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Dentists' Knowledge, Usage and Barriers to Computer-Assisted Technologies in Oral and Maxillofacial Surgery: A Cross-Sectional Study in Saudi Arabia

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Abstract **Background:** Computer-assisted technologies such as CAD/CAM systems, 3D imaging and robotic-assisted surgery are reshaping oral and maxillofacial surgical practices by enhancing diagnostic precision, treatment planning and procedural outcomes. Despite these advancements, their adoption among dentists remains inconsistent. This study assessed the knowledge, usage patterns and barriers to the implementation of such technologies among dentists in Saudi Arabia. **Methods:** A cross-sectional survey was conducted between November and December 2024 using a validated, self-administered online questionnaire. A total of 422 licensed dentists across Saudi Arabia participated. The survey assessed demographics, awareness, usage, perceived benefits, barriers and training needs related to computer-assisted technologies. Data were analyzed using descriptive statistics, chi-square tests and multivariate regression ($p<0.05$). **Results:** Awareness was high for CAD/CAM systems (91.3%) and surgical navigation tools (85.1%), yet practical usage was notably lower-only 41.2% and 56.4%, respectively, reported using these technologies. Robotic-assisted surgery had the highest usage rate (78.7%). Key barriers included high equipment costs (44.5%), lack of adequate training (22.7%) and limited institutional support (12.1%). Knowledge and adoption rates were significantly higher among prosthodontists, orthodontists and private practitioners, while female dentists and those working in government hospitals reported lower adoption. **Conclusion:** A clear gap exists between awareness and practical application of advanced dental technologies, primarily due to financial, educational and infrastructural constraints. To bridge this gap, it is recommended that digital dentistry be fully integrated into undergraduate curricula and continuing professional development programs. Institutions should enhance training accessibility and provide funding or subsidies to support technology adoption. These measures are critical for aligning clinical practice with the innovation goals outlined in Saudi Vision 2030.

Key Words Digital Dentistry, Computer-Assisted Technologies, CAD/CAM, Robotic-Assisted Surgery, Oral and Maxillofacial Surgery, Dental Education, Saudi Arabia

INTRODUCTION

The rapid advancement of healthcare technologies has significantly transformed clinical practices across medical disciplines. In dentistry-particularly in oral and maxillofacial surgery-computer-assisted technologies have redefined diagnostic precision, surgical planning and treatment outcomes [1]. Innovations such as three-dimensional (3D) imaging reconstruction, computer-aided design and manufacturing (CAD/CAM), surgical navigation systems and multimodal imaging are increasingly integrated into clinical workflows, enabling personalized care through the design of patient-specific prosthetics and implants [2,3]. These tools not only improve surgical accuracy but also reduce complications and accelerate recovery times [4,5].

Emerging technologies-including Cone-Beam Computed Tomography (CBCT), Magnetic Resonance Imaging (MRI) and Augmented Reality (AR) systems-are further advancing the digital transformation of dentistry. These innovations are reshaping treatment planning and execution, allowing for less invasive procedures and improved implant positioning [6,7]. The integration of mixed and augmented reality in dental education and practice is shifting the focus toward patient-centered care, enhancing communication, education and surgical training [8].

Despite these advances, successful implementation of digital technologies in dental practice is not guaranteed. A growing body of literature underscores the challenges dentists face-including steep learning curves, limited institutional support and the lack of structured continuing education programs-as major barriers to widespread adoption [9]. These limitations are particularly relevant in regions like Saudi Arabia, where technological infrastructure varies across institutions and many dental professionals report insufficient training opportunities [10]. This situation calls for a closer examination of how dentists' knowledge, readiness and professional development influence their adoption of such tools.

Saudi Arabia's Vision 2030 prioritizes healthcare innovation and digital transformation, making the integration of computer-assisted technologies into dentistry a national objective (Saudi Vision 2030). National institutions and regulatory bodies are therefore positioned to play a crucial role in fostering adoption through targeted training, policy support and funding. Understanding the levels of awareness, practical application and perceived barriers among dental practitioners is essential for developing evidence-based strategies that align clinical practice with these broader national goals [9].

Accordingly, this study aims to evaluate the knowledge, awareness and preparedness of dentists in Saudi Arabia regarding the use of computer-assisted technologies in oral and maxillofacial surgery. It also seeks to identify barriers to adoption and provide evidence to guide the integration of these technologies into dental education and clinical practice.

