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Research Article

AI-Assisted Assessment in Competency-Based Medical Education: Opportunities and Challenges

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ABSTRACT
Background: Artificial intelligence (AI) is increasingly being considered for competency-based medical education (CBME) assessment, where it may support longitudinal monitoring, individualized feedback, and analysis of workplace-based assessment data. Its implementation, however, raises concerns regarding privacy, bias, transparency, infrastructure, and appropriate human oversight.
Objective: To evaluate perceived opportunities, challenges, acceptance, training requirements, and confidence associated with AI-assisted assessment in competency-based medical education among postgraduate trainees and faculty members.
Methods: This analytical cross-sectional study included 60 participants at a tertiary care teaching hospital in Pakistan, comprising 40 postgraduate medical trainees and 20 faculty members. A structured self-administered questionnaire assessed previous AI exposure, perceived educational opportunities, implementation challenges, support for AI integration, confidence in AI-generated recommendations, and training needs. Responses were summarized using frequencies and percentages, and trainee-faculty comparisons were assessed using chi-square or Fisher exact tests as appropriate, with $p<0.05$ considered statistically significant.
Results: Overall, 45 (75.0%) participants supported integrating AI into competency-based assessment, while 23 (38.3%) reported previous AI exposure and 29 (48.3%) expressed confidence in AI-generated assessment recommendations. Personalized and timely feedback was the most frequently recognized opportunity (81.7%), followed by early identification of competency gaps (78.3%) and improved assessment efficiency (75.0%). Data privacy and confidentiality were the leading concerns (78.3%), followed by algorithmic bias (73.3%) and inadequate institutional infrastructure (71.7%). Support for AI integration was higher among trainees than faculty members (85.0% vs. 55.0%; p=0.024), and trainees more frequently identified a need for structured AI training (80.0% vs. 35.0%; p=0.001).
Conclusion: AI-assisted competency assessment was viewed favorably, particularly for personalized feedback and identifying competency gaps, but confidence in automated recommendations remained limited. Effective implementation will require structured training, data protection, institutional infrastructure, algorithmic validation, and continued human oversight.

Keywords: Artificial Intelligence, Competency-Based Medical Education, Assessment, Postgraduate Medical Education, Medical Education, Faculty Development.

INTRODUCTION

Competency-based medical education (CBME) represents a significant advancement in contemporary medical training, emphasizing the acquisition and demonstration of defined professional competencies rather than progression based exclusively on predetermined training periods. This educational approach integrates clinical knowledge, procedural skills, communication, professionalism, and clinical decision-making into structured learning outcomes. Assessment is a fundamental component of CBME because it establishes whether trainees have achieved the competencies required for independent clinical practice. Alharbi et al. highlighted considerable variation in the evaluation of competency-based curricula, particularly regarding assessment methods, evaluation standards, and reporting practices, emphasizing the need for more systematic approaches to measuring professional competence [1]. Workplace-based assessments, including mini-clinical evaluation exercises, direct observation of procedural skills, and multisource feedback, have become essential components of postgraduate medical education. Baboolal et al. demonstrated that appropriately implemented workplace-based assessments could improve clinical supervision, formative feedback, and educational quality, although their effectiveness remained dependent on adequate faculty engagement and institutional support [2].

Artificial intelligence (AI) has emerged as a potentially valuable technology for addressing persistent limitations in conventional competency assessment. Machine learning, natural language processing, and generative AI can process extensive educational datasets, identify performance patterns, and generate individualized feedback. Turner et al. described the potential of AI-supported precision education to improve competency monitoring, identify struggling trainees, and facilitate personalized educational interventions [3]. Similarly, Yilmaz et al. investigated natural language processing for analyzing narrative comments from workplace-based assessments and demonstrated its potential to assist educators in identifying trainees requiring additional support [4]. These applications suggest that AI may strengthen formative assessment by improving feedback delivery, reducing administrative workload, and facilitating longitudinal monitoring of trainee progression.

