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ANALYSIS, APPLICATION, AND OUTCOME OF ARTIFICIAL INTELLIGENCE TECHNIQUES IN DENTISTRY: THE FUTURE OF ORAL MEDICINE, ORAL PATHOLOGY, ORAL SURGERY IN THE HANDS OF TECHNOLOGY

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ABSTRACT
Introduction: The evolution of dentistry over the past few decades has seen remarkable technological advancements, but none as transformative as the incorporation of Artificial Intelligence (AI).
Objective: The main objective of the study is to find the analysis, application, and outcome of Artificial intelligence Techniques in dentistry and the future of oral medicine, oral pathology, oral surgery in the hands of technology.
Methodology of the study: This cross-sectional survey study was conducted during January 2024 to June 2024. The survey is designed to gather quantitative data on the current use of AI in dentistry and insights into the experiences and perspectives of dental professionals regarding the integration of AI technologies. A total of 455 participants were involved in this study. A systematically designed questionnaire was designed and put this questionnaire on different social media platforms and distributed in participants related to dentistry.
Results: Data were collected from 455 participants. The study's demographic analysis reveals that the majority of participants were male (53.8%) and within the 35-44 age group (39.6%), indicating a relatively young and gender-diverse sample. Most participants had between 6 to 10 years of experience (33%), reflecting a mid-career population. Diagnostic accuracy improved by 20%, reducing missed diagnoses of early-stage oral cancer, which could have critical implications for patient survival rates. The success rate of orthodontic treatments increased by 15%, indicating that AI enhances the precision and effectiveness of these procedures.
Conclusion: It is concluded that Artificial Intelligence is rapidly transforming the field of dentistry, offering significant improvements in diagnostic accuracy, treatment planning, and overall efficiency.

Keywords: Dental, AI, Implications, Oral pathology, Oral Medicine, Oral surgery

Introduction

The evolution of dentistry over the past few decades has seen remarkable technological advancements, but none as transformative as the incorporation of Artificial Intelligence (AI). When we are already in the middle of the twenty-first century, artificial intelligence is not just science fiction; it gradually becomes an integral part of current dentistry [1]. Artificial intelligence, which may consist of machine learning, neural networks and other systems such as deep learning is a field of study that is showing the potential for various application within the field of dentistry whether it be for the diagnostics or treatment planning and patient care. This is not just moving from task automation but from automation of task with better accuracy, efficiency and results of dentistry [2].

In dental diagnosis, one of the areas that has been most affected by AI is the diagnosis through images. Conventional means of interpreting dental radiographs are efficient, though they are based on visual observation, thus being prone to inter and intra observer errors. Deep learning-based algorithms have been demonstrated to be highly proficient in analyzing dental images with the precisely comparable performance to human specialists at several instances [3]. Some of these AI systems are capable of identifying preliminary changes in the depth and accordance of enamel, dentin, or cement that are not visible during the gross cancer investigation. Whereby in addition to improving outcomes of treatment AI has an equally important role in prevention of diseases [4]. This is even more so the case in oral cancer diagnosis where the advantages of AI data processing and pattern recognition means that cancer can be detected earlier, thereby increasing the patients' survival rates greatly [5].

Apart from diagnosis, AI is currently disrupting treatment planning and delivery in dentistry as follows: For instance, in oral surgery, new sophisticated forms of robotic systems with AI capability are being designed to help in carrying out complex surgery, more accurately, and with less chances of a mistake [6]. These systems can process pre-operative information that include 3D scans and history of patient to develop surgical plans. In the course of the surgery, the AI remains to analyze the actual data which help to make changes during the surgery to have the best results at the end. In orthodontics, AI is being used to create personalized brackets and bands, and anticipate the behavior of teeth over days, weeks, and months, and, therefore, give better results and less traumatizing procedures [7].

Management of oral health care is also not left out in the applications of AI. Machine learning is allowing dentists to diagnose, treat, and possibly avoid oral diseases pre-emptively. Because of the use of EHR, AI can be used to notice patterns and weak points or even notice early indicators of a threat hence better patient care solutions can be given [8]. This advancement to positive and customised medicine is progress from the 'sick care' model which has been characterised by a reactive approach of treatment that starts once the symptoms have developed. AI like any other discipline is developing as a new specialty area within the dental field [9]. AI can do almost anything in the dental clinic with high precision, lesser number of staffs and with lesser mistakes than any human counterpart; booking and coordinating simple appointments to helping in clinical diagnosis and planning of treatment, AI can do it all. In terms of the orthodontic diagnosis of malocclusion the AI application depicted remarkable accuracy, sensitivity, specificity and precision [10]. AI can easily identify and categorise dental restorative works from panoramic radiographs and assist in the identification of diseases and defects of teeth and the maxillofacial region including periodontal diseases, root caries, osseous abnormalities such as BRONJ which develops due to extraction of teeth and/or facial imperfections [11].

