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Artificial intelligence knowledge, attitudes and application perspectives of undergraduate and specialty students of faculty of dentistry in Turkey: an online survey research

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Abstract

Background This study aimed to investigate the knowledge, attitudes, and perceptions of fourth- and fifth-year undergraduate as well as specialty dentistry students in Turkey concerning artificial intelligence (AI) and its applications.

Methods The study was conducted between October 16, 2023, and January 16, 2024, with participants consisting of volunteers from dental faculties in Turkey. A total of 335 undergraduate students and 62 specialty students participated in the survey, which utilized non-probability convenience and snowball sampling methods. Cronbach's alpha was utilized to measure the internal consistency of the scale. Statistical analysis was performed using IBM SPSS version 26.0, with quantitative data presented as mean ± standard deviation and categorical data as frequency (percentage). The statistical level was set at 0.05, and the analysis involved Pearson's Chi-square test and Fisher-Freeman-Halton tests.

Results The results indicate that undergraduate and specialty students perceive the integration of large datasets as the primary advantage of AI. The speed, objectivity, and potential to reduce misdiagnosis rates associated with AI are also highlighted. Undergraduate students express more significant concern about the impact of AI on patient understanding and empathy compared to specialty students. Additionally, both groups strongly advocate for the inclusion of AI-related courses in dental education and acknowledge the indispensability of AI in dental practice. The significant roles of AI in dentistry, such as providing evidence-based dental approaches and compensating for human intellectual limitations, are widely recognized. Furthermore, consensus exists that AI will primarily assist in diagnosis and treatment decisions.

Conclusions The findings emphasize the importance of cautiously managing AI's role in healthcare services and underscore the need to prioritize patient privacy and data security. AI should be regarded as a complement to the

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work of dental professionals rather than a substitute. The study recommends further research involving a larger and more diverse sample to obtain a comprehensive understanding of attitudes toward AI in dentistry.

Keywords　Artificial Intelligence, Dental Education, Dental Education Assessment, Dental Students, Health Education & Awareness

Background

The revolution of artificial intelligence (AI) in dentistry represents a groundbreaking technological advancement with the potential to reshape the clinical service environment. Although the impact of AI on dentistry has been relatively limited, advanced data-analysis capabilities have led to significant improvements. Notable advancements include automatic disease detection through image analysis, enhanced diagnostic accuracy and precision provided by support systems, simulation and evaluation of future treatment outcomes, prediction of oral disease development and prognosis, automatic detection of oral features through image segmentation, and increased resolution of dental images [1, 2].

Medical and dental undergraduate programs are widely recognized for their comprehensive nature, characterized by rigorous theoretical and practical curricula. However, a broad scope in curriculum design often results in limited attention to rare clinical cases. Specialization programs are critical in effectively managing complex cases and improving patient satisfaction. Specialists gain additional experience in clinical disciplines and develop advanced treatment planning skills, enhancing their foundational education. Such specialization equips specialists to serve specific patient groups more effectively than general practitioners. In Turkey, completion of a five-year undergraduate program in dentistry and success in the Dentistry Specialty Exam (DUS) qualify candidates for advanced specialty training. The final phase of this training involves the preparation of a thesis and the completion of a scientific examination, fostering expertise in managing particular patient needs [3].

The application of AI facilitates the rapid analysis of information collected from patients (demographics, medical history, clinical findings, 2D/3D diagnostic images, and/or intraoral/facial scans) to attain a more comprehensive understanding of patients' health statuses. The use of AI enables rapid analysis of patient information—such as demographics, medical history, diagnostic images, and scans—providing a comprehensive understanding of health statuses [4]. Innovative technologies in healthcare, by providing precise information, reducing unnecessary procedures, increasing treatment effectiveness, shortening treatment times, minimizing complications, lowering costs, and reducing decision-making errors, enhance personalized dental practices, individualized diagnoses, interdisciplinary treatment recommendations, and outcome predictions [4, 5].

Dental education aims to equip students with the ability to develop ethical and effective personalized treatment plans based not only on clinical data but also on individual patient factors. The integration of AI technologies as decision support systems in clinical practice can introduce biases and risks, as healthcare providers may overly depend on AI data and overlook its potential errors. Automation errors may also undermine diagnostic accuracy, posing significant risks to patient safety [6, 7].

Few studies have investigated the opinions and attitudes of dental students in Turkey regarding AI applications [8, 9]. However, the lack of research addressing factors such as expectations, perceived advantages, concerns, and trust toward AI applications indicates a need for further investigation. Based on the analysis of the reviewed literature, several studies have compared AI perception and attitude variables between specialist dentists and/or dental students in dentistry [5, 9, 10]. Nevertheless, a comprehensive study has yet to explore the views and attitudes of undergraduate and specialty dental students in Turkey regarding AI applications in dentistry and factors such as expectations, perceived advantages, concerns, and trust in AI applications.

This study aims to examine the knowledge, attitudes, and perceptions of 4th and 5th-year undergraduate and specialty dentistry students with clinical experience, currently enrolled in Faculties of Dentistry in Turkey, regarding AI and its applications. Furthermore, the study aims to explore the potential impacts of AI on clinical practice, its integration into dental education, and the future prospects of undergraduate and residency students possessing clinical experience.

