and healthcare students in Pakistan, Syria, Lebanon, Saudi Arabia, and other settings have generally reported positive attitudes toward AI, while also identifying gaps in AI knowledge, practical skills, and formal educational opportunities [11–16]. Similar findings have been reported internationally, with students generally recognizing the importance of AI in medicine while identifying insufficient formal training and limited opportunities for structured AI education as important gaps [15,16]. These challenges have led to increasing recommendations for integrating AI competencies, including fundamental concepts, clinical applications, ethical considerations, and practical skills, into medical education programs [17].

Despite increasing international evidence, research from low-resource and conflict-affected settings remains limited. Educational infrastructure, technological accessibility, internet availability, and opportunities for AI training differ substantially from high-income settings, which may influence students' preparedness and limit the generalizability of existing evidence. Within Afghanistan, emerging research has begun to examine AI knowledge, attitudes, and practices among medical students, although the available evidence remains limited [18–20]. However, comprehensive evidence regarding medical students' knowledge, attitudes, and practical utilization of AI remains scarce.

Assessing medical students' preparedness for AI is particularly important because current students will become future healthcare professionals working within increasingly digital and AI-supported healthcare systems. Understanding their knowledge, attitudes, and practices can help identify educational gaps, inform curriculum development, and support responsible and ethical incorporation of AI into healthcare education and professional practice.

Therefore, this study aimed to assess knowledge, attitudes, and practices regarding artificial intelligence among medical students in Jalalabad, Nangarhar Province, Afghanistan. Additionally, the study examined demographic and educational factors associated with AI knowledge and utilization. The findings provide context-specific evidence to support curriculum development, educational planning, and future strategies for responsible AI integration into undergraduate medical education in Afghanistan.

Materials and Methods

Study Design

A cross-sectional study was conducted between November 2025 and February 2026 among undergraduate medical students enrolled at Spinghar Medical University, Rokhan Medical University, Aryana Medical University, and Nangarhar Medical Faculty in Jalalabad, Nangarhar Province, Afghanistan.

Study Setting

The study was conducted among undergraduate medical students enrolled at Spinghar Medical University, Rokhan Medical University, Aryana Medical University, and Nangarhar Medical Faculty in Jalalabad, Nangarhar Province, Afghanistan**.** Students from different academic years and health-related programs, including General Medicine, Stomatology, and Medical Technology, were invited to participate. In this study, General Medicine refers to the undergraduate medical degree program leading to qualification as a medical doctor.

Study Period

Data collection was conducted between November 2025 and February 2026 using a self-administered online questionnaire.

Study Population

The study population comprised undergraduate students enrolled in health-related medical programs at government and private medical institutions in Jalalabad City, including Spinghar Medical University, Rokhan Medical University, Aryana Medical University, and Nangarhar Medical Faculty, during the study period. The participating programs included General Medicine, Stomatology, and Medical Technology. For consistency with the study title and research objectives, these participants are collectively referred to as medical students throughout the manuscript.

Eligibility Criteria

Inclusion Criteria

- Undergraduate medical students enrolled in government or private medical faculties.
- Students from all academic years.
- Students who voluntarily participated in the study and provided informed consent electronically.

Exclusion Criteria

- Students who declined to participate.
- Incomplete questionnaire responses.
- Duplicate questionnaire submissions.

Sample Size Calculation

The sample size was calculated using Epi Info version 7 based on the single population proportion formula: $n = Z^2p(1-p) / d^2$

where n is the required sample size, Z is the standard normal deviate corresponding to a 95% confidence level (1.96), p is the anticipated proportion, and d is the desired margin of error. In the absence of previous local estimates of knowledge, attitudes, and practices regarding artificial intelligence among medical students in Afghanistan, a conservative proportion of 50% was assumed. Using a 95% confidence level and a 5% margin of error, the minimum required sample size was 384 participants. No additional adjustment for non-response was applied because the survey was administered through voluntary, non-probability online recruitment and the number of students who received the invitation could not be reliably determined. A total of 386 complete questionnaires were included in the final analysis, slightly exceeding the minimum required sample size.

Sampling Method

A non-probability self-selection sampling technique was employed because of logistical constraints, limited access to students, and time limitations. The questionnaire link was distributed directly through student WhatsApp groups at the participating universities and was further disseminated by students through their peer networks. Although this approach facilitated broad participation, it may have introduced selection bias because students with greater interest in AI or better internet access may have been more likely to participate.

