

Perception of artificial intelligence in pathology: Insight from clinical laboratory professionals in a tertiary care hospital in Pakistan

Rida Akhtar, Armaghana Qamar Khan, Mehreen Mushtaq, Asma Khattak, Salma Iltaf, Soffia Khursheed

Pakistan Institute of Medical Sciences, Islamabad Pakistan

ABSTRACT

Objective: Our study aims to assess knowledge and perception about artificial intelligence among clinical laboratories professionals in a tertiary care hospital setting.

Material and Methods: A descriptive cross-sectional study was carried out for one month from 2 July 2024 to 2 August 2024 using consecutive sampling with the help of a pre-designed questionnaire that contained six sections: demographics, knowledge of AI in pathology, attitudes towards AI in pathology, perceived benefits and barriers, training and education, and open-ended questions. The study population included doctors, technical staff, laboratory attendants, and technicians working in the PIMS pathology laboratory, a tertiary care setting. A sample size of 100 participants was selected. Both male and female participants were included, while individuals unwilling to participate were excluded from the study. Frequencies were calculated and tables with figures generated for presentation.

Results: A total of $n = 89$ participants completed the survey, with a mean age of 36.8 years ($SD \pm 7.9$). Most were female (75.3%) and pathologists (65.2%). Overall, 93.7% reported some familiarity with AI, though only 34.1% were slightly familiar. More than half agreed that AI could improve diagnostic accuracy (53.9%) and efficiency (60.2%), while concerns included reliability (54.5%) and data privacy (30.7%).

Conclusion: The study suggests that there is a need to develop education and training programs to address this knowledge gap as well as concerns regarding the use of AI in pathology.

Keywords: Artificial Intelligence, Clinical Laboratory Personnel, Education, Medical, Pathology, Tertiary Care Setting.

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INTRODUCTION

Artificial Intelligence (AI) refers to software that mimics human reasoning, with current enthusiasm centered on machine learning (ML). These systems are trained using large datasets, such as images, enabling them to perform specific diagnostic tasks accurately and efficiently [1]. Pathology plays a central and fundamental role in disease diagnosis. The rise of AI offers pathologists and laboratory personnel innovative tools that can augment

their skills [2]. The field of pathology is increasingly adopting AI-based applications for digital pathology, image analysis, and predictive modeling. However, success largely depends on departmental readiness for technology implementation and acceptance by healthcare professionals. Pathologists envision AI applications that enhance performance and reduce workloads—for example, by scanning slides, quantifying mitoses, or detecting metastases [3]. Deep learning models, such as convolutional neural networks, have demonstrated significant contributions [4]. AI has been a subject of interest since the 1950s, owing to the pioneering work of Alan Turing and John McCarthy. AI was first applied in healthcare between 1970 and 1980, with devices designed to assist doctors in diagnosing conditions [5].

Correspondence: Dr. Armaghana Qamar Khan, Assistant Professor, Department of Pathology, Pakistan Institute of Medical Sciences, Islamabad Pakistan

Email: armaghanakhan@gmail.com

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AI can analyze complex data, such as histopathology images and genetic information, primarily through machine learning (ML) and deep learning (DL) algorithms. Notable applications include AI-enabled image analysis services that detect subtle changes often missed by the human eye, thereby reducing misdiagnosis [4, 5]. Cancer, a global health burden, particularly benefits from early detection and treatment, which are especially critical in countries with a high Human Development Index (HDI) [6].

AI systems also enhance services such as slide imaging, specimen management, and reporting, thereby reducing turnaround times. However, significant concerns regarding AI include ethical issues, data privacy, fear of job loss, and the “black box” problem, where prognoses lack quantifiable measures [7, 8]. AI systems can incorporate subtle errors during development that may lead to implicit bias or assumptions, which can only be identified through thorough testing before deployment. Additionally, as treatments evolve, laboratory testing expands, and patient populations with specific diseases change, the characteristics of sample data will also shift, resulting in decreased algorithm reliability over time [9].

