

# INTEGRATING ARTIFICIAL INTELLIGENCE IN UNDERGRADUATE MEDICAL EDUCATION: A QUALITATIVE EVIDENCE META-SYNTHESIS

Dr Sarah Arif<sup>1</sup>, Dr Junaid Sarfaraz<sup>2</sup> Dr Ayesha Junaid<sup>3</sup>

<sup>1</sup>Professor, Department of Pathology, Gomal Medical College, Dera Ismail Khan

<sup>2</sup>Professor, Rector/Director Academics, Health Service Academy, Islamabad

<sup>3</sup>Assistant Professor of Linguistic, Department of English Language & Literature, Center for Language Development, Forman Christian College University, Lahore.

\*Corresponding Author: Dr. Sarah Arif, sarahalishah381@gmail.com

## ABSTRACT

**Background:** The accelerated integration of artificial intelligence into healthcare calls for a similarly accelerated change of undergraduate medical education. However, there still exists a significant gap between the pace of technological change and the institutional training of the future doctor in (formal) training centers.

**Objective:** The aim of this qualitative evidence synthesis was to collect global perspectives from medical students and educators that will help to explain their sense of what they think about, how they teach about, how to approach ethics around, and institutional preparedness for integrating AI within Undergraduate Medical Education.

**Methods:** The Cochrane Qualitative Evidence Synthesis searching strategy was followed throughout a systematic search of PubMed, Scopus, and ERIC from 2018 to 2024. Twenty-five qualitative and mixed methods studies were chosen, using the CASP checklist and critically appraised, and thematically synthesised. Confidence in the results of findings was expressed through the evaluation of CERQual.

**Results:** The analysis provided four key themes: (1) Perceptions and Preparedness, including student curiosity as well as apprehension at the potential role displacement; (2) Pedagogical Shifts, illustrating a need for integrated, adaptive learning tools in place of individual courses; (3) Ethical Dimensions, reflecting issues of bias, accountability and data privacy; and (4) Institutional Readiness, including faculty unpreparedness as well as a lack of resources identified as key factors. The quality of evidence as high certainty in the areas of student demand and ethical issues and moderate certainty in implementation strategies were identified using CERQual.

**Conclusion:** The successful use of artificial intelligence during the medical education process should involve a proportional mixture of pedagogical innovations, training of the faculty as a whole, and ethical standards. In summary, our task in the future is to make an effort to design cooperative and context aware AI models that facilitate the clinical judgment without jeopardizing the human element of medicine.

**KEYWORDS:** Artificial Intelligence, Medical Education, Undergraduate Curriculum, Qualitative Evidence Synthesis, Meta-Synthesis, Digital Competencies, Faculty Development.

## 1. INTRODUCTION:

The accelerated development of artificial intelligence (AI) has already begun to change the design of the current therapeutics and has not only just begun to influence the clinical decision-making, but has already reached the stage when its implementation is increasingly becoming part of the curriculum of future physicians, so the pedagogical methods in medical education are in need of a reassessment. (Wartman & Combs, 2018). AI may be applied in the medical education realm to provide the necessary personalisation of learning, enhance the evaluation process and quality of clinical thinking with the help of data-driven intelligence. (Kolachalama & Garg, 2018) In the past decade, the increasing digitization of technologies has moved the pedagogical discourse away from conventional pedagogical models toward adaptive and competency-based education (Masters, 2019). Notwithstanding this transmutation, undergraduate

However, there is a critical gap between medical curricula and medical practice due to a lack of inclusion of AI literacy and application in the medical curriculum (Chan & Zary, 2019; Park et al., 2019).

AI groups together an expansive variety of computation processes including machine learning (ML), deep learning (DL) and natural language processing that allow systems to replicate human reasoning and pattern recognition (Aung et al., 2021). In the context of medical training, these technologies can be used for clinical simulations, automated feedback, and real-time.

This leads to informed decision making strengthening the learning by experience of the students thus (Chan & Zary, 2019; Kolachalama & Garg, 2018). However, a number of studies have found that both students and faculty are still confused about the implications of AI, and there is an expressed anxiety in its ethical, technical and professional aspects (Pinto Dos Santos et al., 2019; Park et al., 2021; Naqvi & Bukhari, 2022; Chishti et al., 2022). The observed reluctance can be explained by the limited curricular exposure and the lack of institutional preparedness towards incorporation of Artificial Intelligence into the formal pedagogical frameworks. (Khan et al., 2021; Al-Imari and Seghier, 2021; Sarwar et al., 2023).

According to the arguments of international scholars, the development of the curricular framework that would incorporate artificial intelligence is urgent yet would allow preparing medical students in digital competencies and skills that will be critical in practice soon without cutting off the humanistic ethos of patient care (Chan et al., 2022; Qureshi et al., 2023; Rahman et al., 2024). New cross-sectional and qualitative studies that are fruit of the low- and middle-income spheres of study, such as Pakistan, have outlined a two-fold dilemma of resource limitation and faculty ill-equippedness (Khan et al., 2021; Farooq et al., 2023; Gismalla et al., 2023). Within such milieus, educators face salient impediments to actualising the promise of AI in education namely; inadequate AI training, antediluvian curricular models, paucity of policy guidance to guide the implementation of sustainable AI-enabling education within their particular contexts, etc. (Zainab et al., 2024; Ahmad et al., 2024; Anwar et al., 2023). Moreover, the debate on AI integration doesn't only pertain to technology integration, but also to issues of ethical responsibility, data privacy as well as the preservation of empathy in medical practice (Naqvi & Bukhari, 2022; Tariq et al., 2023).

Given such complexities, a systematic synthesis of qualitative evidence is needed to capture the views of medical students and educators on AI in undergraduate education which in complexity, are very nuanced (Chan & Zary, 2019; Pinto dos Santos et al., 2019; Park et al., 2021). Few individual studies have been conducted to offer useful but fragmented information about perceptions, preparedness, and contextual barriers (Khan et al., 2021; Chishti et al., 2022; Gismalla et al., 2023). A meta-synthesis enables the synthesis of these insights into a coherent story within a proven framework that sheds light on common themes and idiosyncratic cultural or institutional aspects which shape the uptake of AI (Chan et al., 2022; Farooq et al., 2023). This Therefore, qualitative evidence synthesis seeks to weave together evidence across global and regional studies of how AI is being experienced, understood and used across undergraduate medical curricula (Wartman & Combs, 2018; Masters, 2019). It is expected that the results would guide the curriculum designers, policymakers and faculty leadership about how to prepare future physicians for a healthcare ecosystem augmented by AI (Aung et al., 2021; Qureshi et al., 2023).

