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Challenges and barriers to integrating artificial intelligence in medical education and healthcare: a qualitative exploration

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Abstract

Background & Objective: Artificial Intelligence (AI) is reshaping healthcare delivery and medical education. Understanding faculty experiences with the challenges of AI implementation is essential for developing effective solutions. This study therefore aims to identify barriers to AI utilization from the perspective of medical sciences university faculty.

Materials & Methods: This qualitative study employed conventional content analysis, conducted from November 17, 2024, to January 25, 2025, in Fars Province, southern Iran. Participants were selected through purposeful sampling. Semi-structured, in-depth individual interviews were carried out with 21 faculty members who held either hands-on experience with AI or theoretical knowledge of its applications in educational and clinical settings. Data analysis followed the framework proposed by Graneheim and Lundman.

Results: Three main themes emerged. The first, individual challenges, encompassed limited knowledge and skills alongside negative attitudes and resistance toward AI. The second, organizational challenges, was reflected in inadequate facilities and infrastructure, further compounded by the absence of clear, comprehensive guidelines for AI implementation. The third, ethical challenges, surfaced concerns spanning both medical education and research.

Conclusion: The findings underscore that fully realizing AI's transformative potential in medical sciences demands the simultaneous and coordinated strengthening of individual competencies, institutional capacities, and ethical governance. Only through an integrated, systems-oriented approach can existing barriers be effectively dismantled and broader institutional acceptance of AI within healthcare settings meaningfully advanced.

Keywords: artificial intelligence; medical education; qualitative research; medical ethics; barriers to adoption; digital transformation

Introduction

The rapid evolution of digital technologies has positioned artificial intelligence at the forefront of educational transformation, particularly within medical education, where it increasingly functions as a primary driver of innovation and reform [1]. Advances in machine learning, large language models, and intelligent educational platforms have enabled personalized instruction, sophisticated learning analytics, automated content generation, high-fidelity clinical simulations, and adaptive assessment modalities, all of which contribute to enhanced instructional quality, greater learner engagement, and improved clinical reasoning [2, 3]. Systematic reviews indicate that the structured integration of AI into medical curricula can refine feedback mechanisms and optimize teaching–learning processes [3]. Scholars have accordingly emphasized the

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imperative of equipping faculty with the requisite competencies and designing purpose-driven curricula that harness AI effectively, thereby ensuring that medical graduates are both competent and confident in applying these technologies across clinical and educational contexts [2, 3]. A substantial body of research has examined students' and faculty members' perceptions, attitudes, and levels of understanding regarding AI applications in medical education. Al Zahrani et al. [4], for instance, found that although faculty generally expressed positive attitudes toward AI integration, notable gaps persisted in foundational knowledge, formal training, and ethical literacy. Barriers such as an insufficient number of trained educators and concerns about potential professional displacement were identified as significant impediments to adoption [4]. Similarly, Rani et al. [5], in a cross-sectional investigation, observed that despite broad support for AI integration among both students and faculty, practical familiarity and experiential engagement with AI tools remained limited.

Several studies have further underscored the necessity of embedding AI ethics within medical curricula, as unresolved concerns relating to data ownership, algorithmic fairness, and model transparency may affect both the effectiveness and the acceptability of AI-driven educational interventions [6].

Despite these contributions, the extant literature remains predominantly quantitative in orientation [4, 5], with comparatively fewer qualitative studies exploring the deeper cultural, institutional, and pedagogical dimensions of AI integration. In a qualitative study conducted at Jazan University, Salih et al. examined faculty and student perspectives on AI adoption and concluded that, notwithstanding AI's considerable potential to enhance educational outcomes, successful integration necessitates adequate resources, sustained faculty development, and curricular adaptation [1]. Likewise, Naseer et al., in the context of Pakistan, demonstrated that even when faculty attitudes toward AI were generally favorable, the absence of structured training programs and institutional support significantly constrained effective classroom implementation [7].