The study was therefore conducted to understand the laboratory professional knowledge and perceptions of AI in a tertiary care hospital, to provide baseline understanding for future work and training, and inform policy moving forward.

MATERIAL AND METHODS

This descriptive cross-sectional study was carried out in the Department of Pathology, Pakistan Institute of Medical Sciences (PIMS), Islamabad, over a one-month period from 2 July to 2 August 2024. Ethical approval was received from an Institutional Ethical Review Board (ERB number: F-5-2/2024(ERRC)/PIMS. The study was designed to assess the knowledge, attitudes, perceived benefits, barriers, and training needs related to the use of artificial intelligence (AI) in pathology. In general, parts of section measuring awareness, perception,

perceived benefits and barriers involved 5-point Likert scale.

The target population included doctors, technical staff, laboratory attendants, and technicians employed in the PIMS pathology laboratory, a tertiary care setting. A total of 100 participants were approached using a consecutive sampling technique. Sample size was calculated by using an application OpenEpi <https://www.openepi.com/SampleSize/SSCohort.htm>.

Both male and female staff members were eligible for inclusion, while individuals unwilling to participate were excluded from the study.

Data were collected through a pre-designed Google Forms questionnaire consisting of 23 questions. The questionnaire was structured into six sections:

1. Demographics
2. Knowledge of AI in pathology
3. Attitudes towards AI in pathology
4. Perceived benefits and barriers
5. Training and education
6. Open-ended questions for additional feedback

The questionnaire link was circulated electronically among the selected participants. Responses were automatically recorded in Google Sheets for analysis.

Out of the 100 individuals invited to participate, 89 completed the questionnaire, resulting in a response rate of 89%. All responses were reviewed for completeness. The collected data were entered into SPSS version 26 (IBM Corp) for statistical analysis. Pearson Chi-square test was applied on 5-point Likert scales of participants' responses. Descriptive statistics were applied to calculate frequencies and percentages for categorical variables, and results were presented using tables, graphs, distribution curves, and cross-tabulations. P-value of 0.05 is considered statistically significant.

RESULTS

Of 100 surveys disseminated, 89 responses were collected (response rate: 89%). Respondents' demographic characteristics are summarized in Table-I, and the relationship between age and gender in Table-II showed a

weak but significant correlation ($r = 0.280$, $p = 0.008$).

A majority of respondents (83; 93.3%) reported having some knowledge of AI. Among laboratory coordinators, 85.7% (5 of 6) considered themselves experts or very knowledgeable. Additionally, 40 (44.9%) were somewhat familiar with AI applications, particularly digital image analysis. No significant relationship was found between education level and AI familiarity ($\chi^2 = 27.492$, $p = 0.282$). Regarding overall AI exposure, 45 (50.6%) reported basic awareness, 37 (41.6%) no exposure, and 7 (7.9%) were unsure. Those with more professional experience were more likely to have encountered AI.

The most common sources of AI knowledge were conferences/seminars (26; 29.2%) and online resources (26; 29.2%), followed by colleagues/peers (25; 28.1%). Vocational training (8; 9.0%) and other sources (3; 3.4%) were less frequent. A significant association was observed between AI knowledge and source of information ($\chi^2 = 35.270$, $p = 0.019$).

Automated image analysis was the most recognized AI application (45; 50.6%), followed by diagnostic support (27; 30.3%). Applications related to analysis provision and workflow optimization were each cited by 11 respondents (12.9%).

Regarding diagnostic accuracy, 48 (53.9%) agreed and 8 (9.0%) strongly agreed that AI could improve pathology diagnoses, while 29 (32.6%) were neutral, 3 (3.4%) disagreed, and 1 (1.1%) strongly disagreed. In terms of efficiency, 53 (60.2%) agreed and 14 (15.9%) strongly agreed that AI may enhance efficiency, whereas 17 (19.3%) were neutral and 4 (4.5%) disagreed or strongly disagreed.