METHODS

Study Design

This research employed a descriptive cross-sectional design to evaluate dentists' knowledge, awareness and adoption of computer-assisted technologies in oral and maxillofacial surgery. Data collection was conducted via a structured, self-administered online questionnaire distributed through Google Forms over a two-month period from November to December 2024. The study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines to ensure transparent and comprehensive reporting.

Study Participants and Sampling

Participants were recruited using a convenience sampling method via professional dental networks, national dental associations and social media platforms including WhatsApp, Telegram and Facebook. Inclusion criteria were: Actively practicing dentists with valid licensure in Saudi Arabia and familiarity with oral and maxillofacial surgery procedures. Exclusion criteria included retired dentists or those not currently practicing.

The required sample size was calculated using OpenEpi software with a 5% margin of error and a 95% confidence interval. Assuming a 50% response distribution due to the lack of prior data on digital dentistry knowledge, the minimum required sample size was estimated at 384. To account for potential non-respondents, a 10% surplus was added, resulting in a final sample size of 422 participants. While convenience sampling ensured accessibility, it may have introduced selection bias by underrepresenting rural or less networked practitioners-this is acknowledged as a study limitation.

Questionnaire Design

A 23-item questionnaire was developed to assess five core domains: (1) Demographic characteristics (age, gender, specialty, practice setting, years of experience and geographic location); (2) Awareness of advanced technologies, including 3D imaging, CAD/CAM, surgical navigation, augmented/virtual reality and robotic systems; (3) Current usage patterns of these technologies; (4) Barriers to adoption, such as cost, training availability and institutional support and (5) Perceived benefits and training needs.

To improve response accuracy, a "Don't know" option was provided for awareness-related questions. The questionnaire's content validity was confirmed through expert review and pilot testing with 35 participants to ensure clarity and relevance. Internal consistency was verified using Cronbach's alpha, with a reliability score of 0.821, indicating acceptable reliability. The survey permitted only one submission per respondent to maintain data quality.

Data Analysis

Data were analyzed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics-including frequencies, percentages, means and standard deviations-were used to summarize demographic data and response patterns. Associations between demographic variables and knowledge or readiness to adopt computer-assisted technologies were evaluated using the chi-square test. Multivariate regression analysis was applied to identify predictors of knowledge and technology use. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the Institutional Research Ethics Committee. A detailed cover letter attached to the questionnaire outlined the study's objectives, voluntary nature of participation and confidentiality assurances. Informed consent was obtained electronically from all participants prior to questionnaire completion. Anonymity and data protection were maintained throughout the research process.

RESULTS

A total of 422 licensed dentists participated in the study, with a nearly even gender distribution-52.4% were male and 47.6% were female (Table 1). The age distribution revealed that the majority of respondents (37.9%) were aged 20-29 years, followed by 30.3% in the 30-39 age group, 17.8% in the 40-49 range and 14.0% aged 50 and above. In terms of

Table 1: Sociodemographic traits of participants (n = 422)

Variable		N	%
Your gender	Male	221	52.4%
	Female	201	47.6%
Your age	20-29 year	160	37.9%
	30-39 year	128	30.3%
	40-49 year	75	17.8%
	More than 50 years	59	14.0%
Type of Specialty	Oral and maxillofacial surgery	94	22.3%
	General dentistry	112	26.5%
	Orthodontics	64	15.2%
	Prosthodontics	72	17.1%
	Other	80	19.0%
Years of experience	Less than 5 years	124	29.4%
	5-15 years	146	34.6%
	16-25 years.	89	21.1%
	More than 25 years.	63	14.9%
What is your primary practice setting?	Private practice	129	30.6%
	Government hospital	221	52.4%
	Academic Institution	72	17.0%

Table 2: Awareness of advanced technologies among participants in oral and maxillofacial surgery