Methods

Study participants

The study was conducted on volunteers from specialty and undergraduate (4th and 5th year) dental students of the Faculties of Dentistry in Turkey. The purpose of the study was explained to participants at the outset of the questionnaire. As it was clearly defined in the note accompanying the questionnaire, the completion of the questionnaire was considered as providing consent to participate in the study. The study included only complete surveys that were voluntarily responded to by dental students actively enrolled in undergraduate (4th or 5th year) or specialty programmes at faculties of dentistry. Surveys from individuals who partially completed the

questionnaire, declined participation, or were not dental students were excluded from the study. This survey was approved by the Clinical Research Ethics Committee of the Afyonkarahisar Health Sciences University (decision no: 2023/438). This study was conducted in accordance with the code of ethics of the World Medical Association (Declaration of Helsinki). Responses were received anonymously, without any identifying data, and only the principal investigator had access to the data. Participation was voluntary, and participants received a bi-weekly reminder to complete the online survey. The scale's reliability was assessed using Cronbach's alpha analysis, yielding α=0.817.

A cross-sectional online survey was conducted between October 16, 2023, and January 16, 2024, using non-probability, convenience, and snowball sampling methods. The survey assessed the familiarity with and attitudes toward using of AI in dentistry among undergraduate and specialty students enrolled in dental faculties across Turkey. Given the study's exploratory nature, sample size estimation and power calculations were waived since no specific hypothesis testing was conducted. Invitations to participate in the survey were distributed via Google Forms (Google LLC, United States) and disseminated through the social media platform WhatsApp (Meta Platforms Inc., United States), targeting 335 undergraduate and 62 specialty students. Consequently, the study sample comprised dental students with diverse educational backgrounds and skills, effectively reflecting the broader dental community in Turkey.

The development of the survey instrument was informed by a comprehensive literature review, with a detailed analysis of existing surveys by Eschert et al. [11] and Jeong et al. [12]. The surveys were translated into Turkish and assessed for accuracy and suitability for undergraduate and specialty dental students in Turkey. Permission for use was obtained from the original authors via email. The final survey, consisting of 29 items, was designed to align with the referenced studies' methodologies and capture relevant data from undergraduate and specialty dental students (Supplementary Material 1 - Table A1). The development of the survey involved an extensive literature review and consultations with specialist dentists. Discrepancies or disagreements regarding the survey questions were resolved through consensus among the study authors (CY, RZE, and LAU). To assess usability and ensure the validity and reliability of the online survey, a pilot study involving 15 students was conducted. The survey was completed independently by students without consulting others. Responses from the pilot study were excluded from the final data.

The survey comprised eight questions addressing participants' basic characteristics and 21 questions related to AI. The AI-related questions were categorized into the following areas: attitudes toward AI, confidence in AI, predictions for AI applications in dentistry, evaluation of the anticipated impact of AI, perceived advantages of AI, and concerns regarding AI. Seven of the 21 AI-related questions utilized a 5-point Likert scale (strongly agree=5 points, agree=4 points, neither agree nor disagree=3 points, disagree=2 points, strongly disagree=1 point).

The survey instrument was divided into six sections. The first section collected demographic data, including age, gender, academic position, area of expertise, year of study (4th or 5th year), knowledge level about AI, and frequency of AI use in daily tasks. Multiple responses were permitted for questions 18 and 19. Knowledge level about AI was assessed using a five-point Likert scale (High=4, 5; Medium=3; Low=1, 2).

The second section explored preferred information sources for AI applications in dentistry (e.g., media, social media, university, friends/family, web searches), perceptions of the major advantages and disadvantages of AI in dentistry, and opinions regarding the integration of AI into undergraduate and specialty dental education. Additionally, the necessity of AI in clinical practice for evaluating disease severity and assisting in early diagnosis was examined.

The third section comprised three questions designed to evaluate confidence in AI. The fourth section focused on determining tasks related to AI application in oral and dental health, identifying areas where AI will be most utilized in dentistry, predicting the first type of oral and dental health institutions to be commercialized, and identifying the dental specialty expected to be used primarily for commercial purposes. The fifth section required participants to report on several factors: (1) the frequency of AI use in dental applications, (2) the anticipated impact of AI on the profession, (3) the expected timeline for a noticeable impact of AI on the profession, (4) expectations regarding the effect of AI on workforce demand in the profession over the next ten years, (5) potential for AI to enhance clinical practice and contribute to professional advancement, and (6) belief in AI's ability to reduce iatrogenic complications and medical errors in the profession. The sixth section evaluated perceived advantages and concerns related to AI use in clinical practice. Different five-point Likert scales were employed to assess the responses in each section.

Statistical analysis

A frequency analysis was conducted to determine the number of responses and response rates of all participants to each question. Pearson's Chi-square and Fisher-Freeman-Halton Exact tests were employed to analyze categorical variables. The analysis results are presented as mean±standard deviation for quantitative variables and

frequency (percentage) for categorical variables. Data were analyzed using IBM SPSS version 26.0, with a significance level set at $p < 0.05$.