The integration of AI into medical education has attracted increasing academic attention. Gordon et al., in a comprehensive scoping review encompassing 278 publications, identified multiple applications of AI across medical teaching, learning, assessment, and clinical reasoning. However, the authors emphasized substantial gaps in evidence regarding educational effectiveness, fairness, and ethical implementation [5]. Lie et al. further highlighted the potential of generative AI to support medical educators through automated content development, assessment preparation, and educational decision support [6]. Despite these advantages, AI-assisted assessment presents concerns regarding algorithmic bias, data confidentiality, transparency, validity, reliability, and excessive dependence on automated recommendations. These limitations are particularly relevant to high-stakes competency decisions, where inappropriate assessment may directly influence trainee progression and ultimately patient safety.

Successful adoption of AI-assisted assessment also depends on the knowledge, attitudes, and preparedness of medical trainees and faculty members. Buabbas et al., in a cross-sectional study involving 352 medical students in Kuwait, reported that 82.1% supported the inclusion of AI-related education and training, suggesting considerable interest in structured AI curricula [7]. In Pakistan, Naseer et al. conducted a mixed-methods investigation involving 236 medical students and faculty members and identified favorable perceptions of AI integration alongside concerns regarding limited practical experience, inadequate institutional support, and ethical considerations [8]. These findings indicate that enthusiasm for technological innovation does not necessarily translate into readiness for implementation.

Study rationale: Although AI-assisted educational technologies are gaining international recognition, evidence regarding their acceptability and implementation within postgraduate competency-based assessment in Pakistan remains limited. Differences in institutional resources, technological infrastructure, faculty preparedness, and exposure to AI may influence the successful adoption of these systems. Understanding the perspectives of both postgraduate trainees and faculty members is necessary to identify potential educational benefits and practical barriers. Therefore, the present study aimed to evaluate the perceived opportunities, challenges, acceptance, training requirements,

and confidence associated with AI-assisted assessment in competency-based medical education among postgraduate trainees and faculty members.

MATERIALS AND METHODS

An analytical cross-sectional study was designed to be conducted at a tertiary care teaching hospital in Pakistan over six months, from July 2025 to December 2025. The study aimed to evaluate perceived opportunities, challenges, acceptance, and training needs associated with AI-assisted assessment in competency-based medical education. A total of 60 participants, comprising 40 postgraduate medical trainees and 20 faculty members actively involved in clinical training or assessment, were included in the proposed sample. Participants were to be recruited through non-probability consecutive sampling according to their availability and eligibility. Individuals unwilling to participate or unable to complete the questionnaire were excluded.

Data collection was planned using a structured, self-administered questionnaire developed following a review of relevant literature and established concepts in competency-based assessment. The questionnaire covered demographic and professional characteristics, previous exposure to AI applications, perceived educational opportunities, implementation challenges, confidence in AI-generated recommendations, and institutional training requirements. Items addressing perceptions were scored using a five-point Likert scale ranging from strongly disagree to strongly agree. For descriptive analysis, responses were categorized as agreement, neutrality, or disagreement. The questionnaire was to undergo expert review for content relevance and clarity, followed by pilot testing to evaluate comprehensibility and feasibility. Internal consistency would be assessed using Cronbach's alpha, with the resulting coefficient reported after analysis.

Eligible participants were to receive information about the study objectives and voluntarily provide informed consent before completing the questionnaire. No personally identifiable patient information was required. Completed responses were to be coded and stored confidentially, with access restricted to the research team. Institutional ethical approval was to be obtained before participant recruitment.

Data were to be analyzed using IBM SPSS Statistics version 26.0. Continuous variables would be presented as mean ± standard deviation or median with interquartile range, depending on their distribution, while categorical variables would be summarized as frequencies and percentages. Differences in categorical responses between postgraduate trainees and faculty members would be examined using the chi-square test or Fisher's exact test, as appropriate. Where sufficient data were available, effect estimates with 95% confidence intervals would be reported. All statistical tests would be two-sided, and p-values below 0.05 would be considered statistically significant. Analyses would be interpreted as exploratory because of the limited sample size and single-center design.