Item		N	%
Are you familiar with 3D imaging reconstruction technologies?	Yes	304	72.1%
	No	118	27.9%
Have you heard of CAD/CAM (Computer-Aided Design and Manufacturing)?	Yes	385	91.3%
	No	37	8.7%
Are you aware of surgical navigation systems?	Yes	359	85.1%
	No	63	14.9%
Do you know about augmented reality (AR) or virtual reality (VR) applications in dental surgery?	Yes	264	62.5%
	No	158	37.5%
Are you aware of robotic-assisted technologies for oral and maxillofacial surgery?	Yes	262	62.0%
	No	160	38.0%

specialization, the largest proportion were general dentists (26.5%), followed by oral and maxillofacial surgeons (22.3%), prosthodontists (17.1%), orthodontists (15.2%) and other dental specialists (19.0%). When assessed by years of clinical experience, 29.4% had less than five years of experience, 34.6% had five to fifteen years, 21.1% had sixteen to twenty-five years and 14.9% had more than twenty-five years. Regarding practice settings, the majority of participants were affiliated with government hospitals (52.4%), followed by private practices (30.6%) and academic institutions (17.0%). These demographics highlight a diverse representation of dental professionals, but also suggest that a significant portion of participants are early-career practitioners in public healthcare environments.

Awareness of Advanced Technologies

Table 2 presents the respondents' awareness of advanced technologies used in oral and maxillofacial surgery. Awareness was highest for CAD/CAM systems, with 91.3% of dentists indicating familiarity, followed closely by 85.1% who were aware of surgical navigation systems. Awareness of 3D imaging reconstruction technologies was also relatively high at 72.1%. However, awareness dropped when it came to emerging technologies-62.5% reported being familiar with augmented or virtual reality (AR/VR) applications, while 62.0% indicated awareness of robotic-assisted surgery. These findings reveal a disparity between knowledge of well-established technologies and that of newer, more specialized tools. Although overall awareness is encouraging, the lower familiarity with AR/VR and robotics suggests a gap in exposure to cutting-edge innovations, particularly in educational and training settings.

Current Usage Patterns

In contrast to high awareness, actual usage rates of these technologies were notably lower, as shown in Table 3. Only 20.4% of participants reported using 3D imaging reconstruction tools in clinical practice, while 41.2% had implemented CAD/CAM systems. More than half of the respondents (56.4%) utilized surgical navigation systems, indicating that these tools may be more readily accessible or better integrated within institutional settings. The adoption rate of AR/VR technologies was lower at 36.7%, potentially due to high costs, steep learning curves, or limited training availability. Interestingly, robotic-assisted technologies had the highest reported usage rate at 78.7%, likely reflecting their use in larger, specialized centers or surgical units.

Regarding experience, 66.8% of respondents had been using advanced technologies for more than three years, indicating some level of sustained engagement. However, the actual integration of these technologies into daily practice remains limited-only 31.3% of participants used them in more than 75% of procedures, while 16.6% used

Table 3: Current usage patterns of advanced technologies in oral and maxillofacial surgery

Item		N	%
Do you use 3D imaging reconstruction technologies in your practice?	Yes	86	20.4%
	No	336	79.6%
Have you implemented CAD/CAM systems in your practice?	Yes	174	41.2%
	No	248	58.8%
Do you utilize surgical navigation systems?	Yes	238	56.4%
	No	184	43.6%
Have you implemented augmented reality (AR) or virtual reality (VR) applications in oral and maxillofacial surgery?	Yes	155	36.7%
	No	267	63.3%
Do you use robotic-assisted technologies for oral and maxillofacial surgery?	Yes	332	78.7%
	No	90	21.3%
How long have you been using advanced technologies in your practice?	≥3 year	282	66.8%
	≤3 years	140	33.2%
What percentage of your procedures involve advanced technologies?	≥25%	70	16.6%
	25-50%	125	29.6%
	50-75%	95	22.5%
	≤75%	132	31.3%

Table 4: Barriers to adoption of advanced technologies in oral and maxillofacial surgery

Item		N	%
What are the main barriers to using advanced technologies in your practice	Lack of training	96	22.7%
	High costs of equipment	188	44.5%
	Limited institutional support	51	12.1%
	Lack of time to learn new systems	87	20.6%
Does your institution provide support for adopting these technologies?	Yes	347	82.2%
	No	75	17.8%
How accessible is training for these technologies in your region?	Easily accessible	172	40.8%
	Moderately accessible	206	48.8%
	Not accessible	44	10.4%

them in less than 25%. These patterns demonstrate that despite technological availability, consistent and widespread integration remains a challenge.