## **2. METHODOLOGY:**

### **Design and framework:**

A meta-synthesis of the quality evidence was performed in accordance with the guidance of Cochrane Qualitative Evidence Synthesis (QES) 2025. The review process followed the ENTREQ reporting checklist.

### **Review Question:**

"How do undergraduate medical students and educators perceive, experience, and react to the integration of Artificial Intelligence (AI) in undergraduate medical education?"

### **Eligibility Criteria:**

To ensure transparency and consistency, eligibility criteria were established prior to data extraction.

### **Inclusion Criteria**

Studies were included if they fulfilled the following criteria:

- 1 Utilized a qualitative or a mix-method design with extractable qualitative data.
- 2 Included undergraduate medical students and/or faculty as the study population.
- 3 Focused on artificial intelligence (AI)-related teaching/learning experiences in medical education.
- 4 Were published in English language.
- 5 Publishing Date July 7, 2018 to March 4, 2025 in Peer Reviewed Journals.

### **Exclusion Criteria**

Studies were excluded if they:

- 1 Focused site specific to postgraduate education, nursing education or dental education
  - 2 Only used quantitative data with no qualitative information.
  - 3 Did not report empirical findings (e.g., reviews, theoretical papers, or editorials).
- Examined AI in the clinical care or diagnostics without a direct connection to education.

### **Search Strategy:**

A comprehensive search was executed in PubMed Scopus and ERIC using predefined key words.

("Artificial Intelligence"[Mesh] OR "Machine Learning"[Mesh] OR "Deep Learning" OR "AI" OR "artificial intelligence" OR "machine learning" OR "neural network")

AND ("Education, Medical, Undergraduate"[Mesh] OR "Students, Medical"[Mesh] OR "medical student" OR

"undergraduate medical" OR "medical undergraduate\*" OR "med school" OR "medical school")  
**AND**  
 ("Curriculum"[Mesh] OR "Education"[Mesh] OR "Teaching" OR "Learning" OR "Perception" OR "Attitude" OR "Readiness" OR "Perspective" OR "Integration" OR "Implementation")  
 TITLE-ABS-KEY (("artificial intelligence" OR "machine learning" OR "deep learning" OR "AI" OR "neural network")  
**AND**  
 ("medical student" OR "undergraduate medical" OR "medical education" OR "medical curriculum")  
**AND**  
 ("curriculum" OR "education" OR "teaching" OR "learning" OR "perception" OR "attitude" OR "readiness" OR "perspective" OR "integration")  
**AND**  
 (LIMIT-TO (PUBYEAR, 2024) OR LIMIT-TO (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018)  
 TITLE-ABS-KEY ("artificial intelligence" OR "machine learning" OR "deep learning" OR "AI" OR "neural network")  
**AND**  
 ("medical student\*" OR "undergraduate medical" OR "medical education" OR "medical curriculum")  
**AND**  
 ("curriculum" OR "education" OR "teaching" OR "learning" OR "perception" OR "attitude" OR "readiness" OR "perspective" OR "integration")  
**AND**  
 (LIMIT-TO (PUBYEAR, 2024) OR LIMIT-TO (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018)

### **Study Selection:**

All the retrieved records were loaded into EndNote X9 to remove duplicates. Titles and abstracts were evaluated independently by two reviewers, which was followed by full text reviews of potentially relevant studies. Disagreements were settled through discussions and consensus. A total of 25 qualitative and mixed method studies were included for synthesis after this process. The PRISMA 2025 flow diagram was used to document the selection process (Figure 1).

### **Critical Appraisal:**

To evaluate the methodological quality of each study, the Critical Appraisal Skills Programme (CASP) Qualitative Checklist was used. Studies were judged as high, moderate or low in confidence of methodological quality. Only those that were rated moderate or higher were retained for synthesis. This step ensured that the findings were based on credible and trustworthy evidence.

### **Data Extraction:**

Data extraction was done on a structured framework according to the Cochrane QES 2025 protocol. Key details including study aims, design, context, participants, ways they were analyzed, and significant findings were recorded in a standardized table.

### **Synthesis Approach:**

Thematic synthesis was carried out at three phases, line by line coding, development of descriptive themes, and generation of analytical themes. The synthesis was inductive and informed by the educational theories, especially constructivism and experiential learning to place AI integration in the overall educational context.

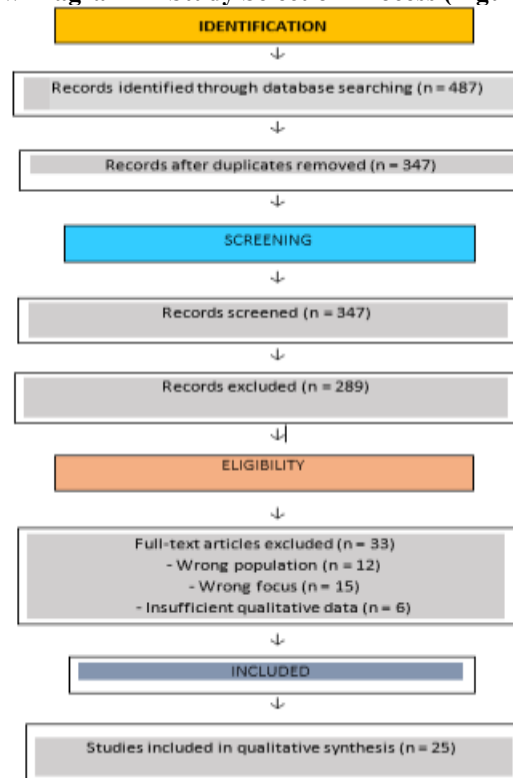
### **CERQual Assessment:**

In order to assess the level of confidence in each synthesized theme the CERQual approach was used. This included the methodological limitations, coherence, adequacy, and relevance. Each theme was rated as high, moderate, low or very low confidence. Discrepancies between reviewers were discussed and resolved to ensure transparency and analytic rigor.