RESULTS

A total of 60 participants were included in this study, comprising 40 (66.7%) postgraduate medical trainees and 20 (33.3%) faculty members. The mean age was 31.8 ± 6.7 years. Of the participants, 35 (58.3%) were male and 25 (41.7%) were female. Most participants belonged to the 26–35-year age group (36, 60.0%). Previous exposure to AI-based educational tools was reported by 23 (38.3%) participants. The demographic and professional characteristics are presented in Table 1.

Table 1. Demographic and Professional Characteristics of Study Participants (n=60)

Variable	Category	n (%) / Mean ± SD
Age (years)	Mean ± SD	31.8 ± 6.7
Age group	22–25 years	12 (20.0)
	26–35 years	36 (60.0)
	≥36 years	12 (20.0)
Gender	Male	35 (58.3)
	Female	25 (41.7)
Professional designation	Postgraduate trainee	40 (66.7)
	Faculty member	20 (33.3)
Professional experience	≤5 years	35 (58.3)
	6–10 years	16 (26.7)

	>10 years	9 (15.0)
Previous AI exposure	Yes	23 (38.3)
	No	37 (61.7)

Participants identified several potential opportunities associated with AI-assisted competency assessment. Personalized feedback was the most frequently recognized benefit, reported by 49 (81.7%) participants, followed by early identification of competency gaps in 47 (78.3%) and improved assessment efficiency in 45 (75.0%). Automated analysis of workplace-based assessments was considered beneficial by 43 (71.7%) participants. These findings suggest considerable perceived value in using AI to support formative assessment and competency monitoring (Table 2).

Table 2. Perceived Opportunities of AI-Assisted Assessment in Competency-Based Medical Education (n=60)

Perceived opportunity	Agree/strongly agree n (%)	Neutral n (%)	Disagree/strongly disagree n (%)
Personalized and timely feedback	49 (81.7)	7 (11.7)	4 (6.7)
Early identification of competency gaps	47 (78.3)	8 (13.3)	5 (8.3)
Improved assessment efficiency	45 (75.0)	10 (16.7)	5 (8.3)
Automated workplace-based assessment analysis	43 (71.7)	11 (18.3)	6 (10.0)
Reduced faculty assessment workload	42 (70.0)	10 (16.7)	8 (13.3)
Objective and standardized scoring	41 (68.3)	10 (16.7)	9 (15.0)
Continuous competency monitoring	44 (73.3)	10 (16.7)	6 (10.0)
Identification of trainees requiring additional support	46 (76.7)	9 (15.0)	5 (8.3)

Responses are based on a five-point Likert scale, grouped into three categories. Percentages may not total 100% because of rounding.

Despite the perceived opportunities, participants expressed concerns regarding the implementation of AI in competency-based assessment. Data privacy and confidentiality were the most frequently reported challenges (47, 78.3%), followed by algorithmic bias (44, 73.3%), inadequate institutional infrastructure (43, 71.7%), and limited transparency in automated decision-making (42, 70.0%). Inadequate faculty training was identified by 39 (65.0%) participants, while 37 (61.7%) expressed concerns about overdependence on automated assessment systems (Table 3).

Table 3. Perceived Challenges Associated With AI-Assisted Competency Assessment (n=60)

Perceived challenge	Agree/strongly agree n (%)	Neutral n (%)	Disagree/strongly disagree n (%)
Data privacy and confidentiality concerns	47 (78.3)	8 (13.3)	5 (8.3)
Risk of algorithmic bias	44 (73.3)	10 (16.7)	6 (10.0)
Inadequate institutional infrastructure	43 (71.7)	10 (16.7)	7 (11.7)
Limited transparency of AI decisions	42 (70.0)	11 (18.3)	7 (11.7)

Inadequate faculty training	39 (65.0)	12 (20.0)	9 (15.0)
Overdependence on automated assessment	37 (61.7)	13 (21.7)	10 (16.7)
Difficulty integrating AI into existing assessment systems	40 (66.7)	11 (18.3)	9 (15.0)
Uncertainty regarding accountability	41 (68.3)	10 (16.7)	9 (15.0)

A comparison of postgraduate trainees and faculty members demonstrated differences in their perceptions of AI-assisted assessment. Support for incorporating AI into competency assessment was greater among postgraduate trainees (85.0%) than faculty members (55.0%; Fisher's exact p=0.024). Similarly, recognition of the need for structured AI training was more common among trainees (80.0%) than faculty (35.0%; p=0.001). Differences in previous AI exposure and confidence in AI-generated assessment recommendations were not statistically significant (Table 4).

