Dental Students and the AI Revolution: Exploring Awareness and Perception

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ABSTRACT

Background: Artificial intelligence (AI) implies a machine's overall capacity to carry out tasks that require human intelligence. AI's active role in medical and dental practices has resulted in the advancement of patient care systems with enhancement in the healthcare industry. This research aimed to assess dental students' awareness and perception of the use of AI and its potential application in the prospects of dentistry.

Methods: This cross-sectional, survey-based research was carried out using an electronic questionnaire at Altamash Institute of Dental Medicine Karachi, from July to August 2022. With convenience sampling, a total of 160 students were selected, questionnaire was divided into three sections demographic details, general awareness, and perception of students for AI. They were directed to rate their responses for each statement on a 5-point Likert scale. Using SPSS version 26, the data was evaluated for descriptive and inferential statistics.

Results: The majority of the students 128 (80%), were aware of AI, with about 105 (65.6%) of them recognizing its use in dentistry. The mean of responses for awareness (1.86) and perception (2.01) sections falls in the range of "agree" (1.81-2.60) to the statements. There was no significant difference present regarding gender and all four years of BDS education for the concept and utilization of AI.

Conclusion: Dental students are well aware of the advantages and utilization of AI tools in dentistry, with a strong perception that some aspect of AI should be added to the undergraduate dental curriculum and clinical training.

Keywords: Dental General Practice, Dental Education, Artificial Intelligence.

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INTRODUCTION

One of the earliest definitions of Artificial Intelligence (AI), among many others, was put forth in the Dartmouth Research Project in 1955 and is still relevant today. It reads, in part, "making a machine behave in ways that would be called intelligent if humans were so behaving." In more detail, it describes a system's ability to effectively take in outside information, learn from it, and apply what it has learned to carry out predetermined tasks and engage in adaptive behavior[1].

One of the pioneers of AI, Marvin Minky, defined it as "the capacity of machines to carry out activities requiring human intelligence". In the symbolic school, symbols can be conceived of as representations of physical entities, and thus AI is thought to function similarly. Although there are numerous definitions of AI, it is generally acknowledged that the study concepts, methodologies, innovations, and implementations of AI are profoundly and substantially altering human life.[2]

Over the years AI has grown quickly, having an impact on all aspects of life. It employs the cognitive function of learning and problem-solving, which is typically associated with the human mind[3]. This branch of applied computer science, also known as machine intelligence, uses computational models to replicate human-like reasoning, critical thinking, judgment, decision-making, and intelligent behavior.[4]

This feature enables AI to reveal patterns and high-dimensional data with subtle relationships that are typically escaped by standard or simple analytical techniques.[5]. Therefore, AI is widely used in image-processing jobs in the fields of pathology, ophthalmology, dermatology, and radiology[6]. Using AI also makes it possible to assess a growing quantity of data for clinical risk assessment, diagnosis, and therapy. AI, for example, makes it possible to combine genomic, proteomic, and radiomic data, which can greatly increase prediction accuracy[7].

AI, with its wide range of applications, has a significant impact on the healthcare industry including dentistry. The application of AI in the clinical context has led to enhancements in dental healthcare systems and improvements in patient care. These developments encompass reduced surgical complications, enhanced quality of life, better decision-making, and a substantial reduction in unnecessary dental procedures. Using AI also makes it possible to assess a growing quantity of data for clinical risk assessment, diagnosis, and therapy[8].

With AI attracting attention in dentistry, it has proven to be a trustworthy tool for clinical data analysis and data keeping9. By tracing cephalometric landmarks, detecting caries, alveolar bone loss, and peri-apical lesions, as well as designing dentures, aligners, and computer-aided design or computer-aided manufacturing (CAD/CAM) crowns can be prepared much more quickly and affordably. The degree of diagnosis, treatment, and prognosis that AI has achieved in dentistry is comparable to that of medical professionals. Before undertaking challenging tasks, the human intellect and psyche require a respite. Machines do, however, have a little edge over humans in terms of the number of working hours that may be completed without becoming exhausted[9].

Despite its numerous technological advancements and its capacity to transform the field of dentistry, AI has been the target of ethical controversy, raising apprehensions about potential data misinterpretation, ethical concerns, and safeguarding patients' privacy. This study was designed to assess dental students' awareness and perception of the use of AI and its potential application in the prospects of dentistry.