Because the survey was circulated through multiple student groups and peer networks, the total number of students who received the invitation could not be determined. In addition, institutional affiliation was not included as a questionnaire item; therefore, the number of respondents from each participating university could not be established. Consequently, an institution-specific eligible population denominator and conventional response rate could not be calculated.

The online questionnaire was administered using Google Forms. The "Limit to 1 response" function was enabled to reduce the possibility of duplicate submissions. Participation was voluntary, and electronic informed consent was obtained before questionnaire completion.

Therefore, the findings should be interpreted with caution, as they may not be representative of the broader population of medical students in Afghanistan.

Participant Flow

A total of 386 complete questionnaires were included in the final analysis. Because the survey invitation was disseminated through WhatsApp groups and peer-to-peer sharing without a record of the number of recipients, the numbers of students invited, exposed to, or completing the survey could not be reliably determined. Therefore, a conventional response rate could not be calculated. The final analytical sample comprised 386 participants.

Data Collection Procedures

A structured questionnaire adapted from the instrument developed by Al-Qeren et al. (2023) was used for data collection. The original instrument was reviewed and adapted to reflect the Afghan undergraduate medical education context, including modification of wording and terminology where necessary while retaining the core constructs of AI knowledge, attitudes, and practices. The adapted questionnaire was subsequently reviewed by subject-matter experts and pilot-tested before final administration.

The questionnaire consisted of three domains:

- **Knowledge:** seven dichotomous (Yes/No) items assessing knowledge of AI concepts and applications. Each correct response was scored as 1 and each incorrect response as 0, giving a possible total knowledge score of **0–7**, with higher scores indicating greater AI knowledge.
- **Attitude:** items rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating more positive attitudes toward AI.
- **Practice:** items rated on a five-point Likert scale ranging from 1 (never) to 5 (very high), with higher scores indicating greater AI-related practice and utilization.

Composite scores were calculated by summing the responses within each domain.

Content validity was evaluated through an expert review involving five specialists in medical education, public health, and artificial intelligence. Based on their recommendations, minor changes were made to enhance the relevance and clarity of the questionnaire. Internal consistency reliability was evaluated using Cronbach's alpha coefficients, yielding values of 0.766 for the knowledge domain, 0.664 for the attitude domain, and 0.843 for the practice domain, indicating acceptable to good reliability.

Study Variables

The primary outcome variables were participants' knowledge, attitudes, and practices regarding artificial intelligence (AI).

Independent variables included age, faculty, academic year, previous exposure to AI training, and other relevant demographic and educational characteristics.

Outcome Measures

The primary outcomes of the study were knowledge, attitudes, and practices regarding AI among medical students. Secondary outcomes included differences in AI knowledge across academic faculties, associations between AI knowledge and AI utilization, associations between attitudes toward AI and AI utilization, and differences in AI utilization patterns across academic years.

Statistical Analysis

Data were entered, cleaned, and analyzed using IBM SPSS Statistics version 23. Participant characteristics and study variables were summarized using descriptive statistics, including frequencies, percentages, means, and standard deviations.

Descriptive statistics were used to summarize participants' characteristics and study variables. Associations between categorical variables were examined using the Pearson chi-square test of independence, while correlation analysis was performed to assess relationships between continuous variables. Multiple linear regression analysis was conducted to identify factors associated with AI-related knowledge, attitudes, and practices. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the Ethics Committee of Spinghar Medical University, Nangarhar, Afghanistan **(**Approval No. 7, approved on 1404/07/28**).** The study was conducted in accordance with the principles of the Declaration of Helsinki. Participation was voluntary, and electronic informed consent was obtained from all participants before questionnaire completion. The online questionnaire was anonymous and did not collect names, telephone numbers, email addresses, student identification numbers, or other directly identifiable information. The "Limit to 1 response" function in Google Forms was enabled to reduce the possibility of duplicate submissions. Data were stored in a password-protected electronic file and were accessible only to the research team. All data were used solely for research purposes and reported in aggregate to maintain participant confidentiality.