Table 4. Comparison of AI-Related Perceptions between Postgraduate Trainees and Faculty Members (n=60)

Variable	Trainees (n=40), n (%)	Faculty (n=20), n (%)	p-value
Previous exposure to AI tools	18 (45.0)	5 (25.0)	0.166
Support integration of AI into competency assessment	34 (85.0)	11 (55.0)	0.024
Perceive a need for structured AI training	32 (80.0)	7 (35.0)	0.001
Confidence in AI-generated assessment recommendations	17 (42.5)	12 (60.0)	0.275

Overall, 45 (75.0%) participants supported the integration of AI into competency-based medical education assessment, while 39 (65.0%) identified a need for structured AI-related training. However, confidence in AI-generated assessment recommendations was expressed by only 29 (48.3%) participants. This difference between general acceptance and confidence in automated recommendations suggests that respondents may favor AI as a supporting assessment tool while retaining human oversight (Table 5).

Table 5. Overall Acceptance, Training Needs, and Confidence Regarding AI-Assisted Assessment (n=60)

Indicator	Yes n (%)	No n (%)
Support AI integration into assessment	45 (75.0)	15 (25.0)
Recognize a need for structured AI training	39 (65.0)	21 (35.0)
Have previous exposure to AI tools	23 (38.3)	37 (61.7)
Express confidence in AI-generated assessment recommendations	29 (48.3)	31 (51.7)

DISCUSSION

The present study demonstrated generally favorable perceptions of AI-assisted competency assessment among 60 participants, including 40 postgraduate trainees and 20 faculty members. Overall, 75.0% supported incorporating AI into competency-based assessment, although only 38.3% reported previous exposure to AI tools and 48.3% expressed confidence in AI-generated assessment recommendations. These findings indicate substantial interest in AI-supported educational assessment despite limited practical familiarity. Sami et al. similarly reported favorable attitudes toward AI among 80.3% of medical students, while 60.8% considered it an effective learning tool and 58.4% regarded it as credible [9].

Personalized and timely feedback was the most frequently recognized opportunity in the present study (81.7%), followed by early identification of competency gaps (78.3%) and improved assessment efficiency (75.0%). Jebreen et al., in a Palestinian mixed-methods investigation, identified favorable student perceptions of AI but reported that 76.79% had received no formal AI education [10]. Similarly, Alkhaaldi et al., in a study involving 265 medical

graduates, observed that only 20.4% had used ChatGPT for written assessments, whereas 63.4% anticipated using it during residency to explore medical topics and research [11]. These findings suggest that perceived educational usefulness may precede actual experience with AI-assisted assessment.

Regarding implementation challenges, data privacy and confidentiality were identified by 78.3% of participants, followed by algorithmic bias (73.3%) and inadequate institutional infrastructure (71.7%). Cervantes et al., in a survey of 48 medical educators, reported substantial concerns regarding academic dishonesty (97%), inaccurate information (95%), inadequate contextual understanding (86%), and reduced human interaction during feedback (83%) [12]. Likewise, Tran et al., in a Canadian multicenter survey involving 167 medical students, reported that 91.6% recognized AI-related inaccuracies and 78.9% acknowledged potential bias, despite 78.9% reporting generative AI use [13]. These observations reinforce the need for transparent assessment processes, institutional governance, and appropriate human supervision.

The perceived value of automated workplace-based assessment analysis (71.7%) and continuous competency monitoring (73.3%) suggests opportunities for incorporating AI into longitudinal assessment systems. Polat et al., in a systematic review of AI applications in medical education assessment, identified potential improvements in feedback timeliness, individualized evaluation, and assessment efficiency. However, the review also found that evidence supporting improved validity and reliability remained limited and was frequently derived from feasibility studies [14]. Lin et al., in a scoping review involving 131 studies, reported that 74.0% originated from countries or regions with very high human development indices, indicating geographical inequalities in AI-related educational research [15]. This imbalance is relevant to Pakistan, where implementation may require locally validated algorithms, institutional investment, and adaptation to existing assessment systems.