METHODS

This survey-based cross-sectional study was carried out at Altamash Institute of Dental Medicine, Karachi. The Ethical Review Board, AIDM granted the clearance for the project (IRB NO. AIDM/ERC/09/2022/02). Overall, 160 students participated in the study by responding to a questionnaire encompassing 35 questions with consecutive sampling techniques [10,11]. The sample size was obtained through a proportion estimation formula from a previous study of dental students, of which 12% indicated not being aware of the use of AI in dentistry, the required sample size was 160 members [16]. The researchers confirmed the survey's content validity through a pilot run (n=5).

Using SPSS 26, reliability statistics for validity were obtained for the 35-statement questionnaire and Cronbach's alpha was 0.883. Dental students were given access to the survey using Google Forms, (via e-mails and WhatsApp groups) during July and August 2022. Inclusion criteria were that only dental students, 19-25 years of age, from all four years of BDS education, had given consent to be a part of the study [10].

The sociodemographic parameters were covered in the first section of the questionnaire, followed by the awareness in the second section, and finally perception of students regarding the role of AI, and recent implementation in the dental field in the third part of the questionnaire. Students were directed to use a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree) to indicate their response for each statement.[11]. Furthermore, the mean scores were calculated for awareness and perception sections, and evaluated that mean range from 1-1.80 suggests strongly agreed and the range of 1.81-2.60 shows agreed. However, 2.61-3.40 indicates neutrality, 3.41-4.20 indicates disagreement and 4.21-5 indicates strongly disagree by the participants.

Microsoft Excel was used to compile the completed surveys into tabular form, and SPSS version 26 was used to analyze the data. The responses' means and specific percentages were determined for descriptive statistics and chi-square for inferential statistics and a p-value < 0.05 was considered significant. All the collected data is stored at Zenodo (with DOI: 10.5281/zenodo.8321100 dated 06-09-2023) under the Data license of Creative Commons Attribution 4.0 International and will be available after manuscript publication.

RESULTS

A total of 160 dental students responded to the online survey, with 75 (46.9%) male students and 85 (53.1%) female students. Around 65.6% and 80% of the students were aware of the AI term and the way artificial intelligence is applied in dentistry respectively.

The BDS students were from 1st year 45(28.1%), 2nd year 38(23.8%), 3rd year 39 (24.4%) and 4th year 38(23.8%). The mean age of the students was 20.65± 1.13 (males 20.5± 1.16 and females 20.35± 1.09). (Table 1)

Table 1: Demographic characteristics and general insight about AI (n=160)

Characteristics	n	(%)
Gender		
Male	85	53.1
Female	75	46.9
Years of Dentistry		
1st year	45	28.1
2nd year	38	23.8
3rd year	39	24.4
4th year	38	23.8
Age (years) Mean±S.D		
Total	20.5	1.13
Male	20.32	1.16
Female	20.65	1.09
General Insight	**Yes** **n (%)**	**No** **n (%)**
Do u understand the concept of artificial intelligence?	128(80)	23(20)
Are you aware of AI utilization in Dentistry?	105(65.6)	55(34.4)

Most of the students agreed that AI can be used as a definitive tool in the diagnosis of multiple diseases 78 (48.8%), as a prognostic tool to predict the course of disease 88 (55%), and for the radiographic diagnosis of tooth caries 81 (50.6%) and periodontal diseases 78 (48.8%). Most of them agree that AI can speed up processes in health care thereby reducing medical errors 124 (77.5%) and AI technology can deliver vast amounts of clinically relevant high-quality data in real-time for many advanced researches 102 (63.8%). The collective mean score for awareness section questions was 1.86 (mean from 1.81-2.60 shows agreement with the statements) (Table 2)

Table 2: Dental students' awareness of AI (n=160)

