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Original Article

Knowledge, Expectation and Concerns Regarding Artificial Intelligence in Surgery Among Surgeons, Medical Officers and General Physicians in Lahore, Pakistan: A Cross-Sectional Survey

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ABSTRACT

Background: Artificial intelligence is increasingly influencing clinical decision-making, diagnostic support, surgical planning, intraoperative guidance, and healthcare workflow optimization; however, its successful integration depends on clinicians' knowledge, expectations, perceived risks, and acceptance. **Objective:** This study assessed the knowledge, expectations, implementation preferences, and concerns regarding artificial intelligence in surgical and clinical practice among surgeons, medical officers, and general physicians in Lahore, Pakistan. **Methods:** A descriptive cross-sectional survey was conducted among 250 healthcare professionals working in academic, government, and private hospitals in Lahore. Data were collected using a structured questionnaire adapted from a validated survey and covering demographics, AI knowledge, surgical expectations, implementation preferences, liability concerns, autonomous surgery acceptance, and Likert-scale attitudes. Data were analyzed using IBM SPSS Statistics version 27, with descriptive statistics, Kruskal-Wallis tests, and Mann-Whitney U tests applied where appropriate. **Results:** Among respondents, 109 were surgeons, 123 were medical officers, and 18 were general physicians. Overall, 60.4% reported clinical use of AI, and 57.2% followed AI developments through professional or scientific journals. The most favored AI applications were intraoperative image processing, surgical planning, and outpatient clinical support. Most respondents supported Ministry of Health involvement in AI implementation. Surgeons were most commonly considered liable for AI-assisted complications, while 45.2% were willing to undergo fully autonomous robotic gallbladder surgery. Academic hospital surgeons reported significantly higher concern scores than government and private hospital surgeons. **Conclusion:** Healthcare professionals in Lahore showed favorable attitudes toward AI, but safe implementation requires structured education, regulatory oversight, liability clarification, and context-specific clinical validation. **Keywords:** Artificial intelligence; surgery; healthcare professionals; knowledge; expectations; concerns; Pakistan; cross-sectional survey.

INTRODUCTION

Artificial intelligence has evolved from the early concept of machines simulating human reasoning into a practical set of computational methods capable of learning from complex data, recognizing patterns, supporting decisions, and improving prediction in real-world environments (1). Recent advances in machine learning and deep learning have accelerated the integration of artificial intelligence into healthcare, where large volumes of electronic health records, diagnostic images, operative videos, laboratory data, and patient-monitoring outputs provide a strong foundation for algorithmic analysis (2). In clinical medicine, artificial intelligence has already demonstrated diagnostic and prognostic value across several specialties, including radiology, pathology, ophthalmology, dermatology, and digital clinical decision support, where automated systems may assist clinicians in image interpretation, risk stratification, workflow prioritization, and individualized care planning (3). These developments have created growing interest in the role of artificial intelligence not only as a technical innovation, but also as a system-level intervention that may influence clinical accuracy, patient safety, professional responsibilities, and healthcare delivery models.

Surgery represents a particularly important field for artificial intelligence because surgical care involves high-stakes decision-making across the preoperative, intraoperative, and postoperative continuum. Artificial intelligence may support preoperative diagnosis and treatment planning, predict postoperative complications, improve intraoperative image guidance, evaluate surgical performance, enhance operating room efficiency, and contribute to the development of semi-autonomous or autonomous robotic systems (4). Despite this potential, translation of artificial intelligence from research settings into routine surgical practice remains limited because successful adoption depends not only on algorithmic performance, but also on clinician knowledge, institutional readiness, ethical governance, medico-legal accountability, data protection, infrastructure, and trust in machine-generated recommendations (5). These issues are especially important in surgery, where clinical responsibility is traditionally centered on the surgeon and where errors related to automated guidance may have immediate consequences for patient safety.

The perceptions of healthcare professionals are therefore central to artificial intelligence implementation in surgical and clinical practice. Clinicians' awareness, expectations, concerns, and willingness to use artificial intelligence can influence whether new tools are accepted, ignored, resisted, or used inappropriately (6). Previous international surveys have shown that many surgeons and clinicians recognize the potential value of artificial intelligence, particularly for improving diagnostics, operative planning, image interpretation, and surgical workflow; however, these positive expectations are commonly accompanied by concerns regarding accountability, professional autonomy, algorithmic bias, explainability, data security, and the possibility that artificial intelligence may alter traditional clinical roles (7,8).