Results

Participants' demographics

Table 1 presents the characteristics of the 397 participants in the study. The study included undergraduate students (US) with a mean age of 22.41 ± 1.24 years and specialty students (SS) with a mean age of 27.52 ± 2.68 years. Regarding subjective knowledge levels about AI, 44.8% of US rated knowledge as 'average,' whereas 46.8% of SS rated it as 'below average' ($p = 0.490$). Additionally, the majority of participants in both groups reported infrequent use of AI in daily practices (US: 53.4%, SS: 69.4%).

Questions related to AI

Attitudes toward AI

Attitudes toward AI were assessed using six questions. Among US (56.7%) and SS (61.3%), the internet and

Table 1 Participants' demographics

Variable	n	%
Age of the Students in Years (SD)	23.21 ± 2.42	
Gender		
Male	145	36.5
Female	252	63.5
Position in Faculty		
Undergraduate Student	335	84.4
Specialty Student	62	15.6
Branch of Specialization		
Oral and Maxillofacial Surgery	4	6.5
Oral and Maxillofacial Radiology	6	9.7
Endodontics	18	29
Orthodontics	6	9.7
Pedodontics	13	21
Periodontology	4	6.5
Prosthodontics	5	8.1
Restorative Dentistry	6	9.7
Year of Education		
4th year	178	53.1
5th year	157	46.9
Level of knowledge about AI		
High (very much, to some extent)	52	13.1
Medium (average)	173	43.6
Low (little, not at all)	172	43.3
Have you ever been involved in the process of developing AI?		
Yes, I have	21	5.3
No, I have not.	376	94.7
How often do you use AI in your daily work?		
Very much (everyday)	82	20.7
Moderately (weekly)	93	23.4
Rarely, not at all (monthly, never)	222	55.9

websites emerged as the preferred source, followed by social media and blogs (US: 36.4%, SS: 46.8%), and educational institutions such as schools, universities, and courses (US: 30.1%, SS: 33.9%). For US utilizing AI daily, the integration of vast amounts of data (35.3%) was identified as the most significant advantage of AI in dentistry. Conversely, students engaging with AI on a weekly, monthly, or less frequent basis cited the fast and objective nature of AI (45.5%, 40.2%, respectively) as the primary benefit. Among SS, a different pattern was observed, with daily users emphasizing the fast and objective nature of AI (64.3%) and students using AI weekly, monthly, or not at all recognizing the integration of vast amounts of data (40.0%, 41.9%, respectively) as the key advantage. Weekly users in the SS group also highlighted the reduction of misdiagnosis rates (40.0%) as a notable benefit. Both US and SS concurred that the fast and objective nature of AI (US: 40.3%, SS: 40.3%) represented the most crucial advantage. The primary disadvantage identified by US was the diminished capacity to understand and empathize with patient emotions (32.2%), whereas SS pointed to the challenge of handling unexpected situations beyond stored information (33.9%).

A high percentage of US (63.9%) and SS (66.1%) strongly agreed or agreed that AI-related courses should be included in the dental education curriculum. Substantial agreement was observed among both US and SS regarding the necessity of AI in dental practice (US: 70.4%, SS: 66.1%) and its potential to assist in evaluating disease severity and facilitating early diagnosis (US: 75.5%, SS: 75.9%).

A small percentage of US (11.1%) and SS (9.7%) believe AI surpasses experienced dentists in diagnostic ability, while a majority of US (54.3%) and SS (51.6%) hold a contrary view. When a disagreement arises between dentists and AI, each group prioritizes different sources of opinion. US tend to rely more on expert opinions (45.1%), whereas SS place greater trust in the dentist's decision (41.8%) ($p = 0.113$). In instances of misdiagnosis attributed to AI, 50.4% of US believe the responsible dentist should be held accountable, while 45.2% of SS attribute responsibility to the company that developed the AI ($p = 0.575$). Details of the findings are provided in Table 2.

Predictions for the application of AI in dentistry

In identifying the roles AI will play in dental healthcare, both US (51.3%) and SS (51.6%) indicated 'providing data on evidence-based dental approaches in clinical practice' as the primary task. The second priority task, as reported by both groups, involves utilizing AI as a tool to compensate for the limitations in human intellectual abilities that may be overlooked by dentists (US: 47.8%, SS: 56.5%). Regarding specific tasks, both US and SS agreed that AI will primarily assist in diagnosis (US: 69.6%, SS: 82.3%)