Results

Socio-Demographic Characteristics of Participants

The study included 386 undergraduate medical students in total. Participants aged 18–22 years represented the largest proportion of the study population (232, 60.1%), followed by those aged 23–27 years (143, 37.0%) and 28–32 years (11, 2.8%). Regarding faculty, 251 (65.0%) participants were enrolled in the Faculty of General Medicine, 88 (22.8%) in the Faculty of Stomatology, and 47 (12.2%) in the Faculty of Medical Technology. First-year students constituted the largest proportion of respondents (143, 37.0%), followed by fourth-year (94, 24.4%), second-year (87, 22.5%), fifth-year (34, 8.8%), and third-year students (28, 7.3%). The socio-demographic characteristics of the participants are illustrated in Table 1.

Table 1: Sociodemographic characteristics of participants (n = 386)

Demographic Characteristics	Category	Frequency (N)	Percentage (%)
Age	18–22 years	232	60.1
	23–27 years	143	37.0
	28–32 years	11	2.8
Faculty	General Medicine	251	65.0
	Stomatology	88	22.8
	Medical Technology	47	12.2
Academic Year	First Year	143	37.0
	Second Year	87	22.5
	Third Year	28	7.3
	Fourth Year	94	24.5
	Fifth Year	34	8.8
Total	386	100	

Comparison of AI knowledge items across academic faculties (N = 386) A Chi-square test of independence was performed to compare artificial intelligence (AI) knowledge items across three academic faculties: Stomatology (n = 88), Medical Technology (n = 47), and General Medicine (n = 251). The analysis demonstrated statistically significant differences across all seven evaluated knowledge items (p < .05).

Regarding basic AI concept familiarity, students from General Medicine exhibited the highest rate of familiarity (81.3%), followed by Stomatology (62.5%) and Medical Technology (57.4%), showing a statistically significant association, χ^2 = 19.691, p < .001, Similarly, awareness of Machine Learning (ML) and Deep Learning (DL) concepts was significantly higher among General Medicine (

59.8%) and Stomatology (52.3%) respondents compared to Medical Technology (23.4%), χ^2= 21.125, p < .001.

A majority of General Medicine students recognized practical AI applications in their discipline (65.3%), whereas less than half of Stomatology (47.7%) and Medical Technology (38.3%) students shared this understanding, χ^2= 16.854, p < .001. Formal academic curriculum exposure was reported by half of General Medicine respondents (50.6%), which was substantially higher than Stomatology (25.0%) and Medical Technology (23.4%), χ^2 = 24.773, p < .001.

Engagement in extra-curricular AI courses was generally low across the board; however, General Medicine students showed relatively higher participation (31.9%) than Stomatology (17.0%) and Medical Technology (10.6%), χ^2 = 13.962, p = .001. Furthermore, understanding the requirement of labelled training data for AI was most prominent in General Medicine (74.9%), followed by Stomatology (61.4%) and Medical Technology (55.3%), χ^2= 10.646, p = .005. Lastly, familiarity with ethical and practical AI challenges was predominant only among General Medicine students (52.6%), while the majority of Stomatology (64.8%) and Medical Technology (68.1%) students lacked awarenessχ^2= 12.246, p = .002. A detailed presentation of the findings is provided in Table 2.

Table 2: Comparison of AI Knowledge Items across Academic Faculties (N = 386)

Knowledge item	Stomatology, *n* = 88, *n* (%)	Medical Technology, *n* = 47, *n* (%)	General Medicine, *n* = 251, *n* (%)	Total, *N* = 386, *n* (%)	Pearson χ^2	*p*
Familiar with basic AI concepts	55 (62.5)	27 (57.4)	204 (81.3)	286 (74.1)	19.691	< .001
Knowledge of ML and DL concepts	46 (52.3)	11 (23.4)	150 (59.8)	207 (53.6)	21.125	< .001
Know practical AI examples in field	42 (47.7)	18 (38.3)	164 (65.3)	224 (58.0)	16.854	< .001
Received formal AI training in curriculum	22 (25.0)	11 (23.4)	127 (50.6)	160 (41.5)	24.773	< .001
Attended online/offline AI courses	15 (17.0)	5 (10.6)	80 (31.9)	100 (25.9)	13.962	.001
Aware that AI requires labeled data	54 (61.4)	26 (55.3)	188 (74.9)	268 (69.4)	10.646	.005
Aware of ethical and practical barriers	31 (35.2)	15 (31.9)	132 (52.6)	178 (46.1)	12.246	.002

Note. Values are presented as *n* (%). Percentages within faculty columns are calculated using the respective faculty denominator; percentages in the total column are based on *N* = 386. Pearson's chi-square test was used to assess the association between faculty and each AI knowledge item. AI = artificial intelligence; ML = machine learning; DL = deep learning. *p* < .05 was considered statistically significant.

