

ORIGINAL ARTICLE

Evaluating the understanding of AI and its Applications in Dentistry amongst Final Year Undergraduate Dental Students, a Multi-Center Survey



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Received: May 5, 2026, **Accepted:** Jun 22, 2026, **Published:** June 30, 2026.

DOI: <https://doi.org/10.47489/szmc.v40i2.968>

Data Availability: The corresponding author can provide access upon request.

Funding: No funding received

Competing Interests: No competing interest to declare.

Author Contributions:

MA, MT, SR, SAZ, LRC, MF

- Each author made substantial contributions to the conception and design of the study, or acquisition, analysis, and interpretation of data.
- All authors were involved in drafting the manuscript or critically revising it for important intellectual content.
- All authors approved the final version of the manuscript to be published and agree to be accountable for all aspects of the work.

ABSTRACT

Background: Dentistry is increasingly adopting AI technology; however, the preparedness of dental students for embracing the technology is still poorly known.

Objective: To examine the perception, attitude, and knowledge of the fourth-year dental students at Islamabad about the application of AI technology in dentistry and to evaluate the understanding of AI and its dental applications among final-year undergraduate dental students in a multi-center setting.

Methods: This cross-sectional survey was conducted from March to July 2025 including 165 Bachelor of Dental Surgery Final year students. After seeking ethical approval and informed consent, Participants were recruited using stratified random sampling with equal allocation from five dental institutions located in Islamabad. Data were collected using questionnaire consisting of 19 items, using a 5-point Likert scale. Statistical analysis was performed with SPSS version 26 including descriptive statistics and inferential tests i.e independent samples t-test (Welch's correction applied where variances were unequal) and one-way ANOVA. Effect sizes (Cohen's d) were calculated for significant t-test results. Assumptions of normality and homogeneity of variance were verified prior to ANOVA.

Results: 73.3% female participants showed strong familiarity with the AI concept (mean 4.36 ± 0.87) but only moderate understanding of machine learning (3.36 ± 1.09) and deep learning (3.27 ± 1.10). Ethical concerns scored the lowest (2.98 ± 1.02). Attitudes were predominantly positive; the highest agreement was for willingness to integrate AI into practice (3.95 ± 0.81) and interest in AI training (3.92 ± 0.80). Males demonstrated significantly higher total knowledge (23.25 ± 2.94 vs 21.21 ± 3.50 , $p=0.001$) and more favorable attitudes (51.20 ± 8.72 vs 48.46 ± 5.73 , $p=0.047$) than females. No statistically significant inter-institutional differences were observed.

Conclusion: Final-year dental students in Islamabad have basic knowledge and an optimistic attitude towards AI. However, deficiencies in technical and ethical knowledge, along with gender-related discrepancies, support the need to incorporate AI education into the dental curriculum.

Keywords: Artificial Intelligence; Students, Dental; Dentistry; Education, Dental; Pakistan

INTRODUCTION: Modern dentistry is undergoing rapid transformations as artificial intelligence (AI) systems present new solutions in the field of diagnostic imaging, treatment planning, and prognosis of patient outcomes [1–4]. The application of AI in dentistry proved to be highly accurate in clinical studies with examples including convolutional neural network systems used in caries diagnosis and machine learning-based approaches in periodontal diseases evaluation [5,6]. AI has already become an integral component of dental practice around the world with an expected improvement in diagnostics, workflow efficiency, and patient care in the long term [7,8]. As AI technologies are becoming widespread in routine dental practice, future readiness of dentists to embrace and apply them becomes increasingly important to achieve successful transition of technology from the laboratory to the clinic.

