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Original Research Article

Knowledge, attitude, and perception of dentists regarding the role of Artificial Intelligence and its applications in Oral Medicine and Radiology: a cross sectional study

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Abstract – Background and objective: There is a paradigm shift in the medical and dental fields due to the introduction of artificial intelligence (AI). Since AI has a potential impact on current and future practitioners, understanding the basic concept, working principle, and likely applications of AI as a diagnostic tool in Oral Medicine and Radiology is necessary for its widespread use. Therefore, this study aims to assess the knowledge, attitude, and perception of dental students and dentists regarding the possible applications of AI in the field of Oral Medicine and Radiology. **Materials and methods:** This was a cross-sectional questionnaire-based study comprising 15 questions circulated through Google Forms® to 460 dental students and professionals. The questionnaire collected demographic data of participants and assessed their knowledge, perception, and attitude about AI in Oral Medicine and Radiology answered using a 5-point Likert scale. Responses obtained were statistically analyzed using descriptive statistics and a chi-square test. **Results:** Out of 460 participants, majority had an idea about AI (94.13%) and its working principle (73.30%). Participants agreed that AI can be used in the diagnosis and formulating of treatment plans (88.47%), early detection of cancer (77.82%), forensic dentistry (74.13%), and as a prognostic (80.65%) and quality control tool (81.30%). A majority felt that AI should be incorporated into the dental curriculum (92.39%) and most of them were against suggesting AI in clinical incorporation (35.87%) with a fear that AI might replace the clinician in the future (76.52%). **Conclusion:** Based on the findings of the study, we strongly recommend that further research and insights into AI should be delivered through lectures, curricular courses, and scientific meetings to explore and increase awareness about this fascinating technology.

Introduction

Development of any system that can replicate human intelligence should include three basic types of intelligence. (1) Perpetual intelligence; (2) cognitive intelligence; and (3) decision-making intelligence [1]. Artificial Intelligence (AI) is one such system that came into existence in 1995 when Alan Turin, cofounder of AI, posed a famous question "Can machines think?" that paved way to Turing test that examined the ability of machine to show intelligence that cannot be differentiated from that of humans [2].

Deep learning (DL) forms an important active field in the research of AI. It is based on representation learning that has multiple layers of neural networks and a subset of machine learning (ML). ML is a part of AI which helps the program or a computer to acquire and learn intelligence without or with least possible human interaction [3]. This is achieved with the help of convolutional neural networks (CNNs) that mimic neuronal network of human brain where learning patterns from a specific dataset and performing autonomic tasks is attainable [4].

Oral medicine is a dental specialty that combines medicine and dentistry by dealing with the diagnosis and treatment of disorders affecting the oral and maxillofacial area. Oral and Maxillofacial Radiography is the area that deals with the production and interpretation of images and data generated by

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all modalities of radiant radiation utilized for disease diagnosis and management [5]. Hence, an early identification and treatment of oral lesions are critical, as misdiagnosis and missed diagnosis can have a negative impact on the patient by imposing excessive expenditures for completing unsuitable or unneeded diagnostic procedures, inappropriate therapy depending on the diagnosis [6], overtreatment [7].

AI effectiveness has been proven through research where it is employed as an image-based automated diagnosis with the help of CNN. AI improves efficiency of Radiology [8] and can also be used to detect carious lesions [9,10], Temporomandibular joint disorders [11], oral cancer with its survival rate and metastasis [12,13], periapical, radiolucent, and cystic lesions [14–16] *etc.*

Establishment of AI in dentistry and other medical fields can significantly improve the clinical practice of future dentists and medical professionals, respectively. Currently, both optimistic and pessimistic views on AI and its potential opportunities exists among dental professionals as well as patients. Recent measures have been taken to incorporate AI into dental and medical training with the help of conceptual framework [17] to teach graduates about the basic principles of AI [18].

AI is considered as a second opinion its to when it comes to its application in dentistry as it influences patient's trust in the radiographic as well as clinical diagnosis and provides a better understanding about the dentist's decision [19]. Patient's acceptance and compliance is of utmost importance for the success of any practitioner and hence clinician's knowledge and awareness regarding AI is mandatory to educate patients about the AI and improve the practice. Hence, specific emphasis is on dental students to incorporate AI and its application during their academic training to make them prepared to be better future.

Hence, this study was carried out similarly to one conducted on Turkish dental students by Yüzbasioglu *et al.* [20] with a modification of inclusion of subjects and a notion of null hypothesis that dental students and practitioners would not be aware of role of AI, its advantages, applications, future implication in the field of Oral Medicine and Radiology. As a result, the purpose of this study is to assess the knowledge, attitude, and perception of dental students and dentists regarding the possible applications of AI in the field of Oral Medicine and Radiology.

Materials and methods

Study design

This was a cross-sectional questionnaire-based study carried out among dental students (undergraduates and postgraduates) and dental professionals (faculties and practitioners) to assess their knowledge, perception, and attitude on the basis of their level of education towards artificial intelligence and its possible applications in the fields of Oral Medicine and Radiology.

Study population

Dental undergraduate students (third and final years), Interns, postgraduate students, faculty and private practitioners.

Inclusion and exclusion criteria

Participants pursuing under graduation or postgraduation, employed as faculty members, or as private practitioners who agreed to participate in this study were included. Undergraduates pursuing first and second year of dental school were not included.

Sample size estimation

The sample size was estimated to be n = 556 (with 10% attrition) based on the previous study [20] and using the formula, where a = 0.05, Z1-a/2 = 1.96.

Data collection instrument

The questionnaire included 4 open-ended questions that allowed the participants to enter their sociodemographic such as name, gender, qualification an institution or workplace, and 15 closed-ended questions about AI and its potential applications in the field of Oral Medicine and Radiology, which were divided into three sections; knowledge (7 questions), attitude (4 questions), and perception (4 questions). Closed-ended questions were structured based on the prior research that evaluated attitudes and perceptions of dental students towards AI [20] and a study conducted in India assessing the knowledge, attitude, and perception of AI in Oral Radiology [21]. Response was aimed to indicate their level of agreement based on a 5-point Likert scale (strongly agree, agree, neither agree nor disagree, disagree and strongly disagree).

Pretest and content validation

The questionnaire was established referring from previous studies and pretested by circulating it to a sample of individuals who were not involved in the final research, and internal consistency was checked using Cronbach's alpha coefficient (α value = 0.85) and then disseminated.

