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Assessing Awareness, Perception and Application of Artificial Intelligence Among Healthcare Professionals and Medical Students in Pakistan: A Cross-Sectional Online Study

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ABSTRACT

Background: Artificial intelligence (AI) is transforming healthcare by improving diagnostic accuracy and clinical workflows; however, there remains a significant knowledge gap regarding AI awareness, perception, and practical application among healthcare professionals and medical students in Pakistan, which may hinder optimal adoption.

Objective: This study aimed to assess the awareness, perception, and application of AI among healthcare professionals and medical students in Pakistan, identify perceived barriers to adoption, and inform educational and policy strategies for AI integration.

Methods: A cross-sectional online survey was conducted among healthcare professionals and medical and dental students ($n = 384$) from diverse institutions in Pakistan. Inclusion criteria comprised registered healthcare workers and currently enrolled students residing in Pakistan, while those unwilling to consent or not completing the survey were excluded. Data was collected using a validated, pretested self-administered questionnaire addressing AI awareness, perceptions, and application. The primary outcome was the proportion of participants familiar with and using AI; secondary outcomes included perceived barriers and support for AI curriculum integration. Ethical approval was obtained from the relevant institutional review board, and the study adhered to the Declaration of Helsinki. Data was analyzed using descriptive statistics in SPSS v25. **Results:** Half of the respondents reported prior AI exposure, with 20.8% rating their AI knowledge as excellent or good. A majority (86%) believed AI could improve diagnostic accuracy, while 36.5% expressed concern about job displacement. Only 52.1% had used AI-based tools, and key barriers included insufficient training (18.2%), infrastructural limitations (26%), and lack of awareness (20.8%). Most participants (57.3%) supported integrating AI training into the national curriculum. **Conclusion:** Moderate AI awareness and positive attitudes exist among Pakistani healthcare professionals and students, but substantial gaps in training and infrastructure remain. Addressing these barriers through targeted education and investment will be crucial for the effective and ethical integration of AI into clinical practice. **Keywords:** Artificial Intelligence, Healthcare, Awareness, Perception, Clinical Competence, Education, Pakistan

INTRODUCTION

Artificial Intelligence (AI), broadly defined as the capacity of machines to perform tasks that typically require human intelligence such as learning, reasoning, and problem-solving, is rapidly reshaping the landscape of healthcare across the world.

Advances in AI-driven technologies have demonstrated significant potential for improving diagnostic accuracy, facilitating predictive analytics, enhancing medical imaging interpretation, personalizing treatment planning, and

streamlining administrative processes (1). In high-income countries, the integration of AI within clinical practice has contributed to more efficient workflows, better patient outcomes, and the reduction of human error, which has prompted many healthcare systems to incorporate AI strategies into national policies (2). However, the successful adoption of AI in healthcare is contingent upon the preparedness of the healthcare workforce, which includes awareness, appropriate perception, and practical readiness to engage with these emerging technologies (3).

Despite global enthusiasm, several barriers hinder the widespread integration of AI into healthcare, particularly in developing nations. In countries with limited resources, challenges such as inadequate digital infrastructure, insufficient technical expertise, and the absence of formal AI training in medical curricula are pervasive (4). Furthermore, previous research highlights that healthcare professionals in such regions often possess only rudimentary knowledge of AI, with their understanding largely shaped by informal exposure or sporadic training sessions, rather than through structured education (5). This limited familiarity is compounded by concerns over ethical implications, data privacy, and the risk of AI replacing clinical roles, which can foster resistance among practitioners and students (6). In South Asia, studies have shown that while there is an increasing interest in AI's potential, significant gaps remain in practical knowledge, perceived benefits, and readiness for adoption among healthcare providers (7).

Within the context of Pakistan, the healthcare system faces longstanding issues, including a high burden of disease, workforce shortages, and underdeveloped infrastructure, creating unique opportunities and challenges for the adoption of AI technologies. While AI holds promise for alleviating some of these systemic burdens—such as enhancing diagnostic capabilities and optimizing patient management—there remains a critical lack of empirical data regarding the current level of awareness, perception, and application of AI among Pakistani healthcare professionals and students (8). The existing literature on AI adoption in Pakistan is sparse, with most studies focusing on general attitudes or single-institution assessments, rather than comprehensive, multicenter perspectives (1, 8). This knowledge gap impedes the development of targeted educational strategies and policy interventions needed to support AI integration.