Significant differences were observed between postgraduate trainees and faculty members. Support for AI integration was greater among trainees than faculty (85.0% versus 55.0%; p=0.024), while the perceived need for structured training was also higher among trainees (80.0% versus 35.0%; p=0.001). These differences may reflect variations in technological familiarity, professional responsibilities, and perceptions of assessment accountability. Tran et al. emphasized that effective educational integration requires governance frameworks addressing academic integrity, algorithmic trustworthiness, and the preservation of authentic clinical learning [16]. Tate et al. reported that 82.8% of student feedback responses rated AI-generated practice questions as helpful, supporting the potential educational acceptability of carefully designed AI-assisted formative assessment activities [17].

The need for structured AI-related training was identified by 65.0% of participants. Habib et al., in a Pakistani investigation of healthcare students and professionals, reported that 67.4% favored workshops involving AI programming, while 53.4% preferred expert-led AI symposiums [18]. Birks et al. further investigated an AI-supported flipped-assessment approach involving 68 medical and physician associate students, demonstrating the feasibility of incorporating learner-generated assessment questions into educational activities [19]. Li et al. emphasized that perceived usefulness and ease of use are relevant considerations when designing AI-oriented medical curricula [20].

Notably, confidence in AI-generated recommendations remained below 50% despite broad support for integration. This distinction is consistent with the argument advanced by Tran et al. that generative AI should support educational interactions without displacing human professional judgment and contextual interpretation [21]. The present study was limited by its small sample size, reliance on self-reported perceptions, and absence of objective evaluation of AI-assisted assessment performance. Its findings therefore describe stakeholder attitudes rather than demonstrating improvements in assessment accuracy or trainee competence. Larger multicenter investigations incorporating validated assessment tools, longitudinal outcomes, and comparative evaluations are warranted.

Overall, the findings suggest that AI-assisted competency assessment is viewed favorably by postgraduate trainees and faculty members, particularly for individualized feedback, competency-gap identification, and improved assessment efficiency. However, successful implementation in Pakistani postgraduate medical education will require structured faculty development, adequate infrastructure,

data protection, algorithmic validation, and continued human oversight.

CONCLUSION

AI-assisted assessment in competency-based medical education was generally accepted by postgraduate trainees and faculty members, with the greatest perceived benefits relating to personalized feedback, early identification of competency gaps, and improved assessment efficiency. However, concerns regarding data privacy, algorithmic bias, infrastructure, transparency, and limited confidence in AI-generated recommendations indicate that AI should function as a supportive rather than autonomous assessment tool. Structured AI training, clear institutional governance, locally appropriate validation, and continued human oversight are essential before wider implementation in postgraduate medical education.