Table 2 Participants' attitudes toward and confidence in AI

Question	Under-graduate Student	Special-ization Student	p value
	n (%)	n (%)	
What is the biggest advantage of AI when applied to dentistry?			
Fast and objective	135(40.3%)	25(40.3%)	0.628**
Integration of vast amount of data	110(32.8%)	23(37.1%)	
Reduction of misdiagnosis rates	47(14.0%)	10(16.1%)	
No spatial or temporal constraints	24(7.2%)	1(1.6%)	
No emotional exhaustion or physical limitations	15(4.5%)	3(4.%8)	
Other	4(1.2%)	0(0.0%)	
What is the biggest disadvantage of AI when applied to dentistry?			
Difficult to handle unexpected situations other than stored information	84(25.1%)	21(33.9%)	0.367**
Somewhat inflexible to apply to individual patients	56(16.7%)	5(8.1%)	
Difficult to apply to controversial issues	67(20.0%)	15(24.2%)	
Decreased ability to consider or empathize with the patient's feelings	108(32.2%)	18(29.0%)	
Developed by experts with little clinical experience	15(4.5%)	3(4.8%)	
Other	5(1.5%)	0(0.0%)	
Do you think AI should be included in the curriculum of undergraduate and specialty education of the faculty of dentistry?			
Strongly agree, agree	224(63.9%)	41(66.1%)	0.697*
Neither agree nor disagree	92(27.5%)	19(30.6%)	
Disagree, strongly disagree	29(8.7%)	2(3.2%)	
I believe that AI is essential in the practice of dentistry.			
Strongly agree, agree	236(70.4%)	41(66.1%)	0.178*
Neither agree nor disagree	74(22.1%)	19(30.6%)	
Disagree, strongly disagree	25(7.5%)	2(3.2%)	
I think AI is helping dentists to assess the severity of the disease and diagnose it early.			
Strongly agree, agree	253(75.5%)	47(75.9%)	0.614*
Neither agree nor disagree	63(18.8%)	14(22.6%)	
Disagree, strongly disagree	19(5.7%)	1(1.6%)	
Do you think the diagnostic ability of AI is superior to that of experienced dental professionals?			
Strongly agree, agree	37(11.1%)	6(9.7%)	0,815*
Neither agree nor disagree	116(34.6%)	24(38.7%)	
Disagree, strongly disagree	182(54.3%)	32(51.6%)	
If there were a significant difference between the treatment recommended by your doctor or dentist and the treatment recommended by AI, and you found yourself torn between different decisions, which one would you trust more?			
Dentist's judgment	140(41.8%)	30(48.4%)	0.113**
AI's judgment	10(3.0%)	2(3.2%)	
Opinions of other experts	151(45.1%)	29(46.8%)	
Opinions of other AI programs	7(2.1%)	1(1.6%)	
Leave it to the patient's choice	27(8.1%)	0(0.0%)	
Who do you think is liable for misdiagnosis by AI?			
Dentist in charge	169(50.4%)	27(43.5%)	0.575**
Dental hygienist in charge	6(1.8%)	0(0.0%)	
Company that developed AI	117(34.9%)	28(45.2%)	
Patient who followed AI's judgment	39(11.6%)	7(11.3%)	
Other	4(1.2%)	0(0.0%)	

n frequency, % percentage

*Pearson's Chi-Square test, **Fisher–Freeman–Halton test

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and aid in treatment decisions (US: 50.7%, SS: 59.7%) (Table 3).

In terms of the commercialization of AI in oral and dental health institutions, US identified primary care institutions such as private clinics (39.7%), while SS pointed to university hospitals (48.4%). Both groups indicated that AI would be primarily utilized for commercial purposes in the field of oral and maxillofacial radiology (US: 35.2%, SS: 54.8%).

Prospects for the application of AI

A significant portion of US, 46.9%, anticipate the widespread application of AI, while 35.5% of SS predict its use will be limited to essential situations. A majority of participants, 70.8% of US and 77.4% of SS, express strong disagreement or disagreement with the notion of AI replacing their professions.

Regarding the anticipated impact of AI in dentistry, 38.2% of US and 32.3% of SS expect significant changes within 6 to 10 years. When considering workforce implications, 45.4% of US and 41.9% of SS foresee a moderate impact over the next decade.

Both groups recognize the potential of AI to enhance clinical practice and professional development, with 64% of US and 74.2% of SS holding this view. Furthermore, there is a strong belief in the role of AI in reducing iatrogenic complications and medical errors within the field, with 63.9% of US and 66.1% of SS strongly agreeing or agreeing. A summary of these findings is provided in Table 3.

Perceived advantages of applying AI in clinical practice

The evaluation of the perceived advantages of AI application in clinical practice by US and SS reveals that "Better access to disease screening" holds the highest importance. Additional significant advantages include "More targeted referrals," "Improved diagnostics," "Reduction in time-consuming routine tasks," and "Increased diagnostic consistency." (Table 4).

Perceived concerns about the application of AI in clinical practice

The principal concerns among both US and SS are liability and responsibility for machine errors and data security and privacy issues. In contrast, concerns regarding challenges to the patient-doctor relationship, the impact on the workforce, the reduced need for specialists, and comparisons between clinicians and AI were notably lower (Table 5).