Sampling and data collection procedure

A simple random sampling was used and ethical approval was acquired from the Institutional Research and Ethics Committee (Ref no 1527). This research lasted three months, from April 2022 to June 2022 and was conducted following the Ethical Standards established by the Helsinki Declaration (Finland) [22]. The questionnaire was distributed in the form of Google forms® link format through social platforms like Whatsapp and Email. Participants were allowed to fill out the form only once with no time restriction and responses were

gathered from participants after gaining their consent and willingness to participate in the study and explaining the aim and maintaining anonymity.

Statistical analysis

Data obtained were sorted, coded and entered into Microsoft Excel® spreadsheet file for ease of data management, and subsequently the computed data were exported into Statistical Package for the Social Sciences (SPSS) 21.0 for Windows for statistical analysis (SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test was used to determine if the distribution of quantitative data was normal or skewed. Descriptive statistics, including frequencies and percentages, were utilized to distribute data from participants based on their qualifications and job experience.

Categorical data were examined using the chi-square test to determine the relationship between research variables and knowledge, attitude, and perception questions. Likert scale was modified into scores for analysis adapted from a study [23] (strongly disagree =1; disagree = 2; neither agree nor disagree = 3; agree = 4; strongly agree = 5). The results were reported in the form of mean ± standard deviation for quantitative data, which included participant ratings on knowledge, perception, and attitude questions. Mann–Whitney *U* test and Kruskal Wallis H test was used for group comparison of mean scores of domains with respect to gender, qualification and years of experience.

To ensure uniformity in scores and to assess the knowledge, attitude and perception of the participant's categorization based on percentile score was carried out similar to a study [24] (% individual score = score obtained by an individual ÷ total obtainable score × 100). Knowledge of the participants were divided into 4 groups [24]. Excellent when scores are ≥75%; Good or acceptable when scores are between 50% and 75%; very poor when scores are between 25% and 49%; very poor when scores are <25% were considered. Attitude was categorized positive when scores are >50% and negative when <50% [24]. Similarly, perception was termed as good when scores are > 50% and bad when < 50% [24]. Spearman's rank correlation coefficient test was also used to assess the relationship between the domain scores and the associated variables. For all tests, the statistical significance was set at $p \leq 0.05$, with $p \leq 0.001$ deemed highly significant.

Results

Demographic details

The questionnaire was circulated to 556 individuals with 460 participants completing the questionnaire yielding a response rate of 82.73%. Almost two-thirds of the participants were females ($n = 336$; 73%). The majority of participants ($n = 95$, 20.7%) were postgraduate students, followed by 92 (20.2%) final-year undergraduate students and 89 (19.3%) third-year students and interns. 13.5% ($n = 62$) of the participants were private practitioners followed by least number of faculty members ($n = 32$, 7%). Table I describes demographic information as well as qualifications and years of dental experience of the participants.

Table I. Demographic variables and distribution of included participants in terms of number and frequency.

Demographic variable	Category	*N* (%)
Gender	Male	124 (27)
	Female	336 (73)
Qualification	3rd Year BDS	89 (19.3)
	4th Year BDS	93 (20.2)
	Interns	89 (19.3)
	Post graduate	95 (20.7)
	Faculty	32 (7.0)
	Practitioners	62 (13.5)
	Not applicable	212 (46.1)
Years of experience	0–4 years	188 (40.9)
	5–8 years	27 (5.9)
	More than 8 years	33 (7.2)

Domains

Frequency distribution of various questions for domains among the study population is given in Table II. Comparison of mean domain scores with respect to gender, qualification and years of experience is provided in Table III. Correlations of the domains (knowledge, attitude and practice) with respect to variables (gender, qualification and years of experience) are shown in Table IV.

Response assessing the knowledge about AI and its possible applications

433 participants (94.13%) were familiar with the term artificial intelligence (AI), while only 339 (73.70%) were aware of its basic working concept with no statistically significant differences noted ($p > 0.05$). When the participants' knowledge was assessed on topics such as whether AI can aid in the formulation of diagnosis and treatment plans, as well as the evaluation of missed details by practitioners, statistically significant differences ($p < 0.05$) were seen, with 88.69% ($n = 408$) and 84.34% ($n = 388$) people agreeing that it can be utilized for these reasons, respectively. Furthermore, more than three-fourths of participants agreed that AI can be used in identifying mucosal lesions and detecting oral cancer ($n = 358$, 77.82%), predicting the course of the disease, and determining the chance of recovery ($n = 371$, 80.65%), and assessing treatment success ($n = 374$, 81.30%) with no statistically significant differences ($p > 0.05$). Table II shows the response of participants regarding the questions assessing the knowledge of AI and its possible applications.

Table II. Response frequencies of participants with their qualifications for the questionnaire. Five points Likert scale was used and responses for each question was tabulated according to the qualification of the participants as undergraduates (third years, final years and interns), postgraduates and faculties and practitioners Statistical test applied – Chi-square test.