Evidence from high-income healthcare systems provides useful insight, but such findings may not be directly transferable to low- and middle-income countries because differences in infrastructure, training opportunities, regulatory oversight, digital health maturity, and patient access may substantially shape how clinicians understand and evaluate artificial intelligence in practice.

Pakistan is a lower-middle-income country with a rapidly expanding healthcare sector, increasing digitalization, and growing academic interest in artificial intelligence, yet there remains limited empirical evidence on how surgical and frontline clinical professionals perceive artificial intelligence in routine practice. Existing Pakistan-based studies have explored general knowledge, attitudes, and readiness toward artificial intelligence among physicians, medical students, and healthcare professionals, but surgery-specific evidence remains comparatively sparse, particularly among mixed clinical groups that include surgeons, medical officers, and general physicians (9,10).

This gap is important because medical officers and general physicians often serve as frontline decision-makers in Pakistani hospitals and may interact with diagnostic systems, referral pathways, emergency care, and perioperative workflows that could be affected by artificial intelligence. Understanding their views alongside those of surgeons may provide a more realistic picture of institutional readiness and professional expectations in local healthcare environments.

Lahore provides a relevant urban setting for studying this issue because it includes academic, government, and private hospitals with variable exposure to digital health infrastructure, specialist services, and clinical training resources. In such settings, artificial intelligence may be perceived both as an opportunity to improve efficiency and access, and as a source of concern because of unclear regulation, limited formal training, uncertain liability structures, and uneven institutional capacity. From a PICO perspective, the population of interest includes surgeons, medical officers, and general physicians working in Lahore; the exposure or phenomenon of interest is their knowledge, expectations, and concerns regarding artificial intelligence in surgical and clinical practice; the comparison may include professional role, hospital type, and years of clinical licensure; and the outcomes include perceived usefulness, awareness, educational interest, implementation preferences, liability concerns, and willingness to accept autonomous surgical technologies.

Therefore, this study aimed to determine the knowledge, expectations, and concerns of surgeons, medical officers, and general physicians regarding artificial intelligence in surgery and clinical practice in Lahore, Pakistan, and to identify whether perceptions differ across relevant professional and institutional characteristics.

MATERIALS AND METHODS

This descriptive cross-sectional observational study was conducted to assess knowledge, expectations, implementation preferences, and concerns regarding artificial intelligence in surgical and clinical practice among healthcare professionals working in Lahore, Pakistan. The study was carried out across multiple hospital settings, including academic or teaching hospitals, government hospitals, and private hospitals, to capture perceptions from clinicians working in different institutional environments. Data collection was performed from December 2025 to March 2026 using a paper-based structured questionnaire administered in person.

The study population comprised actively licensed healthcare professionals involved in surgical or clinical care, including surgeons, surgical residents, medical officers, and general physicians working in participating hospitals in Lahore. Eligible participants were those currently practicing in Lahore, available during the data collection period, and willing to provide voluntary informed consent. Participants who declined consent or returned incomplete questionnaires were excluded from analysis. A non-probability convenience sampling technique was used, and participants were approached at their respective hospital sites during routine working periods. Participation was voluntary, and respondents were informed about the purpose of the study, anonymity of responses, confidentiality of data, and their right to withdraw without any professional or academic consequence.

Data were collected using a structured questionnaire adapted from a previously validated survey assessing surgeons' perceptions of artificial intelligence. The questionnaire was contextually modified for the Pakistani healthcare setting and organized into six domains: sociodemographic and professional characteristics, knowledge and awareness of artificial intelligence, expectations regarding artificial intelligence in surgery, implementation preferences, perceived risks and concerns, and Likert-scale attitudinal statements.

Context-specific modifications included replacing questions about the Dutch Association for Surgery with questions about the Ministry of Health in Pakistan, expanding the respondent categories to include medical officers and general physicians, and broadening surgical specialty options to include cardiac surgery, orthopedics, neurosurgery, urology, ear, nose and throat surgery, and plastic surgery.

The questionnaire collected demographic and professional variables, including professional role, type of hospital, years since licensure among surgeons, and surgical specialty where applicable. Knowledge-related variables included self-reported clinical use of artificial intelligence in the hospital and whether respondents actively followed artificial intelligence developments through scientific or professional journals.