Discussion

Physicians encounter several challenges, including the need to improve clinical decision-making, manage data overload, and translate medical advances into actionable

plans [13]. In dentistry, traditional practices have been modernized through the use of AI-based clinical decision support systems, which are designed to provide expert assistance to healthcare professionals. AI is frequently employed to facilitate diagnostics and data management, thereby aiding specialists and dentists in making clinical decisions, developing preventive strategies, and formulating appropriate treatment plans [14]. To the best of current knowledge, the study represents the first research conducted in Turkey focusing on the knowledge, attitudes, and perceptions of US (4th and 5th year) and SS in dental faculties regarding AI and its applications. The research evaluates the integration of AI into dental education and examines potential impacts on dental practice while offering perspectives on the subject. Survey results indicate a low level of recognition of AI among dental students in Turkey.

S Bisdas et al. [15] conducted a multinational, multicenter study to evaluate the attitudes of medical and dental students toward AI. According to the findings, 60.1% of participants considered browsing the internet to be the primary source of information, while 59.4% preferred social media. On the other hand, university resources were the least preferred, with only 33.6% of participants relying on them, followed by friends or family at 24.6%. Similarly, undergraduate and graduate students in the current study primarily relied on the internet and websites (US: 56.7%, SS: 61.3%) as the main source of information for accessing knowledge about AI. Social media and blogs (US: 36.4%, SS: 46.8%) were mentioned as a secondary source, and educational institutions such as schools, universities, and courses (US: 30.1%, SS: 33.9%) were cited as a tertiary source. The similarities in students' preferences for information access can be attributed to the rapid and easily accessible nature of the internet and social media, while the lower preference for university resources may stem from a perceived lack of currency and accessibility. Differences in preferences likely arise from various factors, including students' information-seeking habits, socio-cultural influences, and the educational system.

The findings of the current study indicate that both US and SS participants regard "Fast and objective" as the greatest advantage of implementing AI in dentistry (US: 40.3%, SS: 40.3%). In contrast, previous studies on AI report differing results. A study examining the perceptions and attitudes of Korean dental hygiene students identified "Reduction in misdiagnosis rates" as the most significant advantage (26.3%) [12]. Additionally, research assessing trust in AI and attitudes toward its medical applications among Korean medical students, trainee doctors (interns, residents, or clinical researchers), university professors, and non-university doctors highlighted "The ability of AI to provide clinically meaningful, large

Table 3 Evaluation of participants' predictions and expected effects of the application of AI in dentistry

Which roles do you think AI will play in dental healthcare?		Undergraduate Student	Specialization Student	Total	*p* value
		n %	*n* %	*n* %	
AI will not be helpful for dental healthcare	1st Priority	74(22.1%)	8(12,9%)	82(20,7%)	0.204*
	2nd Priority	75(22.4%)	18(29,0%)	93(23,4%)	
	3rd Priority	186(55.5%)	36(58,1%)	222(55,9%)	
AI will serve as a guide in rare cases	1st Priority	124(37.0%)	28(45,2%)	152(38,3%)	0.221*
	2nd Priority	124((37.0%)	24(38,7%)	148(37,3%)	
	3rd Priority	87(26.0%)	10(16,1%)	97(24,4%)	
AI will provide data on evidence-based dental approaches in clinical practice	1st Priority	172(51.3%)	32(51,6%)	204(51,4%)	0.332*
	2nd Priority	108(32.2%)	24(38,7%)	132(33,2%)	
	3rd Priority	55(16.4%)	6(9,7%)	61(15,4%)	
AI will be used as a device to compensate for the limitations of human intellectual abilities (neglected by dentists)	1st Priority	87(26.0%)	14(22,6%)	101(25,4%)	0.445*
	2nd Priority	160(47.8%)	35(56,5%)	195(49,1%)	
	3rd Priority	88(26.3%)	13(21,0%)	101(25,4%)	
AI will be used as a reference for each treatment	1st Priority	75(22.4%)	9(14,5%)	84(21,2%)	0.166*
	2nd Priority	142(42.4%)	24(38,7%)	166(41,8%)	
	3rd Priority	118(35.2%)	29(46,8%)	147(37,0%)	
AI will completely replace dentists' judgment	1st Priority	62(18.5%)	6(9,7%)	68(17,1%)	0.232*
	2nd Priority	82(24.5%)	16(25,8%)	98(24,7%)	
	3rd Priority	191(57.0%)	40(64,5%)	231(58,2%)	
Other	1st Priority	79(23,6%)	9(14,5%)	88(22,2%)	0.267*
	2nd Priority	104(31.0%)	23(37,1%)	127(32,0%)	
	3rd Priority	152(45,4%)	30(48,4%)	182(45,8%)	
Which field of dentistry do you think will benefit most from AI?					
Diagnosis	1st Priority	233(69.6%)	51(82,3%)	284(71.5%)	0.034*
	2nd Priority	68(20.3%)	4(6.5%)	72(18.1%)	
	3rd Priority	34(10.1%)	7(11.3%)	41(10.3%)	
Treatment decision	1st Priority	105(31.3%)	18(29.0%)	123(31.0%)	0.325*
	2nd Priority	170(50.7%)	37(59.7%)	207(52.1%)	
	3rd Priority	60(17.9%)	7(11.3%)	67(16.9%)	
Direct treatment (including surgery)	1st Priority	66(19.7%)	9(14.5%)	75(18.9%)	0.450*
	2nd Priority	102(30.4%)	17(27.4%)	119(30.0%)	
	3rd Priority	167(49.9%)	36(58.1%)	203(51.1%)	
Research and development of drugs and materials	1st Priority	151(45.1%)	20(32.3%)	171(43.1%)	0.170*
	2nd Priority	120(35.8%)	28(45.2%)	148(37.3%)	
	3rd Priority	64(19.1%)	14(22.6%)	78(19.6%)	
Dental care support in medically vulnerable areas	1st Priority	115(34.3%)	17(27.4%)	132(33.2%)	0.379*
	2nd Priority	128(38.2%)	23(37.1%)	151(38.0%)	
	3rd Priority	92(27.5%)	22(35.5%)	114(28.7%)	
Development and improvement of social insurance	1st Priority	124(37.0%)	28(45.2%)	152(38.3%)	0.468*
	2nd Priority	110(32.8%)	17(27.4%)	127(32.0%)	
	3rd Priority	101(30.1%)	17(27.4%)	118(29.7%)	
Other	1st Priority	67(20.0%)	12(19.4%)	79(19.9%)	0.388*
	2nd Priority	130(38.8%)	19(30.6%)	149(37.5%)	
	3rd Priority	138(41.2%)	31(50.0%)	169(42.6%)	
How often do you expect AI to be used once applied in dentistry?					
It will be used in all practices, will be used in most practices		157(46.9%)	20(32.3%)	177(44.6%)	0.064*
It will be used in about half the time		71(21.2%)	20(32.3%)	91(22.9%)	
It will only be used when absolutely necessary, seldom used		107(31.9%)	22(35.5%)	129(32.5%)	
Do you think AI can replace your job?					