Questions	Strongly Agree 1	Agree 2	Neutral 3	Disagree 4	Strongly Disagree 5
AI is effective in community disease management	57(35.6%)	78(48.8%)	21(13.1%)	4(2.5%)	0(0%)
AI as a predictive prognostic tool for a dental disease	48(30%)	88(55%)	20(12.5%)	4(2.5%)	0(0%)
Radiographic diagnosis of tooth caries using AI	48(30%)	81(50.6%)	27(16.9%)	4(2.5%)	0(0%)
Radiographic diagnosis of periodontal disorders using AI	50(31.3%)	78(48.8%)	30(18.8%)	2(1.3%)	0(0%)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Maxillofacial operations and structural defects management using AI	46(28.8%)	79(49.4%)	31(19.4%)	4(2.5%)	0(0%)
Three-dimensional implant positioning using AI	64(40%)	67(41.9%)	22(13.8%)	6(3.8%)	1(0.6%)
Radiographic diagnosis of jaw and facial bone diseases using AI	42(26.3%)	89(55.6%)	25(15.6%)	4(2.4%)	0(0%)
AI usage in dental cosmetic and restorative applications	51(31.9%)	76(47.5%)	31(19.4%)	2(1.3%)	0(0%)
Using AI to collect data, and patient monitoring hastens the record-gathering process.	50(31.3%)	80(50%)	29(18.1%)	1(0.6%)	0(0%)
Using AI to identify and forecast systemic disorders development.	42(26.3%)	89(55.6%)	23(14.4%)	5(3.1%)	1(0.6%)
Radiographic diagnosis of tooth decay using AI	45(28.1%)	84(52.5%)	27(16.9%)	4(2.5%)	0(0%)
Soft tissue lesion diagnostics using AI	46(28.8%)	81(50.6%)	32(20%)	1(0.6%)	0(0%)
Using AI in cadaver forensics to recognize and gather information from bodies.	40(25%)	90(56.3%)	23(14.4%)	6(3.8%)	1(0.6%)
AI provides therapeutically relevant, high-quality data in real time.	102(63.8%)	53(33.1%)	3(1.9%)	2(1.3%)	0(0%)
No physical or emotional limitations in AI	65(40.6%)	72(45%)	20(12.5%)	3(1.9%)	0(0%)

Mixed responses to questions received for the questionnaire were obtained as a good proportion strongly agreed that AI will lead to major advances in dentistry and medicine 73 (45.6%) and many believe that the use of AI is exciting 77 (48.1%). Finally, 34.5 % suggested that the latest technology of AI for dental services should be used in public sector hospitals. The collective mean score for perception section questions was 2.01 (1.81-2.60 shows agreement with the statements) (Table 3)

Table 3: Dental students' perception of AI (n=160)

Questions	Strongly Agree 1	Agree 2	Neutral 3	Disagree 4	Strongly Disagree 5
Improvements in dentistry and medicine using AI	69(43.1%)	73(45.3%)	18(11.3%)	0 (0%)	0 (0%)
Using AI in dentistry and medicine	61(38.1%)	77(48.1%)	20(12.5%)	2(1.3%)	0 (0%)
AI as a quality control tool for dental treatments	48 (30%)	85(53.1%)	26(16.3%)	0 (0%)	1 (0.6%)
Incorporating AI into undergraduate education	51(31.9%)	78(48.8%)	26(16.3%)	3(1.9%)	2 (1.3%)
AI to be taught in postgraduate dental courses	71(44.4%)	73(45.6%)	13 (8.1%)	3(1.9%)	0 (0%)
Both medicine and dentistry benefit from AI	73(45.6%)	72 (45%)	12 (7.5%)	2(1.3%)	1 (0.6%)
AI replacing doctors' and dentists' decisions and treatment plans	19(11.9%)	37(23.1%)	36(22.5%)	47(29.4)	21(13.1)
Dental applications of AI are highly promising	46(28.8%)	73(45.6%)	40 (25%)	1(0.6%)	0 (0%)
Using AI for managing complex dental situations	25(15.6%)	53(33.1%)	49(30.6%)	22(13.8)	11(6.9%)
Using AI in clinical dental training and courses	47(29.4%)	82(51.3%)	27(16.9%)	4(2.5%)	0 (0%)
Using AI in daily clinical dental practice	48 (30%)	84(52.5%)	26(16.3%)	1(0.6%)	1 (0.6%)
Newspapers, periodicals, social media, and lectures as information sources for AI	42(26.3%)	86(53.8%)	27(16.9%)	5(3.1%)	0 (0%)
Using AI in medical procedures to lower medical errors.	124(77.5%)	33(20.6%)	2 (1.3%)	1(0.6%)	0 (0%)
AI's ability to diagnose health problems superior to a doctor's clinical expertise	58(36.3%)	78(48.8%)	21(13.1%)	2(1.3%)	1 (0.6%)
Will you follow AI's judgment if it differs from your medical judgment?	11 (6.9%)	42(26.3%)	52(32.5%)	39(24.4%)	16(10%)
Will you suggest others learn and apply AI in clinical settings?	49(30.6%)	78(48.8%)	30(18.8%)	3 (1.9%)	0(0%)
Pakistan's dental industry progresses by incorporating AI into clinical settings	39(24.4%)	81(50.6%)	33(20.6%)	7 (4.4%)	0(0%)