Expectation-related variables assessed perceived hospital departments with the greatest potential value from artificial intelligence and the most promising operating-room applications, including intraoperative image processing, surgical planning, operating-room efficiency, automated performance metrics, and black-box decision-support systems. Implementation-related variables assessed the perceived role of the Ministry of Health in the development and implementation of artificial intelligence for surgery. Risk and concern variables included perceived liability in the event of complications during AI-assisted surgery and willingness to undergo fully autonomous robotic gallbladder surgery.

Attitudinal responses were measured using eight statements rated on a five-point Likert scale, where 1 indicated "strongly disagree" and 5 indicated "strongly agree." These items assessed awareness of artificial intelligence possibilities, interest in further education, perceived benefit-risk balance, expectation of fewer complications, expectation of improved diagnostic ability, perceived value of artificial intelligence in surgery, belief that artificial intelligence could become superior to surgeons' clinical experience and skills, and concern about job replacement. Composite mean scores were calculated for relevant domains, including knowledge, expectations, and concerns, using the corresponding Likert-scale items. Higher scores indicated stronger agreement with the construct being measured.

The sample size was calculated as 250 participants using a proportional estimation approach based on a 95% confidence level, 5% margin of error, and an expected positive attitude proportion of 85% derived from previous literature (5). This sample size was considered sufficient to estimate the overall perception of artificial intelligence among the target healthcare professionals and to allow descriptive comparison across key professional and institutional subgroups.

Completed questionnaires were reviewed for completeness before data entry. Data were entered into IBM SPSS Statistics version 27 for analysis. Categorical variables were summarized as frequencies and percentages. Likert-scale responses were summarized using descriptive statistics and domain-level mean composite scores. Because Likert-scale data and composite scores were treated as non-normally distributed ordinal or ordinal-derived variables, non-parametric tests were applied. The Kruskal-Wallis test was used to compare knowledge, expectation, and concern scores across surgeon license-year categories and hospital types. Where group comparisons required two-category analysis, the Mann-Whitney U test was used. Statistical significance was set at $p < 0.05$.

Bias was addressed by collecting responses anonymously, using the same questionnaire format for all participants, and administering the survey across different types of hospitals to improve institutional diversity. To reduce information bias, the questionnaire used structured response options and standardized Likert-scale scoring. Selection bias was minimized by including clinicians from academic, government, and private hospital settings; however, participants were recruited through convenience sampling. Confounding was considered during subgroup analysis by comparing responses according to hospital type and years of licensure among surgeons.

Ethical approval was obtained from the University of Central Punjab, Lahore. Informed consent was obtained before participation. No names, registration numbers, or personally identifying information were collected. All responses were handled anonymously and used only for academic and research purposes. Data were stored securely, analyzed in aggregate form, and reported without identifying individual participants or institutions.

RESULTS

A total of 250 healthcare professionals completed the survey. Surgeons represented 43.6% of the sample (n = 109), followed by medical officers at 49.2% (n = 123) and general physicians at 7.2% (n = 18). Among surgeons, 45.0% were practicing in academic or teaching hospitals, 30.3% in government hospitals, and

24.8% in private hospitals. Most surgeons had 1–10 years of licensed practice (60.6%), while 26.6% had 11–20 years and 12.8% had more than 20 years of experience.

Cardiac surgery was the most frequently reported surgical specialty among surgeons (33.9%), followed by gastrointestinal and oncological surgery (22.9%), vascular surgery (15.6%), pediatric surgery (10.1%), and traumatology (9.2%). Less frequently represented specialties included orthopedics, general surgery, neurosurgery, plastic surgery, urology, and ear, nose, and throat surgery. Most respondents reported prior clinical exposure to artificial intelligence in their hospital setting. Overall, 151 respondents (60.4%) stated that they had made clinical use of artificial intelligence, whereas 99 respondents (39.6%) reported no such use.

A similarly high proportion of participants reported actively following developments in artificial intelligence through professional or scientific journals, with 143 respondents (57.2%) answering yes and 107 respondents (42.8%) answering no. These findings indicate that more than half of the surveyed clinicians had both perceived clinical exposure to artificial intelligence and ongoing engagement with AI-related professional information. When respondents were asked which hospital department could derive the greatest potential value from artificial intelligence, the outpatient clinic was selected most frequently, accounting for 80 responses (32.0%).