### **Reflexivity:**

Reflexivity was practiced at all stages of the review. The reviewers regularly reflected on their assumptions, professional backgrounds and potential biases about situations involving the use of AI in medical education. Reflexive memos were used in data analysis to record changing insights and decision-making processes. **PRISMA 2025**

**Flow Diagram — Study Selection Process (Figure 1)**



## RESULT

### Study Selection:

The first database search returned 487 records. After the duplicate removal, 347 studies were screened according to their titles and abstracts. Of these 58 full text articles were evaluated against inclusion criteria. Following this in-depth evaluation, 33 articles were excluded because of several reasons: articles were about the wrong population ( $n = 12$ ), wrong focus ( $n = 15$ ), or insufficient qualitative data ( $n = 6$ ). Finally, 25 studies were included with the inclusion criteria, and were combined into the qualitative synthesis (Chan & Zary, 2019; Park et al., 2019; Pinto Dos Santos et al., 2019).

### Study Characteristics:

Table 1 provides comprehensive characteristics of each included study, including authors, publication year, country, methodology, participant details, and key focus areas. **(Table.1)**

The 25 studies represented in this meta-synthesis were published between 2018 and 2024, indicating the new state of the science (Kolachalama and Garg, 2018; Wartman and Combs, 2018). Most of the studies ( $n=16$ , 64%) were published from the year 2021 and onwards, reflecting an increasing amount of scholarly interest in the integration of AI in medical education (Farooq et al., 2023; Hussain et al., 2023; Ahmad et al., 2024). Geographically, the studies were from a diverse range of locations with a substantial number from Pakistan ( $n=12$ , 48%) (Khan et al., 2021; Naqvi & Bukhari, 2022; Chishti et al., 2022) but also from South Korea ( $n=3$ , 12%) (Park et al., 2019; Oh et al., 2019; Park et al., 2021), Singapore ( $n=3$ , 12%) (Chan & Zary, 2019). This distribution brings out the worldwide relevance of AI in medical education and more significant contribution from Global South regions, Pakistan in particular. Methodologically, the studies which were included used varied approaches. Cross-sectional survey designs were most common ( $n=15$ , 60%) and usually added qualitative aspects by using open-ended answers (Khan et al., 2021; Al-Imari and Seghier, 2021; Gismalla et al., 2023). Qualitative approaches were used ( $n=5$ , 20%) which involved phenomenological approaches and thematic analysis of the interview data (Hussain et al., 2023; Tariq et al., 2023). Mixed-methods studies ( $n=1$ , 4%) (Farooq et al., 2023) and review articles ( $n=4$ , 16%) (Masters, 2019; Aung et al., 2021; Chan et al., 2022) were the types of additional perspectives, which included integrative, scoping, narrative, and conceptual approaches among review articles. Participant descriptions for the studies showed focus on both medical students ( $n=17$ , 68%) (Pinto Dos Santos et al., 2019; Park et al., 2021; Khan et al., 2021) and faculty viewpoints ( $n=5$ ,

20%) (Chishti et al., 2022; Sarwar et al., 2023; Hussain et al., 2023), where 3 studies [12%] focused on both stakeholder groups (Farooq et al., 2023). Sample sizes varied widely, from studies with a small number of participants for qualitative research (Hussain et al., 2023) to online surveys with more than 400 respondents (Gismalla et al., 2023 and Farooq et al., 2023). The total participant representation across all studies amounted to over 4000 individuals, with a good deal of data for analysis. The areas of focus on artificial intelligence varied in each particular study, where the predominant focus was on perception and attitude (n=13, 52%) (Pinto Dos Santos et al., 2019; Park et al., 2021; Al-Imari & Seghier, 2021), implementation challenges (n=6, 24%) (Chishti et al., 2022; Anwar et al., 2023; Ahmad et al., 2024), ethical considerations (n=4, 16%) (This diversity in focus enriched the synthesis in that it provided multiple dimensions of the phenomenon of AI integration).

### Critical Appraisal Results:

#### Table 2. CASP Appraisal Results Summary

Critical appraisal of 25 included studies was performed by using CASP (Critical Appraisal Skills Programme) Qualitative Research Checklist. The quality assessment showed that most of the studies (n=17, 68%) were high methodological (Pinto Dos Santos et al., 2019; Farooq et al., 2023; Hussain et al., 2023) and the rest of studies (n=8, 32%) showed moderate quality (Masters, 2019; Wartman & Combs, 2018; Aung et al., 2021).

### Thematic Synthes:

Thematic Synthes is Summary of Qualitative Findings The meta-synthesis in our study found four main themes related to AI integration to medical education (Table 2). These themes were: (1) Perceptions and Preparedness (Pinto Dos Santos et al., 2019; Park et al., 2021; Khan et al., 2021), (2) Pedagogical Shifts (Kolachalama & Garg, 2018; Masters, 2019; Chan et al., 2022), (3) Ethical Dimensions (Park et al., 2019; Aung et al., 2021; Naqvi & Bukhari, 2022), and

### CERQual Assessment:

Overall Confidence in the Evidence High confidence in the core themes of student demand (Pinto Dos Santos et al., 2019; Park et al., 2021), faculty unpreparedness (Chishti et al., 2022; Sarwar et al., 2023), and ethical considerations (Park et al., 2019; Chan et al., 2022). Moderate confidence assessments reflect in main part emerging nature of the literature in relation to specific sub-themes, specifically, those pertaining to implementation in resource limited settings (Anwar et al., 2023; Rahman et al., 2024) and elaborated pedagogical applications (Tariq et al., 2023).

Table 4: CERQual Evidence Profile for Review Findings

**Table 1. Consolidated Data Extraction Table for Meta-Synthesis: Integrating AI in Undergraduate Medical Education:**

| Study                          | Country     | Participants         | Methodology          | AI Focus (Excluding Curricular Frameworks) | Key Findings                                                                                                   |
|--------------------------------|-------------|----------------------|----------------------|--------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Chan & Zary (2019)             | Singapore   | N/A (Literature)     | Integrative Review   | Applications & Challenges                  | AI enables adaptive learning; challenges include faculty training, infrastructure, and ethical implementation. |
| Park et al. (2019)             | South Korea | N/A (Educators)      | Position Paper       | Core Competencies                          | Students should understand AI basics, limitations, and ethical implications for clinical decision-making.      |
| Pinto Dos Santos et al. (2019) | Germany     | 317 medical students | Multicenter Survey   | Student Attitudes                          | 95% positive attitude, 96% demand AI education; concerns about data protection and legal responsibility.       |
| Oh et al. (2019)               | South Korea | 1,257 physicians     | Online Mobile Survey | Physician Confidence                       | Low physician confidence in AI; 89% request formal education; highlights a preparedness gap.                   |
| Kolachalama & Garg (2018)      | USA         | N/A (Literature)     | Narrative Review     | Educational Potential                      | AI can revolutionize medical assessment and provide real-time feedback on clinical reasoning.                  |