Given this background, there is a pressing need to assess the current state of AI-related knowledge, attitudes, and practical experience among those who will drive its adoption in Pakistan's healthcare system. This study is therefore designed to systematically evaluate the awareness, perception, and application of artificial intelligence among healthcare professionals and medical students in Pakistan through a cross-sectional online survey. By identifying knowledge gaps and barriers to adoption, the findings aim to inform future curricular reforms and policy initiatives that can facilitate the safe and effective integration of AI into clinical practice. The central research question guiding this study is: What is the level of awareness, perception, and application of artificial intelligence among healthcare professionals and medical students in

Pakistan, and what barriers do they perceive in adopting AI within the local healthcare context?

MATERIALS AND METHODS

This cross-sectional observational study was conducted to assess the awareness, perception, and application of artificial intelligence among healthcare professionals and medical students in Pakistan. Eligible participants included registered healthcare professionals, such as doctors, nurses, and allied health staff, as well as currently enrolled medical and dental students from recognized institutions within Pakistan. Inclusion criteria required participants to be either actively practicing in a healthcare role or enrolled in a medical or dental program and residing in Pakistan during the study period. Individuals who declined to provide informed consent, were not residing in Pakistan, or did not complete the entire questionnaire were excluded from the analysis.

Participants were recruited using a non-probability convenience sampling strategy, which leveraged digital platforms, including social media, professional networks, and institutional mailing lists. This approach allowed the study to reach a wide range of healthcare professionals and students from diverse geographic and institutional backgrounds across the country. Prior to participation, all respondents were informed about the voluntary nature of the study, the purpose of the research, and the measures taken to ensure data confidentiality. Explicit informed consent was obtained electronically before the questionnaire could be accessed. All procedures involving human participants were carried out in accordance with the Declaration of Helsinki. Ethical approval for the study was granted by the relevant institutional review board.

Data were collected using a structured, self-administered online questionnaire developed specifically for this study after a thorough review of the literature on AI in healthcare (1,2). The questionnaire was designed to evaluate three primary domains: awareness of artificial intelligence, perception of its impact on healthcare, and readiness for application and adoption. Primary outcomes included the proportion of participants familiar with AI concepts, their perceptions regarding the role and potential risks of AI in healthcare, and the extent of AI tool usage or readiness to adopt such tools in practice or education. Secondary outcomes included the identification of perceived barriers to AI adoption and attitudes towards the integration of AI training in national curricula. The questionnaire was pretested on a small group of healthcare professionals and students ($n=20$) to ensure clarity, relevance, and reliability, and minor revisions were made based on their feedback. Confidentiality of responses was strictly maintained throughout the data collection process, with all data anonymized and stored securely.

The statistical analysis was performed using SPSS software version 25. Descriptive statistics, including frequencies and percentages, were used to summarize demographic characteristics and response distributions across all domains. Data were checked for completeness prior to analysis, and responses with missing critical data were excluded. No imputation for missing data was conducted. The results were

interpreted in light of the study objectives and existing literature to ensure a comprehensive understanding of the findings (3).

RESULTS

A total of 384 participants completed the online survey, comprising healthcare professionals and medical and dental students from various regions of Pakistan. The sample included a diverse demographic profile, with the majority aged between

20 and 29 years (59.90%) and a slightly higher proportion of males (59.99%) compared to females (40.01%). Most respondents were medical students (41.67%), followed by doctors (18.23%), nurses (11.72%), allied health professionals (11.72%), dental students (9.11%), and other healthcare staff (7.55%). Table 1 summarizes the sociodemographic characteristics of the respondents.

Table 1. Sociodemographic Characteristics of Respondents (N = 384)

| Category | Frequency | Percentage |
|----------------------------------|-----------|------------|
| Age Group | | |
| Under 20 | 23 | 5.99 |
| 20–29 | 230 | 59.90 |
| 30–39 | 67 | 17.45 |
| 40–49 | 34 | 8.85 |
| 50 and above | 15 | 3.91 |
| Gender | | |
| Male | 235 | 59.99 |
| Female | 149 | 40.01 |
| Current Role | | |
| Medical Student | 160 | 41.67 |
| Dental Student | 35 | 9.11 |
| Doctor | 70 | 18.23 |
| Nurse | 45 | 11.72 |
| Allied Health Professional | 45 | 11.72 |
| Other Healthcare Staff | 29 | 7.55 |
| Education/Year of Study | | |
| Undergraduate (1st–3rd Year) | 95 | 24.74 |
| Final Year/Intern | 120 | 31.25 |
| Graduate/Resident | 105 | 27.34 |
| Postgraduate/Specialist | 64 | 16.67 |
| Clinical Experience | | |
| None | 38 | 9.90 |
| <2 years | 112 | 29.17 |
| 2–5 years | 135 | 35.16 |
| >5 years | 74 | 19.27 |
| Institutional Affiliation | | |
| Government | 210 | 54.69 |
| Private | 118 | 30.73 |
| Semi-government | 45 | 11.72 |
| None | 18 | 4.69 |
| Province/Region | | |
| Punjab | 140 | 36.46 |
| Sindh | 78 | 20.31 |
| KPK | 65 | 16.93 |
| Balochistan | 25 | 6.51 |
| Islamabad | 19 | 4.95 |
| AJK | 10 | 2.60 |
| Gilgit-Baltistan | 8 | 2.08 |

