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REVIEW

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Artificial intelligence integration in medical education in Pakistan: Current landscape, challenges, and future prospects

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ABSTRACT

Artificial Intelligence (AI) is transforming healthcare worldwide, and Pakistan's medical schools are increasingly recognizing its potential. This review synthesizes research on the integration of AI into medical education across Pakistan, focusing on the knowledge, perceptions, and practices of medical students and educators, as well as institutional efforts and policy developments. Studies from 2019 to 2025 indicate strong enthusiasm among Pakistani medical students for AI, with the majority acknowledging its importance for their future careers. However, a significant gap exists between this enthusiasm and actual proficiency in AI, with many students reporting limited exposure to the technology in their curricula. In September 2025, Aga Khan University introduced a five-year integrated AI curriculum for MBBS and nursing students, representing a notable institutional initiative in AI-oriented medical education. Simultaneously, the National AI Policy 2025 is encouraging AI integration across sectors, including healthcare, through government funding, the creation of Centres of Excellence, and organized training initiatives. Despite these advancements, challenges remain. Many educators feel unprepared to teach AI due to insufficient training opportunities, and technical infrastructure in medical schools is often inadequate. Ethical concerns, particularly Around AI accuracy, fairness, and data ownership, continue to present significant obstacles. This review outlines these challenges and proposes a phased framework intended to support the responsible integration of AI into medical education in Pakistan.

KEY WORDS

Artificial intelligence, Medical education; AI curriculum; Digital health literacy; Medical informatics; Implementation science

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Introduction

Global context and rationale

Artificial Intelligence (AI) is revolutionizing healthcare globally, with applications ranging from radiology, where it assists in reading X-rays, to the discovery of new drugs and aiding robotic surgeries [1,2]. Education is also undergoing a transformation, with AI enhancing teaching methods through adaptive learning, smart tutoring, automated grading, and platforms like ChatGPT [3]. Given the rapid advancements in AI, it is crucial that new physicians are equipped with a solid understanding of its fundamentals, including its integration into clinical practice, its limitations, potential biases, ethical considerations, and regulatory aspects [4,5].

For Pakistan, this shift extends beyond a technological trend and reflects emerging systemic pressures within healthcare and medical education. With approximately 80 recognized medical schools in the country, producing over 15,000 MBBS graduates annually to serve a population of over 240 million, integrating AI into medical education is critical [6]. Recent studies conducted between 2023 and 2025 have highlighted both the growing interest in AI among medical students and the gaps in their training, infrastructure, and ethical awareness [7].

Pakistan's medical education context

Pakistan's medical education system faces significant challenges, including budget constraints, high student-to-teacher ratios, intermittent clinical training, and patchy digitization, especially in rural institutions. While public and private medical schools vary in terms of resources and infrastructure, the digital divide remains a major concern.

Despite these challenges, there is a growing workforce of over 100,000 new computer science graduates entering the job market each year, and the field of AI and data science is expanding rapidly. With over 60% of the population under the age of 25, Pakistan's younger demographic is well-positioned to adopt new technologies, including AI, presenting an opportunity to integrate AI into medical education.

Two recent developments are particularly noteworthy:

- The National AI Policy 2025 was approved by the Federal Cabinet, which emphasizes the integration of AI across various sectors, including healthcare and medical training. This policy outlines actionable measures for skill development, training, and infrastructure enhancement [8].
- Aga Khan University launched Pakistan's first fully integrated, five-year AI curriculum for both MBBS and nursing students in 2025, marking a significant step toward embedding AI into medical education [9]. This program integrates AI into various aspects of medical training, aiming to enhance educational competence and foster meaningful learning.

Research gap and purpose of the study

While there is a growing body of literature on the integration of AI in medical education globally, most studies are centered outside of Pakistan. One notable exception is a recent mixed-methods study conducted in Pakistan, which examined the integration of AI in medical education. This study identified

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early signs of interest in AI, but also pointed to significant barriers, including insufficient training, limited institutional readiness, and ethical concerns [7]. Empirical studies from 2023-2025 have consistently highlighted a strong enthusiasm for AI among medical students, yet many institutions lack the infrastructure and curriculum to adequately prepare students for its integration in healthcare [7].

This paper aims to address the following objectives:

- Analyze the current Knowledge, Attitudes, and Practices (KAP) of medical students and educators in Pakistan regarding AI.
- Assess the evolving policies and institutional efforts related to AI integration.
- Identify and evaluate the multi-level barriers to the sustainable incorporation of AI in medical education.
- Examine the benefits of national reforms and institutional initiatives.
- Propose a structured, step-by-step approach for responsible and equitable AI integration over the next five years.

The emergence of national policy initiatives and early institutional reforms suggests that Pakistan is entering an important transitional phase in its AI integration efforts. This paper seeks to provide evidence-based recommendations to harness the enthusiasm for AI while ensuring its ethical, long-term integration into Pakistan's medical education system.

Methods

Study design

This paper utilizes a narrative review approach to synthesize the existing literature on the integration of Artificial Intelligence (AI) in medical education in Pakistan. This methodology consolidates diverse perspectives from empirical studies, policy documents, institutional reports, and grey literature to provide a comprehensive understanding of the current landscape, challenges, and future prospects of AI integration in medical education. The aim of the review is to identify key patterns, highlight gaps, and explore opportunities for AI implementation in Pakistan's medical education sector. An integrative approach was employed to triangulate both qualitative and quantitative data from multiple sources, ensuring a well-rounded and comprehensive synthesis of the issue.