The analysis of the relationship between knowledge and the practical use of Artificial Intelligence

The relationship between students' knowledge of artificial intelligence (AI) and their practical use of AI tools was assessed using Spearman's rank correlation coefficient.

The analysis demonstrated statistically significant positive correlations among different dimensions of AI knowledge (P < 0.01). A moderate positive correlation was seen between knowledge of fundamental AI concepts and knowledge of machine learning and deep learning concepts (r = 0.458).

In contrast, negative correlations were identified between certain AI knowledge domains and practical AI use. Knowledge of fundamental AI concepts showed negative correlations with the use of AI for academic assignments (r = -0.261) and scientific writing and research activities (r = -0.284).

Positive correlations were also observed among different domains of AI utilization. Students' use of AI for idea generation was positively associated with other AI-related activities, including professional guidance and skill development. The detailed correlation coefficients and significance values for the relationship between AI knowledge domains and AI utilization are presented in the relevant table.

Analysis of the Relationship Between Students' Attitudes and Practical Use of AI

The relationship between students' attitudes toward artificial intelligence (AI) and their practical use of AI tools was assessed using correlation analysis and linear regression analysis.

Correlation analysis showed a statistically significant but very weak positive association between the perceived need for learning basic AI concepts and practical AI use (r = 0.104, P = 0.021). Positive correlations were also observed between AI utilization and attitudes related to future technological developments and the perceived diagnostic capabilities of AI. Conversely, negative correlations were observed between AI utilization and concerns regarding potential risks associated with AI, including the possibility of AI replacing educators and increasing medical errors.

Multiple linear regression analysis was conducted to assess the independent association between attitude-related variables and practical AI use. When all attitude variables were included simultaneously in the regression model, none of the predictors showed a statistically significant independent association with AI utilization (P > 0.05). The highest positive regression coefficients were observed for perceived threats to medical professions, such as radiology (β = 0.095), and the perceived importance of understanding basic AI concepts (β = 0.083); however, these associations did not reach statistical significance.

The detailed correlation and regression analysis results are presented in Table 3.

Table 3: Associations between students' attitudes toward AI and practical AI utilization (N = 386)

Attitude variable	Correlation coefficient (*r*)	Regression coefficient (β)	*P Valu*
Need for learning basic AI concepts	0.104	0.083	.178
Acceptance of AI as an important tool in the workplace	0.055	−0.013	.839
Importance of learning the ethical aspects of AI	0.066	0.035	.555
Perception of change in the medical education system	0.070	0.051	.351
Perceived threat to professions (e.g., radiology)	0.096	0.095	.090
Interest in future AI developments	0.037	−0.010	.862
Demand for inclusion of AI in the medical curriculum	0.042	0.002	.975
Perceived diagnostic capability of AI compared with doctors	0.087	0.080	.150
Perception that AI may replace teachers	−0.023	−0.083	.147
Concern about increased medical errors due to AI	−0.001	−0.033	.546

Note. *N* = 386. *r* = correlation coefficient; β = standardized regression coefficient; AI = artificial intelligence. *p* values are two-tailed. *p* < .05 was considered statistically significant.

Relationship Between Students' Academic Level and the Use of Artificial Intelligence

A Pearson chi-square test of independence examined the association between students' academic year (first through fifth year) and their AI utilization patterns across six functional domains (*N* = 386). A statistically significant association was observed between academic year and AI utilization for homework and assignments, $\chi^2(16)$ = 28.80, *p* = .025. The proportion of students reporting frequent or always using AI for homework and assignments was higher among

fifth-year (38.2%) and fourth-year students (36.2%) than among first-year students (20.3%). A statistically significant association was also observed between academic year and AI utilization for research papers and projects, $\chi^2(16) = 30.23$, $p = .017$. Frequent or always use was highest among fourth-year students (36.2%), whereas third-year students had the highest proportion reporting never using AI for this purpose (39.3%). AI utilization for career and professional guidance also differed across academic years, $\chi^2(16) = 26.29$, $p = .050$. In contrast, no statistically significant associations were observed between academic year and AI utilization for exam preparation, $\chi^2(16) = 22.47$, $p = .129$; brainstorming and ideas, $\chi^2(16) = 22.70$, $p = .122$; or personal skill development, $\chi^2(16) = 30.22$, $p = .066$. Detailed results of the chi-square analysis of AI utilization patterns across academic years are presented in Table 4.