Regarding awareness of artificial intelligence, half of the participants (50.3%) reported having heard of AI, and a similar proportion (49.5%) had encountered AI-related topics during their medical education or training. Self-assessment of general AI knowledge in healthcare indicated that only 20.8% rated their knowledge as "excellent" or "good," while 26.1% considered it "fair," 10.4% as "poor," and 3.6% indicated "none." These findings suggest a moderate level of baseline AI awareness in the study

cohort, with considerable variability across respondents. Participants' perceptions of AI were largely positive, with 86% (n = 330) either strongly agreeing or agreeing that AI has the potential to improve diagnostic accuracy. Similarly, 78% (n = 300) believed AI would play a significant role in the future of healthcare. Notably, 36.5% (n = 140) agreed or strongly agreed that AI poses a long-term threat to healthcare jobs, while a similar proportion remained neutral or disagreed. The majority

(67.7%, $n = 260$) supported formal AI training during healthcare education, and 83.3% ($n = 320$) felt that AI systems should complement, but not replace, clinical judgment. Ethical and

privacy concerns related to AI use in patient care were acknowledged by 75.5% ($n = 290$) of respondents.

Table 2. Awareness of Artificial Intelligence Among Healthcare Professionals and Students

| Item | Yes | No | Excellent | Good | Fair | Poor | None | Total |
|---|-----|-----|-----------|------|------|------|------|-------|
| Have you heard of AI? | 193 | 191 | - | - | - | - | - | 384 |
| How would you rate your general knowledge about AI in healthcare? | - | - | 80 | 150 | 100 | 40 | 14 | 384 |
| Have you come across AI-related topics during education/training? | 190 | 194 | - | - | - | - | - | 384 |

Table 3. Perception of Artificial Intelligence in Healthcare (N = 384)

| Statement | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree | Total |
|---|----------------|-------|---------|----------|-------------------|-------|
| AI can improve diagnostic accuracy | 150 | 180 | 40 | 8 | 6 | 384 |
| AI will play a significant role in healthcare's future | 130 | 170 | 50 | 20 | 14 | 384 |
| AI poses a long-term threat to healthcare jobs | 60 | 80 | 90 | 90 | 64 | 384 |
| Formal AI training should be part of healthcare education | 110 | 150 | 50 | 50 | 24 | 384 |
| AI should complement, not replace, clinical judgment | 160 | 160 | 40 | 14 | 10 | 384 |
| AI use raises ethical/privacy concerns in patient care | 120 | 170 | 60 | 20 | 14 | 384 |

In terms of AI application and readiness, 52.1% ($n = 200$) reported having used or interacted with AI-based tools in their practice or education, while 39.1% ($n = 150$) had not, and 8.9% ($n = 34$) were unsure. Confidence in using AI tools in healthcare was moderate: 41.7% ($n = 160$) felt confident, 26% ($n = 100$) lacked confidence, and 31.3% ($n = 120$) were uncertain. Willingness to adopt AI technology in clinical practice or education was expressed by 46.9% ($n = 180$), with 33.9% ($n = 130$) unwilling and 19.3% ($n = 74$) unsure. When asked about perceived barriers to AI adoption, the

most frequently cited issues were cost and infrastructure limitations (26%, $n = 100$), lack of awareness (20.8%, $n = 80$), insufficient training programs (18.2%, $n = 70$), ethical and legal issues (13%, $n = 50$), and resistance from healthcare staff (10.4%, $n = 40$). Notably, 10.4% ($n = 40$) selected "none of the above," suggesting no perceived barriers. The majority of participants (57.3%, $n = 220$) agreed that AI training should be integrated into the national healthcare curriculum.