Information sources and search strategy

A systematic search strategy was developed to gather relevant literature from a range of credible sources:

- **Academic Databases:** The review included reputable academic databases such as PubMed, Google Scholar, and local repositories including JCPSP, JPMA, PJMS, and PJPH. Search terms included: "artificial intelligence" AND ("medical education" OR "MBBS" OR "undergraduate medical"), "AI literacy" AND "Pakistan", and "generative AI" OR "ChatGPT" AND "medical education."
- **Empirical Studies:** Focus was placed on empirical studies from 2023 to 2025, examining the knowledge, attitudes, and practices (KAP) of medical students and faculty regarding the integration of AI in medical curricula.
- **Policy Documents:** Key policy documents, such as the National AI Policy 2025, Higher Education Commission (HEC) policy reports, and other relevant government publications outlining AI's role in educational frameworks, were reviewed.
- **Institutional Innovations:** Information was sourced from institutional innovations, particularly Aga Khan University's AI curriculum, along with similar reforms at other medical schools across Pakistan.
- **Grey Literature:** In addition to peer-reviewed studies, grey literature, including conference reports, institutional documents, and media coverage, was reviewed to capture emerging trends and innovations within the field.

Justification for source selection

Sources were selected based on relevance, credibility, and timeliness. Preference was given to:

- **Peer-Reviewed Articles:** To ensure the incorporation of established knowledge and evidence from academic studies.
- **Government and Institutional Reports:** These were prioritized for insights into policy perspectives and institutional efforts related to AI.
- **Empirical Studies:** Only studies with sufficient methodological rigor, reliable sample sizes, and direct relevance to AI in medical education in Pakistan were selected. Grey literature was included to provide real-time insights into ongoing institutional changes and policy developments.

This selection approach allowed for a comprehensive view of both academic perspectives and the on-the-ground realities of AI integration in Pakistan's medical education landscape.

Minimizing bias

To minimize bias during source selection:

- A systematic search strategy was employed, ensuring a broad representation of studies from both urban and rural institutions in Pakistan, where feasible.
- Peer-reviewed articles and grey literature were incorporated, balancing the potential bias from either source type by relying on methodological rigor and cross-verifying findings.
- The inclusion of empirical studies was subject to a minimum sample size of 50 participants to ensure that results were representative of the broader population.

Limitations of source selection

Several limitations of the source selection process should be acknowledged:

- **Grey Literature:** While essential for capturing emerging trends, grey literature may include unverified data and potential biases due to the lack of peer review.
- **Geographical Bias:** Research from large urban centers was more readily available than studies from rural institutions, potentially skewing the representativeness of the findings.
- **Language Bias:** All included literature was in English, which may exclude valuable local insights published in Urdu or other regional languages, particularly in

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institutions outside the mainstream academic publishing outlets.

Data extraction and synthesis

The extracted data was categorized into key themes, focusing on areas directly relevant to AI integration in medical education:

- **State of AI Knowledge, Perception, and Activity within Institutions:** This theme captures the current understanding of AI among students and faculty and its existing use in medical education.
- **Obstacles and Challenges:** This includes individual, institutional, and systemic barriers to AI integration, including training gaps, infrastructure limitations, and ethical concerns.
- **Opportunities for Future AI Integration:** This theme explores potential strategies for AI adoption, focusing on policy reforms and institutional innovations like those seen at Aga Khan University.

The synthesis involved analyzing common patterns across the data, identifying barriers to integration, and highlighting opportunities for future action. Special attention was given to aligning national policy reforms, institutional initiatives, and student/faculty perspectives, ensuring a comprehensive understanding of AI's potential in Pakistan's medical education system.

Current Landscape of AI in Medical Education in Pakistan

Knowledge, attitudes, and practices among medical students

Recent studies show that while medical students in Pakistan recognize the significance of Artificial Intelligence (AI) for their future clinical practice, there is a gap in actual knowledge and exposure to AI in the curriculum [7]. For example, a study at CMH Medical College Lahore found that while 95.9% of students reported having a good understanding of AI, only 37% believed their institution provided sufficient resources to learn about it [10].

Knowledge and Awareness

A mixed-methods study conducted at CMH Medical College Lahore (March - May 2024) involving 152 students found the following:

- 95.9% of students reported good knowledge of AI.
- 84% recognized a basic level of understanding of AI (mean Likert = 3.84/5).

However, despite this self-assurance, there was a mismatch between students' confidence and their actual training in AI:

- 56% disagreed that their curriculum offered adequate coverage of AI.
- Only 37% believed their institution had the necessary AI educational resources [10].

This discrepancy highlights a gap between enthusiasm and preparedness, with students expressing interest in AI but lacking the educational opportunities to gain practical skills.

Attitudes toward AI integration

The CMH study demonstrated strong support for integrating AI into medical education:

- 72% of participants agreed that AI would improve their learning experience.
- 59% supported including AI in medical courses.
- 75% believed AI would be beneficial in medical education.
- 71% agreed that AI could enhance understanding and retention of concepts.
- 67% viewed AI as a key component of future clinical practice.