Barriers to Adoption

Table 4 identifies the major barriers that hinder the adoption of computer-assisted technologies in dental practice. The most prominent obstacle was the high cost of equipment, cited by 44.5% of respondents. This aligns with global trends where capital investment is a primary constraint, particularly in public healthcare systems. Lack of training was reported by 22.7%, while 20.6% highlighted the lack of time to learn new systems as a significant issue. Limited institutional support was identified by 12.1% of respondents, suggesting that while institutional backing exists in many cases, it may not be comprehensive or well-coordinated. Interestingly, 82.2% of participants indicated that their institutions do provide support for technology adoption, yet only 40.8% found training to be easily accessible. Nearly half (48.8%) rated it as moderately accessible and 10.4% reported that training was not accessible in their region at all. These findings indicate a disconnect between nominal institutional support and the actual availability of training and resources, particularly in underserved or rural areas.

Perceived Benefits and Training Needs

Perceptions about the benefits and training needs for advanced technologies are detailed in Table 5. A majority of dentists (58.1%) agreed that computer-assisted technologies improve patient outcomes, while 40.0% remained neutral and only 1.9% disagreed. Similarly, 52.1% believed these technologies enhance the efficiency of oral and maxillofacial surgery, though a large proportion (42.7%) expressed neutrality, possibly reflecting uncertainty or lack of hands-on experience. When evaluating training adequacy, only 36.7% felt that their training was sufficient, while 47.4% were neutral and 15.9% disagreed, indicating a strong demand for enhanced educational programs. Regarding cost-effectiveness, only 22.7% believed the investment in digital tools is justified by the benefits, with a majority (66.4%) remaining neutral. Notably, 83.4% of respondents supported incorporating these technologies into undergraduate dental curricula and 80.6% expressed a willingness to attend further training if offered. These responses strongly support the case for structured, accessible continuing education and curriculum reform to bridge knowledge and practice gaps.

Finally, Table 6 presents the results of a multivariate linear regression analysis, identifying demographic and professional predictors of knowledge and adoption. Gender emerged as a significant factor, with male participants scoring higher (mean = 5.3±2.2) than female participants (mean = 4.3±2.1; β = -0.67; p = 0.001). Although age and years of experience were not statistically significant, participants over the age of 50 showed a trend toward lower knowledge and adoption scores (p = 0.059). Specialty also played a critical role-prosthodontists demonstrated the highest scores (mean = 6.1±1.9; β = 1.68; p<0.001), while those in the "other" category had significantly lower scores (mean = 2.1±1.6; β = -1.98; p = 0.004). Practice setting was another influential factor, with private practitioners

Table 5: Perceived benefits and training needs for advanced technologies in oral and maxillofacial surgery

Item		N	%
Do you believe advanced technologies improve patient outcomes?	Agree	245	58.1%
	Neutral	169	40.0%
	Disagree	8	1.9%
Do you think these technologies enhance the efficiency of oral and maxillofacial surgery?	Agree	220	52.1%
	Neutral	180	42.7%
	Disagree	22	5.2%
How adequate is the current training you have received for using advanced technologies?	Agree	155	36.7%
	Neutral	200	47.4%
	Disagree	67	15.9%
Do you think the financial investment for these technologies is justified by the benefits?	Agree	96	22.7%
	Neutral	280	66.4%
	Disagree	46	10.9%
Would you recommend incorporating these technologies into undergraduate dental curricula?	Agree	352	83.4%
	Neutral	64	15.2%
	Disagree	4	0.9%
How likely are you to attend further training on these technologies if provided?	Agree	340	80.6%
	Neutral	72	17.1%
	Disagree	10	2.4%

Table 6: Multivariate linear regression analysis of knowledge and adoption of advanced technologies