Table 3 (continued)

Which roles do you think AI will play in dental healthcare?	Undergraduate Student	Specialization Student	Total	*p* value
	n %	*n* %	*n* %	
Strongly agree, agree	33(9.9%)	6(9.7%)	39(9.8%)	0.466*
Neither agree nor disagree	65(19.4%)	8(12.9%)	73(18.4%)	
Disagree, strongly disagree	237(70.7%)	48(77.4%)	285(71.8%)	
In your opinion, when do you think AI will have a noticeable impact on your profession?				
1 year	4(1.2%)	0(0.0%)	4(1.0%)	0.282**
1-5 years	65(19.4%)	20(32.3%)	85(21.4%)	
6-10 years	128(38.2%)	20(32.3%)	148(37.3%)	
>10 years	123(36.7%)	20(32.3%)	143(36.0%)	
Never ever	15(4.5%)	2(3.2%)	17(4.3%)	
To what extent do you expect AI to impact the workforce needed in your profession in the next decade?				
To a great extent (very much, to some extent)	62(18.5%)	12(19.4%)	74(18.6%)	0.881*
Somewhat (average)	152(45.4%)	26(41.9%)	178(44.8%)	
Very little (little, not at all)	121(36.1%)	24(38.7%)	145(36.5%)	
I think that AI applications can improve my clinical practice and enable me to improve in my profession.				
Strongly agree, agree	217(64.8%)	46(74.2%)	263(66.2%)	0.099*
Neither agree nor disagree	77(23.0%)	14(22.6%)	91(22.9%)	
Disagree, strongly disagree	41(12.2%)	2(3.2%)	43(10.8%)	
I believe that the use of AI will reduce iatrogenic complications and medical errors in my profession.				
Strongly agree, agree	214(63.9%)	41(66.1%)	255(64.2%)	0.895*
Neither agree nor disagree	94(28.1%)	17(27.4%)	111(28%)	
Disagree, strongly disagree	27(8.1%)	4(6.5%)	31(7.8%)	

n frequency, % percentage

*Pearson's Chi-Square test, **Fisher–Freeman–Halton test

Table 4 Perceived advantages of AI in dentistry according to 5-point likert scale

Statements	Total Mean(SD)
Better access to disease-screening	3.3(1.5)
More targeted referrals	3.2(1.3)
More cost-efficient healthcare	2.5(1.2)
Better diagnostics	3.2(1.3)
Reduction in time-consuming routine tasks	3.2(1.3)
More consistent diagnostics	3.1(1.2)
More individual and evidence-based treatment	3.0(1.2)
Better prediction of the course of disease	3.2(1.2)

1: low relevance; 5: high relevance

Table 5 Perceived concerns of AI in dentistry, according to 5-point likert scale

Statements	Total Mean(SD)
Concerns over the divestment of healthcare to technology companies	3.0(1.3)
Concerns over data security and privacy issues	3.2(1.3)
Concerns over liability and responsibility for machine errors	3.4(1.3)
Lack of trust in the diagnostic capability of AI	3.0(1.2)
Concerns over a reduced need for specialists	2.6(1.2)
Challenge for the patient–doctor relationship	2.9(1.2)
Concerns regarding the comparison between clinicians and AI	2.3(1.2)
Negative impact on the workforce	2.8(1.2)