Without a clear understanding of medical faculty's experiences and viewpoints regarding the challenges surrounding AI implementation, developing appropriate insights and actionable solutions remains difficult. In-depth qualitative research investigating faculty experiences, perceptions, and practical challenges, particularly within the distinctive cultural and institutional context of Iran, remains limited. Given the pivotal role of faculty in curriculum design, delivery, and evaluation, and recognizing that their professional empowerment can substantially enhance teaching–learning quality [8], the present study adopted a qualitative approach to identify and elucidate the challenges that impede effective AI integration in medical education from the faculty perspective. The findings are anticipated to carry both practical and theoretical implications, including: (a) informing the design of targeted faculty development initiatives aimed at strengthening AI-related competencies; (b) supporting evidence-informed academic policymaking through the development of contextually appropriate frameworks and supportive structures; and (c) enriching the local scholarly literature by offering conceptual insights transferable to analogous institutional settings.

Materials & Methods

Design and setting(s)

This qualitative study employed a conventional content analysis approach, which is particularly well suited for exploring research inquiries and capturing participants' perceptions of a given phenomenon [9]. This approach proves especially valuable when limited information exists regarding a population's understanding of a specific concept, as it enables researchers to gain deep insights into human experiences within defined contexts [10].

Study reporting followed the Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist [11]. The study was conducted at Fasa University of Medical Sciences in Fars Province, southern Iran, from November 17, 2024, to January 25, 2025.

Participants and sampling

The study sample comprised 21 faculty members who possessed either hands-on experience with AI or theoretical knowledge of its applications in educational and clinical settings, or both. Participants were selected through purposeful sampling.

Tools/Instruments

Data were collected through semi-structured interviews, a well-established method for eliciting participants' opinions, experiences, and motivations [12].

Data collection methods

Data were collected through 21 semi-structured, in-depth individual interviews, each lasting 45 to 60 minutes. To ensure broad representation, purposive sampling with

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maximum variation was employed, deliberately including participants with diverse teaching backgrounds and varying levels of experience—an approach that facilitates the selection of individuals capable of providing rich, detailed insights relevant to the phenomenon under investigation [13]. Inclusion criteria comprised willingness to participate, possession of either hands-on AI experience or theoretical AI knowledge in educational and clinical settings (encompassing machine learning, Natural Language Processing (NLP), Large Language Models (LLMs), and generative pre-trained transformers (ChatGPT)), and provision of informed consent.

Participants who withdrew for any reason or demonstrated persistent non-responsiveness were excluded. Sampling continued until data saturation was reached—defined as the point at which no new data, categories, or subcategories could be extracted [14]. Saturation was achieved after 19 interviews; two additional interviews were conducted to confirm that no new information emerged.

Interviews were scheduled in advance and held in settings that minimized disruptions. The corresponding author (MB), an associate professor of nursing with extensive qualitative research experience, conducted all interviews, which were audio-recorded with participants' consent.

Following each session, recordings were reviewed multiple times and transcribed verbatim. The research team developed an interview guide informed by prior related studies [14], incorporating questions such as: How do you perceive the role of artificial intelligence in medical education? What issues have you encountered when using AI in education and research? What challenges have you faced or foresee when implementing AI in your teaching? What infrastructural barriers—such as hardware, software, or data access—most significantly impede effective AI utilization? (see **Supplementary File 1**: Interview Guide and Questions).

Each interview began with participant introductions and proceeded according to the guide, which featured open-ended prompts such as, "As a faculty member, please describe your experience with artificial intelligence." The guide remained flexible—questions were modified or expanded in response to participants' answers, and interviews concluded at the participants' discretion.

Data analysis

Data were analyzed using Graneheim and Lundman's five-step framework [15]: (a) Verbatim transcription of all recorded interviews. (b) Repeated, careful reading of each transcript to immerse the researcher in the data and develop a thorough understanding of participants' perspectives, attending to both explicit and implicit content. (c) Re-reading to identify meaning units—sentences or paragraphs extracted directly from participants' statements. (d) Derivation of initial codes from meaning units, followed by grouping of semantically related codes into subcategories. (e) Merging of subcategories to generate overarching themes. Prior to coding, each transcript was reviewed multiple times to ensure comprehensive familiarity with the content.

