Integrating Artificial Intelligence in a Resource-Constrained Medical Colleges: Challenges, Dilemmas and Way Forward. A Review from Muhammad Medical College, Mirpurkhas

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ABSTRACT:
Like many other sectors, AI (artificial intelligence) is now finding its place into medical education as well. This integration of AI into medical education for middle and low resource institute having financial constraint is more challenging; while making pedagogic improvement using AI it is also imperative to retain the critical thinking and clinical reasoning skills of the students. This paper adopts a narrative review approach, synthesizing findings from peer-reviewed literature published between 2020 and 2025. Sources were identified through databases such as PubMed, Scopus, and Google Scholar using keywords including "AI in medical education," "resource-constrained curriculum," and "developing countries." The review focused on challenges, ethical dilemmas, and proposed solutions relevant to low-resource institutions. Selected studies were critically analyzed to identify recurring themes and practical recommendations that how AI can be incorporated while maintaining cognitive autonomy and striking a balance between technology and fluency, followed by suggestions for evidence-based but resource-efficient curriculum change.

Key words: Artificial Intelligence, Medical Education, AI integrated Medical Curriculum, Pakistan, Low- and middle-income countries.

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Introduction:

During last two decades AI is transforming various sectors and now finding its way into medical education as well. AI has potential to redressed medical curriculum, aid in diagnosis and management planning. Among various AI tools, Large Language Models (LLMs) such as GPT-4, PaLM, and Med-PaLM are commonly in use. LLMs are capable to be incorporated into medical education as these have capacity of personalized learning and teaching, provide clinical reasoning and even help in research. AI applications may provide virtual patient simulations and automated assessment systems; factors that enhance student engagement However, the use of AI has few limitations as well that includes bias, accuracy for local population and ethical concern. Therefore, successful integration of AI tools into Medical Education poses various hurdles in addition to resource limitation in low- and middle-income countries.

Muhammad Medical College (MMC) Mirpurkhas founded in 1998, recognized by Pakistan Medical & Dental Council and World Health Organization. Despite working with resource constraint MMC has secured National Prize for Excellence twice in row reflecting that MMC adhering to the rules of PMDC and WHO yet producing excellent results for both undergraduate / postgraduate students. The remarkable achievement of MMC is based upon the five pedagogical pillars to provide community-based learning and student-centered approach.

However, all institutions even those having resource constraint cannot ignore the rapid development/acceptance of AI and exponential growth of medical knowledge on every day basis. This review examined the challenges and dilemma of integrating AI in medical education without compromising critical thinking and innovative skills of students and therefore may provide roadmap for curriculum reform in resources constraint setting.

The Med-Ed AI Landscape of Pakistani Medical Education

AI Landscape of Pakistani Medical Education

As far as the current landscape of AI in Medical education of Pakistani institution is concerned, there is intense enthusiasm among those concerned however there are various deficiencies. These includes lack of formal training of AI at institutional level, deficient infrastructure and need assessment of curriculum reforms.[1]

Awareness and Attitude towards AI: Current status

Literature search showed that there is significant awareness of AI among both medical students and faculty. National published study reported that 98.5% students heard about AI and 71% consider that incorporation of AI into medical education can improve perspective.[2] Another study reported a positive attitude of both student and faculty towards integration of AI into the medical curriculum.[3] The use of AI into medical education has potential to improve learning task, simple explanation of difficult medical terms and write tutorial using different AI platforms.

Enthusiasm vs Education

Although there is much enthusiasm to use AI, there is critical knowledge gap both among students and faculty. published study reported that only 26% of students and 26.5% of faculty received formal training of AI[3]; while 95% students and 59.5% faculty members were knowing different AI application. [2] This reflects gap between enthusiasm for AI and its formal training resulting in superficial simple knowledge of AI by using internet search engines.[2]

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Policy-Level Directives and Practical Pilots.

