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Knowledge and Opinions of Dental Practitioners for the Use of Artificial Intelligence (AI) in Dentistry

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ABSTRACT

Recent technological developments have paved the way for the application of Artificial Intelligence (AI) in dental care, offering improvements in diagnosis, treatment planning, and overall service delivery. **Objective:** To assess the level of awareness and perceptions of dental practitioners in Pakistan regarding the utilization of AI in clinical dentistry. **Methods:** A cross-sectional survey was executed between January and June 2024, encompassing 126 dental professionals. A structured questionnaire was shared via email and social media, gathering data on demographics, familiarity, and perspectives on AI in dentistry. Perceptions were measured using a 5-point Likert scale. Statistical analysis was performed using SPSS version 21.0, employing both descriptive and inferential methods. A p-value of <0.05 was considered statistically significant. **Results:** The average participant age was 41.14±13.76 years, with a predominance of female respondents (66.7%). A considerable portion (74.6%) reported familiarity with AI, while 77.8% were informed about its uses in dentistry. Although practical engagement was limited, 48% acknowledged AI's potential to enhance the field, while the same proportion expressed concerns over AI possibly replacing dental professionals. Enthusiasm toward AI was notable, with 55% showing interest. Many participants recognized AI's benefits in diagnostics and prognosis. **Conclusions:** Despite strong awareness and interest, the practical implementation of AI in dental practice remains low. Educational updates and supportive policies are essential to promote the integration of AI tools in clinical workflows.

INTRODUCTION

The progression of modern technology has enabled machines to replicate functions associated with human intelligence, such as decision-making, logical reasoning, and recognizing patterns [1]. Artificial Intelligence (AI), among the most impactful innovations, is transforming sectors including healthcare, finance, transport, and education [2]. Using advanced machine learning, AI processes vast datasets to generate accurate predictions and support decision-making [3]. AI has made a deep enrichment in medical sector as well and it is predicted that it will grow by decuple in coming years [4]. Its application in healthcare has expanded significantly, with projections suggesting substantial growth in coming years [5]. AI aims to make medical diagnostics and treatments safer, more efficient, and patient-specific due to its rapidly evolving capabilities [6]. Areas like radiology, ophthalmology, and pathology, which depend on data-heavy analysis, are seeing robust AI integration [6]. There are both optimistic and skeptical views regarding AI's impact on human life. While concerns exist, that AI could replace human roles in various sectors, others believe that its assistance could offer vast opportunities for progress and development [6, 7]. In dentistry, AI is being increasingly used, particularly in diagnostic imaging, to enhance accuracy and improve

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treatment outcomes [8, 9]. AI technologies have been employed in the early detection of oral cancers, management of orofacial conditions, and orthodontic treatment planning using models such as Artificial Neural Networks(ANN), Convolutional Neural Networks(CNN), and support vector machines [2, 10]. Hyperspectral imaging combined with CNNs has successfully identified cancerous from non-cancerous tissues, while predictive models help forecast oral cancer recurrence [11]. In Pakistan, AI adoption in dental settings holds potential for improving care quality and efficiency [12, 13]. However, the success of this transition depends on the readiness, knowledge, and attitudes of dental professionals. A survey in Karachi revealed that although 70.3% of dentists were aware of AI tools, practical usage was limited, with few employing systems like Cone Beam Computed Tomography (CBCT) or Computer-Aided Design and Computer-Aided Manufacturing(CAD-CAM)[13].

This study aimed to assess the understanding, acceptance, and perceived barriers regarding AI use among dental professionals in Pakistan and inform future educational and policy initiatives.