Which area of healthcare should use AI for commercial purposes first?	Public health centers	Primary care in private clinics	Specialized clinics	University Hospital	Governm ent HCU
	55(34.4%)	42(26.3%)	39(24.4%)	18(11.3%)	6(3.8%)

The inferential results were non-significant when compared for gender and year of BDS education for awareness and utilization of AI in dentistry. (Table 4)

Table 4: Dental students' general insight for artificial intelligence with regards to gender and the year of bds (n=160)

Variables	Q1: Do you understand the concept of AI?		Q2: Are you aware of AI utilization in Dentistry?	
	Yes	No	Yes	No
Gender				
Male	64 (40%)	11(6.8%)	52(32%)	23(14.3%)
Female	64(40%)	21(13.1%)	53(33.1%)	32(20%)
p-value	0.113		0.354	
Years of Dentistry				
1st Year	38(23.7%)	07(4.3)	34(21.2%)	11(6.8%)
2nd Year	32(20%)	06(3.7%)	22(13.7%)	16(10%)
3rd Year	28(17.5)	11(6.87%)	21(13.1%)	18(11.2%)
4th Year	30(18.7%)	08(5%)	28(17.5%)	10(6.25%)
p-value	0.354		0.091	

Chi-Square Test Applied ; p-value < 0.05 considered significant

DISCUSSION

When it comes to diagnosis, treatment, and prognosis, dentistry has undergone a revolution. The goal of this study was to evaluate dental students' understanding of artificial intelligence (AI), thoughts on the topic, and points of view in light of the technology's pervasive application in many areas of dentistry[11].

The collective mean of all the responses in awareness (1.86) and perception section (2.06) lies in the range of "agree" (1.81-2.60). So, most of the students are aware of AI use and its importance in dentistry for diagnostic and management aspects. A similar study was carried out by Khanagar, where students agreed to most of the statements regarding the utilization of modern technology and AI, with a fairly equal blend of participants from either gender[10]. In a comparison with previous studies performed in countries such as Saudi Arabia, Turkey, and India, there was an increased percentage of people who comprehended the details of artificial intelligence and its utilization in dental services[11,12]. This demonstrates that dental students across the globe are now quite familiar with AI's concept and implementation as in recent years it has gained limelight[13].

The outcomes of our study are in line with Yüzbasoglu with the findings, in which 52.6% of the participants disagreed about the substitution of dentists with cutting-edge AI technology[13]. Similar to this, 2021 Indian research revealed that 37.78% of dental interns rejected the idea that AI can take the place of dentists[12].

AI technologies can be useful in endodontics for identifying periapical lesions and fractures in roots, assessing the morphology of the root canal system, anticipating the health of dental pulp stem cells, calculating working length measurements, and predicting the efficacy of continued endodontic procedures. In the field of orthodontics, they may assist in the diagnosis of a patient, monitoring the progress of a patient's dental growth and development, and appraisal of the efficacy of a treatment plan[13].

Planning orthognathic surgery, anticipating post-extraction issues, recognizing and discriminating bone abnormalities, and planning implant treatment are all areas in which AI may be helpful in dental surgery. Most of the participants in our survey held the opinion that AI may be employed in surgical procedures for maxillofacial abnormalities and structural deformities. In addition, periodontology incorporates artificial intelligence on an increasing basis. It was applied to gauge periodontal and peri-implant bone loss and predict the course of periodontitis in the investigations mentioned above[14].

The majority of the students were informed of the application of AI in dentistry; this number was equivalent to those of studies conducted in India, Saudi Arabia, and Turkey[9,12,13]. The majority of students desired the AI curriculum to be a part of undergraduate, postgraduate, and clinical training, and most of the information about AI seems to be transmitted through paper and electronic media, which furthered the establishment of its utilization. Additionally, our findings are quite similar to those of a study from India in which the majority of participants predicted that AI would eventually play a key role in contemporary dentistry[15].

The effectiveness of dental treatment quality control can be assessed by employing AI, according to students' opinions. Similar to this, many studies found that AI could be used to diagnose various medical conditions, forecast how they would develop, and evaluate the efficacy of novel dental procedures. The provision of clinically relevant, high-quality data, will result in better healthcare systems and progress research[16].