Comfort with AI tools varied: 9 (10.3%) were not at all comfortable, 31 (35.6%) slightly comfortable, 30 (34.5%) moderately comfortable, 15 (17.2%) very comfortable, and 2 (2.3%) extremely comfortable. A significant association was found between comfort level and concern about AI replacing pathologists (Table III, $p = 0.007$).

Key concerns included system reliability (48; 54.5%), lack of understanding (40; 45.5%), data privacy/security (27; 30.7%), job displacement (21; 23.9%), and ethical issues (19; 21.6%).

Perceived benefits of AI included improved efficiency (53; 59.6%), enhanced research capabilities (40; 44.9%), improved diagnostic accuracy (33; 37.1%), and cost savings (27; 30.3%).

The main obstacles to adoption were lack of training (49; 55.1%), technological limitations (45; 50.6%), cost (43; 48.3%), resistance to change (31; 34.8%), and regulatory issues (17; 19.1%). One respondent (1.1%) cited other barriers.

Looking ahead, 46 (51.7%) expected AI to have a significant impact on pathology, 20 (22.5%) a moderate impact, 9 (10.1%) little impact, and 1 (1.1%) no impact.

Most participants had not received formal AI training (80; 89.9%). Among those trained, formats included "other" (16; 42.1%), seminars (13; 34.2%), online courses (3; 7.9%), and workplace training (3; 7.9%). Preferred training methods were in-person workshops or seminars (55; 64.7%), online courses (12; 14.1%), webinars (10; 11.8%), and self-study (6; 7.1%). Respondents identified promising applications of AI in enhancing diagnostic accuracy, boosting efficiency, automating digital imaging, aiding cytology and histopathology interpretation, differentiating benign from malignant lesions, reducing workloads, and providing rapid screening and second opinions. Other uses included predictive diagnostics, molecular genetics, disease annotation, and integration of laboratory test results. Challenges to AI adoption included cost, lack of training and experience, technical issues, data security concerns, resistance to change (especially among senior pathologists), lack of standardization, and fears of job loss. Participants stressed the need for high-quality datasets, reliable systems, and acceptance within clinical practice. Major obstacles are shown in Figure-I.

Table-I: Baseline characteristics of the study population (n=89).

Table 1: Baseline characteristics of the study population (n=85).					Count	Column N %
What is your age?	25-34				32	36.0%
	35-44				33	37.1%
	45-54				18	20.2%
	55-64				3	3.4%
	Under 25				3	3.4%
What is your gender?	Female				67	75.3%
	Male				22	24.7%
What is your highest level of education?	Associate's degree				1	1.1%
	Bachelor's degree				14	15.7%
	Doctorate or professional degree (MD, PhD, etc.)				43	48.3%
	FCPS pathology				1	1.1%
	High school diploma or equivalent				4	4.5%
	Master's degree				25	28.1%
	MBBS				1	1.1%
How many years of experience do you have in your current role?	1-5 years	What is your primary role in the healthcare field?	Laboratory technician	2	5.3%	
			Medical student	2	5.3%	
			Other (please specify)	3	7.9%	
			Pathologist	25	65.8%	
			Physician (other than pathologist)	6	15.8%	
			Scientist	0	0.0%	
	11-15 years	What is your primary role in the healthcare field?	Laboratory technician	0	0.0%	
			Medical student	0	0.0%	
			Other (please specify)	2	13.3%	
			Pathologist	10	66.7%	
			Physician (other than pathologist)	3	20.0%	
			Scientist	0	0.0%	
	6-10 years	What is your primary role in the healthcare field?	Laboratory technician	1	6.3%	
			Medical student	0	0.0%	
			Other (please specify)	0	0.0%	
			Pathologist	13	81.3%	
			Physician (other than pathologist)	1	6.3%	
			Scientist	1	6.3%	
	Less than 1 year	What is your primary role in the healthcare field?	Laboratory technician	0	0.0%	
			Medical student	1	16.7%	
			Other (please specify)	1	16.7%	
			Pathologist	3	50.0%	
			Physician (other than pathologist)	1	16.7%	
			Scientist	0	0.0%	
	More than 15 years	What is your primary role in the healthcare field?	Laboratory technician	3	21.4%	
			Medical student	1	7.1%	
			Other (please specify)	3	21.4%	
			Pathologist	7	50.0%	
			Physician (other than pathologist)	0	0.0%	
			Scientist	0	0.0%	