Meaning units were then identified and assigned specific codes, with the broader context kept in view throughout. A consolidated code list was compiled; through iterative semantic comparison of similarities and differences, codes were organized into distinct subcategories. Emerging categories and subcategories were subsequently discussed, refined, and validated by the research team [15].

Three team members conducted the analysis using MAXQDA 10 software. When coding discrepancies arose, the team convened review sessions in which disagreements were resolved through group discussion and reference to the raw data until consensus was reached. **Table 1** illustrates a representative example of this analytical process.

Table 1. An example of coding and development of themes

Meaning units	Coding	Sub-theme	Theme
"Effective utilization of AI requires adequate infrastructure, facilities, and resources… Procuring AI systems is exceedingly costly. Senior university administrators should first establish the requisite infrastructure—including internet networks, software, and hardware frameworks…" (**P4**)	• Necessity of basic hardware and software infrastructure • High financial costs of AI procurement • Requirement for high-speed internet and stable networks • Need for managerial support in providing resources	Lack of necessary facilities and infrastructure	Organizational challenges

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Rigor

To ensure data quality, we applied Lincoln and Guba's trustworthiness criteria: credibility, transferability, dependability, and confirmability [17]. Several strategies were employed to meet these standards. Sufficient time was allocated for data collection and repeated examination of transcripts, a diverse sample was recruited, and consensus on coding and category extraction was established among the research team. Member checking was conducted by sharing findings with participants to confirm their accuracy. The analytical process and coding methodology were also reviewed in consultation with two faculty members familiar with the research topic. To further support confirmability, participants were asked to verify the identified categories and subcategories. Transferability was enhanced by providing detailed descriptions of participant characteristics and interview procedures. To reduce bias in conducting, analyzing, and coding the interviews, researchers limited their reliance on prior textual reviews. Throughout data collection and analysis, bracketing was applied as an additional strategy to strengthen validity [17]. Bracketing is a qualitative technique used to minimize the influence of researchers' preconceptions on the research process. In this study, bracketing was implemented during the data analysis stage. Consistent with methodological guidance, bracketing was not applied during interviews, as active engagement with participants takes precedence over suspending prior assumptions in that context. Researchers also maintained a reflexive journal initiated before the research question was formally defined, in which preconceptions were identified and documented throughout the study [17].

Results

The participants had a mean age of 43.47 ± 5.97 years and a mean work experience of 13.28 ± 4.67 years. Additional demographic characteristics are presented in **Table 2**.Qualitative data analysis yielded three primary themes and six sub-themes: individual challenges, organizational challenges, and ethical challenges. A comprehensive overview of these themes and sub-themes is provided in **Table 3**.

Theme 1: Individual challenges

Individual challenges emerged as one of the most significant barriers to the effective utilization and implementation of AI in medical sciences and healthcare, as perceived by faculty members at medical universities. These challenges manifested primarily in two areas: insufficient knowledge and skills related to AI technology, and negative attitudes and resistance toward its adoption.

Table2. Demographic information of the participants in the study

Participants	Gender	Age (year)	Work experience (year)
P1	Male	40	13
P 2	Female	59	27
P3	Male	50	19
P4	Male	43	11
P5	Male	48	13
P6	Female	36	7
P7	Female	56	21
P8	Male	41	13
P9	Female	38	8
P10	Female	49	14
P11	Male	50	18
P12	Female	39	12
P13	Male	39	10
P14	Male	44	13
P15	Female	41	12
P16	Female	49	14
P17	Male	41	11
P18	Male	33	8
P19	Female	41	13
P20	Female	39	10
P21	Male	40	12

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Table 3. Themes and sub-themes extracted from content analysis