A significant body of research based on surveys conducted worldwide has revealed that there are a number of general characteristics associated with the attitudes and knowledge about AI among dental students. Although largely positive attitudes prevail among students, there is relatively low knowledge about AI and ethical issues are commonly identified. Thus, Yilmaz et al. found out that only 44.8% of undergraduate and 46.8% of specialist dental students regarded their level of AI knowledge as "average" in Turkey [9]. Likewise, Roganovic et al. found that only 14.6% of Serbian dental students and dentists knew something about the use of AI in healthcare services, and skepticism towards using it in medicine was related to fear of replacement and lack of proper regulations [10]. Similarly, Shratch et al. found that despite the assertion of having basic knowledge of AI by 77% of Palestinian dental students, the information source was social media, and ethical issues prevailed [11]. A survey of Egyptian postgraduate dental students has revealed that they have a moderate level of AI usage and raised concerns over accuracy and ethical aspects, along with the lack of clinical validation [12]. According to the results of the systematic review by Dashti et al., an average basic knowledge of AI score among dental students all around the world is only 58.62%, while still a relatively high percentage (72.01%) believes that AI will help in advancing dentistry [13].

The adoption of AI technologies into dental education is also rather incipient in Pakistan. In particular, Patoli stated that the process of incorporating health informatics in the country is in its very early stage [14], while Abid et al. found that a medical curriculum involving AI topics was completely absent [15]. Thus, Akhtar et al. found that 58.3% of Pakistani dental students in Karachi had basic knowledge of AI, but only 85.6% said that it was not included in the curriculum [16]. Abdullah et al. conducted a survey of private dental practitioners from Islamabad and Rawalpindi and found out that only 9.7% thought that AI would change their practice within 5–9 years, while 40% anticipated a 16–20 year horizon [17]. In recent times, Naureen et al. evaluated knowledge and attitudes towards ChatGPT among the first and final year dental students at one institution in Islamabad and revealed insufficient knowledge and negative attitudes, as well as inadequate use of AI instruments: only 40.6% of first-year and 30% of final-year dental students utilized AI tools currently [18].

Final-year dental students comprise a crucial group because they make a step from academic education to independent patient care and should be prepared to appropriately apply innovative solutions. Islamabad, with its concentration of multiple dental institutions, provided a suitable setting for conducting this multicenter investigation into the readiness of future dental specialists for AI adoption. While a few single-institution studies have explored AI perceptions among dental students in Pakistan, multicenter data from Islamabad remain limited. Given the increasing integration of AI into clinical dentistry, understanding the baseline knowledge and attitudes of final-year students across multiple institutions is essential for informed curriculum development. Accordingly, this study aimed to investigate the knowledge, attitudes, and perceptions regarding AI and its applications in dentistry among final-year undergraduate dental students in Islamabad

METHODS: This study utilized a descriptive cross-sectional survey design, targeting BDS final year students at five dental colleges in Islamabad, Pakistan. These institutions included the Rawal Institute of Health Sciences (RIHS), Hazrat Bari Imam Sarkar Dental College (HBS), Islamabad Medical & Dental College (IMDC), the School of Dentistry (SoD), and the Islamic International Dental College (IIDC). Data was collected between March to July 15, 2025.

The study recruited final-year BDS students from five institutes. Candidates eligible for inclusion in the study included all students in the final year in any of the five institutes and willingness to give written informed consent. Those who declined consent and gave incomplete questionnaires were excluded.

With Open Epi 3.0, using a confidence level of 95%, a margin of error of 5%, and estimating a population of 257 final-year students in the five institutes, the required sample size would be 165. A stratified random sampling technique was employed, with each dental institute serving as a stratum. To ensure equal representation across strata, 33 students were randomly selected from each institute, yielding a total sample size of 165.

A structured, self-administered questionnaire comprising 19 items was adapted from previously validated scales [9,10,19,20]. These original instruments had undergone rigorous content and construct validation in comparable dental student populations, establishing their validity for assessing AI-related knowledge, concerns, and attitudes. Items were carefully selected and contextualized for final-year dental students in Pakistan and distributed across three domains: (i) demographic characteristics (age, gender, institution), (ii) knowledge and

concerns about artificial intelligence (6 items), and (iii) attitudes towards the use of AI in dentistry (13 items). For sections II and III, responses were recorded on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), with higher mean scores indicating greater awareness, more favorable attitudes, or heightened concerns. Following adaptation, a pilot study was conducted with 20 final-year BDS students from one institute (not part of the main sample) to assess face validity, clarity of instructions, and comprehensibility of the adapted items. Internal consistency for the combined knowledge and attitude scales was evaluated using Cronbach's alpha, which yielded a value of 0.81, indicating acceptable reliability for this adapted version in the target population. Following these steps, data collection commenced.