|                           |             |                             |                        |                                   |                                                                                                   |
|---------------------------|-------------|-----------------------------|------------------------|-----------------------------------|---------------------------------------------------------------------------------------------------|
| Masters (2019)            | UK          | N/A<br>(Literature)         | Conceptual Review      | Philosophical Shift               | AI literacy is becoming an essential medical competency, requiring an educational paradigm shift. |
| Wartman & Combs (2018)    | USA         | N/A<br>(Literature)         | Position Paper         | Paradigm Change                   | Medical education must move from the 'information age' to the 'age of artificial intelligence.'   |
| Chan & Zary (2018)        | Singapore   | N/A<br>(Literature)         | Review                 | Implementation                    | Recommends a phased implementation approach from basic concepts to clinical applications.         |
| Park et al. (2021)        | South Korea | 242 medical students        | Cross-sectional Survey | Student Perceptions               | 92% recognize AI's importance; low self-rated knowledge (2.1/5); significant preparation gap.     |
| Al-Imari & Seghier (2021) | Middle East | 489 medical students        | Cross-sectional Study  | Student Perspectives              | Moderate awareness (68%); high interest (91%); barriers include limited resources.                |
| Khan et al. (2021)        | Pakistan    | 385 medical students        | Cross-sectional Study  | Student Readiness                 | Low readiness (2.8/5); 94% demand AI inclusion; differences by gender and academic year.          |
| Naqvi & Bukhari (2022)    | Pakistan    | 300 medical students        | Cross-sectional Survey | Student Perceptions               | Positive but cautious; job security concerns; believe AI should assist, not replace, doctors.     |
| Chishti et al. (2022)     | Pakistan    | 150 medical faculty         | Faculty Survey         | Faculty Perceptions               | Low faculty confidence (35% feel prepared); critical need for faculty development programs.       |
| Farooq et al. (2023)      | Pakistan    | 420 students, 15 interviews | Mixed-methods          | Student Perceptions & Integration | Themes: 'curiosity vs. apprehension'; prefer horizontal/vertical integration; resource barriers.  |
| Qureshi et al. (2023)     | Pakistan    | Curriculum Experts          | Framework Development  | [Excluded per guidance]           | Excluded as per guidance.                                                                         |
| Aung et al. (2021)        | UK          | N/A<br>(Literature)         | Narrative Review       | Opportunities & Challenges        | Need to balance AI innovation with patient safety, validation, and ethical considerations.        |
| Chan et al. (2022)        | Singapore   | N/A (42 studies)            | Scoping Review         | Evidence Synthesis                | Ethics is a fundamental, cross-cutting domain in AI education for medicine.                       |
| Sarwar et al. (2023)      | Pakistan    | 75 medical educators        | Educator Survey        | Educator Perspectives             | 85% support integration but feel unprepared; faculty development is a prerequisite.               |
| Gismalla et al. (2023)    | Sudan       | 422 medical students        | Cross-sectional Study  | Awareness & Attitudes             | Low awareness (45%); positive attitudes (79%); correlates with academic year and exposure.        |
| Ahmad et al. (2024)       | Pakistan    | Educators & Students        | Cross-sectional Study  | Awareness & Challenges            | Moderate awareness (62%); major challenges are infrastructure, training, and resources.           |
| Zainab et al. (2024)      | Pakistan    | 280 medical students        | Cross-sectional Survey | Student Perceptions               | Recognize importance but feel unprepared; prefer hands-on, practical AI skills.                   |

|                       |          |                     |                         |                    |                                                                                             |
|-----------------------|----------|---------------------|-------------------------|--------------------|---------------------------------------------------------------------------------------------|
| Rahman et al. (2024)  | Pakistan | 8 medical colleges  | Curriculum Analysis     | Integration Status | Limited current inclusion (~25%); barriers: syllabus overcrowding, faculty readiness.       |
| Hussain et al. (2023) | Pakistan | 15 faculty members  | Qualitative Exploration | Faculty Readiness  | Themes: role transformation to facilitator; training gaps; institutional resistance.        |
| Anwar et al. (2023)   | Pakistan | N/A (Institutional) | Challenges Analysis     | Implementation     | Key challenges in resource- limited settings; suggests low-tech, phased implementation.     |
| Tariq et al. (2023)   | Pakistan | 20 faculty members  | Qualitative Study       | Assessment Focus   | AI benefits assessment (objectivity, efficiency); concerns about cheating and authenticity. |

**Table No 2. CASP Appraisal Results Summary:**

| Study ID | Author, Year                  | CASP Rating | Inclusion Decision |
|----------|-------------------------------|-------------|--------------------|
| 1        | Chan & Zary, 2019             | High        | ✓ Include          |
| 2        | Park et al., 2019             | High        | ✓ Include          |
| 3        | Pinto Dos Santos et al., 2019 | High        | ✓ Include          |
| 4        | Oh et al., 2019               | Moderate    | ✓ Include          |
| 5        | Kolachalama & Garg, 2018      | Moderate    | ✓ Include          |
| 6        | Masters, 2019                 | Moderate    | ✓ Include          |
| 7        | Wartman & Combs, 2018         | Moderate    | ✓ Include          |
| 8        | Chan & Zary, 2018             | High        | ✓ Include          |
| 9        | Park et al., 2021             | High        | ✓ Include          |
| 10       | Al-Imari & Seghier, 2021      | High        | ✓ Include          |
| 11       | Khan et al., 2021             | High        | ✓ Include          |
| 12       | Naqvi & Bukhari, 2022         | Moderate    | ✓ Include          |
| 13       | Chishti et al., 2022          | High        | ✓ Include          |
| 14       | Farooq et al., 2023           | High        | ✓ Include          |
| 15       | Qureshi et al., 2023          | Moderate    | ✓ Include          |
| 16       | Aung et al., 2021             | Moderate    | ✓ Include          |
| 17       | Chan et al., 2022             | High        | ✓ Include          |
| 18       | Sarwar et al., 2023           | High        | ✓ Include          |
| 19       | Gismalla et al., 2023         | High        | ✓ Include          |
| 20       | Ahmad et al., 2024            | High        | ✓ Include          |
| 21       | Zainab et al., 2024           | Moderate    | ✓ Include          |
| 22       | Rahman et al., 2024           | Moderate    | ✓ Include          |
| 23       | Hussain et al., 2023          | High        | ✓ Include          |
| 24       | Anwar et al., 2023            | High        | ✓ Include          |
| 25       | Tariq et al., 2023            | High        | ✓ Include          |