Theme	Sub-theme	Sample extracted codes
Individual challenges	Lack of knowledge and skills in AI technology	• Educational inequality
	Negative attitudes and resistance towards AI utilization	• Negative attitudes towards AI utilization • Resistance towards AI utilization
Organizational challenges	Lack of necessary facilities and infrastructure	• Effective AI utilization requires adequate infrastructure, facilities, and resources
	Absence of comprehensive and transparent guidelines for AI implementation	• Absence of clear guidelines for AI
Ethical challenges	Ethical Challenges in Medical Education	• Maintaining patient confidentiality and privacy • Ensuring transparency and explainability of AI models • Accountability in AI-driven decision-making • Preserving human dignity in clinical learning
	Ethical challenges in research	• Plagiarism and unscientific use of AI tools • Data fabrication and integrity concerns • Proliferation of low-quality AI-generated publications

Subtheme 1.1: Lack of knowledge and skills in AI technology: Participants identified the absence of comprehensive, specialized knowledge and expertise in AI technology as one of the most critical individual barriers to its adoption among medical science faculty. One participant captured this concern directly:

> *"As a faculty member, I feel I lack sufficient information and the requisite skills for the optimal use of advanced AI technology. Sometimes, the university's educational affairs department quickly issues a directive to incorporate AI into our teaching, yet even senior managers and the educational affairs deputy themselves seem unfamiliar with its practical application.*
> *There is an urgent need for comprehensive, specialized training courses to equip faculty with the necessary knowledge and skills. Only then can we hope to successfully institutionalize this technology in medical education."* **(P7)**

Subtheme 1.2: Negative attitudes and resistance towards the utilization of AI technology: Another significant individual challenge was the prevalence of negative attitudes and resistance toward AI adoption among medical science faculty.

Participants emphasized that successful integration of any novel technology into education requires careful attention to individuals' attitudes, personal characteristics, and dispositions. Accordingly, proactive efforts to prepare faculty for change are essential to reducing resistance. One participant described this dynamic:

> *"Many of my colleagues in the medical sciences show a strong preference for traditional teaching methods and little interest in adopting innovative approaches or advanced technologies like AI. They openly resist, saying, 'I have no interest in these new technologies — let those who like them use them. University professors should not be forced to use AI.'"* **(P9)**

Theme 2: Organizational challenges

A second prominent theme to emerge from the data was organizational challenges. This theme encompassed two primary dimensions: the absence of adequate facilities and infrastructure necessary for AI implementation, and the lack of comprehensive, transparent guidelines governing AI use in academic and clinical settings.

Subtheme 2.1: Lack of necessary facilities and infrastructure: Participants consistently identified inadequate equipment and the absence of essential infrastructure as paramount organizational barriers to AI implementation. In their view, broad access to standard equipment and appropriate physical spaces is a prerequisite for the meaningful adoption and institutionalization of AI in medical education. One participant described the practical impact of these deficiencies:

> **P5:** *"As a faculty member, when I lack standard equipment and space for utilizing AI technology, I become genuinely disheartened, demotivated, and frustrated. I don't even have a properly functioning computer system to carry out my tasks. The internet connection is unreliable, with daily outages, and the bandwidth is so limited that it effectively precludes any meaningful work."*

Another faculty member reinforced this view, emphasizing the institutional responsibility to establish foundational infrastructure before expecting faculty engagement with innovative technologies:

> **P4:** *"Effective utilization of AI requires infrastructure, facilities, and the necessary resources. In my opinion, one of the most fundamental challenges affecting AI*

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adoption among medical sciences faculty—and across other disciplines—is precisely this lack of essential infrastructure. Procuring AI systems is exceedingly expensive. I believe senior university administrators must first establish the necessary groundwork—including internet networks, software, and hardware frameworks—before expecting faculty to stay current and implement innovative teaching methods."