Questions	Response	Response frequencies of participants with their qualification *n* (%)				Statistics
		Undergraduates	Post graduates	Faculties and Practitioners	Total	*p*-value
Knowledge based questions						
You are aware of term Artificial Intelligence (AI).	Strongly agree	75 (27.7)	27 (28.4)	29 (30.9)	131	0.989
	Agree	179 (66.1)	62 (65.3)	61 (64.9)	302	
	Neither agree nor disagree	6 (2.2)	2 (2.1)	1 (1.1)	9	
	Disagree	11 (4.1)	4 (4.2)	3 (3.2)	18	
	Strongly disagree	–				
You are aware of the working principle of AI.	Strongly agree	38 (14)	20 (21.1)	15 (16.0)	73	0.648
	Agree	160 (59)	54 (56.8)	52 (55.3)	266	
	Neither agree nor disagree	52 (19.2)	14 (14.7)	22 (23.4)	88	
	Disagree	19 (7)	7 (7.4)	5 (5.3)	31	
	Strongly disagree	2 (0.7)	–	–	2	
AI can assist in patient diagnosis and formulating an integrated treatment plan.	Strongly agree	50 (18.5)	23 (24.2)	26 (27.7)	99	0.005*
	Agree	197 (72.7)	63 (66.3)	38 (51.1)	309	
	Neither agree nor disagree	21 (7.7)	7 (7.4)	16 (17)	44	
	Disagree	3 (1.1)	2 (2.1)	4 (4.3)	9	
	Strongly disagree	–				
AI can be used to evaluate details in radiographs which are missed by practitioners at times.	Strongly agree	62 (22.9)	20 (21.1)	16 (17)	98	0.015*
	Agree	177 (65.3)	63 (66.3)	50 (53.2)	290	
	Neither agree nor disagree	26 (9.6)	11 (11.6)	24 (25.5)	61	
	Disagree	5 (1.8)	1 (1.1)	3 (3.2)	9	
	Strongly disagree	1 (1.1)	–	1 (1.1)	2	
AI can be used in identification of oral mucosal lesions and detection of oral cancer.	Strongly agree	53 (19.6)	20 (21.1)	20 (21.3)	93	0.310
	Agree	168 (62)	52 (54.7)	35 (47.9)	265	
	Neither agree nor disagree	46 (17)	21 (22.1)	26 (27.7)	93	
	Disagree	2 (0.7)	2 (2.1)	2 (2.1)	6	
	Strongly disagree	2 (0.7)	–	1 (1.1)	3	
AI can be used as prognostic tool to predict the course of disease and determine the chance of recovery.	Strongly agree	46 (17)	18 (18.9)	19 (20.2)	83	0.300
	Agree	175 (64.6)	63 (66.3)	50 (53.2)	288	
	Neither agree nor disagree	42 (15.5)	12 (12.6)	19 (20.2)	73	
	Disagree	8 (3)	2 (2.1)	5 (5.3)	15	
	Strongly disagree	–	–	1 (1.1)	1	
AI can be used to assess the success of any treatment as treatment quality control.	Strongly agree	52 (19.2)	19 (20)	23 (24.5)	94	0.252
	Agree	178 (65.7)	54 (56.8)	48 (51.1)	280	
	Neither agree nor disagree	37 (13.7)	19 (20)	20 (21.3)	76	
	Disagree	4 (1.5)	2 (2.1)	2 (2.1)	8	

Table II. (continued).

Questions	Response	Response frequencies of participants with their qualification *n* (%)				Statistics
		Undergraduates	Post graduates	Faculties and Practitioners	Total	*p*-value
	Strongly disagree	–	1 (1.1)	1 (1.1)	2	
Attitude based questions						
AI can switch the current health care system into a secure digital environment with latest technologies.	Strongly agree	38 (14)	14 (14.7)	17 (18.1)	60	0.858
	Agree	164 (60.5)	57 (60)	51 (54.3)	272	
	Neither agree nor disagree	61 (22.5)	19 (20.0)	20 (21.3)	100	
	Disagree	6 (2.2)	4 (4.2)	5 (5.3)	15	
	Strongly disagree	2 (0.7)	1 (1.1)	1 (1.1)	4	
AI should be an integral part of undergraduate or postgraduate dental training.	Strongly agree	48 (17.7)	18 (18.9)	19 (20.2)	85	0.065
	Agree	184 (67.9)	71 (74.7)	53 (56.4)	308	
	Neither agree nor disagree	35 (12.9)	5 (5.3)	21 (22.3)	61	
	Disagree	2 (0.7)	–	–	2	
	Strongly disagree	2 (0.7)	1 (1.1)	1 (1.1)	4	
AI can be incorporated into private practice after acquiring proper knowledge and training.	Strongly agree	49 (18.1)	20 (21.1)	19 (20.2)	88	0.728
	Agree	182 (67.2)	64 (67.4)	58 (61.7)	304	
	Neither agree nor disagree	32 (11.8)	11 (11.6)	15 (16)	58	
	Disagree	6 (2.2)	–	2 (2.1)	8	
	Strongly disagree	2 (0.7)	–	–	2	
I believe that I will recommend fellow clinical practitioners to implement AI in their clinical practice.	Strongly agree	42 (15.5)	15 (15.8)	12 (12.8)	69	0.264
	Agree	174 (64.2)	56 (58.9)	53 (56.4)	283	
	Neither agree nor disagree	46 (17.3)	21 (22.1)	28 (29.8)	96	
	Disagree	6 (2.2)	3 (3.2)	–	9	
	Strongly disagree	2 (0.7)	–	1 (1.1)	3	
Perception based questions						
AI can be implicated in forensic dentistry for pattern analysis and identification of unknown individual.	Strongly agree	66 (24.4)	25 (26.3)	47 (50)	138	0.001**
	Agree	175 (64.6)	62 (65.3)	41 (43.6)	278	
	Neither agree nor disagree	29 (10.7)	8 (8.4)	6 (6.4)	43	
	Disagree	1 (0.4)	–	–	1	
	Strongly disagree	–				
AI facilitates storage of patient information and data with quick and accurate accessibility.	Strongly agree	85 (31.4)	38 (40)	30 (31.9)	153	0.724
	Agree	166 (61.3)	52 (53.7)	55 (58.5)	272	
	Neither agree nor disagree	18 (6.6)	6 (6.3)	8 (8.5)	32	
	Disagree	2 (0.7)	–	1 (1.1)	3	
	Strongly disagree	–				

Table II. (continued).

Questions	Response	Response frequencies of participants with their qualification n (%)				Statistics
		Undergraduates	Post graduates	Faculties and Practitioners	Total	*p*-value
AI has a better diagnostic ability than a clinically experienced practitioner.	Strongly agree	30 (11.1)	9 (9.5)	9 (9.6)	48	0.071
	Agree	111 (41)	25 (26.3)	29 (30.9)	165	
	Neither agree nor disagree	89 (32.8)	36 (37.6)	35 (37.2)	160	
	Disagree	35 (12.9)	22 (23.2)	15 (16)	72	
	Strongly disagree	6 (2.2)	3 (3.2)	6 (6.4)	15	
You think that AI can replace the radiologists or clinician in the near future.	Strongly agree	21 (7.7)	7 (7.4)	8 (8.5)	36	0.516
	Agree	85 (31.4)	19 (20)	25 (26.6)	129	
	Neither agree nor disagree	82 (30.3)	36 (37.9)	36 (38.3)	154	
	Disagree	69 (25.5)	29 (30.5)	20 (21.3)	118	
	Strongly disagree	14 (5.2)	4 (4.2)	5 (5.3)	23	

* denotes statistically significant differences ($p \leq 0.05$).
** denotes highly statistically significant values ($p < 0.001$).