Parameters	Mean	β[95% CI]	p-value
Gender			
Male (Ref)	5.3 (2.2)		
Female	4.3 (2.1)	-0.67[-1.06- 0.27]	0.001*
Age			
20-29 year (Ref)	4.9 (1.9)		
30-39 year	4.8 (1.9)	0.03[-0.63- -0.69]	0.922
40-49 year	4.8 (1.7)	-0.18[-1.13- 0.77]	0.708
more than 50 years	3.9 (2.2)	-1.20[-2.5- 0.05]	0.059
Experience			
Less than 5 years(Ref)	4.9 (1.8)		
5-15 years	5.1 (2.3)	-0.07[-0.71- 0.57]	0.832
16-25 years.	4.7 (2.4)	-0.33[-1.17- 0.51]	0.440
More than 25 years	4.3 (1.9)	-0.21[-1.43- 0.42]	0.421
Specialty			
General dentistry(Ref)	4.3 (2.1)		
Oral and maxillofacial surgery	4.8 (1.6)	0.41[-0.29- 1.11]	0.252
Orthodontics	5.8 (2.5)	1.33[-0.62- 3.28]	0.180
Prosthodontics	6.1 (1.9)	1.68[1.09- 2.26]	0.000*
Other	2.1 (1.6)	-1.98 [-3.34- -0.62]	0.004*
Practice			
Private practice(Ref)	4.7 (2.3)		
Government hospital	4.1 (2.1)	-0.79[-1.31- -0.26]	0.003*
Academic Institution	5.1 (1.9)	-0.014[-0.59- 0.56]	0.862

Ref: The reference, *Significance difference ≤0.05

outperforming their counterparts in government hospitals (β = -0.79; p = 0.003). No significant difference was observed between academic institutions and private settings. These results highlight specific subgroups-particularly female dentists, government hospital practitioners and those in non-specialist roles-that may benefit from targeted training and institutional support to foster more equitable technology adoption across the profession.

DISCUSSION

The rapid integration of computer-assisted technologies into dental practice is fundamentally transforming the field of oral and maxillofacial surgery, driving demand for both theoretical knowledge and practical application among clinicians. This study aimed to assess the levels of awareness, utilization and perceived barriers to such technologies among dental professionals in Saudi Arabia. The findings revealed substantial disparities in adoption, particularly influenced by professional specialty, institutional setting and gender-highlighting the urgent need for targeted educational strategies and institutional support mechanisms to bridge the gap between awareness and implementation.

Consistent with prior research, this study confirms high awareness levels of established technologies such as computer-aided design and manufacturing (CAD/CAM) systems and surgical navigation tools among Saudi dentists [11]. These technologies have become embedded within prosthodontic and oral surgery training, which may explain their widespread recognition in this study. However, newer technologies such as Augmented Reality (AR), Virtual Reality (VR) and robotic-assisted systems remain less familiar, echoing earlier findings

by Rios *et al.* [12], who reported similar trends in limited exposure to these emerging tools. While CAD/CAM awareness reached 91.3%, only 41.2% of dentists had implemented it in practice-a trend that suggests familiarity alone is insufficient without corresponding infrastructure and training.

The disparity between awareness and actual clinical application was a key theme of this study. Although 85.1% of respondents were aware of surgical navigation systems, only 56.4% utilized them. For AR/VR applications, 62.5% indicated awareness, but just 36.7% used them clinically. This disconnect is supported by Alkhayatt *et al.* [13], who found that both high costs and lack of structured training are critical barriers to implementation. In our findings, the cost of equipment was the most frequently cited obstacle (44.5%), followed by lack of training (22.7%) and insufficient time to learn new systems (20.6%). These issues mirror those identified by Bernauer *et al.* [14], who emphasized the importance of overcoming financial and logistical barriers to facilitate broader technology adoption in prosthodontic workflows.

Specialty-based variation in digital technology use was also evident. Prosthodontists showed the highest knowledge and application rates, consistent with the technology-intensive nature of their procedures, particularly in designing crowns, bridges and implant-supported restorations using CAD/CAM systems [15]. Conversely, general dentists and those practicing in government hospitals showed significantly lower adoption levels. Radwan *et al.* [9] noted that public sector institutions in Saudi Arabia often lack the necessary infrastructure and institutional commitment to integrate advanced technologies, creating disparities in access and application between public and private practice settings.

The importance of educational exposure was reinforced by this study, as participants affiliated with academic institutions reported higher awareness and readiness than their counterparts in private and government settings. This reflects the impact of ongoing academic engagement with emerging tools and methods, a finding supported by Lin *et al.* [11], who underscored the value of incorporating mixed and augmented reality tools into dental education. Encouragingly, 83.4% of study participants agreed that digital dentistry should be integrated into undergraduate curricula and 80.6% expressed willingness to attend further training-findings that align with Ciulla [16], who highlighted the transformative role of additive manufacturing and digital learning modules in building practical competence.