METHODS

This was a descriptive, cross-sectional study carried out over a six-month duration, spanning from January to June 2024.In addition to descriptive analysis, the study incorporated analytical elements and examined the associations between participants' knowledge levels and their perception scores.The target population comprised dental professionals, including general dentists, medical officers, postgraduate residents, and consultant dental surgeons. Eligible participants were those aged 18 years and above, of either gender, with active internet connectivity.However, including only participants with internet access may have introduced a selection bias favoring individuals more familiar or comfortable with technology, which could influence their awareness or perceptions of AI. Individuals who did not provide consent were excluded from the study.A non-probability convenience sampling technique was employed to enroll participants.To determine the appropriate sample size, the OpenEpi sample size calculator was used. Based on a presumed awareness rate of 70.3% regarding AI use in dentistry, with a margin of error set at 8% and a 95% confidence interval, a total of 126 participants were required [13].The study followed ethical standards applicable to human subjects' research, and informed consent was obtained from each respondent prior to data collection. A structured questionnaire was developed and circulated through online platforms including Google Forms, and shared via emails and social networking applications such as WhatsApp, Facebook, and LinkedIn. The questionnaire consisted of three parts.The first section of the questionnaire gathered demographic details such as age, gender, qualification, designation, and years of practice.The second section assessed participants' knowledge and awareness of AI applications in dentistry, including tools like CAD-CAM, CBCT, digital intraoral radiographs, and clinical decision support systems. The third section featured 15 statements adapted from a previous study by Akhtar *et al.*, designed to evaluate participants' perceptions [14]. These items were rated on a 5-point Likert scale, ranging from 1(Strongly Disagree) to 5 (Strongly Agree). A composite perception score was then derived by calculating the average of the individual item responses.The questionnaire was pretested on a small group of dental professionals (n=15) to ensure clarity, relevance, and consistency of the items. Necessary adjustments were made based on their feedback.This helped enhance the validity and reliability of the instrument.Cronbach's alpha value was estimated as 78%.All responses were stored securely in password-protected digital files to maintain data confidentiality. Statistical analysis was performed using SPSS software version 21.0. For categorical variables, frequencies and percentages were calculated, while continuous variables were analyzed using means and standard deviations. To evaluate the relationship between AI-related knowledge and perception scores, independent samples t-tests were conducted. Prior to performing the independent samples t-test, assumptions of normality and equality of variances were assessed. Normality was evaluated using the Shapiro-Wilk test, and Levene's test was used to check for homogeneity of variances. The assumptions were met, justifying the use of the t-test for group comparisons. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Out of 126 respondents, the average age was 41.14 ± 13.76 years, with 33.3% male and 66.7% female participants. The largest group had 1-5 years of professional experience (29.4%) and were primarily general dental practitioners (32.5%), (Table 1).

Table 1: Baseline Characteristics of Study Participants(n=126)

Variables	Mean ± SD / Frequency (%)
Age in Years	41.14 ± 13.76
Gender	
Male	42 (33.3)
Female	84 (66.7)
Years of Experience	
< 1 Year	30 (23.8)
1-5 Years	37 (29.4)
6-10 Years	16 (12.7)
11-15 years	20
> 15 years	23

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Current Designation	
General Dental Practitioner	41 (32.5)
Medical officer	30 (23.8)
Resident	25 (19.8)
Specialist Consultant Dental Surgeon	30 (23.8)

Approximately 74.6% reported basic knowledge of AI, and 77.8% knew of AI applications in dentistry. The most recognized AI tool was digital dental records, while decision support systems were less familiar.

Figure 1 shows some awareness of various AI tools among dental professionals; a significant portion remains uninformed about key technologies (22%). The highest awareness was for digital dental records (17%), whereas clinical decision support systems had the lowest awareness(14%).