These findings align with a 2022 national survey, which found that 81.8% of doctors and 70% of medical students believe that AI will enhance diagnostic accuracy without replacing clinicians [11].

Concerns and perceived risks

Despite the positive outlook, students raised several concerns:

- 51% feared job displacement due to AI.
- 56% cited a lack of ethics in AI development as a major challenge.
- 40% expressed doubts about the accuracy of AI-generated recommendations.

Additional qualitative feedback identified concerns regarding:

- Data privacy and security.
- Bias in AI algorithms.
- The dependence on automation.
- The erosion of empathy in AI-assisted healthcare processes.
- Poor digital infrastructure in medical institutions.

These concerns underline the need for ethical considerations and robust infrastructural support in the integration of AI.

Informal use of AI tools

Students have started using generative AI tools in their studies without formal training :

- 50% reported that AI-generated feedback improved their understanding (mean = 3.43/5).
- 50% found AI tools helpful in time management and studying efficiently.

This informal use reflects the growing influence of AI in students' study practices and emphasizes the need for more structured guidance on its appropriate and responsible use.

Table 1 . Summary of Pakistan-specific studies on AI in medical education (2024–2025).

Study	Institution / Setting	Population (n)	Primary Focus	Key Findings
Farooq & Usmani (2025)	CMH Medical College, Lahore	152 medical students	Knowledge, attitudes, practices; curriculum exposure; concerns	95.9% reported good AI awareness; 75% supported AI integration into medical education; the majority reported insufficient curricular exposure (Farooq & Usmani, 2025).

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Yousaf & Hasnain (2025)	Pakistan (mixed-methods study)	Medical education stakeholders (mixed)	AI in medical education; readiness; barriers; opportunities	Strong interest in AI integration, alongside gaps in formal training, institutional readiness/infrastructure, and ethical/governance concerns; (Yousaf & Hasnain, 2025)
Ahmed et al. (2022)	National cross-sectional study	Doctors & medical students	Attitudes toward AI in clinical practice	81.8% of doctors and 70% of students believed AI enhances diagnosis rather than replacing clinicians (Ahmed et al., 2022).
Regional Surveys (2024-25)	Multiple Pakistani medical colleges	Various (institution-dependent)	Attitudes and usage patterns of AI tools	75–90% support for integrating AI into the curriculum; widespread informal use of generative AI tools such as ChatGPT among students.

Faculty perspectives and readiness

Limited data is available on faculty attitudes in Pakistan, but preliminary findings from workshops and faculty development programs highlight key patterns:

- There is broad recognition among educators that AI is an essential tool in clinical practice and that future medical graduates must be AI-literate.
- However, many faculty members are concerned that integrating AI into an already packed curriculum will complicate teaching efforts.
- A common concern is the rise in academic dishonesty linked to generative AI tools in assignments.
- There is also a perceived lack of AI literacy among faculty, which affects their ability to teach AI concepts such as ethics, algorithmic biases, and clinical applications.

These patterns indicate the need for significant faculty development to enable meaningful AI integration into curricula.

Institutional initiatives: The Aga Khan University model

In September 2025, Aga Khan University introduced Pakistan's first fully integrated five-year AI curriculum for both MBBS and nursing students. This initiative provides an exemplary model of institutional reform in AI education.

Curriculum features

The curriculum includes:

- Integrated AI in basic sciences, clinical sciences, and professional development.
- Ethical use of AI, health data analytics, AI in clinical diagnosis, and remote patient monitoring.
- The curriculum is reviewed every 2-3 years and externally validated every 5 years.

Pedagogical features

The curriculum emphasizes:

- Interdisciplinary integration rather than isolated AI courses.
- Data literacy workshops and AI clinical tools.
- Teleconsultation training to address patient load.
- AI case scenarios that encourage practical application of knowledge.
- Emphasis on professional responsibility, ethics, and empathy when using AI.

This model illustrates how AI content can be embedded within biomedical curricula under well-resourced institutional conditions, offering insights that may inform adaptation in comparable settings.

Policy environment: National AI policy 2025

The Ministry of IT & Telecom published the National AI Policy 2025, which provides a comprehensive framework for integrating AI in education and healthcare in Pakistan [12].

Relevance for medical education

- The policy mandates the incorporation of AI education at all levels of the national curriculum, including higher education and professional training.
- Centres of Excellence (CoE-AI) will be established in major cities to support AI infrastructure and resource development.
- A national AI skill development programme will be launched, with a target of training 200,000 individuals per year by 2027.
- The policy aims to place 20,000 trainees in AI-related internships annually.

Healthcare priorities

- AI will focus on enhancing healthcare by digitizing health records, upgrading clinics, and expanding telemedicine services.
- CoE-AI will collaborate with the Higher Education Commission (HEC) and medical universities to develop AI curricula for healthcare professionals.

Funding and research

The National Artificial Intelligence Fund (NAIF) will support:

- Up to 400 AI-related projects annually (with a maximum grant of PKR 1 million).
- 200 graduate AI research projects (with a maximum funding of PKR 200,000).

The policy signals a shift toward more coordinated national planning for AI development, although its sector-specific implementation in medical education remains to be fully operationalized.