Currently PMDC and HEC has not yet issued any dedicated policy for regulating use of AI into Medical Education. However, HEC has taken initiative for AI education across all universities of Pakistan while PMDC has advised to regularly update curriculum, assessment methods without formal AI policy. At Govt level there is awareness to align all academic Institutes with emending technology including AI. [1] Very recently the Pakistan Nursing and Midwifery Council (PNMC) has initiated collaborations to test autonomous AI education assistants designed to accelerate nursing training through adaptive learning–a crucial step given Pakistan's shortage of skilled nurses.[4]

Challenges and the Road Ahead

Current challenges with AI integration include ethical issues, data privacy and overzealous dependence on AI by students, resistance at Institutional and faculty level due to inadequate technological infrastructure and lack of regulatory framework. These issues need to be addressed so that AI integration into Medical Education may be done at appropriate time.

Briefly the AI for Medical Education in Pakistan is in its early infancy, it has support from faculty while students being more familiar with technology willing to accept AI integration into Medical Education. Yet gap being informal enthusiasm and formal structured education. This integration may successfully be achieved by sustained institutional support, addressing associated ethical issues and intensive capacity building of faculty.

Current State and Barriers:

Higher Education Commission and Pakistan Medical & Dental Council, though taken few steps regarding AI integration into degree awarding Institutes (For example module regarding introduction and uses of AI), however structured standardized policy/guidelines yet not issued. Few institutes at their own taken steps for integration of AI into medical education. The current barriers include, deficiency of infrastructure, faculty training, curriculum reforms, resources constraint, policy maker of degree awarding institutes as few still not convinced and consider AI as a threat to traditional methods of teaching, ethical concerns that includes privacy of patient data, as shown in table 1.

Table No 1: Barrier with brief description.

Barrier	Details
Infrastructure Limitations	Many medical colleges lack advanced computing facilities, reliable internet, or access to AI platforms.
Faculty Training Gaps	Few educators are skilled in AI, leading to reliance on external workshops or collaborations.
Curriculum Rigidity	Existing medical curricula are already overloaded, making it difficult to add AI modules without restructuring.
Cost & Resource Constraints	AI tools, licenses, and training programs are expensive, limiting adoption in public-sector institutions.
Awareness & Resistance	Some faculty and policymakers remain skeptical, viewing AI as a threat to traditional teaching or clinical judgment.
Ethical & Regulatory Concerns	Lack of clear guidelines on AI use in patient data, privacy, and medical decision-making slows integration.

We at Muhammad Medical College, conducted a cross-sectional survey of 451 participants (189 male, 262 female), comprising 346 medical students and 105 doctors from a tertiary care setting in Pakistan, during January-March 2026 (the article is being submitted for publication). Using the validated 15-item ISUM Affective Domain in AI Health Management Scale (ISUM-ADAI), we identified a two-factor structure: Factor 1, "Perceived Neglect by AI" (9 items, $\alpha = 0.892$), captures concerns that AI cannot address emotional needs, lacks empathy, and overlooks patients' feelings; Factor 2, "AI-Human Collaboration" (6 items, $\alpha = 0.871$), reflects beliefs that AI can be improved by integrating affective data with clinician input. Doctors scored significantly higher than medical students on total scores (mean difference 3.45, $p = 0.022$, $d = 0.25$), Factor 1 ($p = 0.041$, $d = 0.23$), and Factor 2 ($p = 0.027$, $d = 0.22$). Senior doctors scored higher than junior doctors on Factor 2 ($p = 0.002$, $d = 0.62$), and participants aged ≥30 years scored higher than younger participants on all measures ($p < 0.05$). Fifth-year students scored higher than first-year students on total scores ($p = 0.039$, $d = 0.44$). No gender differences were found. These findings indicate that professional experience and age strongly shape perceptions of AI's affective neglect, and the ISUM-ADAI is a valid, reliable instrument for measuring these perceptions in health management contexts. A similar study at Bolan Medical College, Quetta,[5] revealed that almost all teaching faculty lacked formal education on AI applications; however, the majority of the participants deemed specific training modules necessary. In Pakistan, some of the challenges include lack of technology infrastructure, inconsistent internet access, poor institutional policies and lack of faculty expertise.

The Global Perspective:

A systematic review and a narrative review of 19 studies (2015–2025) demonstrated that AI modalities such as ChatGPT, VR-based simulation, automated tutor, and decision-support tools improved examination performance, procedural skills, self-directed learning ideas and student engagement. However, when using AI, there is always risk of algorithmic bias, inaccuracy and patient data privacy breach necessitating continuous human oversight. A study published in Frontiers in Medicines [6] concludes that AI provides "personalized learning, adaptive assessment, and simulation-based training," yet pedagogical potential of AI should be used within ethical framework and by continuous faculty development.