Upon securing ethical clearance, the researchers collaborated with representatives of the class in each of the five institutes. Third parties who were unrelated to the research handed out printed questionnaires anonymously in person to minimize social desirability bias. The respondents were briefed about the study objectives and asked to complete the questionnaire independently and anonymously. Informed consent was sought from all respondents prior to data collection. The questionnaires were returned on the same day to enhance response rates. Completion of all questions in each respondent's questionnaire was required, thus leaving zero missing values. The 100% response rate was achieved because the questionnaire was administered during mandatory class sessions with direct supervision, and all students present agreed to participate and returned fully completed forms on the spot.

All data were entered and analyzed using IBM SPSS Statistics for Windows, version 26.0. Descriptive statistics including means, standard deviations, frequencies, and percentages were used to summarize demographic variables and responses to survey items. Prior to applying parametric tests, the assumption of normality was checked using the Shapiro–Wilk test ($p > 0.05$ considered indicative of normal distribution). For the t-test comparisons, homogeneity of variances was assessed using Levene's test; where variances were unequal ($p < 0.05$), Welch's t-test was employed instead of the standard independent-samples t-test. For one-way ANOVA, homogeneity of variances was verified using Levene's test, and normality of residuals was confirmed. Differences between institutions and gender were evaluated using independent samples t-tests (or Welch's t-test as appropriate) for two groups or one-way ANOVA where applicable. Statistical significance was set at $p < 0.05$. Institutional Review Board and Ethical Review Committee of Rawal Institute of Health Sciences, Islamabad, approved the study (approval number: RIHS/RDC/ERC/25/15, approval date: 12thMar 2025). The current study was conducted following Helsinki Declaration and COPE ethical guidelines. Informed written consent was obtained from all participants with guarantees of anonymity and confidentiality. There were no participation incentives involved.

AI use disclosure

Following the recommendations of the International Committee of Medical Journal Editors (ICMJE), the authors declare that no generative artificial intelligence tools were employed in the study design, data collection, statistical analysis, or interpretation of results.

Reporting guideline

This study adheres to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement for cross-sectional studies.

RESULTS: A total of 165 final-year BDS students participated, yielding a 100% response rate. Of these, 121 (73.3%) were female and 44 (26.7%) were male. By design, 33 students were enrolled from each of the five dental institutes. The gender composition within each institute is displayed in Table 1.

Table 1: Gender distribution of participants by institute

Institute	Males, n (%)	Females, n (%)	Total, n
RIHS	4 (12.1%)	29 (87.9%)	33
HBS	9 (27.3%)	24 (72.7%)	33
IMDC	3 (9.1%)	30 (90.9%)	33
SoD	16 (48.5%)	17 (51.5%)	33

IIDC	12 (36.4%)	21 (63.6%)	33
Total	44 (26.7%)	121 (73.3%)	165

Percentages within each institute are calculated row-wise (percentage of that institute's total).

Overall familiarity with AI and attitudes towards AI in dentistry

Descriptive statistics for all individual questionnaire items are summarized in Table 2. Overall, participants demonstrated strong familiarity with the general concept of AI; however, mean scores for technical subdomains such as machine learning and deep learning were comparatively modest, while ethical concerns received the lowest mean score. All attitudinal statements scored above the neutral midpoint, with the highest agreement observed for willingness to integrate AI into practice, preference for clinical judgment over AI output in case of conflict, and interest in formal AI training programs.