The surgical ward or emergency department was selected by 73 respondents (29.2%), while the operating room was selected by 62 respondents (24.8%). A smaller proportion of participants considered artificial intelligence valuable across all hospital departments (10.8%), while very few selected no department (1.2%) or other responses (2.0%).

Regarding operating-room applications, intraoperative image processing for surgical guidance was the most frequently selected use case, reported by 94 respondents (37.6%). Surgical planning and operating-room efficiency followed closely, selected by 85 respondents (34.0%). Automated performance metrics for surgeons were selected by 42 respondents (16.8%), while 13 respondents (5.2%) selected black-box applications. These findings suggest that respondents perceived the strongest AI potential in patient-facing clinical flow and intraoperative decision-support functions.

Table 1. Demographic and Professional Characteristics of Respondents

Characteristic	Category	n	%
Professional role, total sample (n = 250)	Surgeon	109	43.6
	Medical officer	123	49.2
	General physician	18	7.2
Hospital type among surgeons (n = 109)	Academic or teaching hospital	49	45.0
	Government hospital	33	30.3
	Private hospital	27	24.8
Years since licensure among surgeons (n = 109)	1–10 years	66	60.6
	11–20 years	29	26.6
	More than 20 years	14	12.8
Surgical specialty among surgeons (n = 109)	Cardiac surgery	37	33.9
	Gastrointestinal and oncological surgery	25	22.9
	Vascular surgery	17	15.6
	Pediatric surgery	11	10.1
	Traumatology	10	9.2
	Orthopedics	3	2.8
	General surgery	2	1.8
	Neurosurgery	1	0.9
	Plastic surgery	1	0.9
	Urology	1	0.9
	Ear, nose, and throat surgery	1	0.9

Table 2. Knowledge and Awareness of Artificial Intelligence among Respondents

Variable	Response	n	%
Clinical use of artificial intelligence in hospital practice (n = 250)	Yes	151	60.4
	No	99	39.6
Actively follows artificial intelligence developments through professional or scientific journals (n = 250)	Yes	143	57.2
	No	107	42.8

Table 3. Expectations Regarding Artificial Intelligence Applications and Implementation

Domain	Question	Response	n	%
Hospital department with greatest potential value from AI (n = 250)	Which department could have the most significant potential value from AI?	Outpatient clinic	80	32.0
		Operating room	62	24.8
		Surgical ward/emergency department	73	29.2
		All departments	27	10.8
		No department	3	1.2
		Other	5	2.0
Operating-room AI application with greatest potential (n = 250)	Which AI application in the operating room has the greatest potential?	Intraoperative image processing for surgical guidance	94	37.6
		Automated performance metrics of surgeons	42	16.8
		Black-box system	13	5.2
		Surgical planning/operating-room efficiency	85	34.0
		All of the above	7	2.8
		None	4	1.6
		Other	5	2.0
Preferred role of Ministry of Health in AI implementation (n = 250)	What role should the Ministry of Health take in AI development and implementation for surgery?	Advisory and coordinating role	109	43.6
		Active central role	98	39.2
		No role	37	14.8
		Research role	2	0.8
		Other	4	1.6

Regarding implementation, 109 respondents (43.6%) preferred the Ministry of Health to take an advisory and coordinating role in the development and implementation of artificial intelligence for surgery. A further 98 respondents (39.2%) supported an active central role, indicating that 82.8% of participants favored some level of Ministry involvement. Only 37 respondents (14.8%) believed the Ministry should have no role. This pattern suggests broad support for institutional or governmental oversight in the introduction of surgical artificial intelligence.

In relation to liability, 113 respondents (45.2%) believed that the surgeon should be held primarily responsible in the event of a complication during AI-assisted surgical guidance. The AI software or algorithm company was identified as responsible by 70 respondents (28.0%), while 41 respondents (16.4%) selected the hospital. Fewer respondents attributed responsibility to the patient who signed the consent form (4.8%), all listed parties (2.0%), or other parties (3.6%). When asked about personal willingness to undergo fully autonomous robotic gallbladder surgery controlled by artificial intelligence, 113 respondents (45.2%) answered yes and 137 respondents (54.8%) answered no.