Response assessing the attitude about AI and its implementation

Four questions assessing the participants attitudes revealed no statistically significant differences ($p > 0.05$). When asked if AI might transform the present healthcare system into a digital and safe workplace utilizing rapidly emerging technology, almost three-fourth of the participants answered affirmatively ($n = 332$, 72.17% agreement). Furthermore, many participants ($n = 393$, 85.43% agreement) stated that AI should be integrated into the undergraduate and postgraduate curriculums of dental schools to stay up with current breakthroughs and said that AI can be incorporated into their private practice after gaining enough knowledge and training ($n = 394$, 85.65%). Similarly, 352 (76.52%) participants believed that they will recommend their coworkers and fellow practitioners to incorporate AI into their clinical practice. Table II shows the response of participants regarding the questions assessing the attitude about AI and its implementation.

Responses assessing the perception towards AI and its probable utilization

In terms of the usage of artificial intelligence (AI) in forensic dentistry, majority of ($n = 416$, 90.43%) respondents were aware that it offers applications such as bite mark pattern analysis and personal identification with statistically significant difference ($p < 0.05$). In terms of patient information and data storage and accessibility, 92.39% of participants ($n = 425$) believed that AI is useful in this respect, with no statistically significant difference ($p > 0.05$). Less than half of the participants ($n = 213$, 46.30%) believe that AI has better diagnostic ability than a clinically experienced doctor and also agreed that AI would eventually replace doctors or radiologists ($n = 155$, 35.87%). Table II shows the response of participants regarding the questions assessing the perception of AI and its probable utilization.

Mean scores of knowledge, attitude, and perception of the participants

Mean domain scores with respect to gender, qualification and years of experience was carried out as shown in Table III. The maximum knowledge score was 35 when scored 5 for each question ($n = 7$, $7 * 5 = 35$); Maximum attitude and perception scores were 20 when scored 5 for 4 question each in respective domains ($5 * 4 = 20$). Statistically significant differences were noted when knowledge scores were compared with genders ($p < 0.05$) with mean score of 28.52 ± 3.30 and 27.85 ± 3.12 for males and females, respectively. Similarly, statistically significant differences were noted when attitude scores were compared with qualification ($p < 0.05$) with mean scores of 15.82 ± 2.14 for undergraduates, 15.68 ± 1.97 for postgraduates and 15.66 ± 1.46 for faculty and practitioners. Table III reveals mean scores of knowledge, attitude and perception of the participants with respect to gender, qualification and years of experience.

Table III. Mean domain scores with respect to gender, qualification and years of experience for knowledge, attitude and perception.

		Knowledge score			Perception scores			Attitude scores		
		n	Mean ± SD	*p*- value	*n*	Mean ± SD	*p*- value	*n*	Mean ± SD	*p*- value
Gender[a]	Male	124	28.52 ± 3.30	0.033*	124	15.11 ± 2.24	0.182	124	15.77 ± 2.12	0.749
	Female	336	27.85 ± 3.12		336	14.79 ± 2.02		336	15.75 ± 1.93	
Qualification[b]	Undergraduates	271	28.06 ± 3.35	0.932	271	14.80 ± 2.17	0.932	271	15.82 ± 2.14	0.015*
	Postgraduates	95	28.14 ± 3.39		95	14.68 ± 2.09		95	15.68 ± 1.97	
	Faculty & practitioners	94	27.84 ± 2.38		94	15.30 ± 1.76		94	15.66 ± 1.46	
Years of experience[b]	Not applicable	212	28.17 ± 3.47	0.594	212	14.79 ± 2.14	0.219	212	15.84 ± 2.05	0.547
	0–4 years	188	28.02 ± 2.93		188	15.05 ± 2.00		188	15.66 ± 2.01	
	4–8 years	27	28.04 ± 3.16		27	15.00 ± 2.48		27	16.15 ± 1.73	
	>8 years	33	27.21 ± 2.48		33	14.39 ± 1.77		33	15.45 ± 1.60	

[a] represents statistical test used – Mann–Whitney U test.
[b] represents statistical test used – Kruskal Wallis test.
* denotes statistically significant differences ($p \leq 0.05$).

Correlation among knowledge, attitude, and perception of participants toward AI with associated variables

Spearman correlation coefficient test revealed that perception of the knowledge of the participants correlated positively with respect to attitude ($r = 0.510$) and perception ($r = 0.476$) with statistically significant differences ($p < 0.05$). Similarly, statistically significant differences were noted ($p < 0.05$) when attitude of the participants were correlated with perception (positive correlation $r = 0.453$). Gender of the participants had a negative correlation with respect to years of experience ($r = -0.131$) and positive correlation with respect to knowledge of the participants ($r = 0.094$) with both having statistically significant differences ($p < 0.05$). Also, qualification of the participants correlated positively with years of experience ($r = 0.677$) with statistically significant differences ($p < 0.05$). Table IV reveals correlations of the domains (knowledge, attitude and practice) with respect to variables (gender, qualification and years of experience).

Overall knowledge, attitude and perception of the participants

Knowledge of the participants was categorized into very poor, poor, good and excellent based on the percentile obtained from knowledge scores. Except for a few undergraduates (1.1%), nearly two-third of the participants had excellent knowledge about AI. Almost one-third of the participants had good knowledge and majority of the participants had excellent knowledge about AI and its possible applications as shown in Figure 1.

Attitude of the participants were categorized into positive and negative attitude. Only few participants (1.1%) had negative attitude towards AI among undergraduate and postgraduate students. All the dental faculties and practitioner along with majority of undergraduates and postgraduates had a positive attitude towards AI and its implementation as depicted in Figure 2.

Similarly, perception was classified as good or bad perception. Only 0.7% of the undergraduates had bad perception which is almost negligible. All the postgraduates and the faculties and private practitioners had a good perception about AI and its probable utilization as shown in Figure 3.

Discussion

AI has a wide range of medical applications and has lately become increasingly widespread, and it is essential to diligently explore its application in Dentistry. Smartphones and internet connectivity have enabled the integration of AI into the domains of Medicine and Dentistry on a level with recent advances in engineering and technology. However, many scientists and medical professionals are unacquainted with AI and how it may impact their personal and professional life. To the best of our knowledge, this survey is unique because most research on the application of AI emphasizes either radiology or dentistry.