Deploying AI Without Hindering Critical Thinking and Innovation. (Catch-22)

The biggest of all challenges, a medical educator currently facing is, the conflict while using AI as teaching tool and sustaining the cognitive capabilities and practical skills of the students.

Challenges of Deskilling, Mis-skilling and Never-skilling

For critical thinking and clinical reasoning, the phenomenon of differential diagnosis is time tested, however while using extensive automation of AI, a medical student may not develop cognitive ability of critical thinking and reasoning. In a recent study published in New England Journal of Medicines [6] the terms deskilling, mis-skilling and never-skilling are highlighted as danger for medical education.

Deskilling is the loss of clinical competency due to overzealous dependence over AI machine tool. When using AI to teach medical students, students' may be trained in skills that do not match with international standards leading to mis-skilling. While never-skilling is simply never getting

any training in some areas for example with extensive machine dependent medical education student may not be familiar with interpersonal communication, empathy and role as team leader.

Automation Bias and Cognitive Erosion

Budzyń K et al [7] in a prospective multicenter study has shown that gastroenterologist once become accustomed to use AI assisted colonoscopy, when asked to performed colonoscopy at their own the ability to detect polys was 20% worse than it was before the onset of AI assisted colonoscopy; this reflects decline in cognitive decision making without AI. This is an example of automation bias adversely affecting procedural capabilities and clinical decision making.

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Cognitive Autonomy and "Thought-Skipping"

Izquierdo-Condoy JS [8] the effects of GenAI on critical thinking were evaluated and found that currently the evidence is inconsistent suggesting ways to enhance learner engagement after balancing non-participation and vulnerability to misinformation of the medical students and concluded that GenAI may impair cognitive autonomy of medical students when used without prior integration into curriculum after being critically and ethically evaluated.

While considering integration of AI into medical curriculum another factor worth considering is "LLM-brain rot" rightly point out is study (Texas A&M, UT Austin, and Purdue University). It has been observed that when LLMs are repeatedly exposed to low quality junk data leads to chronic cognitive deterioration in LLMs; that also includes skipping thoughts (the act of drawing conclusion without following a methodological reasoning process). Consequently "student face the risk of taking on similar behaviors themselves when they emulate such behaviors". Several recent studies [8-10] highlight concerns that AI use in medical education can undermine critical thinking and clinical judgment, particularly among novice learners who may over-rely on algorithmic outputs instead of developing independent reasoning.

The Innovation Paradox:

The cognitive erosion is bad enough, but there's a deeper fear: If students learn to settle for the answer of whichever AI model they happen to draw upon, then will they muster the curiosity, creativity and intellectual guts needed to challenge orthodoxy or produce inventive answers? Lujan, H.L [11] discussed "paradox of Knowledge" where students know more understand less. AI generated Information overload, structured, standardized learning with focus on examination leads to superficial learning and students are not well prepared to face the ground realities of the practice. This further aggravate when AI provides convenient answer and eliminate the use of mental practice which is necessary for mastery in practice

But there is a productive way forward. The "cyborg" and "centaur" models of human-AI collaboration – adaptive practices where clinicians critically engage with AI outputs rather than blindly trusting them were described by Abdulnour RE.[12] In a review published BMJ open [13] states, "medical students need to learn how to use GenAI tools and develop the skills needed for critically evaluating AI outputs", while the curriculum should "emphasizes enhanced training in clinical skills and clinical reasoning, critical thinking, patient-centered care, ethical considerations, and recognizing AI limitations".

The Knowledge Explosion: How to Lord it Over an Unmanageable Curriculum

The Year That Medical Knowledge Doubled

The exponential growth of biomedical knowledge is arguably the strongest impetus for curricular change in medical education.[14] It has been estimated that the doubling time of medical knowledge to be 50 years in 1950, seven years in 1980, three and a half years in 2010 and projected to be just 73 days by the year 2020. By 2020, a student who began medical school in 2010 would have hoped to master just 6 percent of the relevant knowledge.