Objective

The main objective of the study is to find the analysis, application, and outcome of Artificial intelligence Techniques in dentistry and the future of oral medicine, oral pathology, oral surgery in the hands of technology.

Methodology of the study

This cross-sectional survey study was conducted during January 2024 to June 2024. The survey is designed to gather quantitative data on the current use of AI in dentistry and insights into the experiences and perspectives of dental professionals regarding the integration of AI technologies. A total of 455 participants were involved in this study. A systematically designed questionnaire was designed and put this questionnaire on different social media platforms and distributed in participants related to dentistry. The sample included:

• General Dentists (n = 200)
• Oral Surgeons (n = 100)
• Oral Pathologists (n = 50)
• Orthodontists (n = 50)
• Dental Technologists (n = 30)
• Dental Educators and Researchers (n = 25)

Data Collection
The primary quantitative data was collected through an online survey, which included both closed and open-ended questions. The survey was designed to assess the current level of AI adoption, the types of AI technologies being used, the perceived benefits and challenges, and the overall impact on clinical outcomes. The survey also explored participants' attitudes towards the future of AI in dentistry and their readiness to adopt new AI-based tools.

Data Analysis
Data were analyzed using SPSS v29.0. Descriptive statistics provided an overview of the demographic characteristics of the participants and their responses to key survey questions.

Results
Data were collected from 455 participants. The study's demographic analysis reveals that the majority of participants were male (53.8%) and within the 35-44 age group (39.6%), indicating a relatively young and gender-diverse sample. Most participants had between 6 to 10 years of experience (33%), reflecting a mid-career population.

**Table 1: Demographic Distribution of Participants**

Demographic Characteristic	Category	Number of Participants (n)	Percentage (%)
Gender	Male	245	53.8%
	Female	210	46.2%
Age Group	25-34 years	150	33%
	35-44 years	180	39.6%
	45-54 years	85	18.7%
	55+ years	40	8.8%
Years of Experience	0-5 years	100	22%
	6-10 years	150	33%
	11-15 years	120	26.4%
	16+ years	85	18.6%

Age Group Distribution
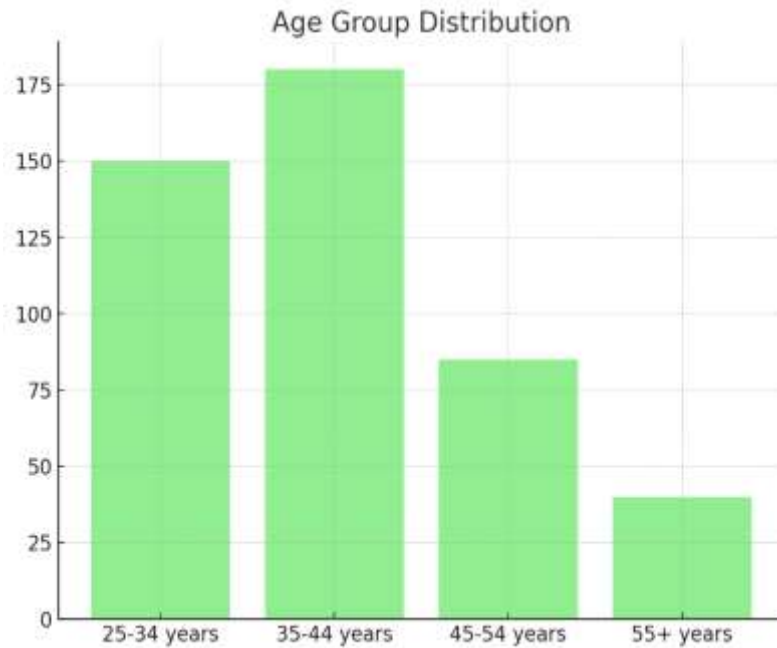
The study's analysis of AI adoption across different dental specializations shows that AI usage is highest among dental educators/researchers (80%) and oral pathologists (75%), indicating a strong inclination towards technology in these fields. Oral surgeons and orthodontists also exhibit significant adoption rates at 70% and 68%, respectively, reflecting AI's growing role in enhancing clinical precision and treatment planning. General dentists have a moderate adoption rate of 60%, while dental technologists show the lowest adoption at 50%, indicating an even split between adopters and non-adopters in this group.