In contrast to similar studies, one on Turkish dental school students by Yüzbasolu *et al.* [20], which had a response rate of 21.69%, and a mobile-based online survey by Oh *et al.* [25] of Korean physicians and doctors' confidence in AI, which had a response rate of 22.3%, our study's response rate (82.73%) was higher. In terms of gender, there were 73% female participants ($n = 336$) and 27% male participants ($n = 124$). This was per two studies that had a female predilection, one conducted in Turkey [20], where 59% ($n = 650$) of the participants were females and the rest were males (41%, $n = 453$), and a multicentre survey on German medical students attitude towards AI [26] that comprised of 63.8% of females ($n = 166$) and 36.2% males ($n = 94$).

Table IV. Correlation coefficient between knowledge, attitude, and perception variables with gender, qualification of the participants and their years of experience. Statitical test used: Pearson's Correlation Coefficient test.

	Gender	Qualification	Years of experience	Knowledge	Attitude	Perception
Gender	1					
Qualification	−0.029	1				
Years of experience	−0.131*	0.677*	1			
Knowledge	0.094*	0.022	0.066	1		
Attitude	0.005	0.035	0.034	0.510*	1	
Perception	0.069	−0.079	0.012	0.476*	0.453*	1

* denotes statistically significant values ($p \leq 0.05$)

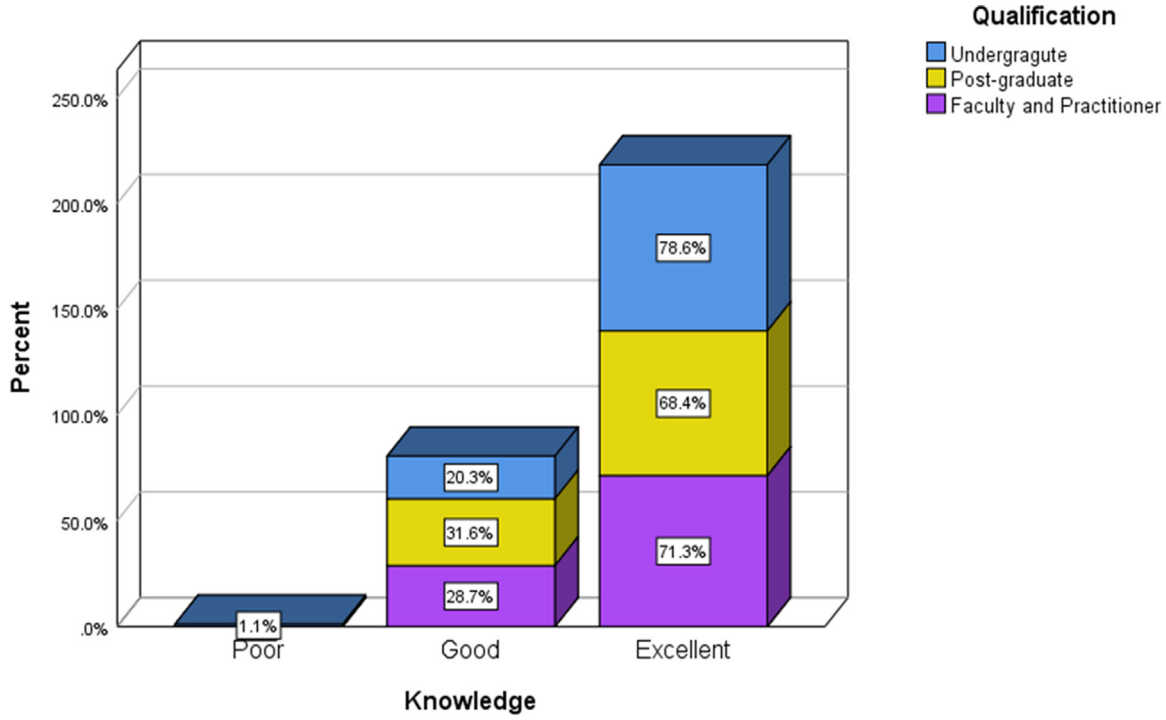

Fig. 1. Knowledge about AI and its potential application in Oral Medicine and Radiology represented as poor, good and excellent according to the qualification of the participants described in terms of percentage. Blue colored bar represents undergraduates (third year, final year and interns), Yellow colored bar represents postgraduates and Violet colored bar represents faculty and practitioners.

The concept of AI and its working principle is primarily essential to explore the potential applications of AI. Our study participants had a higher level of basic knowledge about AI (93.8%) and its working principle (73%). This was more when compared to similar studies that assessed about the concept, familiarity and working principle of AI among students from various countries like Turkey [20,27], India [21,28–31], Korea [25], Syria [32], and Saudi Arabia [33] results were 78.9%, 60%, 68%, 59%, 64.1%, 89.63%, 80.4%, 46.2%, 70%, and 49.9% respectively.

Regarding application of AI in dentistry, first and foremost thing is its part in diagnosis and treatment planning. 88.48% of the participants felt that it would be beneficial. Our findings were comparable to studies in which 71.5% [29], 82.8% [32], 91.4% [27], 83.4% [25], 52.5% [33], 57% [28] and 30% [20] participants agreed that AI can enhance clinical decision, respectively. Similarly, 70.8% [34], 63% [31], 75.4% [20], 67.6% [33], 53.8% [25], 69% [21] and 50.9% [35] of the participants from various studies concurred that AI helps in formulating a treatment plan, respectively.