Table 4. Risks, Concerns, Liability, and Willingness Toward Autonomous Robotic Surgery

Variable	Response	n	%
Primary liability in the event of a complication during AI-assisted surgical guidance (n = 250)	Surgeon	113	45.2
	Hospital	41	16.4
	Software/algorithm company	70	28.0
	Patient who signed consent	12	4.8
	All of the above	5	2.0
	Other	9	3.6
Willingness to undergo fully autonomous robotic gallbladder surgery controlled by AI (n = 250)	Yes	113	45.2
	No	137	54.8

Likert-scale responses showed generally favorable expectations toward artificial intelligence, particularly for education, diagnostic improvement, complication reduction, and surgical value. A majority of respondents agreed or completely agreed that they were interested in further education about artificial intelligence, with 50.5% agreeing and 16.5% completely agreeing, giving a combined positive response of 67.0%.

Awareness of the possibilities of artificial intelligence was also common, with 46.8% agreeing and 11.0% completely agreeing, yielding 57.8% positive agreement. More than half of respondents expected artificial intelligence to improve diagnostic ability, with 38.5% agreeing and 18.3% completely agreeing, and 55.9% expected it to reduce complications, with 44.0% agreeing and 11.9% completely agreeing. The perceived value of artificial intelligence in surgery was supported by 50.4% of respondents, consisting of 38.5% agreement and 11.9% complete agreement.

Responses were more cautious for the statement that artificial intelligence could become superior to a surgeon's clinical experience. For this item, 47.7% of respondents disagreed or completely disagreed, 32.1% remained neutral, and only 20.2% agreed or completely agreed.

Concern about job replacement was low relative to other items: 64.3% disagreed or completely disagreed that artificial intelligence would replace their job, while 13.8% agreed or completely agreed. Overall, the Likert findings indicate a pattern of practical optimism, with respondents supporting education and clinical usefulness while remaining less convinced that artificial intelligence could surpass surgical experience or directly threaten employment.

Table 5. Likert-Scale Attitudinal Responses Toward Artificial Intelligence

Statement	Completely Disagree %	Disagree %	Neutral %	Agree %	Completely Agree %	Positive Agreement %
I am aware of the possibilities of AI	8.3	4.6	29.4	46.8	11.0	57.8
I am interested in further education about AI	6.4	9.2	17.4	50.5	16.5	67.0
The benefits of AI will outweigh the potential risks	3.7	11.0	37.6	38.5	9.2	47.7
I expect to reduce complications with help of AI	5.5	8.3	30.3	44.0	11.9	55.9
I expect to improve my diagnostic ability with help of AI	6.4	7.3	29.4	38.5	18.3	56.8
AI can be of value in the surgical field	7.3	7.3	34.9	38.5	11.9	50.4
AI could become superior to a surgeon's clinical experience	13.8	33.9	32.1	17.4	2.8	20.2
I am worried AI will replace my job	29.4	34.9	22.0	10.1	3.7	13.8

Subgroup analysis among surgeons showed that mean knowledge composite scores were similar across years of licensure, with scores of 3.6 among surgeons licensed for 1–10 years, 3.5 among those licensed for 11–20 years, and 3.6 among those licensed for more than 20 years.

This difference was not statistically significant ($p = 0.936$). Expectation scores were also identical across licensure groups, with each group having a mean score of 3.3 and no statistically significant difference ($p = 0.730$). Concern scores were numerically highest among surgeons licensed for 1–10 years (2.3), followed by those licensed for 11–20 years (2.1) and more than 20 years (2.0), but this difference did not reach statistical significance ($p = 0.347$).

Across hospital types, surgeons from academic or teaching hospitals had a mean knowledge score of 3.6, compared with 3.4 among surgeons from government hospitals and 3.6 among surgeons from private hospitals; this difference was not statistically significant ($p = 0.189$). Mean expectation scores were 3.4 in academic or teaching hospitals, 3.1 in government hospitals, and 3.3 in private hospitals, with no statistically significant difference ($p = 0.339$).

However, concern scores differed significantly by hospital type. Surgeons in academic or teaching hospitals had the highest mean concern score at 2.5, compared with 1.9 among government-hospital surgeons and 2.1 among private-hospital surgeons, with a statistically significant between-group difference ($p = 0.040$). Thus, the only statistically significant subgroup difference observed was higher concern among surgeons working in academic or teaching hospitals.