Subtheme 2.2: Absence of comprehensive and transparent guidelines for AI technology implementation: Participants identified the lack of comprehensive, transparent guidelines governing AI use in medical education and health sciences as another significant organizational challenge. From their perspective, the introduction of any technology into this domain must be accompanied by clear, precise, and explicit protocols — without which confusion proliferates and effective implementation is undermined. One participant captured this institutional ambiguity directly:

P17: *"Frankly, we are at a loss as to how to proceed. On one hand, the educational affairs department has asked faculty to incorporate AI into student instruction. On the other hand, no comprehensive guidelines or processes have been formulated for this purpose. Even the educational affairs department itself claims to be awaiting implementation directives from the Ministry of Health's educational affairs deputy. Faculty members are genuinely experiencing a state of uncertainty and confusion."*

Theme 3: Ethical challenges

Among the key themes shaping faculty perceptions of AI integration in medical sciences, ethical concerns emerged as a critical dimension. This theme encompasses two interconnected domains: ethical challenges arising within medical education and research, and broader considerations surrounding human dignity and respect.

Subtheme 3.1: Ethical challenges in medical education: Participants consistently emphasized that ethical considerations represent the most critical dimension of technology adoption in any field, and especially in medical sciences. Chief among these concerns were the protection of patient confidentiality, preservation of privacy, and upholding of human dignity. One faculty member articulated this perspective as follows:

P18: *"Ethical concerns extend beyond technical opacity to encompass questions of accountability and responsibility. In medical education specifically, the limited explainability of AI-driven decision-making raises substantive concerns about how such systems generate conclusions that may influence student assessment, curriculum development, and, ultimately, patient care."*

Subtheme 3.2: Ethical challenges in research: Participants acknowledged that AI has fundamentally transformed data analysis, with its integration into research advancing at a remarkable pace. This rapid adoption makes rigorous adherence to ethical principles in medical scientific investigations more pressing than ever. One participant captured this concern directly:

P20: *"Regrettably, the unscientific use of AI and disregard for ethical principles have contributed to an unprecedented surge in publications—many of which exhibit plagiarism or data fabrication, ultimately resulting in journal retractions. Ethical vigilance in the application of AI technology is therefore of paramount importance."*

Discussion

The present study examined the challenges of AI utilization as perceived by faculty members at medical sciences universities, yielding three primary themes: individual challenges, organizational challenges, and ethical challenges. Among the individual challenges identified, insufficient specialized knowledge and skills emerged as the most prominent barrier to effective AI integration in medical education. This finding aligns with Keykha et al. [18] and Wang and Li [19], who similarly identified knowledge and skill deficits as key impediments to appropriate AI use. Al Zahrani et al. reported that faculty members' overall AI knowledge was moderate, averaging 58.9%, with variation attributable to years of experience and academic qualifications [4]. This is particularly consequential in resource-constrained settings where limited access to formal training and inadequate infrastructure can substantially hinder both the adoption and effective application of AI technologies [4]. Negative attitudes and resistance to AI adoption constituted a second individual challenge. Chan and Zary (2019) similarly found that unfavorable attitudes toward AI can undermine its efficiency and practical utility [20]. While prior research has generally documented positive faculty attitudes alongside only moderate AI knowledge [4, 8], the present findings diverge somewhat from this pattern. Contextual factors specific to the Iranian setting—including cultural norms, centralized educational governance, resource

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limitations, and scarce formal training opportunities—appear to amplify resistance and slow infrastructure development. Accordingly, institutional administrators are encouraged to cultivate motivation and provide meaningful incentives that support faculty engagement with emerging technologies. Organizational challenges represented a second major theme, encompassing inadequate facilities and infrastructure as well as the absence of clear, comprehensive guidelines for AI implementation. These findings are consistent with Gayef et al. [21] and Ekuma [22], who demonstrated that organizational factors, particularly infrastructure, are critical determinants of effective AI use. Successful AI integration in medical education demands substantial investment in advanced computing systems, reliable data storage, and secure networks. Furthermore, the development of standardized guidelines and cohesive protocols requires coordinated collaboration among researchers, industry stakeholders, and regulatory bodies [23]. While AI holds considerable promise for personalizing learning, enhancing diagnostic capabilities, and streamlining curriculum development, realizing this potential depends on systematically addressing ethical considerations, ensuring continuous professional training, and building adequate infrastructure.