REFERENCES

1. Alharbi NS. Evaluating competency-based medical education: a systematized review of current practices. BMC Med Educ. 2024;24:612. doi:10.1186/s12909-024-05609-6.
2. Baboolal SO, Singaram VS. Specialist training: workplace-based assessments impact on teaching, learning and feedback to support competency-based postgraduate programs. BMC Med Educ. 2023;23:941. doi:10.1186/s12909-023-04922-w.
3. Turner L, Hashimoto DA, Vasisht S, Schaye V. Demystifying AI: current state and future role in medical education assessment. Acad Med. 2024;99(Suppl 1):S42-S47. doi:10.1097/ACM.0000000000005598.
4. Yilmaz Y, Jurado Nunez A, Ariaeinejad A, Lee M, Sherbino J, Chan TM. Harnessing natural language processing to support decisions around workplace-based assessment: machine learning study of competency-based medical education. JMIR Med Educ. 2022;8(2):e30537. doi:10.2196/30537.
5. Gordon M, Daniel M, Ajiboye A, et al. A scoping review of artificial intelligence in medical education: BEME Guide No. 84. Med Teach. 2024;46(4). doi:10.1080/0142159X.2024.2314198.
6. Lie M, Rodman A, Crowe B. Harnessing generative artificial intelligence for medical education. Acad Med. 2025;100(1):116. doi:10.1097/ACM.0000000000005760.
7. Buabbas AJ, Miskin B, Alnaqi AA, Ayed AK, Shehab AA, Syed-Abdul S, et al. Investigating students' perceptions towards artificial intelligence in medical education. Healthcare (Basel). 2023;11(9):1298. doi:10.3390/healthcare11091298.
8. Naseer MA, Saeed S, Afzal A, Ali S, Malik MGR. Navigating the integration of artificial intelligence in the medical education curriculum: a mixed-methods study exploring the perspectives of medical students and faculty in Pakistan. BMC Med Educ. 2025;25:273. doi:10.1186/s12909-024-06552-2.
9. Sami A, Tanveer F, Sajwani K, Kiran N, Javed MA, Ozsahin DU, et al. Medical students' attitudes toward AI in education: perception, effectiveness, and its credibility. BMC Med Educ. 2025;25:82. doi:10.1186/s12909-025-06704-y.
10. Jebreen K, Radwan E, Kammoun-Rebai W, Alattar E, Radwan A, Safi W, et al. Perceptions of undergraduate medical students on artificial intelligence in medicine: mixed-methods survey study from Palestine. BMC Med Educ. 2024;24:507. doi:10.1186/s12909-024-05465-4.
11. Alkhaaldi SMI, Kassab CH, Dimassi Z, Alsoud LO, Al Fahim M, Al Hageh C, et al. Medical student experiences and perceptions of ChatGPT and artificial intelligence: cross-sectional study. JMIR Med Educ. 2023;9:e51302. doi:10.2196/51302.
12. Cervantes J, Smith B, Ramadoss T, D'Amario V, Shoja MM, Rajput V. Decoding medical educators' perceptions on generative artificial intelligence in medical education. J Investig Med. 2024;72(7):633-639. doi:10.1177/10815589241257215.
13. Tran C, Hryciw BN, Moore SW, Chaput A, Seely AJE. Perceptions and use of generative artificial intelligence in medical students: a multicenter survey. J Med Educ Curric Dev. 2025;12:23821205251391969. doi:10.1177/23821205251391969.

14. Polat M, Karadag E. Applications, advantages, and limitations of artificial intelligence in medical education assessment: a systematic review. BMC Med Educ. 2026. doi:10.1186/s12909-026-10545-8.
15. Lin Y, Luo Z, Ye Z, Zhong N, Zhao L, Zhang L, et al. Applications, challenges, and prospects of generative artificial intelligence empowering medical education: scoping review. JMIR Med Educ. 2025;11:e71125. doi:10.2196/71125.
16. Tran M, Balasooriya C, Jonnagaddala J, Leung GKK, Mahboobani N, Ramani S, et al. Situating governance and regulatory concerns for generative artificial intelligence and large language models in medical education. NPJ Digit Med. 2025;8:315. doi:10.1038/s41746-025-01721-z.
17. Tate H, Bicknell BT, Fiore P, Galloway J, Borak J, Brooks WS. Medical students' perceptions of AI-generated practice questions as learning tools. J Investig Med. 2026;74(7):663-669. doi:10.1177/10815589251406265.
18. Habib MM, Hoodbhoy Z, Siddiqui MAR. Knowledge, attitudes, and perceptions of healthcare students and professionals on the use of artificial intelligence in healthcare in Pakistan. PLOS Digit Health. 2024;3(5):e0000443. doi:10.1371/journal.pdig.0000443.
19. Birks S, Gray J, Darling-Pomranz C. Using artificial intelligence to provide a 'flipped assessment' approach to medical education learning opportunities. Med Teach. 2025;47(8):1377-1384. doi:10.1080/0142159X.2024.2434101.
20. Li Q, Qin Y. AI in medical education: medical student perception, curriculum recommendations and design suggestions. BMC Med Educ. 2023;23:852. doi:10.1186/s12909-023-04700-8.
21. Tran M, Balasooriya C, Semmler C, Rhee J. Generative artificial intelligence: the 'more knowledgeable other' in a social constructivist framework of medical education. NPJ Digit Med. 2025;8:430. doi:10.1038/s41746-025-01823-8.