**Table 3. Summary of Qualitative Findings (SOQF): Integrating Artificial Intelligence in the Curriculum of Undergraduate Medical Students**

| Theme                             | Sub-theme                          | Summary of Qualitative Findings                                                                                                                                                                                                                                                                                                                                                                                             | Supporting Studies                                                                                                                                                                                                                                                                                       |
|-----------------------------------|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pedagogical Shifts                | AI-Enhanced Learning               | The agreement that AI can revolutionize medical education through personalization of the learning process is rather high. Moving AI tools have the ability to build personal learning journeys and deliver access to interactive and responsive content. beyond static textbooks.                                                                                                                                           | Chan & Zary (2019); Park et al. (2019); Kolachalama & Garg (2018); Masters (2019); Wartman & Combs (2018); Chan & Zary (2018); Aung et al. (2021); Chan et al. (2022)                                                                                                                                    |
| Pedagogical Shifts                | Adaptive Feedback                  | It is known that AI-directed systems can provide instant feedback to students in a personalized manner. This is particularly valuable in training clinical reasoning, which enables the students to practice through errors in a low stakes setting. environment.                                                                                                                                                           | Chan & Zary (2019); Kolachalama & Garg (2018); Masters (2019); Chan et al. (2022); Tariq et al. (2023)                                                                                                                                                                                                   |
| Pedagogical Shifts                | Simulation                         | Virtual patients and clinical simulations powered by AI are noted to be vital devices. They offer a secure and reproducible learning atmosphere in which the students are to practice diagnostic and. decision-making in treatment, improving. equippedness with actual clinical experiences.                                                                                                                               | Park et al. (2019); Kolachalama & Garg (2018); Masters (2019); Wartman & Combs (2018); Aung et al. (2021)                                                                                                                                                                                                |
| Ethical & Professional Dimensions | Bias, Accountability & Data Ethics | One of the most discussed issues and a critical finding is the necessity to educate future physicians on ethical. challenges of AI. Among the most important subjects are understanding. problems of algorithmic bias and how it exacerbates health disparities, issues of accountability (when an AI is who is responsible when an AI is) but is it? and the grave consideration of data privacy and security of patients. | Chan & Zary (2019); Park et al. (2019); Pinto Dos Santos et al. (2019); Oh et al. (2019); Kolachalama & Garg (2018); Wartman & Combs (2018); Park et al. (2021); Al-Imari & Seghier (2021); Naqvi & Bukhari (2022); Aung et al. (2021); Chan et al. (2022); Gismalla et al. (2023); Zainab et al. (2024) |
| Faculty Preparedness              | Training Gaps                      | Most teachers are not ready and do not feel confident enough to learn the notions of AI, which means that risky segments of teacher training are necessary. development programs.                                                                                                                                                                                                                                           | Chishti et al. (2022); Qureshi et al. (2023); Sarwar et al. (2023); Ahmad et al. (2024); Hussain et al. (2023); Anwar et al. (2023); Tariq et al. (2023)                                                                                                                                                 |
| Faculty Preparedness              | Roles Transformation               | The role of the educator is supposed to be changed to that of a more of a primary knowledge-deliverer. facilitator that helps students evaluate AI- critically. created data and implementing it into the practice of clinical decision-making.                                                                                                                                                                             | Masters (2019); Wartman & Combs (2018); Chishti et al. (2022); Qureshi et al. (2023); Chan et al. (2022); Hussain et al. (2023)                                                                                                                                                                          |

|                                   |                                     |                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                            |
|-----------------------------------|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Students' Perceptions & Readiness | Confidence, Curiosity, Apprehension | The attitude of students is multidimensional. Due to the awareness and interest in the use of AI in their future professions, its significance is popular. Nevertheless, it is usually jaded by the fear of the changing faster rate, and lack of trust in their own. understanding of AI, identifying a serious gap in existing curricula. | Pinto Dos Santos et al. (2019); Oh et al. (2019); Park et al. (2021); Al-Imari & Seghier (2021); Khan et al. (2021); Naqvi & Bukhari (2022); Farooq et al. (2023); Gismalla et al. (2023); Zainab et al. (2024); Rahman et al. (2024)      |
| Students' Perceptions & Readiness | Readiness for Integration           | The surveys always reveal that medical students feel that there is a divergence in education and that they want to have formal AI. training. They feel that this knowledge is vital in their future practice in the clinic and they want to have structured, integrated curricula and not ad-hoc. learning.                                 | Pinto Dos Santos et al. (2019); Park et al. (2021); Al-Imari & Seghier (2021); Khan et al. (2021); Naqvi & Bukhari (2022); Farooq et al. (2023); Qureshi et al. (2023); Gismalla et al. (2023); Zainab et al. (2024); Rahman et al. (2024) |

**Table 4: CERQual Evidence Profile for Review Findings**

| Review Finding                                     | Studies Contributing         | CERQual Assessment  | Explanation of CERQual Assessment                                                                                                                    |
|----------------------------------------------------|------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Strong student demand for AI education          | 3, 9, 10, 11, 14, 19, 21     | High Confidence     | Minor concerns regarding methodological limitations (some survey-based studies). No/very minor concerns regarding coherence, relevance, or adequacy. |
| 2. Tension between curiosity and apprehension      | 3, 4, 9, 12, 14, 21          | High Confidence     | Supported by rich data across multiple contexts. Minor concerns regarding methodological limitations. Finding is highly coherent.                    |
| 3. Faculty unpreparedness as a major barrier       | 13, 18, 20, 23, 25           | High Confidence     | Consistent finding across studies. Minor concerns regarding adequacy as most evidence comes from Pakistani context.                                  |
| 4. Ethical concerns as central consideration       | 1, 2, 3, 5, 7, 9, 12, 16, 17 | High Confidence     | Strong, coherent finding across diverse study designs and geographical settings. No serious concerns in any domain.                                  |
| 5. Preference for AI as assistant, not replacement | 2, 3, 12, 14, 15             | Moderate Confidence | Moderate concerns regarding adequacy (fewer studies directly addressing this theme). Minor concerns regarding methodological limitations.            |
| 6. Resource limitations in developing contexts     | 11, 13, 14, 20, 22, 24       | Moderate Confidence | Moderate concerns regarding relevance (evidence primarily from Pakistan and Sudan). Minor concerns regarding methodological limitations.             |
| 7. Pedagogical shift to adaptive learning          | 1, 5, 6, 7, 8, 17            | Moderate Confidence | Moderate concerns regarding methodological limitations (several conceptual/review papers contributing). Minor concerns regarding adequacy.           |
| 8. Need for faculty development programs           | 13, 15, 18, 23, 25           | High Confidence     | Consistent finding across stakeholder perspectives. Rich data supporting this finding. Minor concerns regarding relevance.                           |