Table-II: Correlation between age and gender. Test of significance applied.

		What is your age?	What is your gender?
What is your age?	Pearson Correlation	1	.280**
	Sig. (2-tailed)		.008
	Sum of Squares and Cross-products	88.989	10.753
	Covariance	1.011	.122
	N	89	89

What is your gender?	Pearson Correlation	.280**	1
	Sig. (2-tailed)	.008	
	Sum of Squares and Cross-products	10.753	16.562
	Covariances	.122	.188
	N	89	89

**Correlation is significant at the 0.01 level (2-tailed).

Table-III: Cross-tabulation of respondents' opinions on ai replacing pathologists and their comfort level with using ai tools in daily work (n = 89).

		How comfortable are you with using AI tools in your daily work?						
		Extremely comfortable	Moderately comfortable	Not at all comfortable	Slightly comfortable	Very comfortable	---	Total
Do you think	Agree	0	3	2	7	5	0	17
AI will	Disagree	1	16	3	14	4	1	39
replace	Neutral	0	5	2	8	5	0	20
pathologists	Strongly agree	1	0	0	0	1	0	2
in the future?	Strongly disagree	0	6	2	2	0	1	11
Total		2	30	9	31	15	2	89

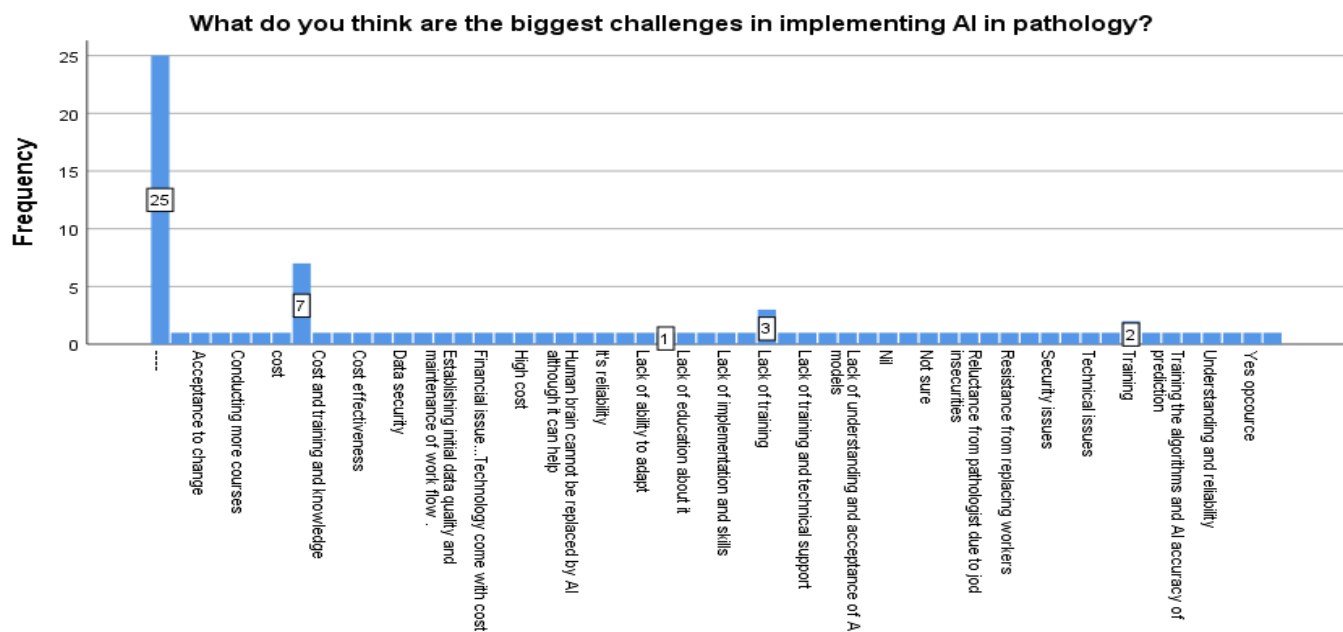


Figure-I: Respondents stated about the biggest challenges in implementation of artificial intelligence in pathology.

DISCUSSION

This research offers important insights into the demographics, knowledge, attitudes, and perceived obstacles related to the adoption of artificial intelligence (AI) in pathology. The majority of respondents were female (n = 67; 75.3%), aged between 25 and 44 years (n = 65; 73.1%), and at early to mid-career stages. Many participants had 1 to 5 years of experience (n = 38; 42.7%), indicating that the survey primarily reflected the perspectives of actively involved healthcare professionals. Pathologists represented the largest group (n = 57; 65.2%),

followed by physicians (n = 11; 12.4%), laboratory technicians (n = 6; 6.7%), and scientists (n = 4; 4.5%). Educational levels were high, with most holding doctoral or master's degrees (n = 68; 76.4%).

Awareness of AI was common, with 93.3% (n = 83) reporting at least some familiarity, which tended to increase with professional experience. In particular, 85.7% of laboratory coordinators considered themselves very knowledgeable or experts. These results are consistent with a study from Pakistan involving physicians, where nearly 70% reported being aware of AI [11].