Also 81.6% of the participants of our study answered that AI can be used in the detection of soft tissue lesions and oral cancer. This was in accordance with the studies that reported 51.6% [36], 55.5% [33], 57.4% [30], 65.7% [34], and 69.2% [20] of the people agreeing to the abovesaid notion. Misdiagnosis and missed diagnoses are challenges in the practice of Medicine and Dentistry since they jeopardize the quality of care offered to patients or the appropriateness of the treatment plan. Because radiographs are now commonly utilized in investigations, subtle changes may probably go unnoticed. Given this, when asked about the use of AI in assessing subtleties that sometimes elude the clinician's eye,

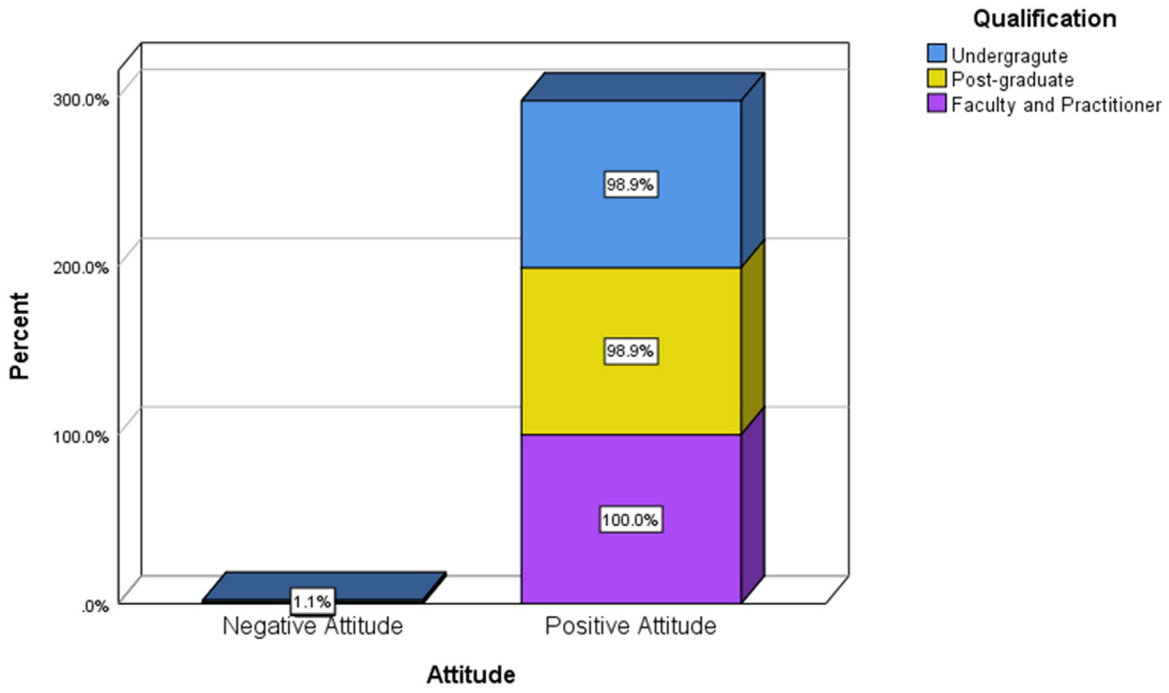

Fig. 2. Attitude about AI and its implementation in Oral Medicine and Radiology represented as positive and negative according to the qualification of the participants described in terms of percentage. Blue colored bar represents undergraduates (third year, final year and interns), Yellow colored bar represents postgraduates and Violet colored bar represents faculty and practitioners.

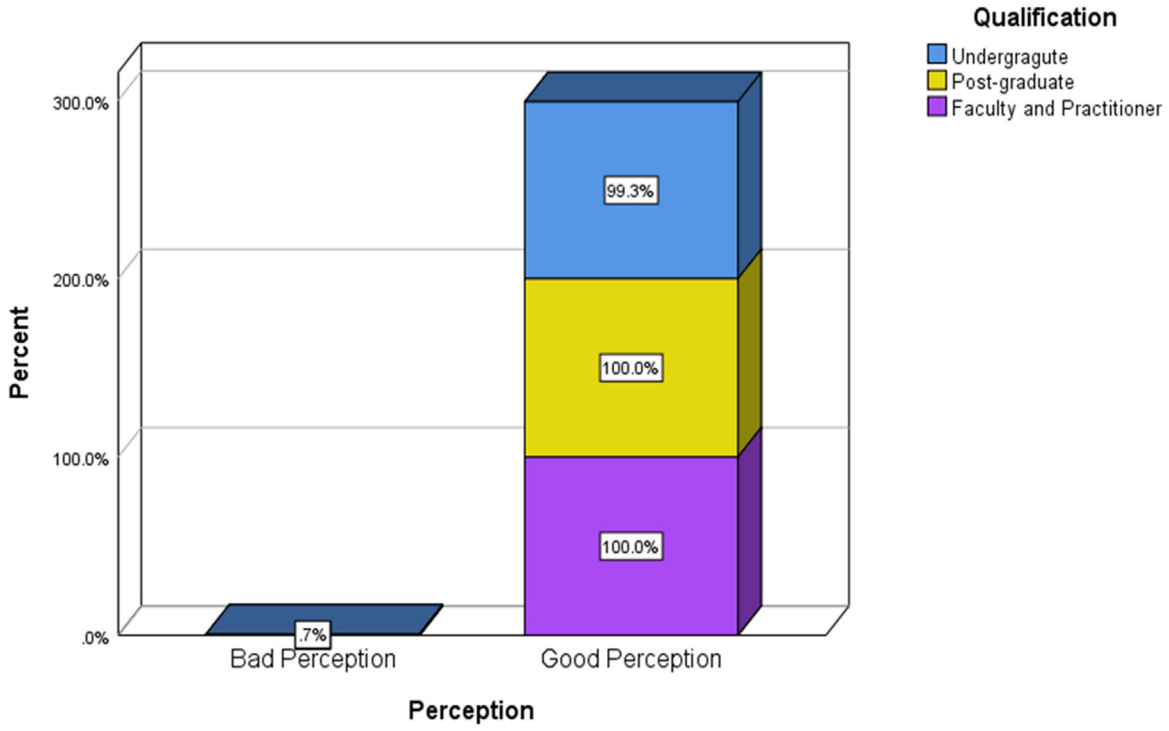

Fig. 3. Perception about AI and its probable utilization in Oral Medecine and Radiology represented as good or bad according to the qualification of the participants described in terms of percentage. Blue colored bar represents undergraduates (third year, final year and interns), Yellow colored bar represents postgraduates and Violet colored bar represents faculty and practitioners.

88.2% of our survey participants said AI comes to the rescue and enhances radiologic diagnosis, compared to studies where 68%, 59.4% and 89.4% of reported by Sur *et al.* [24], Yüzbasolu *et al.* [21] and Awawdeh *et al.* [34] respectively agreed to the same. Apart from those changes, AI can also help radiographic diagnosis of dental pathological conditions such as caries, periodontal diseases and pathologies of jaw [20,34].