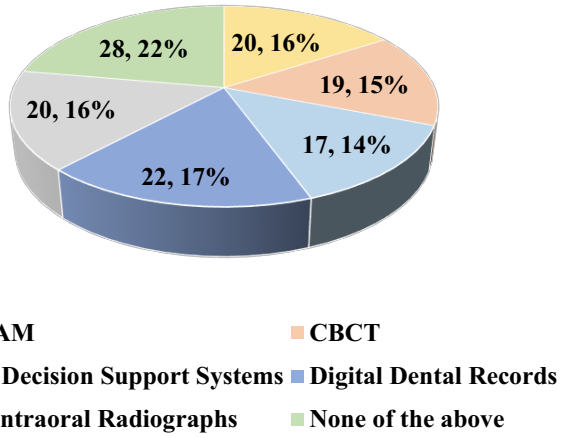

Figure 1: Awareness of Dental Professionals Regarding AI Tools in Dentistry

Table 2 shows the attitudes and perceptions of dental professionals towards AI in various aspects of dentistry. A significant proportion of dental professionals express positive attitudes towards the integration of AI in dentistry. A majority (strongly agree: 27% and agree: 21%) believe AI can lead to significant advancements. A considerable proportion (strongly agree: 26% and agree: 22%) think AI could replace dentists. A majority (strongly agree: 25% and agree: 30%) are excited about using AI in dentistry. Over half (strongly agree: 25% and agree: 28%) agree that AI can serve as a diagnostic tool. Half (strongly agree: 29% and agree: 21%) believe AI can be a prognostic tool. Nearly half (strongly agree: 18% and agree: 27%) see AI as useful for diagnosing tooth caries. A significant portion (strongly agree: 29% and agree: 26%) agree AI can diagnose periodontal diseases. A majority (strongly agree: 27% and agree: 30%) believe AI can diagnose soft tissue lesions. More than half (strongly agree: 23% and agree: 29%) support AI's use in 3D implant positioning. Over half (strongly agree: 25% and agree: 27%) agree AI can aid in treatment planning. Almost half (strongly agree: 21% and agree: 25%) think AI can be a quality control tool. More than half (Strongly Agree: 29% and Agree: 25%) believe AI can diagnose jaw pathologies. Nearly half (strongly agree: 20% and agree: 26%) support AI's use in forensic dentistry. A majority (strongly agree: 26% and agree: 27%) support integrating AI into undergraduate dental training. Almost half (strongly agree: 18% and agree: 22%) agree AI should be part of postgraduate dental curricula. Overall, dental professionals show strong support for the incorporation of AI into various aspects of dentistry, particularly in diagnostic, prognostic, and educational applications.

Table 2: Opinions of Dental Professionals Regarding AI in Dentistry

Item	Strongly disagree Frequency (%)	Disagree Frequency (%)	Neutral Frequency (%)	Agree Frequency (%)	Strongly Agree Frequency (%)
AI Advancement in Dentistry	11 (8.7)	16 (12.7)	26 (20.6)	44 (34.9)	29 (23.0)
AI Replace Dentists	3 (2.4)	9 (7.1)	32 (25.4)	39 (31.0)	43 (34.1)
Excited for AI Use	4 (3.2)	9 (7.1)	30 (23.8)	36 (28.6)	47 (37.3)
AI as Diagnostic Tool	5 (4.0)	8 (6.3)	39 (31.0)	32 (25.4)	42 (33.3)
AI as Prognostic Tool	4 (3.2)	9 (7.1)	38 (30.2)	32 (25.4)	43 (34.1)
AI in Radiographic Diagnosis of Caries	2 (1.6)	9 (7.1)	40 (31.7)	31 (24.6)	44 (34.9)
AI in Radiographic Diagnosis of Periodontal Diseases	4 (3.2)	11 (8.7)	38 (30.2)	40 (31.7)	33 (26.2)
AI in Diagnosis of Soft Tissue Lesions	4 (3.2)	9 (7.1)	38 (30.2)	39 (31.0)	36 (28.6)
AI in 3D Implant Planning	3 (2.4)	11 (8.7)	37 (29.4)	41 (32.5)	34 (27.0)
AI in Treatment Planning	3 (2.4)	9 (7.1)	40 (31.7)	40 (31.7)	34 (27.0)
AI as Quality Control Tool	10 (7.9)	7 (5.6)	38 (30.2)	37 (29.4)	34 (27.0)
AI in Radiographic Diagnosis of Jaw Pathologies	10 (7.9)	7 (5.6)	37 (29.4)	35 (27.8)	37 (29.4)
AI in Forensic Dentistry	4 (3.2)	9 (7.1)	38 (30.2)	38 (30.2)	37 (29.4)
AI in Undergraduate Training	5 (4.0)	10 (7.9)	36 (28.6)	37 (29.4)	38 (30.2)
AI in Postgraduate Training	6 (4.8)	8 (6.3)	38 (30.2)	33 (26.2)	41 (32.5)

Table 3 shows the comparison of the perception with knowledge of AI and AI usage in dentistry. Participants who had basic knowledge of AI had higher perception score compared to those who did not. Although no statistically

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significant difference was found between general AI knowledge and perception scores (p = 0.461). Moreover, Participants who were of aware of AI usage in dentistry had a significantly higher perception score compared to those who were not aware, showing a significant difference (p=0.001).