Global adoption trends suggest that while prosthodontics and oral surgery lead the way in integrating digital tools, other specialties-such as pediatric and preventive dentistry-are lagging. Study emphasized that these slower-adopting specialties must also embrace technological advancement to provide comprehensive patient-centered care. Our findings reinforce this need and advocate for expanding workshops and continuing education initiatives targeting underrepresented specialties, where awareness and integration remain limited.

Furthermore, readiness to adopt these technologies is not solely a function of training but also of contextual accessibility. Despite 82.2% of respondents stating their institutions support technology adoption, only 40.8% described training as easily accessible, while 10.4% said it was not accessible at all. This reinforces the conclusion by Radwan *et al.* [17] that institutional efforts, while present in policy, often fall short in execution, especially in rural or under-resourced areas.

From a policy perspective, these findings are particularly relevant in the context of Saudi Vision 2030, which emphasizes digital transformation and innovation within the healthcare system (Saudi Vision 2030). To align with these national objectives, stakeholders-including academic institutions, professional associations and health policymakers-must collaborate to address financial, logistical and educational barriers to digital dentistry. Investments in infrastructure, subsidies for digital tools and structured training programs will be essential in facilitating widespread adoption across all regions and practice settings.

This study provides a comprehensive assessment of the current landscape of digital technology adoption in Saudi oral healthcare. While awareness is strong, the gap between knowledge and clinical application remains wide, driven by resource limitations, inconsistent training and institutional disparities. To accelerate progress, Saudi Arabia must adopt a multi-faceted strategy encompassing curricular reform, equitable access to training and infrastructural development-ensuring that all dental practitioners are prepared to meet the demands of a rapidly evolving, technology-driven healthcare environment.

Strengths of the Study

This study presents several notable strengths. First, the relatively large sample size (n = 422) enhances the reliability and generalizability of the findings within the Saudi dental community. Second, the questionnaire design was both comprehensive and methodologically sound, covering a wide range of dimensions including awareness, usage, perceived benefits and barriers related to digital technologies. The inclusion of demographic variables also enabled valuable subgroup analysis, allowing for deeper insight into how gender, specialty and practice environment influence technology adoption. The use of multivariate regression further supported robust analytical conclusions, distinguishing this study as a detailed contribution to understanding the digital readiness of oral healthcare providers in the region.

Implications for Clinical Practice

The findings carry significant implications for dental practice, especially in the context of Saudi Arabia's healthcare modernization efforts under Vision 2030. The low adoption rate of technologies despite high awareness levels points to an urgent need for accessible, practical training programs and institutional support mechanisms. The

strong support among participants for integrating digital dentistry into undergraduate curricula suggests that foundational training must begin early in dental education. However, the study could be strengthened by offering clearer recommendations for how clinicians-particularly those in under-resourced environments-can incrementally build digital competencies and navigate financial barriers, such as by adopting scalable, entry-level tools.

CONCLUSIONS

This study highlights critical disparities in the knowledge, usage and adoption of computer-assisted technologies among dentists in Saudi Arabia, particularly in oral and maxillofacial surgery. While awareness of tools such as CAD/CAM and surgical navigation systems is relatively high, actual clinical application remains limited due to barriers including high equipment costs, inadequate training and insufficient institutional support-especially in government and underserved settings. Prosthodontists demonstrated the highest levels of adoption, underscoring the role of specialty-specific integration, while general dentists and public practitioners lagged behind, reflecting unequal access to digital resources. These findings underscore the urgent need for comprehensive strategies, including integration of digital dentistry into undergraduate and postgraduate curricula, expansion of hands-on training and targeted investment in infrastructure and continuing education. Policymakers and educational institutions must prioritize digital inclusion to ensure equitable access, enhance clinical competency and advance national healthcare goals in alignment with Saudi Vision 2030.

Limitations

Despite its contributions, the study has several limitations that must be acknowledged. The use of a convenience sampling strategy may introduce selection bias and limit the generalizability of results, particularly for underrepresented populations such as rural practitioners or those outside mainstream professional networks. Additionally, the two-month data collection window may have constrained the diversity of responses, potentially excluding individuals with limited digital access during that time. The reliance on self-reported data introduces the possibility of recall bias and over- or under-estimation of technology use. Furthermore, the study did not explore low-cost or alternative digital technologies that could benefit resource-constrained practices, nor did it assess the potential impact of regional disparities between urban and rural dental clinics.

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