Table 4: AI utilization patterns across academic years (N = 386)

AI utilization domain and practice level	1st year, *n* = 143	2nd year, *n* = 87	3rd year, *n* = 28	4th year, *n* = 94	5th year, *n* = 34	Total, *N* = 386	Pearson χ^2	*p*
Exam preparation							22.47	.129
Frequent/Always	18.2	24.1	28.6	24.5	23.5	27.5		
Occasional/Sometimes	63.6	66.7	46.4	63.8	70.6	63.7		
Never	18.2	14.9	25.0	11.7	5.9	15.3		
Homework and assignments							28.80	.025
Frequent/Always	20.3	24.1	25.0	36.2	38.2	26.9		
Occasional/Sometimes	61.5	60.9	50.0	55.3	58.8	58.8		
Never	18.2	14.9	25.0	8.5	2.9	14.2		
Research papers and projects							30.23	.017
Frequent/Always	25.9	20.7	7.1	36.2	26.5	25.9		
Occasional/Sometimes	49.7	55.2	53.6	47.9	50.0	50.8		
Never	24.5	24.1	39.3	16.0	23.5	23.3		
Brainstorming and ideas							22.70	.122
Frequent/Always	34.3	23.0	17.9	31.9	32.4	29.8		
Occasional/Sometimes	43.4	57.5	53.6	55.3	58.8	51.6		
Never	22.4	19.5	28.6	12.8	8.8	18.7		
Career and guidance							26.29	.050
Frequent/Always	24.5	25.3	25.0	31.9	29.4	26.9		
Occasional/Sometimes	47.6	56.3	46.4	57.4	55.9	52.6		
Never	28.0	18.4	28.6	10.6	14.7	20.5		
Personal skill development							30.22	.066
Frequent/Always	25.9	20.7	25.0	31.9	29.4	26.4		
Occasional/Sometimes	46.9	62.1	50.0	52.1	52.9	52.3		
Never	27.3	17.2	25.0	16.0	17.6	21.2		

Note. Values are percentages. Percentages within each academic-year column are based on the respective year-specific denominator; percentages in the Total column are based on $N = 386$. Pearson's chi-square test was used to assess the association between academic year and AI utilization level for each domain. AI = artificial intelligence. Statistical significance was set at $p < .05$.

Discussion

This study assessed knowledge, attitudes, and practices regarding artificial intelligence (AI) among medical students in Jalalabad, Nangarhar Province, Afghanistan. The findings demonstrated that students generally had positive perceptions toward AI; however, important gaps remained regarding formal AI education, practical utilization, and institutional preparation for AI-supported healthcare environments. Differences were observed according to faculty type, academic level, and AI-related knowledge domains, highlighting the influence of educational background and learning opportunities on students' AI readiness.

Students enrolled in the Faculty of General Medicine demonstrated significantly higher knowledge of fundamental AI concepts and practical AI applications compared with students from the Stomatology and Medical Technology faculties ($P < 0.001$). This finding is broadly consistent with previous research showing that medical students recognize the growing relevance of AI in healthcare, although substantial gaps remain in formal AI education and preparedness [14,15]. One possible explanation is that General Medicine students have greater exposure to clinical fields such as radiology, medical imaging, diagnostic decision-making, and clinical applications of AI, where these technologies are becoming increasingly visible [3]. However, despite higher knowledge among medical students, the limited availability of formal AI education remains a common challenge internationally. Studies from South Korea and other settings have reported that medical curricula have not yet adequately adapted to the rapid development and implementation of AI technologies despite strong student interest [15].