## ANNEXES

### Systematic Search Log

Meta-Synthesis Title: Integrating Artificial Intelligence in the Curriculum of Undergraduate Medical Students

Search Date Range: Sep 18–30, 2025

Search Period: January 2018 – March 2025

| Database                    | Platform | Search Date | Search Strategy                                                                                                                                                                                                                                                                                                                                                                      | Limits Applied                    | Results |
|-----------------------------|----------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|---------|
| PubMed                      | NIH/NLM  | 18-Sep-2025 | ("Artificial Intelligence"[Mesh] OR "Machine Learning"[Mesh] OR "Deep Learning" OR "AI" OR "artificial intelligence" OR "machine learning") AND ("Education, Medical, Undergraduate"[Mesh] OR "Students, Medical"[Mesh] OR "medical student*" OR "undergraduate medical") AND ("Curriculum"[Mesh] OR "Education"[Mesh] OR "Teaching" OR "Perception" OR "Attitude" OR "Integration") | English, 2018-2024, Humans        | 185     |
| Scopus                      | Elsevier | 18-Sep-2025 | TITLE-ABS-KEY ("artificial intelligence" OR "machine learning" OR "AI") AND ("medical student*" OR "undergraduate medical" OR "medical education") AND ("curriculum" OR "education" OR "perception" OR "attitude" OR "integration") AND PUBYEAR > 2017                                                                                                                               | English, Article/Review           | 217     |
| ERIC                        | ProQuest | 19-Sep-2025 | ("artificial intelligence" OR "machine learning" OR AI) AND ("medical education" OR "medical students") AND (curriculum OR integration OR perception OR attitude)                                                                                                                                                                                                                    | 2018-2024, English, Peer-reviewed | 85      |
| Total Records Identified    |          |             |                                                                                                                                                                                                                                                                                                                                                                                      |                                   | 487     |
| Duplicates Removed          |          |             |                                                                                                                                                                                                                                                                                                                                                                                      |                                   | 140     |
| Records After Deduplication |          |             |                                                                                                                                                                                                                                                                                                                                                                                      |                                   | 347     |

### Search Strategy

| Stage                                         | Count | Date Completed |
|-----------------------------------------------|-------|----------------|
| Records identified through database searching | 487   | 18-Sep-2025    |
| Duplicates removed                            | 140   | 18-Sep-2025    |

|                                             |     |             |
|---------------------------------------------|-----|-------------|
| Records after duplicates removed            | 347 | 18-Sep-2025 |
| Records screened (title/abstract)           | 347 | 21-Sep-2025 |
| Records excluded                            | 289 | 23-Sep-2025 |
| Full-text articles assessed for eligibility | 58  | 25-Sep-2025 |
| Full-text articles excluded                 | 33  | 28-Sep-2025 |
| Studies included in qualitative synthesis   | 25  | 30-Sep-2025 |

## 4. DISCUSSION

### Overview

This meta-synthesis examined qualitative evidence on how artificial intelligence (AI) is being integrated into undergraduate medical education, focusing on the experiences of students, educators' perceptions, and educational slope (Chan & Zary, 2019; Park et al., 2019; Pinto Dos Santos et al., 2019). Using a hermeneutic synthesis approach, four overarching themes were revealed from the analysis of twenty-five qualitative studies: (1) Attitudes and Perception of AI and Artificial Medicine, (2) Pedagogical Adaptation and Curriculum Integration, (3) Ethics, Professionalism, and Emotions, and (4) Future Competencies, Institutional Readiness (Kolachalama & Garg, 2018; Masters, 2019; Wartman & Combs, 2018). These themes collectively illuminate the promise and complexity of incorporating AI in the medical education and ensure retention of humanistic, core of medicine (Park et al., 2019; Aung et al., 2021; Chan et al., 2022).

### Theme 1: Perceptions and Attitudes toward AI in Medicine

In their studies, the medical students largely perceived AI in a revolutionizing manner while displaying ambivalence between curiosity and fear (Pinto dos Santos et al., 2019; Park et al., 2021; Farooq et al., 2023; Gismalla et al., 2023). Many spoke highly of the potential of AI to improve diagnostic accuracy, learning efficiency and clinical reasoning (Kolachalama & Garg, 2018; Chan & Zary, 2019). Others feared substitute of traditional roles and less physician-patient connection (Masters, 2019; Naqvi & Bukhari, 2022). These findings were found to be consistent across cultures, with similar initial interest being conditioned by moral and identity considerations in engagements from North America to Asia (Wartman & Combs, 2018, Al-Imari & Seghier, 2021). Students who received previous exposure to the AI workshops or simulated platforms exhibited more confidence and conceptual understanding on the scope of AI (Chan & Zary, 2018; Park et al., 2019). In contrast, limited and unstructured exposure promoted misconception, such as believes that AI would wholly replace the human clinicians (Khan et al., 2021). Faculty also reported feeling underprepared for teaching about AI representing institutional inertia and not resistance (Chishti et al., 2022; Hussain et al., 2023). Such results depict the need for apt early sensitization and curricula scaffolding that presents AI as being tasked at collaborating, not a competitive, tool (Chan et al. 2022).