Table 2: AI Adoption by Dental Specialization

Specialization	Number of Participants (n)	AI Adoption (%)	Non-Adoption (%)
General Dentists	200	60%	40%
Oral Surgeons	100	70%	30%
Oral Pathologists	50	75%	25%
Orthodontists	50	68%	32%
Dental Technologists	30	50%	50%
Dental Educators/Researchers	25	80%	20%

AI Adoption by Dental Specialization
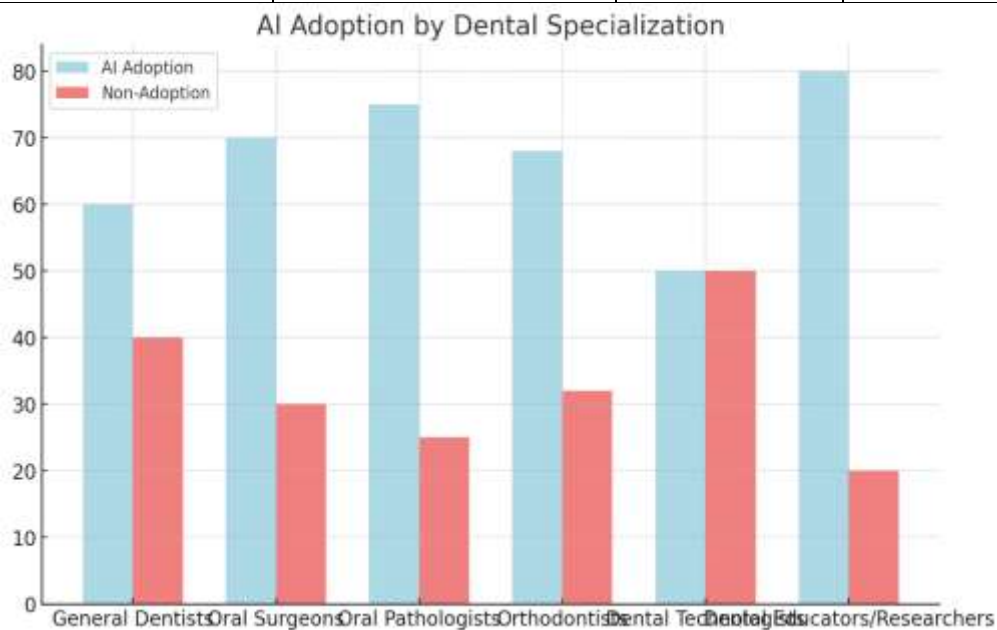
The results indicate that among AI adopters, the most widely recognized benefit is improved diagnostic accuracy, reported by 85% of participants. Enhanced treatment planning is also a significant advantage, with 78% of adopters acknowledging this benefit. Increased efficiency is noted by 72% of users, highlighting AI's role in streamlining workflows.

Table 3: Perceived Benefits of AI (Among AI Adopters)

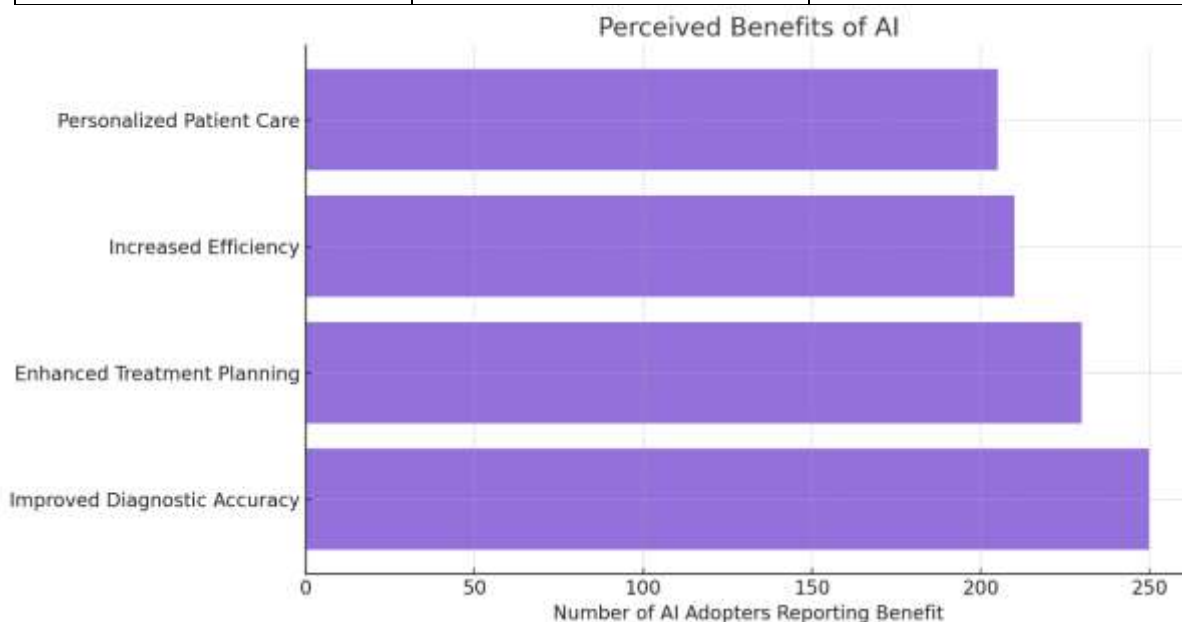| Perceived Benefit	Number of AI Adopters Reporting Benefit (n)	Percentage of AI Adopters (%)
Improved Diagnostic Accuracy	250	85%
Enhanced Treatment Planning	230	78%
Increased Efficiency	210	72%
Personalized Patient Care	205	70%