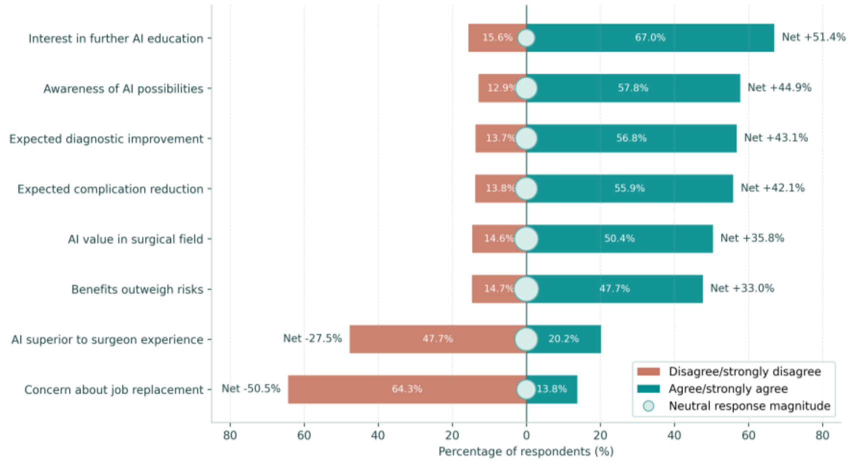

Figure 1. Net Endorsement Profile of Artificial Intelligence Attitudes in Surgical and Clinical Practice

The net endorsement profile showed the strongest positive attitude for further artificial intelligence education, with 67.0% agreement versus 15.6% disagreement, producing a net endorsement of +51.4%. Awareness of AI possibilities also showed strong positive alignment, with 57.8% agreement and 12.9% disagreement, yielding a net endorsement of +44.9%. Clinically oriented expectations were similarly favorable, including diagnostic improvement (+43.1%), complication reduction (+42.1%), perceived value in surgery (+35.8%), and benefits outweighing risks (+33.0%). In contrast, respondents showed negative endorsement for AI becoming superior to surgeons' clinical experience, where disagreement exceeded agreement by 27.5 percentage points, and concern about job replacement was even lower, with 64.3% disagreement and only 13.8% agreement, producing a net endorsement of −50.5%. Overall, the figure demonstrates high educational and clinical receptivity toward AI while showing limited perceived threat to professional replacement.

DISCUSSION

This study provides context-specific evidence on the perceptions of artificial intelligence among surgeons, medical officers, and general physicians working across academic, government, and private hospital settings in Lahore, Pakistan. The findings indicate a generally favorable attitude toward artificial intelligence in surgical and clinical practice, with 60.4% of respondents reporting clinical use of AI and 57.2% reporting that they actively followed AI developments through professional or scientific journals. This level of reported exposure is notable in a lower-middle-income healthcare setting and suggests that artificial intelligence is no longer perceived as a distant technological concept, but as an increasingly visible component of clinical discussion and practice. However, the interpretation of self-reported AI use requires caution because clinicians may differ in how they define artificial intelligence, ranging from formal clinical decision-support systems and imaging algorithms to general digital tools or generative AI platforms. This distinction is important because meaningful implementation of AI in surgery depends not only on awareness, but also on clinicians' ability to distinguish validated clinical AI systems from broader digital or algorithmic technologies (11,12).

The strong interest in further education about artificial intelligence was one of the most clinically relevant findings. Overall, 67.0% of respondents agreed or completely agreed that they were interested in additional AI education, while 57.8% reported awareness of AI possibilities. This pattern suggests that clinicians are receptive to AI but still recognize the need for structured learning. Such educational demand is especially important in surgical environments, where artificial intelligence may influence operative planning, image-guided decision-making, postoperative risk prediction, and performance evaluation. Without formal training, clinicians may either overestimate the capabilities of AI systems or underuse potentially beneficial tools because of uncertainty, mistrust, or lack of interpretability. International literature has similarly emphasized that AI literacy should become part of medical and surgical education, with emphasis on algorithmic limitations, clinical validation, bias, explainability, data governance, and medico-legal responsibility (13). In the Pakistani context, where formal AI training opportunities remain limited, the high educational interest observed in this study supports the need for AI-focused continuing professional development, postgraduate surgical curricula, and institutional workshops tailored to clinical practice.