Understanding what will happen in the future is vital for patients, researchers, and clinicians. A prognostic tool is something that can foretell your future outcomes. 81.6% of the participants agreed that AI can be used to predict the course of the disease and determine the chance of recovery. This was similar to other studies where 66.7% [33], 67.3% [20], 82.5% [34], and 97.6% [37] of the participants fall in with favoring the use of AI for determining the prognosis.

Success of any treatment is essential for assessing the quality of the treatment provided. 84.9% of the participants agreed that AI can be used as quality assessment tool which was similar to previous studies that reported 60.6% [34], 70.9% [33], 75.6% [20], and 96.45% [37] respectively.

Forensic Dentistry is a field of Dentistry, a subset of Forensic Science that helps in identification of individuals as well as guides in civil and legal proceedings when need arises. AI can be implicated in Forensic Dentistry for pattern analysis and identification of unknown individual which was agreed by 89% of the participants. This was in concordance to studies by Awawdeh *et al.* [34], Khanagar *et al.* [33] and Yüzbasolu *et al.* [20] 41.6%, 58.4% and 67.6% people felt that AI can be beneficial in field of Forensic Dentistry, respectively.

When asked about AI's diagnostic ability compared to an experienced clinician, 46.3% responded that AI has an edge in diagnosis over the latter. Sur *et al.* [21] and Oh *et al.* [25] reported similar findings in which 43.9 % of subjects stated that AI was less precise than the clinician.

Replacing a doctor is more challenging than replacing other vocations, particularly now that robots and computers can do human tasks. This is because, as stated by Krittanawong *et al.* [37], AI is unlikely of replacing clinicians at the bedside. When asked whether AI could replace the clinician or radiologist, 33.7% of our study participants agreed which was identical to studies reporting 2.5% by Pauwel *et al.* [35], 8% by Awawdeh *et al.* [34], 21.5% by Swed *et al.* [32], 28.6% by Yüzbasolu *et al.* [20], 35.2% by Abouzeid *et al.* [36] and 35.4% by Oh *et al.* [25].

Furthermore, AI cannot emulate how a doctor-patient relationship is maintained by an intriguing conversation, expressing empathy, uplifting them, or acquiring their trust [38]. Second, while AI may aid in diagnosis and treatment [38], merging medical history with physical examination in ambiguous scenarios is not conceivable with AI. 76.52% of participants stated they would strongly advocate for the use of AI in clinical practice, whilst minor people claimed they would not. 20.5% of the participants in our study were faculty and private practitioners and owing to their experience in the field of Dentistry, who have a basic knowledge about various pitfalls and practical difficulties in making use of AI in their practice. According to the results of our study, dental students are particularly interested in learning about emerging technologies that might significantly revolutionize Dentistry for their practice (85.43%). More than three fourth of the participants in our study felt the need of incorporating AI as an integral part of undergraduate and postgraduate curriculum. Several participants emphasized the need of embedding basic working principles and the potential future use of AI in their curriculum, as described in other existing pieces of literature. This must be due to the previously stated assumption, as well as practical difficulties in using AI in routine work contexts rather than teaching, which is realistically achievable.

Limitations

Our study has certain shortcomings that should be addressed in future research. To begin with, the questions meant to assess AI awareness did not analyze how effectively a participant defined the notion of AI, as everyone interprets AI differently. The sample size was not representative of all dentists and the gender distribution was disproportionate concerning the issue addressed. Closed-ended questions employing Likert scales may have impeded recommendations or ideas for questions demanding many points of view, resulting in misunderstanding.

Finally, rather than AI specialists, questions were designed based on previously published research conducted by clinicians. A larger sample size with participants from diverse educational institutions should be used, along with precise and reliable sample categorization based on gender and qualification. Modifying the questionnaire to incorporate questions from an AI expert's perspective, including the use of open-ended questions, may assist participants to express their positive ideologies on this swiftly advancing technology.

Conclusion

According to the findings of this study, dental students and practitioners are familiar with AI and its potential applications in Oral Medicine and Radiology. The findings led us to highlight key flaws that must be addressed, necessitating the inclusion, development, and augmentation of AI training in dental schools to eliminate erroneous and inaccurate views and motivate professionals to work in this area.

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Conflicts of interest

The authors declare that there are no conflicts of interests.

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Ethical Approval

Ethical approval was acquired from the Institutional Research and Ethics Committee (Ref no 1527).

Informed consent

Informed consent was obtained from all the participants prior to enrollment in this study.

Author's contribution

Sridhar M: Conceptualization; Data Curation; Investigation; Methodology; Validation; Writing - Original DraftAnjana Bagewadi: Investigation; Methodology; Supervision; Writing - review and editing. Lokesh Kumar S: Methodolgy; Supervision; Writing - review and editing. Anabelle Fernandes: Supervision; Visualization; Writing - review and editing.Jayapriya T: Investigation; Methodology; Supervision; Writing - review and editing. Arun Panwar - Supervision; Visualization. Vaishali Keluskar - Supervision; Visualization; Validation