Key Challenges to AI Integration in Pakistani Medical Education

AI has garnered significant enthusiasm and attention from policymakers, which should theoretically ease its integration into Pakistan's medical education system. However, the reality is more complex, as various obstacles remain at the personal,

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organizational, and systemic levels. These challenges must be addressed collectively to ensure that AI integration is successful and sustainable. Without a unified approach, the necessary changes may not be achieved.

Individual-level challenges

Knowledge action gap

Despite widespread recognition of AI's importance, a significant knowledge-action gap exists among medical students. While many students acknowledge the relevance of AI to their future clinical practice, their actual knowledge and exposure to AI in the curriculum remain limited. A study at CMH Medical College Lahore (2020) found that 95.9% of students reported having "good knowledge" of AI. However, many of these students also reported a lack of exposure to AI-related content in their medical curricula, coupled with an inability to interpret AI-derived results [10]. This suggests a misalignment between perceived knowledge and actual competence, highlighting the need for targeted AI literacy programs that bridge this gap and align theoretical knowledge with practical applications in medical practice [13,14].

Faculty capacity gaps

Another key issue is the lack of preparedness among faculty. Most medical educators in Pakistan have been trained in traditional curricula, with limited exposure to computer science, data science, or algorithmic thinking. This has resulted in:

- Limited understanding of AI fundamentals.
- Insufficient confidence in teaching AI-related concepts.
- Uncertainty about AI's integration into an already crowded medical curriculum.

These faculty challenges point to the urgent need for comprehensive faculty development programs to equip educators with the necessary skills and confidence to teach AI effectively in medical education.

Partial ethical and critical appraisal literacy

Students have expressed concerns about the ethical implications of AI, particularly regarding:

- Job displacement (51%).
- Ethical concerns (56%).
- Data privacy and accuracy issues (40%).

These concerns stem from a lack of formal training in AI ethics, algorithmic bias, and the legal aspects of AI use in healthcare [10]. Without clear instruction on these critical topics, students are left to navigate AI's risks and potential with only basic awareness, which could lead to the misuse of AI technologies in clinical practice. Addressing this gap requires dedicated modules on AI ethics, regulation, and data governance.

Institutional-level challenges

Diversity and integration issues within the curriculum

AI poses significant challenges within the context of Pakistan's dense and traditional MBBS curricula. Key questions remain about how to effectively incorporate AI:

- Should AI be taught as a separate discipline or integrated into existing subjects?
- How should institutions balance AI with biomedical disciplines, which remain the core of medical education?
- What specific technical skills should be taught to ensure graduates are AI-literate?

Without a strategic approach to curriculum reform, AI risks being treated as an elective rather than a core subject, hindering its potential impact on medical education.

Shortage of required infrastructure

Teaching AI in medical education demands advanced infrastructure, which is lacking in many institutions:

- Reliable internet connectivity.
- Modern computing resources.
- Access to AI-integrated software and platforms.
- Dedicated spaces for digital learning.

The CMH study revealed that only 37% of students believed their institution had sufficient AI teaching resources. This issue is particularly pronounced in rural and public institutions, where access to digital tools is more limited, exacerbating the digital divide.

Absence of institutional policies on AI

Most medical schools in Pakistan lack clear institutional policies on the use of AI in medical education, including:

- The appropriate academic use of AI.
- Access to AI tools and related data privacy and security measures.
- Detection of AI misuse (e.g., plagiarism).
- Ethical issues surrounding the covert use of AI by students and faculty.

The absence of standardized policies has led to inconsistencies in how AI is taught and used, leaving faculty with too much discretion regarding AI's integration into the curriculum [15].

System level challenges

National AI policy framework gaps

While the National AI Policy 2025 aims to create a framework for AI integration in various sectors, including healthcare, specific guidelines for medical education are still lacking:

- There are no AI competency standards for MBBS graduates.
- No accreditation or licensing frameworks for AI education have been developed.
- There is limited collaboration between key stakeholders, such as the Pakistan Medical Commission (PMC), the Higher Education Commission (HEC), and the Ministry of IT & Telecom, which hinders cohesive policy implementation.

These gaps prevent medical schools from aligning their curricula with national AI standards and stifle systemic AI integration in education.

Limited local AI infrastructure and datasets

Most AI tools are developed using data from high-income countries, which do not always reflect Pakistan's diverse epidemiology and health system constraints. The development of local AI tools requires:

- Representatively secure datasets.

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- Collaboration between computer scientists and clinicians.
- Robust data governance.

Without this localized infrastructure, context-specific AI training remains unfeasible.

Potential deepening of educational inequities

The unequal adoption of AI in medical education could deepen existing educational inequities in Pakistan. As well-resourced urban institutions integrate AI, under-resourced rural colleges may fall behind, resulting in:

- A two-tiered medical education system.
- Graduates with unequal proficiency in AI, potentially compromising patient care.
- Widening educational disparities between rural and urban students.

Equitable access to AI education must be prioritized to ensure that all medical students, regardless of location or institution, have the opportunity to become AI-literate healthcare providers [16].