In our survey, 53.9% of participants believed that AI could enhance diagnostic accuracy, while 60.2% thought it improved efficiency; however, a significant portion remained neutral (32.6% and 19.3%, respectively). Participants generally reported moderate comfort with AI tools, with most indicating slight (35.6%) or moderate (34.5%) comfort levels; fewer were very comfortable (17.2%) or not comfortable at all (10.3%). Major concerns highlighted were system reliability, limited knowledge of AI functioning, data security, and ethical issues. Overall, the responses showed optimism about AI's potential benefits, tempered by caution regarding practical and ethical challenges, aligning with results from a study conducted in Pakistan [12].

In our research, participants identified AI as enhancing efficiency (59.6%), expanding search capabilities (44.9%), improving diagnostic accuracy (37.1%), and lowering costs (30.3%). Additionally, open-ended feedback emphasized advantages like digital image analysis, quick differentiation between benign and malignant results, faster report generation, and offering a second opinion in difficult cases. The main focus of efficiency and diagnostic assistance suggest that AI is seen as an additional tool. This is similar to the reports published in the *Journal of Scientific Research in the Arab Gulf*. This raised similar issues as some of the concerns related to the use of AI in the health field [13]. The most significant challenges were lack of training or knowledge, limitations in technology, and costs. Also, resistance to changes especially in contrast to senior pathologists, the ambiguity of regulatory substances, and the lack of standards or protocols. Repeat subjects included fears about data quality or confidentiality and system reliability. These findings mirror similar studies in other regions. For example, one study published in *Frontiers in Digital Health* found that healthcare professionals identified lack of structured training, lack of infrastructure, and cost as the primary barriers to implementing Artificial Intelligence tools in diagnostic pathology. The same survey administered to radiologists described similar barriers, most

notably barriers around data privacy, ethics, and a lack of regulatory clarity, which ultimately slow the adoption of AI into real world clinical practice. Overall, the studies suggest that although stakeholders recognize AI's potential, challenges of lack of education, lack of resources, and uncertainty regarding legality and licensure create major barriers to implementing AI into healthcare systems [14].