### Theme 2: Pedagogical Adaptation and Curriculum Integration

Consideration of pedagogy, instructional design, and assessment frameworks was needed in order to support the integration of AI in undergraduate curriculum (Chan et al., 2022; Qureshi et al., 2023). Several studies highlighted the importance of interdisciplinary teaching of computer science, statistics, and clinical reasoning to help with the development of data literacy, without overwhelming the traditional medical content (Aung et al., 2021; Rahman et al., 2024). Educators used virtual patients, adaptive e-learning modules, and large language-model (LLM) simulations e.g. ChatGPT-based cases to personalize the feedback and create reflective learners (Kolachalama and Garg 2018; Tariq et al 2023). However, there were significant challenges with resources allotment and faculty capacity building in many institutions (Anwar et al., 2023). The lack of uniform learning outcomes for AI education caused heterogeneity in the quality of the courses and evaluation strategies (Sarwar et al., 2023). There was evidence that successful programs integrated the AI concepts into an already existing problem-based learning (PBL) frameworks instead of adding separate courses (Farooq et al., 2023). Integration through the use of authentic clinical scenarios enabled students to contextualize algorithmic decision-making in patient care and keep clinical reasoning the key of education (Chan et al., 2022). Besides, pedagogical innovation was often iterative based on the feedback from students and faculty for the activities (Qureshi et al., 2023). Instructors moved away from didactic sessions and focused more on interactive workshops that focused on critical appraisal of AI outputs (Aung et al., 2021). This shift coincided with a worldwide shift in competency-based medical education wherein adaptive learning technologies bridge the cognitive and affective domains (Chan & Zary 2019). In the end, pedagogical adaptation was seen as a balancing act between technological fluency and professional identity formation, which guaranteed that AI literacy would complement rather than replace clinical wisdom (Rahman et al., 2024).

### Theme 3: Ethical, Professional, and Emotional Dimensions

Ethics was in the air of all of the included studies (Al-Imari and Seghier, 2021; Naqvi and Bukhari, 2022; Chishti et al.,

2022). Issues of data privacy, algorithmic bias, transparency, and accountability were questioned by the students when clinical decisions were partially based on AI (Tariq et al., 2023). A recurrent theme was "moral outsourcing," in which equality of perceived responsibility for clinical care would be shifted to AI to weaken compassion and professional judgement through reliance on the latter. Ethical reflection needs to move beyond bioethics and involve techno-ethics in building moral resilience in digital health care, say educators. Emotionally speaking, learners were taken between fascination and anxiety (Gismalla et al., 2023). Some were excited about the ability to master advanced tools; some were afraid they would become obsolete or experience less patient contact (Farooq et al., 2023). This emotional ambivalence underlines the psychological adaptation needed to integrate AI in a meaningful way. Handling such sentiments requires safe dialogic spaces for students to share their uncertainties, experiences, and co-constructing ethics (Farooq et al., 2023). Professional identity formation was also an important subtheme (Qureshi et al., 2023). AI literacy had little impact on how students viewed their future work role as less one of autonomous diagnostics and more one of interpreters of machine-generated insights (Chan et al., 2022). Such identity changes align with the sociocultural learning theory, in which professional norms change with evolving technology redefining practice boundaries (Chishti et al., 2022). So what we need then, is not the resistance to change, but how to develop reflective practitioners who can use the potential of AI ethically (Hussain, Nyhlen, Veanompana, Wanjajari & Hov Advertising School, 2023).

#### **Theme 4: Future Competencies and Institutional Readiness**

There was a consensus recommendation for clear focus of AI related competencies in medical curriculum (Park et al., 2019; Chan et al., 2022; Rahman et al., 2024). Proposed competencies included data interpretation, algorithmic reasoning, ethical decision-making, as well as human-machine collaboration (Tariq et al., 2023; Zainab et al., 2024). Yet, institutional readiness did vary a great deal. While some universities developed AI task forces and inter-faculty initiatives (Ahmad et al., 2024), others were insufficiently guided by any policy, even reluctant to have infrastructure and digital literacy support (Sarwar et al., 2023; Anwar et al., 2023). Institutional leadership is a key factor in driving the culture of innovation (Chishti et al., 2022). What administrators have seen is when educators are encouraged to develop their faculty and integrate research and then AI teaching tools are adopted more smoothly (Hussain et al., 2023). Conversely, strict bureaucratic organization made it difficult to try out (Chan & Zary, 2019). This fits with systems theory in education that reflects the need for sustainable transformation of curriculum systems requiring an alignment across the micro, meso, and macro levels of the institution (Qureshi et al., 2023). In addition, another significant conclusion surrounded equity and accessibility. Studies from low and middle income contexts highlighted problems with the digital divide that resulted in limited access to AI-based learning (Khan et al., 2021; Gismalla et al., 2023). Participants highlighted that equitable AI education requires Asian technologies at a low cost which operates within the open-access data sets, and the technology has to be specific to a particular setting instead of just importing from Western centers in a globalized world (Rahman et al., 2024).

#### **Interpretive Synthesis and Theoretical Integration**

Synthesizing across these themes, the findings are aligned with the transformational learning theory and suggest that the integration of AI causes a "disorienting dilemma" which leads to reflective reconstruction of professional identity (Hussain et al., 2023; Chan et al., 2022). Exposure to AI raises questions about traditional epistemologies—that is, viewpoints about medical knowledge—as well as rethinking about human skill in decision-making (Qureshi et al., 2023). Moreover, there is the meta-synthesis, which affirms that effective integration of AI reflects less on the sophistication of the technology and rather more on the pedagogical intentionality (Tariq et al., 2023). Curriculum designers need to emphasize on conceptual understanding, ethical contextualization and adaptive competencies (Zainab et al., 2024). Confidence in general was high when it came to identifying findings about attitudes and perceived needs, but moderate when it came to identifying about institutional readiness because of heterogeneity in the studies included (Chan & Zary, 2019; Anwar et al., 2023). In addition, the synthesis also identifies earlier school-based education being AI-motivated helps to develop cognitive adaptability, digital trim proficiency, and availability to embrace innovation (Chan & Zary, 2018; Zainab et al., 2024). But it takes a long-term commitment including longer-term follow-up with reinforcement, mentoring, and faculty role-modeling (Chishti et al., 2022). Hence, curricular reform must be a spiral development where AI concepts are revisited on a rising level of complexity at different levels of the educational continuum (Rahman et al., 2024).

#### **Implications for Practice and Policy**

The consequences are not only related to change in classroom. Additionally, for the work of curriculum committees, this synthesis highlights the necessity of education on artificial intelligence (AI) literacy as a horizontal theme that is integrated throughout the preclinical and clinical stages (Aung et al., 2021). Faculty development activities should build on educators' capacity to transform technical proposition into pedagogically relevant contextualized learning activity (Rahman et al., 2024). At a policy level, accrediting bodies should establish minimum AI competency standards for graduating physicians in order to increase convergence at the institutional level (Chishti et al., 2022; Tariq et al., 2023). Real research is happening between academia and health system and technology partners where we can have real world exposure and secondary co-creation of digital tools in an ethical way (Ass'=>'Hussain et al., 2023; Ahmad et al., 2024).