The present findings are broadly consistent with emerging evidence from Afghanistan. A recent study among medical students and interns at Herat University reported high general knowledge of AI and predominantly positive attitudes, but identified limitations in detailed AI knowledge and practical experience. These findings, together with the present study, suggest that positive perceptions of AI may coexist with important gaps in formal education and practical AI competencies among Afghan medical learners [18].

One of the key findings emerging from the study was the inverse relationship between some AI knowledge domains and practical AI utilization. Students with greater knowledge of AI concepts, limitations, and ethical considerations reported lower use of AI tools for certain academic activities. This finding should be interpreted cautiously because the cross-sectional design does not establish causal relationships. One possible explanation is that students with greater AI literacy may report more selective use of AI tools because of greater knowledge of their limitations, accuracy concerns, and ethical implications. However, this interpretation was not directly assessed in the present study and should therefore be considered hypothesis-generating rather than causal. The use of AI tools also raises concerns regarding the accuracy of AI-generated information, ethical use, and academic integrity, which may influence how students critically evaluate and use these technologies [21].

Although students expressed generally favorable attitudes toward AI, attitude-related variables were not significant independent predictors of AI utilization in the regression analysis. This finding suggests that positive perceptions alone may not be sufficient to translate into practical AI adoption. Similar observations have been reported among medical students in different countries, where interest in AI was not always accompanied by adequate practical competency because of limited training opportunities, insufficient institutional support, and restricted access to AI learning resources [11–14]. In the Afghan context, factors such as access to digital resources, availability of AI-related educational materials, and opportunities for structured AI training could potentially influence the translation of positive attitudes into practical AI use. However, these factors were not directly measured in the present study and therefore cannot be considered explanations for the observed findings. Future studies should examine these contextual factors explicitly.

The present study identified differences in AI utilization across academic years for selected activities. AI use for homework and assignments differed significantly by academic year, with the proportion reporting frequent or always using AI being higher among fifth-year (38.2%) and fourth-year students (36.2%) than among first-year students (20.3%). AI utilization for research papers and projects also differed significantly across academic years, with frequent or always use highest among fourth-year students (36.2%). In contrast, utilization for exam preparation, brainstorming and idea generation, and personal skill development did not differ significantly across academic years. These findings do not indicate a consistent pattern of greater AI use among either junior or senior students [22]. Differences across specific activities may reflect variation in academic demands and learning requirements at different stages of undergraduate education. However, because the study was cross-sectional, these findings should be interpreted as associations rather

than evidence that academic progression causes changes in AI utilization.

From an educational and clinical perspective, improving AI literacy among future healthcare professionals is essential to ensure safe, effective, and ethical adoption of AI technologies. Healthcare providers with adequate AI competencies will be better prepared to critically evaluate AI-generated information, recognize limitations of automated systems, and maintain appropriate clinical judgment when using AI-assisted technologies. In resource-limited settings such as Afghanistan, responsible AI integration may provide opportunities to strengthen medical education, expand access to learning resources, support clinical decision-making, and improve healthcare service delivery. However, achieving these benefits requires structured training programs, institutional policies, and ethical frameworks guiding AI implementation [17].

This study has several strengths. First, it contributes evidence from Afghanistan, a setting where research regarding AI preparedness among medical students remains limited. Second, the inclusion of students from multiple health-related faculties allowed comparison of AI knowledge and utilization patterns across different educational disciplines. Third, the study assessed multiple dimensions of AI engagement, including knowledge, attitudes, and practices, providing a thorough understanding of students' readiness for AI-supported healthcare environments.

Several limitations should also be considered. First, the cross-sectional design prevents establishing causal relationships between AI knowledge, attitudes, and utilization. Second, the use of voluntary online participation may have introduced selection bias because students with greater interest in AI or better access to digital resources may have been more likely to participate. Third, the study was conducted among students from selected medical faculties in Jalalabad, Nangarhar Province, Afghanistan therefore; findings may not represent medical students in other provinces of Afghanistan. Fourth, AI knowledge, attitudes, and practices were self-reported and may have been influenced by recall bias, differences in interpretation of questionnaire items, or social desirability bias. Fifth, the use of an online data collection approach may have resulted in the exclusion of students with limited internet access or lower digital engagement, potentially affecting representation of some student groups. Finally, the quantitative design did not explore deeper contextual factors affecting AI adoption, including institutional readiness, faculty perspectives, ethical concerns, and students' perceived barriers. Future qualitative studies involving students, faculty members, and policymakers could provide further insights into these factors.