Respondents identified the outpatient clinic as the hospital department with the greatest potential value from artificial intelligence, selected by 32.0% of participants, followed by the surgical ward or emergency department at 29.2% and the operating room at 24.8%. This distribution is important because it shows that clinicians did not restrict AI value to technically advanced operative environments. Instead, they appeared to recognize its potential role in high-volume clinical settings where diagnostic triage, patient flow, risk stratification, and referral decisions are often challenging. In resource-constrained systems, outpatient and emergency departments may benefit from AI-assisted prioritization, structured clinical decision support, and early identification of high-risk patients. At the same time, operating-room applications remained highly relevant: intraoperative image processing for surgical guidance was the most frequently selected operating-room use case at 37.6%, followed by surgical planning and operating-room efficiency at 34.0%. These findings are consistent with the broader direction of surgical AI research, where image interpretation, workflow recognition, operative navigation, and prediction of surgical outcomes remain major areas of development (14,15).

The implementation findings showed strong support for institutional governance. A total of 82.8% of respondents favored either an advisory and coordinating role or an active central role for the Ministry of Health in AI development and implementation for surgery. This preference reflects an important concern in healthcare AI: clinicians may be willing to adopt innovation, but they expect oversight, standards, and accountability frameworks before AI becomes embedded in clinical decision-making. In Pakistan, where AI-specific regulation in clinical practice is still evolving, a central coordinating role could help establish minimum standards for validation, procurement, patient consent, cybersecurity, liability, and monitoring of AI tools after implementation. Such governance is particularly important for surgical AI because intraoperative or perioperative recommendations may directly affect patient safety. International discussions on medical AI regulation have emphasized that clinical deployment should be accompanied by transparent evaluation, continuous monitoring, and clear responsibility pathways involving clinicians, hospitals, software developers, and regulators (16,17).

Liability concerns were prominent in this study. In the event of a complication during AI-assisted surgical guidance, 45.2% of respondents considered the surgeon primarily responsible, while 28.0% attributed liability to the software or algorithm company and 16.4% to the hospital. This distribution suggests that clinicians continue to view the surgeon as the central accountable professional but also recognize that AI-assisted care introduces shared responsibility across the clinical, institutional, and technological ecosystem. The relatively high attribution of liability to software companies may reflect awareness that algorithmic errors, training-data limitations, or poor system design can contribute to patient harm. It may also reflect uncertainty about how responsibility should be assigned when clinicians rely on AI-generated recommendations. These findings reinforce the need for clear medico-legal frameworks before surgical AI tools are widely implemented. Surgeons must understand whether AI outputs are advisory, semi-autonomous, or autonomous, and hospitals must define how such outputs should be documented, audited, and incorporated into clinical decision-making (18).

A particularly notable finding was that 45.2% of respondents reported willingness to undergo fully autonomous robotic gallbladder surgery controlled by artificial intelligence. This level of acceptance may indicate optimism toward technological innovation, perceived confidence in robotic precision, or expectations that AI may reduce human error. However, willingness to accept fully autonomous surgery should be interpreted in relation to current clinical realities. Fully autonomous surgical systems remain far more complex than AI-assisted decision-support tools because they require real-time anatomical interpretation, intraoperative judgment, management of unexpected bleeding or injury, and safe conversion to human control when needed. Therefore, the finding may also indicate incomplete understanding of the present limitations of autonomous surgery. The contrast between high willingness for autonomous surgery and low belief that AI could become superior to a surgeon's clinical experience is informative: only 20.2% agreed or completely agreed that AI could become superior to surgeons' experience, while 47.7% disagreed or completely disagreed. This suggests that respondents may support AI as a useful adjunct while remaining hesitant to accept replacement of human surgical judgment (19).

The Likert-scale findings support a pattern of practical optimism rather than uncritical enthusiasm. More than half of respondents expected AI to improve diagnostic ability (56.8%) and reduce complications (55.9%), while 50.4% agreed that AI could be valuable in the surgical field. At the same time, only 13.8% agreed or completely agreed that AI could replace their job, whereas 64.3% disagreed or completely disagreed with this statement. This indicates that clinicians generally perceived AI as a supportive technology rather than a direct professional threat. Such a view is beneficial for implementation because resistance may be lower when AI is framed as augmenting clinical reasoning, improving workflow, and enhancing patient safety rather than replacing clinicians. Nevertheless, this optimism should be balanced by structured education on limitations such as automation bias, algorithmic bias, poor generalizability across populations, data privacy risks, and overreliance on systems that may not have been validated in local clinical environments (20).