Our findings were similar to the studies conducted in Saudi Arabia and Turkey when it came to the question, "Will AI lead to major innovations in medicine and dentistry?" In contrast to this, in an Indian study where 45% were unsure and thought that AI's diagnostic capabilities were better than a physician's assessment[9,12]. When asked how they would respond in a scenario, the majority of respondents preferred AI diagnosis compared to human judgment and chose to stay uncommitted. But in another Indian study, 59% of respondents opted to put more faith in human judgment than artificial intelligence[17]. A person can build substantial trust, composure, and compassion, which are essential traits in dental treatment against the AI-powered computer diagnosis[18,19].

By simplifying tasks and delivering findings faster, artificial intelligence has revolutionized the accuracy of diagnosis and dental treatment planning[20]. This has allowed dentists to employ fewer resources and operate their practices more successfully. Similar data about the usage of artificial intelligence was endorsed by about 80% of the research participants[21].

Even though it will require some time for AI to be fully accepted in every profession, while addressing the future, it cannot replace a dentist or a physician. Nowadays, AI and neural networks are primarily used in dental radiology to make diagnosis, treatment planning, and treatment result prediction easier[14]. A core curriculum for dentistry education needs to be altered in this fast-changing environment since health care is fundamentally changing, along with teaching and learning methods. In reality, a variety of benefits are anticipated from the use of AI in dentistry. For instance, including the fundamentals of AI in the undergraduate curriculum can assist dentists in becoming more knowledgeable so they can evaluate and purposefully use AI technologies afterward[22]. When the specifics of cadavers are needed, dental forensics plays a crucial role. Our students enthusiastically support the use of AI to extract demographic information from ancient mummies for cadaver forensics. A recent meta-analysis found that the precision and accuracy of AI forensic models are comparable to those of experienced examiners. These models have the potential to be helpful resources for identifying catastrophe victims and acting as an additional resource in medico-legal situations[23].

In the study results no significant differences were observed statistically in regards to gender and the year of dental education for the awareness and concept of understanding of AI. Similar results were obtained by Khanagar in his study, where students had no significant difference for the question "Do you have the basic knowledge about the working principle of Artificial Intelligence?" but for the next question "Are you aware of the usage of Artificial Intelligence in Dentistry?" significant difference was observed between the years of dental education which is in contrast to our results 10. Similarly, when inferential statistics for gender were applied non-significant differences were observed for the concept and utilization of AI in our study. Whereas, Murali in his study documented a significant difference between the genders for the basic concept of AI and non-significant differences in the perception and utilization of AI for dental management among students[24].

The results demonstrate that most of the participants concur with the statements about the use of artificial intelligence in dentistry. A core curriculum for dentistry education needs to be altered in this fast environment since health care is fundamentally changing, along with teaching and learning methods. It is possible to add elective courses in digital dentistry to the curriculum if undergraduate as most of the students are interested in doing so. The curriculum can be expanded to include new developments for under and postgraduate dental students as well[24].

Implementing educational seminars on AI in dentistry and looking into the potential of including AI training in

a couple of the study programs can both help to support this. Contrary to what we discovered, a recent study of medical students revealed their limited knowledge of AI, but still, they are quite optimistic about its potential to revolutionize current healthcare practices and believe that it should be incorporated into their curricula to better prepare them for future challenges. The discrepancy between the BDS and MBBS students' responses may be due to the increased use of AI in dentistry nowadays compared to modern medicine and related health professions [25].

The small sample size and a single area of focus, characterize this study which can be a limitation. Additionally, response bias must be taken into consideration because participation was done by online survey only. This study serves as a starting point for future qualitative and quantitative research on a similar topic. Prospective studies might provide more attention to the quality and effectiveness of the educational initiatives and regulations that have been put in place to show how AI models might enhance dental practices.

CONCLUSION
From this study, it could be concluded that dental students are well aware of the advantages and utilization of AI tools in dentistry and with a strong perception that some aspects of AI should be covered in the undergraduate dental curriculum and clinical training. The attitudes and viewpoints of Pakistani dental students about the use of AI in dental diagnosis and treatment may serve as a guide for developing future research.

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CONFLICT OF INTEREST
The authors of this study have no conflict of interest to declare.

ETHICAL APPROVAL
Ethical approval was given by the ethical review committee of Altamash Institute of Dental Medicine, Karachi (IRB NO. AIDM/ERC/09/2022/02).

AUTHORS CONTRIBUTION
RA Presented the main idea, provided the concept, drafted the article, did the literature search and write-up, and revised it critically, and approved the final version to be published. ZK designed the study, did a literature search, and did the write-up. RA did the sampling, acquisition, and analysis of data and NQ did the writeup, paraphrasing, and proofreading of the article.

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