1: very low level of concern; 5: very high level of concern

amounts of high-quality data in real-time" as the primary advantage, cited by 62.3% of participants [16]. The findings underscore the variability in perceived advantages of AI in dentistry across different geographical regions and participant groups. Such discrepancies may be attributed to several factors. The educational and experience levels of participants can significantly influence perceptions of

AI's advantages. Individuals with more exposure to AI technology or advanced training may prioritize different benefits compared to those with limited experience. Variations in healthcare delivery systems and technological applications across countries could also contribute to the

differences. Regions with advanced AI integration may emphasize real-time data processing as a primary benefit, while areas with limited integration may prioritize the reduction of misdiagnosis rates. The stage of AI technology development and its integration into clinical practice can also influence perceptions. Regions with emerging AI technologies may focus on different advantages than those with more established systems. The integration of AI into dental education provides several benefits, including the enhancement of practical experience for students, the support of informed treatment decisions, and the inclusion of AI-supported decision-making systems in clinical education.

The integration of AI into dental education offers numerous benefits, including the enhancement of students' practical experience, the facilitation of informed treatment decisions, and the incorporation of AI-supported decision support systems into clinical education. Furthermore, AI enhances competencies in the analysis and interpretation of radiographic images. AI also has the potential to significantly increase the efficiency and accuracy of administrative and documentation tasks in dentistry, as well as assist in processes such as appointment scheduling and patient record management [19].

A survey conducted by M Karan-Romero et al. [5] examined university students' attitudes and perceptions regarding the use of AI in dentistry, revealing that 45% of participants did not support the idea that AI would replace dentists and doctors in the future. Moreover, participants agreed on the necessity of integrating AI into both undergraduate and specialty education. Consistently, in the present study, participants from both groups did not expect AI to replace dentists in the future, and a consensus was reached on the importance of including AI within the dental education curriculum.

A study conducted among Korean medical doctors [16], demonstrated that 44% of participants recognized the superior diagnostic abilities of AI compared to experienced physicians, and 35.4% believed in AI's potential to replace medical professionals in the future. However, 45% of respondents indicated that AI was rarely or never considered in the decision-making process for medical care. Additionally, participants identified diagnosis (83.4%) and treatment planning (53.8%) as the areas within healthcare where AI would be most beneficial. Furthermore, 66.2% of respondents anticipated that the first commercial application of AI in the field of oral and dental health would occur in university hospitals.

In the present study, participants expressed the belief that the diagnostic ability of AI does not surpass that of dentists and that AI cannot replace the dental profession. However, participants acknowledged the necessity of AI in dental practice, particularly in assisting with the evaluation of disease severity and facilitating early diagnosis.

Among SS, 35.5% indicated that AI should only be used when absolutely necessary or on rare occasions, a view not as commonly held by undergraduate students. Both studies underscore the incomplete trust in AI among participants and emphasize the enduring importance of the human factor in dentistry.

Several factors may account for the observed similarities across these studies. An underlying skepticism toward AI may arise from the belief that human elements—intuition, experience, and empathy—are irreplaceable in clinical decision-making. Despite AI's ability to analyze extensive datasets and provide evidence-based recommendations, professionals in medicine and dentistry may express concerns about aspects of patient care that go beyond data analysis. Such concerns likely encourage a cautious stance toward AI integration, particularly in areas where human judgment is considered critical.

Variability in AI adoption likely results from differing levels of exposure and familiarity with AI technologies among various groups. Medical professionals and dental specialists, while recognizing the potential benefits of AI, often express hesitation due to limited hands-on experience and a lack of understanding regarding practical applications. In contrast, undergraduate students, who encounter digital tools and emerging technologies more frequently during their education, may hold a different perspective. However, the study indicates a common skepticism across these groups regarding the role of AI.

Cultural factors and the broader healthcare ecosystem in various regions significantly influence attitudes toward AI. In countries with highly structured and hierarchical medical systems, trust in AI may vary compared to regions characterized by more decentralized healthcare delivery or faster technology adoption. The Korean study's emphasis on AI applications in university hospitals suggests that academic and research institutions might play a critical role in advancing AI integration, potentially explaining the expectation of initial deployment in these settings. The observed partial consistency in the findings reflects a complex interplay of trust, perceived utility, and the importance of human expertise in healthcare. Such elements contribute to the cautious optimism expressed by medical and dental professionals regarding the future integration of AI into clinical practice.

In the study by J Roganovic et al. [10], a cross-sectional online survey was conducted to investigate the perspectives of experienced dentists (PhD/specialists) and final-year undergraduate students on AI and its potential applications in dentistry. The findings revealed a lack of knowledge among participants, particularly final-year students, regarding the use of AI in dentistry, along with expressed doubts about its implementation. Insufficient

knowledge of AI technology and concerns about AI potentially replacing dentists were identified as the underlying reasons for these findings. Participants indicated that in the event of harm to patients caused by AI, the dentist would bear responsibility, while accountability for incorrect recommendations made by the AI system would fall on the developers.

The findings of the present study show partial consistency with the work of J. Roganovic et al. [10]. Both US and SS exhibited a moderate to low level of knowledge about AI technology and did not support the notion that AI could replace dentists. Additionally, while SS believed that responsibility for incorrect diagnoses made by AI should be assigned to the developers of the AI system, US argued that such responsibility should rest with the dentist.