Based on these findings, medical universities should consider integrating AI competencies into undergraduate medical curricula through structured courses or interdisciplinary modules addressing AI fundamentals, healthcare applications, ethical considerations, critical evaluation of AI-generated information, and practical skills. Universities should also establish AI training programs, workshops, and seminars for both students and academic staff to promote responsible AI use and improve digital competencies. Furthermore, institutional guidelines should be developed to address transparency, appropriate acknowledgment of AI-assisted work, and prevention of academic misconduct. Future multicenter studies across Afghanistan, including qualitative investigations, are recommended to explore institutional readiness, barriers, and effective strategies for responsible AI integration into medical education and healthcare practice.

Conclusion

This study demonstrates that among the participating medical students in Jalalabad, Nangarhar Province, Afghanistan, there is emerging knowledge and positive perceptions regarding artificial intelligence (AI); however, significant gaps remain in formal AI education and practical application. Although students recognize the potential benefits of AI in medical education and healthcare, effective adoption requires more than individual interest and depends on supportive educational environments, technological infrastructure, and access to structured training opportunities.

These findings underscore the importance of integrating AI competencies into undergraduate medical education, with emphasis on fundamental concepts, clinical applications, ethical considerations, critical evaluation of AI-generated information, and responsible use practices. Universities and relevant educational authorities should develop context-appropriate AI education strategies to prepare future healthcare professionals for the increasing role of AI in medicine.

However, given the non-probability, voluntary self-selection sampling approach used in this study, the findings may be subject to selection bias and should be interpreted with caution. The results may not be generalizable to all medical students in Jalalabad, Nangarhar Province, or Afghanistan. Strengthening AI literacy among medical students remains important to ensure that emerging technologies are adopted safely, effectively, and ethically within healthcare systems. Future research should further assess AI readiness among healthcare professionals and evaluate effective approaches for integrating AI education within the Afghan academic and healthcare context.

Acknowledgments

The authors gratefully acknowledge all medical students who participated in this study and the academic institutions that supported data collection.

Authors' Contributions

Dr. Nasratullah Akbari conceptualized the study, developed the protocol, supervised data collection, performed data analysis, and drafted the manuscript. Teaching assistant Dr. Faheemullah Behsoodwal contributed to data collection, interpretation of findings, and critical revision of the manuscript. Safiullah Muhabat contributed to data collection, literature review, and manuscript revision. All authors read and approved the final version of the manuscript.

Funding Statement

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Ethical Approval

Ethical approval was obtained from the Ethics Committee of Spinghar Medical University, Nangarhar, Afghanistan (Approval No. 7, approved on 1404/07/28). All participants provided electronic informed consent before participating in the study.

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

References

1. Wang F, Preininger A. AI in health: state of the art, challenges, and future directions. Yearb Med Inform. 2019;28(1):16-26. doi: https://doi.org/10.1055/s-0039-1677908
2. Murdoch TB, Detsky AS. The inevitable application of big data to health care. JAMA. 2013;309(13):1351-1352. doi: https://doi.org/10.1001/jama.2013.393
3. Martín Noguerol T, Paulano-Godino F, Martín-Valdivia MT, Menias CO, Luna A. Strengths, weaknesses, opportunities, and threats analysis of artificial intelligence and machine learning applications in radiology. J Am Coll Radiol. 2019;16(9 Pt B):1239-1247. https://doi.org/10.1016/j.jacr.2019.05.047
4. Lee S, Mohr NM, Street WN, Nadkarni P. Machine learning in relation to emergency medicine clinical and operational scenarios: an overview. West J Emerg Med. 2019;20(2):219-227. https://doi.org/10.5811/westjem.2019.1.41244