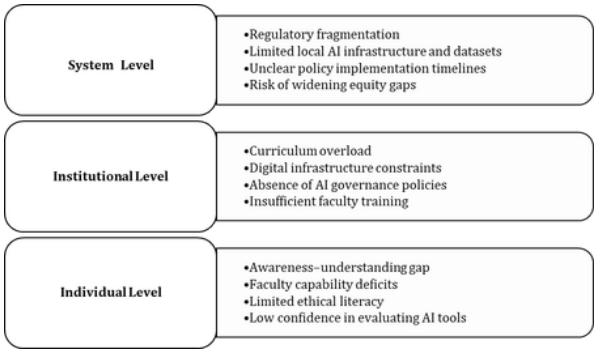

Figure 1. Multi-level barriers to AI integration in Pakistani medical education.

Future Opportunities and Prospects

While the previous sections highlight the challenges facing AI integration in Pakistan's medical education, there are significant opportunities for advancing AI adoption. These opportunities arise from institutional innovations, national policy support, and the country's growing expertise in computer science and data analytics.

Models of institutional innovations

A notable model for AI integration in medical education is Aga Khan University (AKU)'s longitudinal AI curriculum, which marks a significant milestone in AI education. The program provides a framework for nationwide adaptation and showcases several key features that can guide other institutions:

Strategic vision and leadership commitment

The success of the AKU curriculum is attributed to strong institutional leadership and support from academic deans and multidisciplinary faculty teams. This leadership ensures that AI integration is prioritized, with faculty actively involved in the process.

Longitudinal, competency-based educational design

The five-year AI curriculum at AKU incorporates AI-related competencies into basic medical sciences, clinical education, and professional development. This approach aligns with global best practices by integrating AI as part of a competency-based model, rather than offering it as a separate subject [17, 18].

Inclusion of diverse disciplines

The curriculum was developed collaboratively with clinicians, computer scientists, ethicists, and educational experts, ensuring a comprehensive approach to content, ethical frameworks, and clinical relevance.

Iterative curriculum development

The curriculum is reviewed every 2-3 years and validated externally every five years to incorporate the latest technological advancements and global educational standards. This iterative approach ensures that AI education remains relevant and up to date.

The features of the AKU model demonstrate its potential as a scalable template for other institutions seeking to modernize their curricula with AI.

Encouraging policy environment

The National AI Policy 2025 provides the structural support needed for widespread AI integration in medical education. Key policy initiatives include:

Strategic instructions and infrastructure

- National curriculum integration of AI across all levels of education.
- Establishment of AI Centres of Excellence (CoE-AI) in major cities, with regional hubs in Peshawar, Quetta, Faisalabad, and Hyderabad.
- Training programs aimed at producing 200,000 AI specialists annually by 2027 and offering 20,000 AI internships per year.

AI healthcare and medical training

The policy outlines initiatives to integrate AI into healthcare, including the digitization of health records, the enhancement of telemedicine, and the development of AI-driven diagnostic and decision-support tools. These efforts will equip medical graduates with the necessary skills to apply AI effectively in healthcare settings.

Research and funding initiatives

The National Artificial Intelligence Fund (NAIF) will fund AI-related projects, with an annual allocation for 400 projects (maximum PKR 1 million) and 200 postgraduate AI research projects (maximum PKR 200,000 each). This funding will facilitate collaboration between medical schools and computer science departments, driving locally relevant innovations in AI.

The policy framework supports both structural development and institutional capacity building, positioning Pakistan to transition from isolated initiatives to systemic, nationwide AI integration in medical education.

Practical applications of Artificial Intelligence in medical education

Given Pakistan's limited resources and varied infrastructure, there are several short- and medium-term AI applications that could significantly enhance medical education:

Personalized and adaptive learning

AI-powered systems can help create customized learning paths, particularly useful in large classes. Key applications include:

- Adaptive question banks.

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- Automated feedback systems.
- Generative AI tools to explain complex concepts in simpler terms.

These tools can support individual learning, especially in contexts where student-to-teacher ratios are high.

Clinical reasoning and simulation

AI-based case generators and virtual patient tools can provide students with diverse examples of clinical cases, enhancing diagnostic reasoning and compensating for the limited clinical placements in some institutions. These tools require minimal infrastructure and are effective for addressing pedagogical challenges.

Automation of assessment and feedback

AI-supported assessment tools can assist in:

- Automated grading of short-answer questions.
- Analysis of student performance trends.
- Quick generation of feedback after assessments.

These tools help maintain academic rigor while reducing faculty workload, enabling more efficient use of instructional time.

Practice-based evidence and synthesis of literature

AI tools can assist students with managing vast amounts of medical literature, synthesizing evidence, and conducting critical appraisals. This aligns with global trends in digital scholarship, enhancing students' ability to engage with the evolving body of medical knowledge.

AI in teaching radiology and pathology

AI tools in diagnostic specialties, such as radiology and pathology, can help students understand:

- Augmented diagnostic workflows [19, 20].
- The strengths and weaknesses of algorithmic procedures.
- The importance of human oversight in AI-assisted diagnoses.

These tools, though requiring sophisticated infrastructure, offer medium-term benefits for enhancing diagnostic education.

Table 2 . Feasible AI use-cases in Pakistani medical education (Enhanced Presentation).