In oncology, this proliferation is palpable: when many attendings did their fellowship training, lung cancer treatment consisted of a handful of chemotherapeutic agents and radiation. To date, as genomic mutations have been managed differently over the years there has arisen a plethora of therapies and algorithmic pathways.[15] The quantity of new knowledge — more than 87,500 papers of its kind were published on COVID-19 alone in the first ten months of the pandemic[16]— means that no curriculum can ever be truly "comprehensive" in a traditional sense.

The Evidence-Based Medicine Gap

The rise of evidence-based medicine has been met with an explosion of systematic reviews and guidelines but "much less change in the medical curriculum" The paradox is stark: although biomedical knowledge increases exponentially, the time allocated to medical training does not (typically four to six years). Students have an impossible task — and AI, by offering rapid access to synthesized information, runs the risk of creating an illusion of competence without the underlying cognitive scaffolding.

The Need for a Paradigm Shift:

The conventional delivery of large volume of factual knowledge through lectures, textbooks, and rote memorization cannot be justify in current era of AI. The process of metacognition; where student find evaluate and apply knowledge; is important. Keeping inn view the "paradox of knowledge" medical educator should focus on student-cantered, inquiry driven pedagogy with appropriate integration of basic and clinical medical science. When these facts are considered while integrating AI into medical curriculum, AI has the potential to bring dramatic change.

Muhammad Medical College, Mirpurkhas: A Case Study of Excellence Under Difficulties

Institutional Background and Achievements

Muhammad Medical College was founded in year 1998, and therefore it is oldest private medical college. It has purpose-built campus on 40-acre land having separate boys and girls' hostels with attached hospital. The college fulfils all requirements of rules set by the PMDC and is affiliated with LUMHS but remains faithful to its mission statement "to groom young people to be best human beings and doctors, providing them with a highest standard of medical education."

Despite this limited access to resources, MMC has achieved the National Prize of Excellence for two succes-

sive years and continues to be top achievers at the undergraduate as well as postgraduate levels. The college has adopted a vertically integrated, outcomes-based MBBS curriculum mapped to the seven PMDC core competencies – described by its own journal as "replicable in other medical colleges in Pakistan".

The SRMLG Pillars

The pedagogy of MMC is underpinned by five pillars – SRMLG – that exemplify the kinds of active, student-centered learning that will be needed for AI-augmented education:

- **Survive:** Weekly tests with compulsory follow up post-test discussion, providing educative retrieval practice and instant feedback.
- **RLSE** (Running Lives by Sharing Experiences) – Weekly mentoring programmes where teachers and senior students support juniors in their clinical experiences.
- **MCS** (Mobile Clinics by Students) – Mobile clinics run by students in underserved communities to facilitate real-world learning and enhance empathy.
- **LBAS** (Learner-Based Annual Symposia) – Repetition of annual symposia that are designed and conducted by students, promoting skills in presentation of research and ownership over the content.
- **GSAT** (Gastroenterology Students as Teachers) – An innovative programme where students teach gastroenterology to their contemporaries, learning through peer instruction.

These pillars are not just add-ons; they are a cohesive pedagogical philosophy that calls for active learning, community engagement, and metacognitive development exactly the attributes that will make the difference in whether AI is a cognitive enhancer or a cognitive crutch.

Innovating While following instructions of PMDC and LUMHS

Despite being a follower of PMDC rules and LUMHS affiliation, MMC has found role for innovation. The college has introduced competency-based medical education (CBME), which focuses on the "development of observable and measurable professional capabilities, to ensure that graduating doctors meet real-world health care challenges". The seven PMDC core competencies are embedded within a "hybrid, vertically integrated spiral curriculum [that culminates in] active learning from day one, with clinical experience, technology-enhanced learning and multidimensional, competency-aligned assessment".

AI Integration at Resource-Constrained Institutions: A Proposed Framework

Reflecting on the literature as well as the case study of MMC, we recommend a four-pillar framework for integrating AI into medical curricula without diminishing critical thinking, innovation or evidence-based rigor.

Pillar 1: Faculty Development First

All AI integrations depend on trained faculties to succeed. Faculty do not need to become AI experts, but they do need to understand the strengths, weaknesses and ethical pitfalls of A.I. tools. It is possible to apply a train-the trainer model, using open access resources and peer learning approaches even in resource constrained settings. As the stand-alone Pakistani mixed-methods study concluded, "addressing technological constraints is critical; providing faculty training may specifically be needed to increase adherence and developing ethical guidelines are critical steps".