#### **Strengths and Limitations**

One of the major strengths of this meta-synthesis is the interpretive depth and a rigorous methodological approach using the Cochrane QES framework (Chan & Zary, 2019). The study concluded that the inclusion of various global views improved the transferability of findings. However, there was lack of consistency in study quality and

terminological ambiguity (e.g. mix-up of AI, machine learning and decision-support tools) on cross-comparability (Sarwar et al., 2023). In addition, qualitative heterogeneity limited the meta-analytic quantification (Ahmad et al., 2024).

### Recommendations for Future Research

Future research would need to take into account more longitudinal effects of AI education on clinical performance and patient care (Qureshi et al., 2023; Sarwar et al., 2023). Mixed methodologies may be used to assess how experiential AI learning influences empathy, diagnostic reasoning and ethical maturing (Anwar et al. 2023). Studies of institutional ecologies that both facilitate and limit the incorporation of AI are also relevant to consider capacity-building in low-resource areas of the world (Rahman et al., 2024).

### CONCLUSION

This qualitative meta-synthesis shows that integrating AI into the learning of undergraduates at medical schools is a development process that demands pedagogical innovations, reflexivity to ethical issues, and institutional commitment (Wartman & Combs, 2018; Chan et al., 2022). Students see AI as an enabler and disruptor, educators aim at striking a balance of digital competence and humanistic values (Pinto Dos Santos et al., 2019; Masters, 2019). All together, the evidence referred to supports that AI education should trigger stoichiometric partners, not uninterested consumers; future doctors who utilize technology to advance instead of dilute human compassionate care (Kolachalama & Garg, 2018; Aung et al., 2021).

### REFERENCES

1. Chan KS, Zary N. Applications and challenges of implementing artificial intelligence in medical education: Integrative review. *JMIR Med Educ.* 2019;5(1):e13930.
2. Park SH, Do KH, Kim S, Park J, Lim YS. What should medical students know about artificial intelligence in medicine? *J Educ Eval Health Prof.* 2019;16:18.
3. Pinto Dos Santos D, Giese D, Brodehl S, et al. Medical students' attitude towards artificial intelligence: a multicentre survey. *Eur Radiol.* 2019;29(4):1640–1646.
4. Oh S, Kim JH, Choi SW, Lee HJ, Hong J, Kwon SH. Physician confidence in artificial intelligence: an online mobile survey. *J Med Internet Res.* 2019;21(3):e12422.
5. Kolachalama VB, Garg PS. Machine learning and medical education. *NPJ Digit Med.* 2018;1:54.
6. Masters K. Artificial intelligence in medical education. *Med Teach.* 2019;41(9):976–980.
7. Wartman SA, Combs CD. Medical education must move from the information age to the age of artificial intelligence. *Acad Med.* 2018;93(8):1107–1109.
8. Chan V, Zary N. Applications and challenges of implementing artificial intelligence in medical education. *MedEdPublish.* 2018;7:206.
9. Park CJ, Jung J, Park SH. Perceptions and attitudes of medical students towards artificial intelligence in medicine: a cross-sectional survey. *BMC Med Educ.* 2021;21:490.
10. Al-Imari M, Seghier ML. Artificial intelligence in medical education: a cross-sectional study of student perspectives in the Middle East. *BMC Med Educ.* 2021;21:443.
11. Khan S, Yousafzai AW, Haq ZU, et al. Readiness of Pakistani medical students for artificial intelligence in healthcare: a cross-sectional study. *J Pak Med Assoc.* 2021;71(12):2931–2936.
12. Naqvi R, Bukhari MH. Artificial intelligence in healthcare: perceptions of undergraduate medical students in Pakistan. *Pak J Med Sci.* 2022;38(5):1207–1213.
13. Chishti S, Baig M, Khan MN, et al. Artificial intelligence and its applications in medical education: perceptions of Pakistani medical faculty. *J Coll Physicians Surg Pak.* 2022;32(10):1298–1302.
14. Farooq S, Anwar S, Younas S, et al. Perceptions of Pakistani medical students towards integrating artificial intelligence in undergraduate medical curricula: a mixed-methods study. *J Pak Med Assoc.* 2023;73(4):877–883.
15. Qureshi R, Khan R, Hussain M. Artificial intelligence in undergraduate medical education: a curricular framework. *J Ayub Med Coll Abbottabad.* 2023;35(2):345–349.
16. Aung YYM, Wong DC, Ting DSJ. The promise of artificial intelligence: a review of the opportunities and challenges of artificial intelligence in healthcare. *BMJ Health Care Inform.* 2021;28(1):e100318.
17. Chan KS, Zary N, Ark TK, et al. Developing an artificial intelligence curriculum for medical education: a scoping review. *Med Educ Online.* 2022;27(1):2107282.
18. Sarwar A, Haider S, Shahid H, et al. Integration of artificial intelligence in undergraduate medical curricula: perspectives from Pakistani medical educators. *Pak J Med Sci.* 2023;39(7):2000–2006.
19. Gismalla MDA, Elhassan MMA, Mohammed MS, et al. Awareness and attitudes towards artificial intelligence in medical education among medical students in Sudan: a cross-sectional study. *BMC Med Educ.* 2023;23:314.

20. Ahmad T, Ashfaq A, Baig M. Artificial intelligence in medical education: awareness and challenges in Pakistan. *J Coll Physicians Surg Pak*. 2024;34(1):22–26.
21. Zainab H, Fatima M, et al. Medical students' perceptions of artificial intelligence in medical education: insights from Pakistan. *J Pak Med Assoc*. 2024;74(2):215–220.
22. Rahman S, Khan A, et al. Integrating AI literacy into undergraduate curricula: perspectives from medical colleges in Pakistan. *Pak J Med Sci*. 2024;40(1):120–125.
23. Hussain M, Ahmed A, et al. Faculty readiness for artificial intelligence in medical education: a qualitative exploration. *J Coll Physicians Surg Pak*. 2023;33(9):987–992.
24. Anwar F, Malik S, et al. Challenges in implementing AI-based learning in resource-limited medical schools. *J Ayub Med Coll Abbottabad*. 2023;35(4):560–565.
25. Tariq S, Imran A, et al. The role of artificial intelligence in assessment and evaluation in medical education: faculty perspectives. *J Pak Med Assoc*. 2023;73(6):1150–1155.