Domain	AI Tool / Approach	Educational Application	Feasibility	Implementation Timeline
Self-Study	Adaptive question banks; Large Language Models	Personalized practice, concept reinforcement	High	2025–2026
Clinical Reasoning	AI case generators; virtual patients	Scenario-based diagnostic training	Medium	2026–2027
Assessment	Automated scoring aids; pattern analysis tools	Support for grading and feedback workflows	Medium	2026–2027
Evidence-Based Practice	AI literature search engines	Research training and evidence synthesis	High	2025–2026
Imaging and Diagnosis	AI-enhanced diagnostic tools	Radiology and pathology education	Medium–Low	2027–2028

Pakistan's competencies in computer science and AI research

Pakistan's growing competence in computer science and AI research presents a significant opportunity for advancing medical education. Leveraging this potential is crucial for the successful integration of AI in the country's medical curriculum.

Human capital

- Every year, approximately 100,000 new computer science graduates enter the workforce in Pakistan, providing a substantial talent pool to support AI integration in various sectors, including healthcare.
- Research capacity in AI is rapidly expanding, with increasing activity in both the university sector and private sector AI research labs. This growing expertise is key to driving innovation and developing local AI solutions tailored to Pakistan's healthcare needs.

Potential for development in applied AI

Collaborations between medical colleges and computer science departments have the potential to accelerate several key areas of AI development:

- Building regionally appropriate AI datasets for prevalent health conditions such as Tuberculosis, Dengue Fever, Diabetes, and others, ensuring AI tools are relevant to the local healthcare context [20].
- Developing AI diagnostic tools that are tailored to Pakistan's specific health challenges, enhancing diagnostic accuracy and support for clinicians.
- Creating tools to explore the fairness, safety, and explainability of AI systems within Pakistan's healthcare system, addressing ethical concerns and ensuring responsible AI deployment.

These partnerships will not only enhance the breadth and depth of AI education in Pakistan but also position the country at the forefront of the digital health field, contributing to a global conversation on the ethical, practical, and effective use of AI in healthcare.

Proposed Framework: Phased AI Integration in Pakistani Medical Education

This paper proposes a three-phase implementation plan (2025–2030) for the systematic, equitable, and sustainable integration of AI into Pakistan's medical education system. The plan aims to align national policy objectives, AI education

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best practices, institutional integration capabilities, and Pakistan-specific challenges.

Phase 1: Foundations and awareness (2025–2026)

Objectives

The goal of Phase 1 is to establish the foundational infrastructure necessary for AI integration into medical education. This includes:

- Building institutional integration capabilities.
- Improving the understanding of AI fundamentals among educators and students.
- Institutionalizing policies and governance structures to support AI.
- Launching pilot AI-driven educational tools.

Key Actions

Institutional AI committee development

Each medical college should establish a multi-disciplinary AI steering committee with representation from faculty, IT personnel, administrators, and students. These committees will be responsible for planning AI integration, capacity-building, and policy development.

- **Faculty training and development**

  The first faculty training program should focus on:

  - Understanding core AI concepts.
  - Pedagogical applications of AI tools.
  - Pedagogical applications of AI tools.
  - Curriculum design for AI-integrated education.

This phase should aim for at least 500 faculty members to complete AI literacy programs.

- **Basic AI literacy for students**

  All first-year MBBS students should complete an AI awareness module [21] (8-12 hours), covering:

  - Basic AI definitions and how it functions.
  - Clinical use cases and current limitations.
  - Ethical concerns: bias, fairness, and accountability.
  - AI-assisted decision-making and critical appraisal.

- **Pilot AI learning initiatives**

  Medical institutions should implement pilot projects such as:

  - Adaptive question databases in subjects like pathology and pharmacology.
  - AI-enabled clinical case discussions.
  - Generative AI tools for basic science study aids.

- **Development of institutional AI policies**

  Institutions should establish clear policies covering:

  - Responsible AI usage by students and faculty.
  - Academic integrity and the detection of AI-assisted plagiarism.
  - Data privacy and security in AI applications.

Measurable outcomes for Phase 1

- AI committees established in 80% of medical schools.
- 500 faculty members trained in AI fundamentals.
- AI literacy modules completed by all first-year MBBS students.
- 5-10 pilot AI learning initiatives implemented.
- Institutional AI policies adopted in 20 colleges.

Phase 2: Systematic curriculum integration (2027–2028)

Objectives

Phase 2 will focus on the systematic integration of AI into the MBBS curriculum through competency-based education.

Key Actions

- **Curriculum integration across disciplines**

  AI-related competencies should be incorporated into:

  - Medical informatics.
  - Radiology and pathology rotations.
  - Research methodology courses.
  - Evidence-based practice and ethics courses.

This ensures AI is integrated longitudinally, rather than as a standalone subject.

- **Expanded faculty development**

  At least 1,000 faculty members should be trained in:

  - Applied AI in medical practice.
  - Pedagogical design for AI-based education.
  - AI ethics.
  - Using AI tools in clinical teaching settings.

- **Cross-departmental collaborations**

  Formal partnerships should be established between medical schools and computer science departments to:

  - Facilitate integrated teaching of AI.
  - Develop AI tools and share datasets for teaching and research.

- **Creation of medical AI datasets**

  There should be funding to develop regionally appropriate AI datasets (e.g., for radiology, dermatology, and infectious diseases) that align with local healthcare needs.

- **Curriculum and assessment redesign**

  MBBS assessments should include:

  - Questions on AI literacy.
  - Evaluation of the interpretation of AI-generated responses.
  - AI ethics in clinical scenarios.
  - Analysis of algorithmic recommendations.