Table 4. Application and Readiness for Artificial Intelligence Adoption (N = 384)

| Question/Barrier | Yes | No | Not Sure | Lack of Awareness | Insufficient Training | Cost/ Infrastructure | Ethical/Legal Issues | Resistance from Staff | None | Total |
|--|-----|-----|----------|-------------------|-----------------------|----------------------|----------------------|-----------------------|------|-------|
| Used/interacted with AI-based tool | 200 | 150 | 34 | - | - | - | - | - | - | 384 |
| Confidence in using AI tools | 160 | 100 | 120 | - | - | - | - | - | - | 384 |
| Willingness to adopt AI technology | 180 | 130 | 74 | - | - | - | - | - | - | 384 |
| Perceived barriers to AI adoption | - | - | - | 80 | 70 | 100 | 50 | 40 | 40 | 384 |
| Support for AI training in national curriculum | 220 | 100 | 64 | - | - | - | - | - | - | 384 |

While no inferential statistics (such as chi-square, t-tests, or regression analysis) are available from the provided data, descriptive findings indicate a moderate to high level of awareness and generally positive perceptions toward AI among the surveyed group. The proportion of respondents confident in their ability to use AI tools (41.7%) suggests a need for further educational interventions to build capacity. The identification of barriers, most notably infrastructural limitations and lack of training—reflects a significant opportunity for policy and curricular reform. The observation that 52.1% have interacted with AI-based tools, yet only 41.7% express confidence, may indicate the existence of a knowledge-practice gap, a finding that is clinically significant for targeted educational strategies.

The substantial support for formal AI education underscores a critical area for future investment and national policy direction.

The results demonstrate moderate awareness and generally favorable attitudes towards AI among healthcare professionals and medical students in Pakistan, though substantial gaps exist in confidence and training. Barriers such as inadequate infrastructure, insufficient training programs, and ethical concerns remain prominent and may impede the widespread adoption of AI in Pakistani healthcare settings. These findings inform the need for systematic curricular enhancements and policy-level strategies to foster readiness and safe integration of AI in clinical practice. The visualizations (Figure 1) illustrate that

cost and infrastructure (n=100), insufficient training (n=70), and lack of awareness (n=80) were the most commonly reported barriers to AI adoption among respondents, with smaller proportions citing ethical/legal issues (n=50), resistance from staff (n=40), or no barriers (n=40). Regarding confidence in AI tool usage, 160 participants reported feeling confident, while 100

were not confident and 120 were unsure. Support for integrating AI training into the national curriculum was high (n=220), compared to those not in support (n=100) or unsure (n=64), reflecting strong endorsement for formal AI education among healthcare professionals and students.

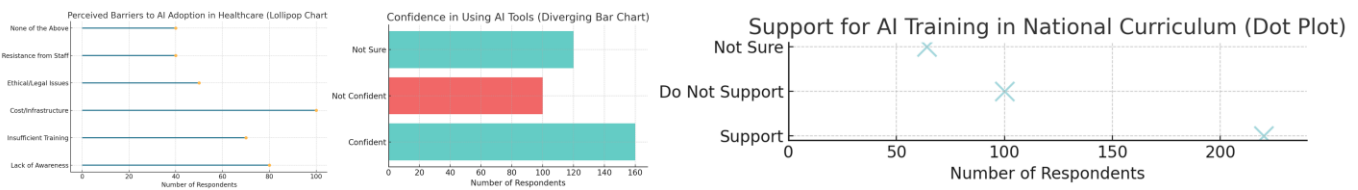


Figure 1 Key Barriers, Confidence Levels, and Support for AI Training Among Healthcare Respondents in Pakistan

DISCUSSION

The findings of this study provide important insights into the current landscape of artificial intelligence (AI) awareness, perception, and application among healthcare professionals and medical students in Pakistan, highlighting both progress and ongoing challenges. The observation that approximately half of the respondents had prior exposure to AI, and that most participants considered their general knowledge of AI in healthcare to be fair or good, signals a growing but still moderate baseline awareness. These findings align with recent studies from South Asia and the Middle East, which similarly report variable but generally improving levels of AI awareness among medical trainees and practitioners (1,2). In contrast, investigations conducted in high-income countries often reveal higher baseline familiarity with AI, a difference likely attributable to greater integration of digital health technologies and formalized training opportunities in those settings (3).

The present study's results demonstrate a predominantly positive perception of AI's potential, with a substantial majority agreeing that AI can enhance diagnostic accuracy and play a significant role in the future of healthcare. This is consistent with existing literature, including recent cross-sectional surveys from Pakistan and other developing countries, which report a widespread belief in AI's capacity to improve diagnostic precision and clinical outcomes (1,4). However, the finding that over one-third of respondents expressed concern about job displacement due to AI parallels global anxieties among healthcare professionals regarding automation and potential redundancy, a theme recurrent in studies from both resource-limited and advanced health systems (5,6). The endorsement of AI as a tool to complement, rather than replace, clinical judgment highlights an understanding of the technology's current capabilities and limitations, underscoring the importance of maintaining human oversight in decision-making processes.