Emphasis feedback also stated that without high quality, easy access training and suitable infrastructure, artificial intelligence will ultimately hit significant problems, especially in the resource-limited settings. A notable finding is the absence of formal AI training among many participants, with nearly 90% of the study sample ($n = 80$, 89.9%) reporting that they are not involved with any formal training regarding AI. Of those trained ($n = 9$, 10.1%), the majority of reporting training formats were seminars and workshops ($n = 13$, 34.2%), while other teaching formats of waves ($n = 16$, 42.1%) were identified as important, but they reported infrequent engagement with online courses ($n = 3$, 7.9%). The response that personal seminars could be the main preference for future training ($n = 55$, 64.7%) suggests that interactive practical training is important, particularly for the development of technical skills and trust in using AI tools.

These findings are in line with the global literature, which also indicated training gaps to be a significant barrier to AI adoption in healthcare. For example, a study around digital pathology adoption in low-resource environments pointed out that the shortage of trained staff, lack of structured education, and lack of infrastructure prevent the widespread adoption of AI [14]. A recent review of AI in laboratory medicine in low- and middle-income countries reiterated that deficits in training and the lack of standardized educational curricula remain significant barriers to moving forward, thus also emphasizing the need for specific-context educational mechanisms [15].

Looking further into the future, most respondents anticipated a significant improvement in pathology due to the use of AI ($n = 33$, 37.1%;

pathology $n = 46$, 51.7%) over the next ten years. Furthermore, 20 respondents (22.5%) expected AI to be only somewhat effective, 9 (10.1%) predicted minimal impact, and one respondent (1.1%) believed AI would be of no value. These responses reflect cautious optimism about the role of AI in pathology, alongside ongoing uncertainty regarding the pace and extent of its integration into clinical research processes.

The results are consistent with those of other international surveys, in which healthcare professionals are seen as useful adjuncts to human expertise, but not as replacements. For example, a multicenter simulation study on AI implementation in diagnostic medicine found that although most clinicians believed there was an opportunity to support their accuracy and efficiency, many expressed concerns about implementation timelines, ethical considerations, and healthcare systems' readiness to integrate these technologies [22]. Thus, it is possible to recognize the potential value of AI in pathology practice while simultaneously being concerned about the rate of change.

LIMITATIONS

Our research was conducted in a single hospital and involved a relatively small group of laboratory professionals, which may limit the generalizability of our findings. Additionally, Cronbach's alpha was not calculated because the items were designed as independent indicators rather than as components of a unidimensional scale measuring a single construct.

RECOMMENDATIONS

Structured Training Programs: Introduce AI education into pathology and laboratory science syllabus

CONCLUSION

The survey results suggest a well-informed community of professionals who comprehend the potential of AI and are generally optimistic about its role in pathology, albeit with caution regarding reliability, training, costs, and continuation in use without being integrated into current workflows. AI is universally recognized

as a tool for improved diagnostic accuracy, efficiency, and research effectiveness; however, implementation is affected by a number of practical and cultural challenges.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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Declared none

AUTHORS CONTRIBUTION

Rida Akhtar: Substantial contributions to study design, acquisition of data, manuscript drafting, critical review, final approval, accountable for all aspects of publication.

Armaghana Qamar Khan: Acquisition of data, manuscript drafting, reviewing it critical for important intellectual content, final approval, accountable for all aspects of publication.

Mehreen Mushtaq: Manuscript drafting, critical review, final approval, accountable for all aspects of publication.

Asma Khattak: Study design, critical review, final approval, accountable for all aspects of publication.

Salma Iltaf: Data acquisition, critical review, final approval, accountable for all aspects of publication.

Soffia Khursheed: Critical review, final approval, accountable for all aspects of publication.

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