Table 2: Institutional means and standard deviations for questionnaire items

Section	Item	RIHS (n=33)	HBS (n=33)	IMDC (n=33)	SoD (n=33)	IIDC (n=33)	Total (N=165)
II Knowledge & Concerns	Familiar with AI concept	4.24 0.97	± 4.39 1.00	± 4.39 0.66	± 4.45 0.83	± 4.33 0.89	± 4.36 ± 0.87
	Aware of AI use in daily life	3.96 0.88	± 4.06 0.80	± 4.09 0.80	± 4.18 0.85	± 4.27 0.88	± 4.11 ± 0.84
	Ethical concerns regarding AI	3.06 0.93	± 2.76 1.12	± 3.09 0.98	± 2.97 1.13	± 3.03 0.95	± 2.98 ± 1.02
	Advantages outweigh risks	3.24 0.87	± 3.88 0.89	± 3.27 0.98	± 4.09 0.80	± 3.88 0.89	± 3.67 ± 0.94
	Basic understanding of deep learning	3.21 1.05	± 3.51 1.03	± 3.15 1.03	± 3.58 1.03	± 3.33 1.23	± 3.36 ± 1.09
	Basic understanding of machine learning	3.21 0.93	± 3.24 1.15	± 3.03 1.07	± 3.58 1.12	± 3.27 1.20	± 3.27 ± 1.10
III AI in Dentistry	Satisfactory understanding of AI applications in dentistry	3.36 0.86	± 3.48 0.87	± 3.30 0.77	± 3.51 1.00	± 3.24 1.09	± 3.38 ± 0.92
	AI can revolutionise dentistry	3.81 0.81	± 3.57 1.06	± 3.78 0.74	± 3.96 0.95	± 4.51 0.80	± 3.86 ± 0.89
	Attempted to incorporate AI-related software into academics	3.69 0.95	± 3.54 0.97	± 3.42 0.94	± 3.75 0.97	± 3.69 1.13	± 3.62 ± 0.99
	AI as diagnostic tool	3.60 0.86	± 3.90 0.91	± 3.66 0.82	± 3.90 1.01	± 3.90 0.95	± 3.80 ± 0.91
	AI as quality control system	3.60 0.93	± 3.66 0.78	± 3.54 0.79	± 3.81 0.85	± 4.00 0.75	± 3.73 ± 0.83
	AI improves patient outcomes	3.60 0.75	± 3.90 0.72	± 3.63 0.82	± 3.96 0.84	± 3.96 0.73	± 3.82 ± 0.78
	AI helpful for decision-making	3.78 0.70	± 3.75 0.94	± 3.63 0.70	± 3.78 0.96	± 3.75 0.79	± 3.74 ± 0.82
	AI as partner not competitor	3.63 1.11	± 3.51 1.15	± 3.72 0.91	± 3.75 1.03	± 3.84 0.75	± 3.70 ± 1.00

Section	Item	RIHS (n=33)	HBS (n=33)	IMDC (n=33)	SoD (n=33)	IIDC (n=33)	Total (N=165)
	Agreement with dentist over AI	3.81 0.95	± 3.94 0.83	± 4.00 0.79	± 3.90 0.91	± 3.93 0.99	± 3.92 ± 0.89
	Recommend AI in academic applications	3.93 0.80	± 3.75 0.97	± 3.72 0.80	± 3.84 1.03	± 3.90 0.76	± 3.84 ± 0.87
	Training programme valuable	3.87 0.78	± 3.75 0.94	± 3.96 0.73	± 3.84 1.03	± 4.09 0.63	± 3.90 ± 0.83
	Interested in training programme	3.93 0.50	± 3.72 1.01	± 3.90 0.52	± 3.90 1.13	± 4.12 0.65	± 3.92 ± 0.80
	Receptive to integrating AI	4.00 0.43	± 3.87 0.93	± 3.87 0.78	± 4.00 0.97	± 4.00 0.87	± 3.95 ± 0.81

Data presented as mean ± standard deviation. All items measured on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree).