The subgroup analysis among surgeons showed no statistically significant differences in knowledge or expectation scores by years of licensure or hospital type, suggesting that AI awareness and general expectations may be relatively consistent across experience levels and institutional settings. However, concern scores differed significantly by hospital type, with surgeons from academic or teaching hospitals reporting higher mean concern scores than those from government and private hospitals (2.5 versus 1.9 and 2.1, respectively; $p = 0.040$). This finding may reflect greater exposure among academic surgeons to research discussions, ethical debates, clinical validation requirements, and the limitations of emerging technologies. Academic clinicians may be more familiar with the risks of algorithmic bias, inadequate external validation, unclear liability, and premature clinical adoption, which could explain higher concern despite similar knowledge and expectation scores. Rather than indicating resistance, higher concern in academic settings may represent more critical awareness and could be useful for designing balanced implementation strategies.

The findings also have implications for healthcare policy and institutional planning in Pakistan. The combination of high educational interest, favorable expectations, and strong preference for Ministry-level involvement suggests that AI implementation should proceed through coordinated, evidence-based pathways rather than fragmented adoption by individual hospitals or departments. Priority areas may include AI literacy training for clinicians, national guidance on clinical AI validation, ethical and legal frameworks for AI-assisted decision-making, and multidisciplinary committees involving surgeons, medical officers, data scientists, hospital administrators, legal experts, and patient representatives. Teaching hospitals may be well positioned to lead pilot implementation programs because they combine clinical service, education, and research capacity. However, government and private hospitals should also be included to prevent unequal access and ensure that AI systems are evaluated across diverse clinical environments.

This study has several strengths. It included clinicians from multiple hospital types and incorporated surgeons, medical officers, and general physicians, thereby capturing perspectives from both specialist and frontline clinical groups. The use of a structured questionnaire allowed assessment of knowledge, expectations, implementation preferences, and concerns across several domains. The inclusion of items on liability, Ministry of Health involvement, operating-room applications, and willingness toward autonomous robotic surgery provides a broader view of AI readiness than simple awareness-based surveys. These findings are particularly relevant for a lower-middle-income setting where local evidence on surgical AI perceptions remains limited.

The study also has limitations that should be considered when interpreting the findings. The use of convenience sampling may have introduced selection bias because clinicians with greater interest in artificial intelligence may have been more likely to participate. The study was limited to Lahore and may not represent perceptions among healthcare professionals in rural, peri-urban, or less digitally resourced regions of Pakistan. The survey relied on self-reported knowledge and AI use, which may overestimate actual clinical exposure if respondents interpreted general digital tools as artificial intelligence. In addition, the cross-sectional design captures perceptions at one point in time and cannot determine whether educational exposure, hospital infrastructure, or clinical experience directly influenced attitudes. Despite these limitations, the study provides useful baseline evidence for understanding AI perceptions among surgical and clinical professionals in an urban Pakistani healthcare setting.

Overall, the findings suggest that healthcare professionals in Lahore are receptive to artificial intelligence in surgery and clinical practice, particularly as a tool for education, diagnostic support, complication reduction, surgical planning, and intraoperative guidance. At the same time, respondents identified important concerns related to liability, professional responsibility, autonomous surgery, and the need for government oversight. The central message is therefore not simply that clinicians are ready for AI, but that readiness must be supported by education, regulation, institutional governance, and locally relevant validation. In a healthcare system facing increasing clinical demand and uneven resource distribution, responsible AI integration may offer meaningful benefits, but only if implementation is guided by evidence, transparency, clinician engagement, and patient safety.

CONCLUSION

Healthcare professionals in Lahore demonstrated generally positive perceptions toward artificial intelligence in surgical and clinical practice, with substantial self-reported clinical exposure, active engagement with AI-related developments, and strong interest in further AI education. Respondents viewed AI as particularly useful for outpatient care, emergency and surgical ward workflows, intraoperative image processing, surgical planning, diagnostic improvement, and reduction of complications, while most did not perceive AI as an immediate threat to professional employment. At the same time, the findings highlight important implementation challenges, including uncertainty regarding liability in AI-assisted complications, cautious attitudes toward AI exceeding surgical experience, and the need for structured oversight by the Ministry of Health. The higher concern scores among surgeons in academic or teaching hospitals suggest that greater exposure to emerging technologies may be associated with more critical awareness of their risks. These findings support the need for formal AI literacy programs, context-specific clinical validation, clear medico-legal frameworks, data governance standards, and multidisciplinary implementation strategies to ensure that AI is integrated into Pakistan's surgical healthcare system in a safe, ethical, and clinically meaningful manner.

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