5. Egger J, Gsaxner C, Pepe A, Pomykala KL, Jonske F, Kurz M, et al. Medical deep learning—a systematic meta-review. Comput Methods Programs Biomed. 2022;221:106874. https://doi.org/10.1016/j.cmpb.2022.106874
6. Londhe VY, Bhasin B. Artificial intelligence and its potential in oncology. Drug Discov Today. 2019;24(1):228-232. https://doi.org/10.1016/j.drudis.2018.10.005
7. Alagappan M, Brown JRG, Mori Y, Berzin TM. Artificial intelligence in gastrointestinal endoscopy: the future is almost here. World J Gastrointest Endosc. 2018;10(10):239-249. https://doi.org/10.4253/wjge.v10.i10.239
8. Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. Nat Med. 2019;25:44-56. https://doi.org/10.1038/s41591-018-0300-7
9. Khumrin P, Ryan A, Judd T, Verspoor K. Diagnostic machine learning models for acute abdominal pain: towards an e-learning tool for medical students. Stud Health Technol Inform. 2017;245:447-451. https://doi.org/10.3233/978-1-61499-830-3-447
10. Shorey S, Ang E, Yap J, Ng ED, Lau ST, Chui CK. A virtual counseling application using artificial intelligence for communication skills training in nursing education: development study. J Med Internet Res. 2019;21(10). https://doi.org/10.2196/14658
11. Ahmed Z, Bhinder KK, Tariq A, Tahir MJ, Mehmood Q, Tabassum MS, et al. Knowledge, attitude, and practice of artificial intelligence among doctors and medical students in Pakistan: a cross-sectional online survey. Ann Med Surg (Lond). 2022;76:103493. https://doi.org/10.1097/MS9.0000000000000241
12. Swed S, Alibrahim H, Elkalagi NKH, Nasif MN, Rais MA, Nashwan AJ, et al. Knowledge, attitude, and practice of artificial intelligence among doctors and medical students in Syria: a cross-sectional online survey. Front Artif Intell. 2022;5:1011524. https://doi.org/10.3389/frai.2022.1011524
13. Doumat G, Daher D, Ghanem NN, Khater B. Knowledge and attitudes of medical students in Lebanon toward artificial intelligence: a national survey study. Front Artif Intell. 2022;5:1015418. https://doi.org/10.3389/frai.2022.1015418
14. Alabbad FA, Almeneessier AS, Alshalan MH, Aljarba MN. Knowledge, attitude, and practice of artificial intelligence among doctors and medical students in Saudi Arabia. J Fam Med Prim Care. 2025;14(4):1459-1464. https://doi.org/10.4103/jfmpc.jfmpc_1812_24
15. Civaner MM, Uncu Y, Bulut F, Giounous Chalil E, Tatli A. Artificial intelligence in medical education: a cross-sectional needs assessment. BMC Med Educ. 2022;22:772. https://doi.org/10.1186/s12909-022-03852-3
16. Mousavi Baigi SF, et al. Attitudes, knowledge, and skills towards artificial intelligence among healthcare students: a systematic review. Health Sci Rep. 2023;6. https://doi.org/10.1002/hsr2.1138
17. Masters K. Artificial intelligence in medical education. Med Teach. 2019;41(9):976-980. https://doi.org/10.1080/0142159X.2019.1595557
18. Azimi M, Salehi SA, Rahimi A. Assessment of Knowledge, Attitudes and Practices of Medical Students at Herat University Regarding the Use of Artificial Intelligence in Healthcare Services. Salamat Academic & Research Journal. 2025;2(4):1–8. https://doi.org/10.61438/sarj.v2i4.198
19. Fazil AW, Hakimi M, Shahidzay AK, Hasas A. Exploring the broad impact of AI technologies on student engagement and academic performance in university settings in Afghanistan. RIGGS J Artif Intell Digit Bus. 2024;2(2):56-63. https://doi.org/10.31004/riggs.v2i2.268
20. Burhani Z, Akbari AA, Azizi B. Impact of AI Language Models on the Academic Performance of Afghan Students: A Case Study. Kunduz University International Journal of Islamic Studies and Social Sciences. 2024;1(2):84-90. https://doi.org/10.71082/5bhens78
21. Bond M, Khosravi H, De Laat M, Bergdahl N, Negrea V, Oxley E, Pham P, Chong SW, Siemens G. A meta-systematic review of artificial intelligence in higher education: a call for increased ethics, collaboration, and rigour. Int J Educ Technol High Educ. 2024;21:4. https://doi.org/10.1186/s41239-023-00436-z
22. Gandhi R, et al. Bridging the Artificial Intelligence (AI) Divide: Do Postgraduate Medical Students Outshine Undergraduate Medical Students in AI Readiness? Cureus. 2024;16(8). https://doi.org/10.7759/cureus.67288