The issue of responsibility for misdiagnoses caused by AI presents varying opinions among US and SS. In the present study, 50.4% of US believed the responsible dentist should bear the responsibility, while 34.9% attributed it to the company that developed the AI, and 11.6% believed the patient who consented to the AI's decision should be held accountable. Among SS, 43.5% assigned responsibility to the dentist, 45.2% to the AI-developing company, and 11.3% to the patient who provided consent for the AI's decision. Another study found that 49.3% of participants believed the responsible party should be the doctor, 19.4% believed it should be the company that created the AI, and 31.2% assigned responsibility to the patients who consented to the AI's decision [16]. These differences underscore the need for further research and discussion to clarify the ethical and legal responsibilities that may arise from the use of AI in medical applications.

In survey studies by V Ranjana et al. [17], investigating the awareness of AI in healthcare among dental students, 57% of participants expressed the belief that AI has the potential to revolutionize clinical decision-making and diagnostic processes. Notably, respondents emphasized that AI-based systems are not expected to disrupt the traditional doctor-patient relationship but are anticipated to serve as valuable tools for supporting and augmenting the capabilities of healthcare professionals. The findings of the present study align with the conclusions drawn in this research.

The similarities observed in these studies could stem from several underlying factors. First, the moderate to low level of knowledge about AI among both undergraduate and specialty students suggests a general unfamiliarity with the technology, which likely contributes to skepticism regarding its role in dentistry. This lack of familiarity may cause students to rely more heavily on traditional methods and express caution toward AI's integration into clinical practice.

The differences in opinions between undergraduate and specialty students regarding responsibility for AI errors may also reflect varying levels of professional maturity and experience. Specialty students, who have more practical experience, may recognize the complexities of AI systems and the challenges in attributing blame solely to the technology or its developers. In contrast, undergraduate students, with less clinical experience, might place greater emphasis on the dentist's role, possibly due to a stronger reliance on human judgment in their training.

In the study conducted by T Eschert et al. [11], an examination of the knowledge and perceptions of AI among dental clinicians in Germany revealed a consensus regarding accountability for errors caused by AI, particularly in terms of responsibility for machine errors and associated concerns (3.7 ± 1.3). Additionally, concerns were raised regarding the transfer of healthcare services to big data and technology companies (3.5 ± 1.3), along with issues related to data security and privacy (3.5 ± 1.2). Similar concerns were identified in the present study among undergraduate and graduate dental students. The highest levels of concern were associated with responsibility and accountability for machine errors (3.4 ± 1.3) and data security and privacy (3.2 ± 1.3). The alignment of these findings with those observed among dental clinicians in Germany indicates a widespread concern about the implications of AI. Furthermore, the results underscore the necessity for careful management of AI's role in healthcare, emphasizing the importance of safeguarding patient privacy and data security.

Numerous studies in dentistry have identified the potential applications of AI [14, 18, 19]. However, the likelihood of these systems completely replacing dental professionals is considered minimal. AI should be viewed as a complementary tool that enhances the capabilities of dentists and other professionals [14]. Interestingly, there was no significant difference in the views of participants from both groups regarding the impact of AI on their professions and the workforce. This suggests a shared consensus among the participants that AI can serve as a complement to their work rather than a substitute.

No significant differences were observed between the two groups regarding the impact of AI on their professions and the workforce, indicating a shared perspective that AI serves as a supplement rather than a replacement.

The study presents limitations, potentially constraining the generalizability of its findings to other countries or educational systems. Focusing on the attitudes of both dental and specialty students may not fully capture the perspectives of more experienced practitioners. Incorporating insights from expert physicians or general dentists is crucial, as such professionals might offer more nuanced or critical viewpoints regarding the impact of AI technology on medical education and practice. Additionally,

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careful attention should be given to the sample size and composition, as the findings may not fully represent the broader population of dental students and professionals. The study recommends further research involving a larger and more diverse sample to gain a comprehensive understanding of attitudes toward AI in dentistry.

Conclusions

This study provides valuable insights into the evolving role of AI in dentistry and the perspectives of future dental professionals in Turkey. The research also highlights participants' attitudes and concerns regarding AI applications within the field. Addressing these concerns and ensuring clarity about the ethical and legal dimensions of AI use in dentistry is essential for fostering a positive and informed perspective among future dental professionals in Turkey.

In conclusion, this study contributes to the growing body of knowledge on the role of AI in dentistry and establishes a foundation for future research and development in this domain. Understanding the viewpoints and expectations of both undergraduate and specialty students is crucial for shaping the future of dentistry and ensuring the effective integration of AI into clinical practice, ultimately leading to enhanced patient care and outcomes.

Abbreviations
AI	Artificial Intelligence
2D	Two-dimensional
3D	Three-dimensional
DUS	Dentistry Specialty Exam
PhD	Doctor of Philosophy
US	Undergraduate Students
SS	Specialty Students

Supplementary Information

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Supplementary Material 1

Declarations

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