Gender-based analysis

The composite scores were derived using the total scores from Section II (knowledge and concerns, score range 6 to 30) and Section III (attitudes toward AI in dentistry, score range 13 to 65). Using an independent samples t-test (Welch's correction applied due to unequal variances as indicated by Levene's test, $p < 0.05$ for both comparisons), a significant difference was found between males and females on both constructs (Table 3). Males had significantly higher scores than females on knowledge and concerns (23.25 ± 2.94 vs. 21.21 ± 3.50 , Welch's $t(90.04) = 3.73$, $p = 0.001$, Cohen's $d = 0.61$ [medium effect]) and attitudes toward AI in dentistry (51.20 ± 8.72 vs. 48.46 ± 5.73 , Welch's $t(57.07) = 1.94$, $p = 0.047$, Cohen's $d = 0.42$ [small-to-medium effect]).

Table 3: Gender-wise comparison of total scores (independent-samples t-test with Welch's correction)

Domain	Gender	n	Mean ± SD	Welch's t	df	p-value	Cohen's d	Effect size
Knowledge & Concerns (Section II)	Male	44	23.25 ± 2.94	3.73	90.04	0.001	0.61	Medium
	Female	121	21.21 ± 3.50					
AI in Dentistry (Section III)	Male	44	51.20 ± 8.72	1.94	57.07	0.047	0.42	Small-to-medium

Welch's t-test was used as Levene's test indicated unequal variances between genders ($p < 0.05$ for both domains). Cohen's d : 0.2 = small, 0.5 = medium, 0.8 = large effect.

The mean total scores of the five institutes are presented in Table 4. The SoD received the highest mean total score of knowledge and concerns (22.85 ± 3.37), which was followed closely by IIDC (22.12 ± 3.91). In terms of attitudes to AI, the highest mean score was attained by IIDC (50.64 ± 6.34), followed by SoD (50.00 ± 8.41). One-way analysis of variance revealed that there were no significant differences among the institutes in both the domains of knowledge and concerns ($F(4,160) = 1.765$, $p = 0.138$) and attitudes ($F(4,160) = 0.820$, $p = 0.514$). Levene's test confirmed homogeneity of variances across institutions for both domains (knowledge: $p = 0.312$; attitudes: $p = 0.421$), supporting the validity of the ANOVA assumptions.

Table 4: Institution-wise total score comparison

Domain	Institute	n	Mean $\pm$ SD	F(4,160)	p-value
Knowledge & Concerns (Section II)	RIHS	33	20.94 $\pm$ 3.33	1.765	0.138
	HBS	33	21.85 $\pm$ 3.44		
	IMDC	33	21.03 $\pm$ 3.06		
	SoD	33	22.85 $\pm$ 3.37		
	IIDC	33	22.12 $\pm$ 3.91		
AI in Dentistry (Section III)	RIHS	33	48.70 $\pm$ 5.33	0.820	0.514
	HBS	33	48.42 $\pm$ 7.63		
	IMDC	33	48.21 $\pm$ 5.53		
	SoD	33	50.00 $\pm$ 8.41		
	IIDC	33	50.64 $\pm$ 6.34		

Abbreviations: RIHS = Rawal Institute of Health Sciences; HBS = Hazrat Bari Imam Sarkar Dental College; IMDC = Islamabad Medical & Dental College; SoD = School of Dentistry; IIDC = Islamic International Dental College. No significant inter-institutional differences were observed ($p > 0.05$ for both domains).

DISCUSSION: This study is an example of a multicenter cross-sectional study regarding the knowledge, perceptions, and attitude of final year dental students concerning artificial intelligence in Islamabad, Pakistan. In general, students exhibited substantial baseline knowledge of AI and had favorable attitudes about its use in the practice of dentistry, although there were still some gaps in their understanding of technical terms like machine learning and deep learning. However, there were significant differences between male and female students in terms of knowledge and attitudes toward AI, with male students having significantly better knowledge and a more favorable attitude than females. Moreover, there were no statistical differences between the five institutions.