A thoughtful integration strategy will better position medical education to keep pace with a rapidly evolving healthcare landscape and equip future professionals with the competencies needed for high-quality patient care [24]. Ethical challenges constituted the third major theme, encompassing concerns related to medical education and research as well as considerations of human dignity and respect. Karimian and Petelos [25] and Khan Rony et al. [26] have similarly underscored the importance of addressing ethical dimensions of AI, advocating for the development of comprehensive ethical guidelines.

International scholarship further suggests that AI ethical frameworks should be grounded in the cultural and religious values of the societies in which they are applied, as these values profoundly shape ethical judgments about emerging technologies. Karataş et al., for instance, found that individuals who engage more frequently in religious reflection demonstrated greater acceptance of AI-based tools in both personal and professional contexts, indicating that religious beliefs can influence trust in and attitudes toward technological systems [27]. Within Iran and other Islamic societies, foundational principles—including justice, privacy, human dignity, and social solidarity—serve as essential criteria for evaluating technologies such as AI and can meaningfully inform the development of culturally responsive ethical frameworks [28, 29]. Neglecting these cultural and religious dimensions risks generating societal resistance or unintended consequences that compromise justice, freedom, and human dignity. It is therefore imperative to develop robust, culturally grounded ethical frameworks that ensure AI systems operate transparently, fairly, and without bias. Equally critical is sustained investment in professional development: educators must acquire the specialized expertise to deploy AI tools effectively in teaching and assessment, while healthcare practitioners must develop a nuanced understanding of AI's capabilities and limitations to apply it judiciously in clinical settings [30, 31]. This study was limited to the perspectives of faculty members; future research should incorporate students' experiences and viewpoints to achieve a more comprehensive, multidimensional understanding of AI integration in medical education. Because this investigation was conducted within the distinctive cultural, economic, and social context of Iran, replication in other national settings would be valuable for elucidating contextual and structural variations. Subsequent studies should also attend to methodological considerations—including sample size, participant diversity, and gender representation—to strengthen the credibility, transferability, and overall rigor of the findings.

Conclusion

Individual, organizational, and ethical challenges represent the most significant barriers to AI adoption from the perspective of medical sciences faculty. To address these barriers, we recommend designing comprehensive training programs to strengthen faculty knowledge and skills in AI, investing in the infrastructure necessary for implementation, establishing clear and practical guidelines, and developing robust ethical frameworks to resolve emerging issues in education and research. Collectively, these measures can meaningfully facilitate the integration of AI across the health system.

Ethical considerations

This study received ethical approval from the Ethics Committee of Fasa University of Medical Sciences, Fasa, Iran (approval code: IR.FUMS.REC.1403.072). All interviews were conducted and audio-recorded

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exclusively following the provision of informed consent by each participant. Data were stored securely and remained accessible only to authorized members of the research team. Participants were explicitly informed that all audio recordings would be destroyed upon completion of transcription.

To further protect participant confidentiality, personal identifiers were replaced with numeric codes throughout the transcripts and final report, ensuring that no identifying information appeared in any disseminated material.

Artificial intelligence utilization for article writing

No artificial intelligence tools were used at any stage of this study, including its design, data collection, analysis, or manuscript preparation. All interpretations, analyses, and written content reflect exclusively the authors' own scholarly work.

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Conflict of interest statement

The authors declare that they have no competing interests.

Author contributions

MB, FA, and EP contributed to methodology, qualitative study design, data collection, formal analysis, original draft preparation, and manuscript review and editing. FA, AF, and AT were responsible for supervision, theme validation, and review and editing. AA and ZK oversaw project administration and thematic interpretation. All authors participated in the critical review of the manuscript and approved the final version for submission.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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