References

1. Xu Y, Liu X, Cao X, Huang C, Liu E, Qian S, Liu X, Wu Y, Dong F, Qiu CW, Qiu J. Artificial intelligence: A powerful paradigm for scientific research. The Innovation 2021;2:100179.
2. Turing A. 1995. Computing Machinery and Intelligence (American Association for Artificial Intelligence).
3. Lecun Y, Bengio Y, Hinton G. Deep learning. Nature 2015;521:436–444.
4. Eschert T, Schwendicke F, Krois J, Bohner L, Vinayahalingam S, Hanisch M. A survey on the use of artificial intelligence by clinicians in dentistry and oral and maxillofacial surgery. Medicina 2022;58:1059.
5. Spielman A. The future of oral medicine. Oral Dis 2018;24:285–288.
6. Ehtesham H, Safdari R, Mansourian A, *et al.* Developing a new intelligent system for the diagnosis of oral medicine with case-based reasoning approach. Oral Dis 2019;25:1555–1563.
7. Schwendicke F, Samek W, Krois J. Artificial intelligence in dentistry: chances and challenges. J Dent Res 2020;99:769–774.
8. Van Leeuwen KG, de Rooij M, Schalekamp S, van Ginneken B, Rutten MJCM. How does artificial intelligence in radiology improve efficiency and health outcomes? Pediatr Radiol 2021 1–7.
9. Lee J-H, Kim D-H, Jeong S-N, *et al.* Detection and diagnosis of dental caries using a deep learning-based convolutional neural network algorithm. J Dent 2018;77:106–111.
10. Cantu AG, Gehrung S, Krois J, Chaurasia A, Rossi JG, Gaudin R, Elhennawy K, Schwendicke F. Detecting caries lesions of different radiographic extension on bitewings using deep learning. J Dent 2020;100:103425.
11. Bas B, Ozgonenel O, Ozden B, Bekcioglu B, Bulut E, Kurt M. Use of artificial neural network in differentiation of subgroups of temporomandibular internal derangements: a preliminary study. J Oral Maxillofac Surg. 2012;70:51–59.
12. Lu C, Lewis JS, Dupont WD, Plummber WD, Janowczyk A, Madabhushi A. An oral cavity squamous cell carcinoma quantitative histomorphometric-based image classifier of nuclear morphology can risk stratify patients for disease-specific survival. Mod Pathol 2017;30:1655–1665.
13. Ariji Y, Fukuda M, Kise Y, *et al.* Contrast-enhanced computed tomography image assessment of cervical lymph node metastasis in patients with oral cancer by using a deep learning system of artificial intelligence. Oral Surg Oral Med Oral Pathol Oral Radiol 2019;127:458–463.
14. Ekert T, Krois J, Meinhold L, *et al.* Deep learning for the radiographic detection of apical lesions. J Endod 2019;45:917–922.e5.
15. Ariji Y, Yanashita Y, Kutsuna S, *et al.* Automatic detection and classification of radiolucent lesions in the mandible on panoramic radiographs using a deep learning object detection technique. Oral Surg Oral Med Oral Pathol Oral Radiol 2019;128:424–430.
16. Lee J, Kim D, Jeong S. Diagnosis of cystic lesions using panoramic and cone beam computed tomographic images based on deep learning neural network. Oral Dis. 2020;26:152–158.
17. Johnston SC. Anticipating and training the physician of the future: the importance of caring in an age of artificial intelligence. Acad Med 2018;93:1105–1106.
18. Bordage G. Conceptual frameworks to illuminate and magnify. Med Educ 2009;43:312–319.
19. Uzuner O, Mailoa J, Ryan R, Sibanda T. Semantic relations for problem-oriented medical records. Artif Intell Med 2010;50:63–73.
20. Yüzbasıoglu E. Attitudes and perceptions of dental students towards artificial intelligence. J Dental Educ 2021;85:60–68.
21. Sur J, Bose S, Khan F, et al. Knowledge, attitudes, and perceptions regarding the future of artificial intelligence in oral radiology in India: a survey. Imag Sci Dent 2020;50:193–198.
22. World Medical Association Declaration of Helsinki. JAMA. 2013;310:2191–2194.
23. Adisa R, Anifowose AT. Pharmacists' knowledge, attitude and involvement in palliative care in selected tertiary hospitals in southwestern Nigeria. BMC Palliative Care. 2019;18:1–3.
24. Al Rashed WA, Shihah AS, Alhomoud AS, et al. Knowledge, attitude, and practice toward glaucoma and its management among adult Saudi patients. Saudi J Ophthalmol. 2020;34:261.
25. Oh S, Kim JH, Choi S-W, *et al.* Physician confidence in artificial intelligence: an online mobile survey. J Med Internet Res 2019;21:e12422.
26. Pinto Dos Santos D, Giese D, Brodehl S, *et al.* Medical students' attitude towards artificial intelligence: a multicentre survey. Eur Radiol 2019;29:1640–1646.
27. Keser G, Pekiner FM. Attitudes, perceptions and knowledge regarding the future of artificial intelligence in oral radiology among a group of dental students in Turkey: A survey. Clin Exp Health Sci 2021;11:637–641.
28. Ranjana V, Gayathri R, Priya VV, *et al.* Awareness on application of artificial intelligence in medicine among dental students-A survey. Ann Rom Soc Cell Biol 2021; 1137–1153.
29. Fernandes S, Bafna Y. Knowledge Attitude and Practice of Dental Students Towards Artificial Intelligence (AI): A Questionnaire based Survey. https://doi.org/10.37896/jxu16.8/029.
30. Asmatahasin M, Pratap KV, Padma TM, Kalyan VS, Kumar VS. Attitude and perception of dental students towards artificial intelligence. Indian J Basic Appl Med Res 2021;10:305–314.

31. Priyadarshini S, Sharma S, Arish M, Warikoo A, Kalsi R. Determining the factors associated with knowledge and practice regarding artificial intelligence in dentistry among the dental professionals of North India. Asian J Converg Technol 2022;8:41–46.
32. Swed S, Alibrahim H, Elkalagi NK, Nasif MN, Rais MA, Nashwan AJ, et al. Knowledge, attitude, and practice of artificial intelligence among doctors and medical students in Syria: a cross-sectional online survey. Front Artif Intell 2022;5.
33. Khanagar S, Alkathiri M, Alhamlan R et al. Knowledge, attitudes, and perceptions of dental students towards artificial intelligence in Riyadh, Saudi Arabia. Med Sci 2021;25:1857–1867.
34. Pauwels R, Del Rey YC. Attitude of Brazilian dentists and dental students regarding the future role of artificial intelligence in oral radiology: a multicenter survey. Dentomaxillofac Radiol 2021;50:20200461.
35. Abouzeid HL, Chaturvedi S, Abdelaziz KM, *et al.* Role of robotics and artificial intelligence in oral health and preventive dentistry-knowledge, perception and attitude of dentists. Oral Health Prev Dent 2021;19:353–363.
36. Awawdeh M, Dervis H. Artificial Intelligence (Ai) Application in Dentistry: The Knowledge, Concerns and Challenges Of Syrian Dental Care Professionals. https://doi.org/10.2139/ssrn.4017021.
37. Krittanawong C. The rise of artificial intelligence and the uncertain future for physicians. Eur J Intern Med 2018;48: e13–e14.
38. Inkster B, Sarda S, Subramanian V. An empathy-driven, conversational artificial intelligence agent (Wysa) for digital mental well-being: real-world data evaluation mixed-methods study. JMIR Mhealth Uhealth. 2018;6:e12106.