For example, Shrateh et al. found that 77% of dental students from Palestine stated their basic knowledge of artificial intelligence, with social networks being the main information source [11]. Furthermore, Yilmaz et al. revealed that 78.1% of undergraduate and specialist students from Turkey agreed that artificial intelligence would result in breakthroughs in dentistry [9]. In the current sample, the item "AI can revolutionize dentistry in general" gained the mean of 3.86 points, which means sufficient trust in AI potential.

Yet, the average understanding of machine learning and deep learning (means 3.36 and 3.27, correspondingly) points to a conceptual fragility. This finding is consistent with another study conducted among Serbian dental students, where only 7.9% were aware of contemporary AI-based software for dentistry, and ignorance of its application was significantly correlated with skepticism towards AI [10]. The least marked knowledge and concern score pertained to ethics (mean 2.98), implying ignorance of ethical issues in AI or a minor degree of importance attributed to them. Nonetheless, ethical concerns have been proven to predict resistance to implementing AI among dental specialists. Despite the present finding indicating better knowledge in male dental students, ethical issues were the only question on which females scored higher than males in some subsamples.

These results concerning gender differences are consistent to some extent with previous studies. As seen from the results obtained in the present sample, males showed better results than females in both knowledge/concerns and attitudes toward AI. In comparison with these results, the Palestinian study showed that female students were more inclined to think that there would be major breakthroughs because of AI [11], while in the Serbian study, women thought that ethical problems associated with AI are more important [10]. Gender differences in perceptions of AI have yielded contradictory results; sometimes, there were no gender differences in perceptions of AI, but sometimes, men were found to show more confidence in technical aspects, which could be explained by different socialization processes and experiences in childhood [9,10]. These findings may be attributed to the highly imbalanced gender ratio (73.3% women) in the sample, which could amplify small differences and limit generalizability. Additionally, cultural factors related to the predominance of men in science and technology fields in Pakistan may contribute to differential exposure to AI concepts prior to dental school [21]. The medium effect size (Cohen's $d = 0.61$) for knowledge differences suggests a practically meaningful gap that warrants educational intervention. Future research should employ balanced sampling and

qualitative methods to explore the underlying reasons for these gender differences. Further research with more balanced samples and qualitative exploration of underlying reasons is recommended.

Despite the lack of statistical significance between institutions, SoD and IIDC demonstrated significantly higher descriptive scores on several occasions, suggesting early informal exposure to AI which could be used as pilot sites for a formal curriculum. Such positive attitudes should not override their clinical judgment; the students need to learn to appreciate the strengths of both man and machine.

The limitations of the study include the cross-sectional design, limitation to one urban setting, self-reports vulnerable to response bias, significant disparity in male:female ratio, and utilization of a tool that has never been subjected to a confirmatory factor analysis. Lack of an objective assessment of AI competencies, as well as exclusion of Shifa College, also impacts generalizability. However, the results highlight the need to include formal AI modules in dental curricula of Pakistan, which should incorporate not only theoretical learning but also the application and ethics of AI. Hands-on training workshops, collaboration with developers of technologies [12,13], and regulatory framework governing accountability and confidentiality of patients' data [10] must be incorporated to ensure students are able to use AI responsibly.

Concluding remarks show that the dental students belonging to their final year at Islamabad have knowledge about AI and an optimistic attitude about it in relation to the field of dentistry. There is a great lack of technical knowledge, ethics, and significant differences between the genders in terms of knowledge, which make it imperative to provide education regarding AI in the dental field. In this way, future dentists would be competent and ethically sound enough to use AI for their patients.

CONCLUSION: Final-year dental students in Islamabad demonstrate a positive attitude and basic awareness of AI in dentistry. However, important gaps exist in technical knowledge (e.g., machine learning, deep learning) and ethical considerations. Gender differences in knowledge and attitudes persist, while no institutional differences were observed, suggesting uniformly low AI exposure across curricula. Given students' strong interest in AI training, integrating structured AI modules into the undergraduate dental curriculum is recommended to prepare future dentists for competent and ethical AI use.

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