Pillar 2: Scaffolding Student Engagement – The DEFT-AI Model

We promote the use of the "cyborg/centaur" partnership concepts and DEFT AI (Deliberation, Evidence, Feedback, Transparency) platform. The centaur model is better for novice learners, as it forces them to critique, justify, and adapt AI outputs—aligning directly with DEFT's principles of deliberation and evidence. While cyborg suits only to advanced learners.

• Rather than using AI to make all of your decisions, use it as a cognitive assistant or second opinion.
• Always examine the accuracy, bias, and relevance of AI outputs carefully
• Always compare response of AI with clinical reasoning as AI sometime is prone to make deliberate mistakes.
• Identify areas where human judgment is better than the AI, for example taking a history, performing a physical examination, interpersonal communication.

Pillar 3: Curriculum Integration, Not Addition

Integrate AI literacy into already-existing courses rather than developing stand-alone AI programs. For instance:
• Ask students to create differentials before comparing them with AI during clinical reasoning sessions.
• When teaching evidence-based medicine, ask students to check primary sources after using AI to go through literature at their own pace.
• In ethics debates, examine case studies of bias and mistakes associated with AI.

Pillar 4: Maintaining and Innovating SRMLG Powered by AI

AI can supplement but will not replace the pillars of MMC's SRMLG.

Survive (weekly tests): AI can produce tailored formative quizzes, but post-test discussions must be human Male/female.

RLSE (mentoring): AI can supplement resources, but the relational aspect of mentorship must be human.

MCS. (mobile clinics): Student learning can be improved with AI-assisted diagnostic support in mobile clinics, but clinical decisions need to be supervised.

LBAS (symposia): Students may use AI to perform literature searches, and aid in preparing a presentation but must provide their own critical analysis.

GSAT (students teaching gastroenterology): While AI can aid with generating teaching materials, the teaching process is still a human cognitive effort that cements what has just been learnt.

Recommendations:

Based upon the findings of current review, the recommendation for Muhammad Medical College and other resource constraint institute includes:

- Develop AI Medical education task force comprising of teachers, students and IT experts to develop policy for using AI considering ethical principles and implementation in phases
- Conduct a Faculty Development Programme – leveraging free e-resources (e.g., Coursera's "AI for Medicine", WHO's digital health training modules) with a train-the-trainer model to maximise reach.
- Embrace the DEFT-AI Framework – taking an open approach to educate students on AI as a "cyborg" and "centaur" collaborator, with levels of accountability rising as they did.
- Redesign Assessment – Add tasks that ask students to critique AI outputs, compare AI-created differentials with their own and reflect on the limitations of AI.

Leverage Open-Source and Low-Cost AI Tools – Use low-hassle LLMs available for free (ChatGPT free tier, Claude,

Gemini) for educational inquiry, institute advocacy for subscription to curated medical AI platforms within your institution.

- Monitor and Evaluate – Routinely examine the influence of incorporating AI into learning on student critical thinking, clinical reasoning, and innovation metrics through quantitative (e.g., pre-post tests) and qualitative (e.g., focus groups) approach.
- Share Learnings – Document MMC's experiences through peer-reviewed publications to inform the global evidence on combinations of AI within resource-limited settings.

Conclusion:

Simply put, the times have changed and what is needed now is not adaptation but transformation. In resource-constrained institutions like Muhammad Medical College, Mirpurkhas, we consider the advent of artificial intelligence to be an opportunity rather than a threat — as long as its adoption is judicious, evidence-based and true to our fundamental objective of creating empathetic, critical thinking physicians.

Fortunate to have secured two consecutive National Prizes for Excellence, outstanding undergraduate and postgraduate results, and innovative SRMLG pillars — MMC has already shown that the conditions of success can exist together. As such, by perceiving AI as a cognitive enhancer – not a replacement – and by rooting all reforms in the active, student-centred learning principles that SRMLG encapsulates, MMC can become an exemplar of AI-augmented medical education for Pakistan and beyond. The time to act is now.

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