Table 3: Comparison of Knowledge of AI and AI Usage in Dentistry with Perception

Variable	Perception Score Mean ± SD	p-Value
Knew about AI		
Yes	3.76 ± 0.52	0.461
No	3.69 ± 0.33	
Knew About AI Usage in Dentistry		
Yes	3.87 ± 0.32	0.001*
No	3.30 ± 0.65	

DISCUSSION

The findings of this study align with previous research conducted globally.Similar studies, such as those by Akhtar *et al.*, and Yüzbaşıoğlu reported high levels of awareness and positive attitudes towards AI among dental students and professionals [6, 14]. However, like the current study, they also noted a gap between awareness and actual use. A study by Sajjad *et al.*, similarly observed strong awareness in Pakistan but found limited use of tools such as CAD-CAM or CBCT in routine practice [2]. Singh and colleagues observed a moderate understanding of AI among dental professionals, alongside recognition of its diagnostic capabilities [15]. A study conducted by Muller *et al.*, found that both patients and healthcare providers believed in potential benefits of AI in dental diagnostics, such as improved accuracy, reduced workload, and better patient care.However, concerns about reliance on AI, accountability, and transparency need to be addressed before widespread adoption [16].Another study by Parthasarathy *et al.*, revealed dental professionals had a positive attitude towards AI, but expressed concerns about technical barriers, costs, and ethical implications. Factors like perceived utility and ease of use significantly influenced AI adoption [17]. Aboalshamat found that dental professionals in Saudi Arabia were optimistic about AI's role in enhancing diagnostic accuracy but identified a significant need for structured training programs to improve AI literacy [18].In this study specific awareness of AI use in dentistry positively influences perception, whereas general knowledge of AI does not exhibit the same effect.This may indicate that practical or field-specific exposure to AI tools fosters more favorable opinions.The non-significant difference in perception among those with general AI knowledge (p = 0.461) may reflect limited relevance to clinical practice or could be due to insufficient statistical power.This underlines the importance of profession-specific AI education rather than generalized technological awareness.This study's primary strength lies in its use of a structured questionnaire to gather detailed insights into dental practitioners' knowledge and perceptions of AI. However, several limitations should be noted.The convenience sampling method may restrict the generalizability of the results, as the sample might not accurately represent the broader population of dental practitioners in Pakistan.Furthermore, the reliance on self-reported data could lead to response bias, with participants potentially overestimating their knowledge or downplaying challenges. Another limitation of this study is that it included only participants with internet access, which may have skewed the sample toward more technologically inclined professionals.This selection bias could affect the generalizability of findings, particularly regarding knowledge and attitudes toward digital tools like AI. While a composite perception score was calculated, the study did not define cut-off points for categorizing low, moderate, or high perception levels.Establishing such thresholds could enhance the interpretability of future findings.The findings highlight the need for targeted educational programs to address gaps between awareness and the practical use of AI in dentistry.Updating dental curricula to include comprehensive training on AI tools and their applications is essential.Policymakers should consider developing supportive frameworks to promote AI integration into dental practice, including financial incentives, subsidies for acquiring AI technologies, and guidelines for effective implementation.Future research should focus on identifying barriers to AI adoption, such as costs, usability, and trust in AI tools. Additionally, raising public awareness of the benefits of AI in dentistry could create greater demand for AI-driven dental services, encouraging wider adoption among practitioners.The integration of artificial intelligence (AI) into dental practice is gaining momentum, with growing interest in its potential to enhance diagnostic accuracy, treatment planning, and clinical efficiency. Hamd *et al.*, in 2023 reported that while dental professionals acknowledge the relevance of AI, there remains a gap in comprehensive knowledge and preparedness for its implementation [19]. Similarly, a study by Alzahrani in 2024 highlighted mixed perceptions among dental practitioners in Saudi Arabia, revealing both optimism about AI's benefits and concerns regarding its ethical, legal, and practical implications [20].

CONCLUSIONS

The findings highlight significant awareness and generally positive attitudes toward AI among dental practitioners in Pakistan. However, the gap between recognition and routine usage calls for targeted interventions. Educational institutions must revise curricula to include practical AI

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training, while policymakers should establish frameworks that ease the adoption of emerging technologies in clinical settings. Addressing key barriers can lead to a more widespread and effective implementation of AI, improving both practitioner efficiency and patient outcomes.

Authors Contribution

Conceptualization: IM
Methodology: SAI, IM
Formal analysis: SAP
Writing, review and editing: SAI, SN, SA, IM, AFU

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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