Despite these positive perceptions, the study reveals several notable barriers to AI adoption in the Pakistani healthcare context. The most frequently cited obstacles—cost and infrastructure limitations, lack of formal training, insufficient awareness, and ethical or legal concerns—echo challenges described in previous reports from similar healthcare settings (2,7). Inadequate infrastructure and limited access to advanced technologies remain persistent impediments to the implementation of digital innovations in low- and middle-income

countries. The identification of insufficient training and lack of awareness as key barriers aligns with studies that emphasize the critical need for structured AI education within both undergraduate and postgraduate medical curricula (8). This finding is particularly relevant given that only about half of the participants had interacted with AI-based tools, and even fewer reported confidence in their ability to use such technologies, indicating a clear gap between theoretical knowledge and practical competence. Similar gaps have been reported in studies from neighboring regions, where exposure to AI during formal education is rare, and most learning occurs through informal or incidental means (9).

The strong support for the inclusion of AI training in the national healthcare curriculum observed in this study provides an actionable recommendation for policymakers and curriculum developers. Integrating AI competencies into medical education would not only enhance knowledge but also improve confidence and preparedness for future clinical practice, bridging the observed knowledge-practice gap. The willingness of nearly half of the respondents to adopt AI technology in their practice, despite notable barriers, is an encouraging sign that targeted interventions could yield significant improvements in AI uptake. Comparative research indicates that structured AI education, mentorship, and hands-on exposure can foster more positive attitudes and greater readiness for adoption, reinforcing the need for systemic educational reform (8,10).

Mechanistically, the moderate level of confidence in AI use among respondents may reflect broader challenges in Pakistan's healthcare infrastructure, including inconsistent access to digital resources, variable quality of training programs, and ongoing concerns regarding data privacy and ethical standards. These issues are not unique to Pakistan and have been recognized globally as key determinants of successful AI implementation (7). Theoretical implications of these findings extend to the evolving relationship between technology and clinical practice; as AI tools become more sophisticated, the necessity for clinicians to possess digital literacy and critical appraisal skills becomes paramount. Clinically, increasing AI adoption has the potential to alleviate workforce burdens and improve patient care, provided that ethical and operational concerns are addressed through appropriate regulation and stakeholder engagement. This study's strengths include its diverse, multi-institutional sample and comprehensive

exploration of both attitudes and practical readiness for AI adoption. However, several limitations should be considered. The reliance on convenience sampling and online survey methodology may have introduced selection bias, potentially overrepresenting younger or more technologically inclined individuals and limiting generalizability to the broader healthcare workforce. Self-reported data are also subject to recall bias and social desirability bias, which may have influenced responses regarding AI awareness or attitudes. The cross-sectional design precludes conclusions about causality or temporal changes in attitudes. Additionally, while the sample size met calculated requirements for precision, larger and more geographically diverse samples would enhance the robustness of future studies.

Looking forward, future research should aim to include a broader range of participants, including administrators, policymakers, and IT professionals, to gain a more comprehensive understanding of the multifaceted challenges and opportunities surrounding AI integration in healthcare. Longitudinal studies evaluating the impact of targeted educational interventions and infrastructure investments on AI readiness and adoption rates would provide valuable insights into effective strategies for advancing digital health in Pakistan and comparable contexts. Furthermore, qualitative research exploring the nuanced attitudes and experiences of different healthcare roles could inform more tailored and impactful curriculum and policy development. Overall, these findings support an urgent need for systemic educational and infrastructural reforms to enable safe, effective, and equitable integration of AI in healthcare, ensuring that Pakistan's health system can capitalize on the transformative potential of digital innovation while safeguarding ethical and professional standards (1,2,7,8,10).

CONCLUSION

This cross-sectional study assessing the awareness, perception, and application of artificial intelligence among healthcare professionals and medical students in Pakistan reveals that, while there is moderate awareness and generally positive attitudes towards the potential of AI to improve diagnostic accuracy and healthcare delivery, significant barriers such as insufficient training, limited infrastructure, and ethical concerns impede widespread adoption. These findings underscore the urgent need to enhance AI-related education and practical exposure within healthcare curricula and to address systemic obstacles at the institutional and policy level. Clinically, improving readiness for AI integration holds promise for augmenting patient care, reducing diagnostic errors, and optimizing resource utilization, while future research should focus on evaluating the impact of targeted educational and infrastructural interventions to facilitate the safe, ethical, and effective incorporation of AI technologies into Pakistan's healthcare system.

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