Measurable outcomes for Phase 2

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- AI learning outcomes are included in 40 medical schools.
- 10+ collaborations between computer science and medical faculties.
- Creation of two or more national medical AI datasets.
- 1,000+ faculty members trained in advanced AI.
- 30% of assessments incorporate AI-related competencies.

Phase 3: System-level consolidation and scaling (2029–2030)

Objectives

Phase 3 aims to establish uniform AI competencies across the medical education system in Pakistan, focusing on equitable access and scalable integration.

Key Steps

Development of a national AI competency framework

The Pakistan Medical Commission (PMC) and Higher Education Commission (HEC) should collaborate to develop a national competency framework for AI, which should include:

- Core AI knowledge and skills for medical graduates.
- Ethical and legal reasoning related to AI.
- Application of AI-assisted clinical tools.

This framework should be incorporated into accreditation and licensing standards [22].

- **Integration of AI into Licensing Exams**

  AI literacy and competency should be included in the national medical licensing exam (NLE), ensuring that all graduates possess a foundational understanding of AI.

- **Equity-Focused Support for Under-Resourced Institutions**

  Rural and public-sector institutions should receive additional funding, infrastructure, and faculty development support to ensure they are not left behind in AI integration efforts.

- **Scaling Successful Models Nationwide**

  Successful initiatives, such as AKU's AI curriculum, should be disseminated through academic consortia and national training networks, ensuring that best practices are shared and scaled across the country.

- **Strengthening the Research Ecosystem**

  Research should focus on:

  - The impact of AI on medical teaching and learning.
  - Healthcare ethics in AI applications in Pakistan.
  - Developing local datasets for AI.
  - Assessing AI equity and bias.

Measurable Outcomes for Phase 3

- National AI competency framework implemented in 75–90% of medical schools.
- AI subjects included in licensing exams.
- 15,000 MBBS graduates per year trained with AI competencies.
- Initiation of 5+ major AI-related projects in medical education.
- Reduced urban-rural disparities in AI education access.

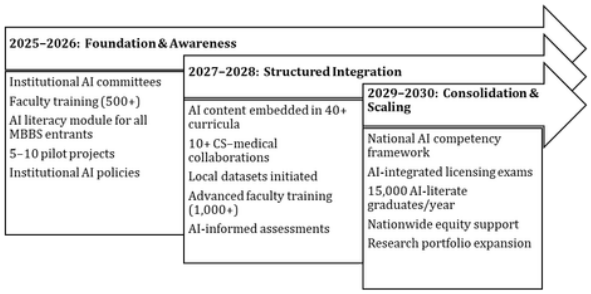

Figure 2. Phased roadmap for AI integration in Pakistani medical education (2025–2030).

Discussion

Synthesis: Current state and critical juncture

This research highlights that Pakistan's medical education system is on the verge of integrating artificial intelligence (AI). Several factors collectively present a unique opportunity to enhance the system, despite the challenges discussed earlier.

A key finding is the enthusiasm for AI among medical students, with 75–95.9% expressing a positive outlook and recognizing AI's relevance to their future clinical practice. This enthusiasm is consistent with global trends and demonstrates a clear demand for AI integration in medical curricula. Notably, students are already using generative AI tools for learning, even in the absence of structured educational support. This indicates a pressing need for institutional frameworks that can formalize this student-driven interest.

Moreover, the Aga Khan University (AKU) has demonstrated leadership in AI integration, offering the country's first longitudinal AI curriculum for MBBS and nursing students. This initiative serves as a practical model for other institutions and shows how AI can be effectively embedded within Pakistan's medical education system.

The National AI Policy 2025 provides a comprehensive framework for AI integration across Pakistan, focusing on education, healthcare, and infrastructure development. Pakistan is among the countries that have articulated a formal national policy addressing AI integration in education and healthcare, offering a coordinated strategic direction for future implementation.

Despite these advancements, gaps remain in students' knowledge and comprehension of AI, as well as challenges with faculty preparedness and institutional infrastructure. These issues, if unaddressed, could hinder the progress of AI integration and its long-term sustainability in medical education. Addressing these gaps is critical for maximizing the potential of AI to enhance medical training.

Comparison with global and regional context

Alignment with global trends

Globally, there is a growing optimism about AI's potential to revolutionize medical education. However, a disconnect remains between enthusiasm and readiness for AI integration in clinical practice. Similar to students in countries like Canada, Saudi Arabia, and Europe, Pakistani students express

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concern over insufficient exposure to formal AI education. Ethical concerns, such as bias, privacy, and job displacement, are also widespread, highlighting the need for robust training in AI ethics.

Distinctive National Strengths

Pakistan holds several unique advantages compared to other low- and middle-income countries (LMICs):

- A rapidly expanding pool of computer science graduates, with approximately 100,000 new graduates annually.
- Increasing research activity in AI, particularly in the private sector and universities.
- A digitally literate and predominantly young population, well-positioned to adopt new technologies.
- The establishment of a national policy framework specifically targeting AI integration.

Collectively, these factors suggest that Pakistan possesses enabling conditions that may support comparatively earlier AI adoption among some low- and middle-income countries, subject to implementation capacity.

Contextual Constraints

Despite these strengths, Pakistan faces challenges typical of LMICs:

- Disparities in digital infrastructure, particularly in rural areas.
- Limited faculty proficiency in advanced technologies.
- Insufficient resources in public institutions.
- Regulatory fragmentation, with overlapping responsibilities between various governmental bodies.

These structural challenges underscore the importance of ensuring equitable access to AI education and resources, particularly for under-resourced institutions in rural areas.

Critical success factors for implementation

Several critical factors must be addressed for the successful integration of AI into medical education in Pakistan:

Leadership

Strong leadership at both the institutional and national levels is essential for driving AI integration. A clear vision from academic leaders and policymakers is needed to transform AI from a buzzword into a core component of medical education.

Faculty Development

Faculty readiness is a significant factor in the success of AI integration. Curriculum changes must be supported by comprehensive faculty training that goes beyond one-time workshops. This should include ongoing professional development in AI pedagogy, AI ethics, and clinical applications of AI [23, 24].

Ethical Education

AI education should not only focus on technical aspects but also incorporate ethics as a central theme. Topics such as bias, fairness, data governance, and accountability should be embedded throughout the curriculum. Ethics should be a core component of the curriculum, not an afterthought [25, 26].

Equity

The digital divide in Pakistan's educational system poses a risk to the equitable implementation of AI. Efforts must focus on ensuring that AI resources and training are accessible to all institutions, including those in rural and under-resourced areas. Targeted investments in infrastructure and faculty development are necessary to prevent a widening gap between urban and rural institutions.

Context-Specific Research

Pakistan must prioritize local research on AI, focusing on the unique needs of its healthcare system. Research should explore the impact of AI on teaching, AI-related ethical issues, and the development of locally relevant AI tools. These efforts will help ensure that AI tools and practices are contextually appropriate and effective in Pakistan's healthcare setting.

Curriculum Flexibility

AI is a rapidly evolving field. The curriculum must be flexible and adaptable to keep pace with technological advances. Regular updates and revisions are necessary to ensure that students are taught the most current and relevant AI concepts.

Collaborative Efforts

The successful integration of AI requires a collaborative approach involving medical educators, computer scientists, ethicists, and policymakers. Interdisciplinary teams will be essential for creating a comprehensive, sustainable model for AI education in medical schools.

Limitations

This review presents several limitations that should be considered when interpreting the findings.

Scope and methodological constraints

As this is an integrative review rather than a systematic review, the search process may be subject to selection bias. The review relied on a range of sources, including academic databases and grey literature. However, it is possible that some relevant literature, particularly unpublished reports from institutions or literature still in the early stages of development, was not incorporated. As a result, the findings may not fully capture the breadth of available information on AI integration in medical education in Pakistan.

Geographical and institutional representation

Research on AI integration in Pakistan's medical education is predominantly concentrated in large urban centers and economically prosperous universities, particularly those with established research infrastructures. Consequently, there is a lack of data from rural or economically disadvantaged institutions, which limits the review's ability to provide a comprehensive understanding of AI adoption across the entire country. Thus, the findings may not fully represent the regional disparities in AI readiness or implementation within Pakistan's medical schools.

Language and publication bias

The review focused on English-language literature, which may have excluded valuable reports and studies published in

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local languages, such as Urdu. This language bias could result in the omission of important insights from regional policies, micro-level studies, and institutional reports that may have addressed AI adoption in less formal sectors of medical education. As such, the findings may not capture the full spectrum of AI integration in Pakistan's healthcare and educational contexts.

Time limitations

AI technology and related policies evolve rapidly, and many developments are still in their early stages. Given that new policies (such as those introduced in late 2024 and early 2025) were not yet fully implemented at the time of this review, this work may not reflect the most recent and ongoing shifts in AI adoption. Additionally, as AI integration in medical education remains in the early phases across many institutions, the evidence may not fully reflect the outcomes of long-term AI implementation.

Limitations of data in empirical studies

The volume of empirical research on AI in Pakistan's medical education is still relatively limited. Furthermore, much of the existing research is homogeneous, often based on small sample sizes from single institutions. Many studies rely on self-reported data, which can introduce biases in how participants perceive their AI knowledge, attitudes, and practices. These limitations hinder the ability to construct a coherent narrative on the effects of AI on medical education, particularly in terms of its impact on student skills and educational outcomes.

Generalizability outside Pakistan

Although the findings from this review may be relevant to other low- and middle-income countries (LMICs), the contextual specificity of Pakistan's policy landscape, institutional conditions, and digital infrastructure must be considered. The review's conclusions are closely tied to Pakistan's unique educational and healthcare system, and care must be taken when attempting to generalize these findings to other countries with different challenges or infrastructural capacities.

Conclusions

The integration of artificial intelligence (AI) in Pakistan's medical education is already underway and is not a distant possibility. AI is actively being utilized in daily student activities, and its incorporation into university curricula is gradually taking shape. At the national level, the emphasis on AI skill development in both education and healthcare is becoming imperative. As these factors reshape the landscape, medical education must adapt to equip future physicians for a workforce increasingly influenced by AI technologies.

Despite strong enthusiasm from students, who recognize the significance of AI for their future careers, the gap between excitement and competence remains significant. The majority of students lack the necessary knowledge and ethical understanding to use AI responsibly in patient care. The challenges are not limited to students alone—faculty preparedness is also a concern. Institutional resources remain unevenly distributed, and policy gaps hinder the integration process.

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