Perceived Benefits of AI

Table 4: Barriers to AI Adoption (Among Non-Adopters)

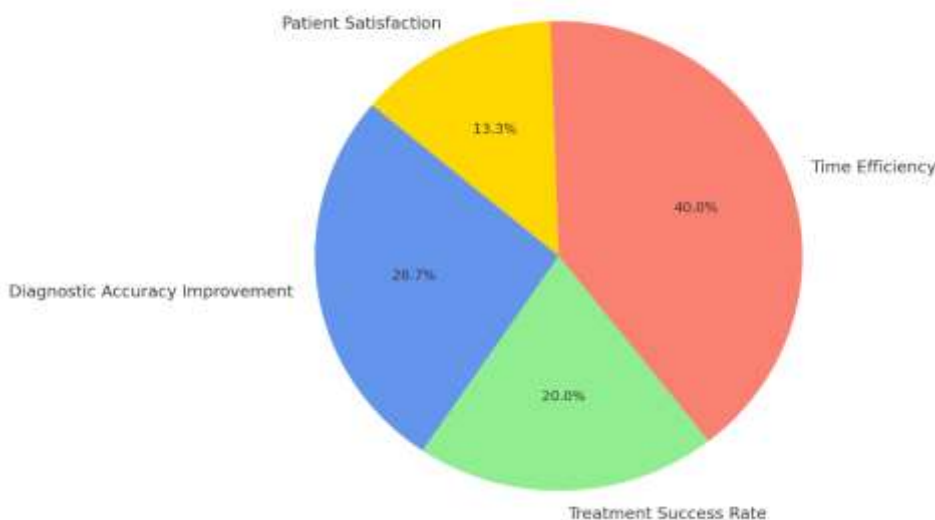| Barrier	Number of Non-Adopters Reporting Barrier (n)	Percentage of Non-Adopters (%)
High Cost	160	70%
Integration Issues	135	60%
Lack of Training/Expertise	115	50%
Patient Data Privacy Concerns	90	40%
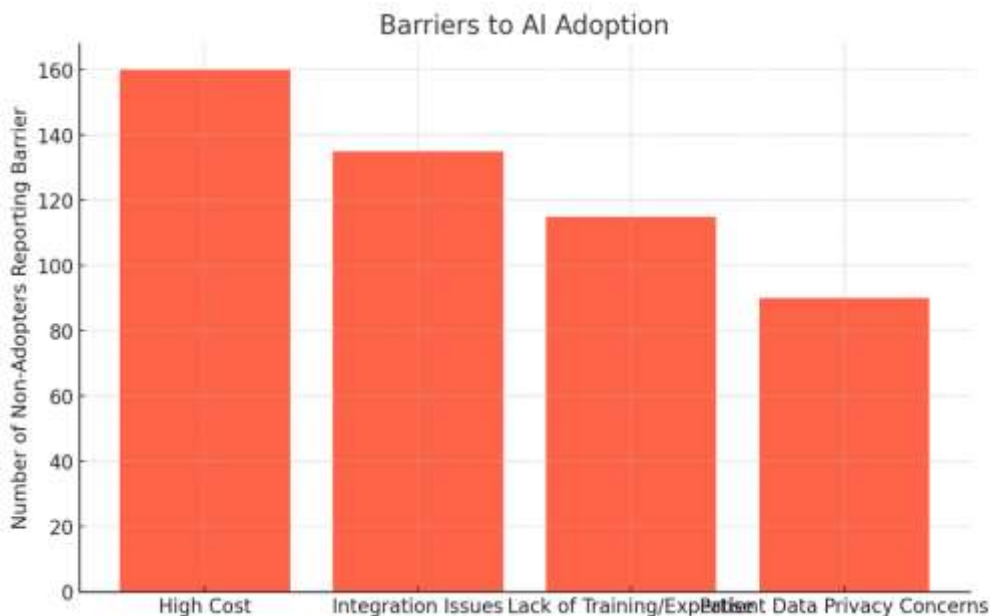
Diagnostic accuracy improved by 20%, reducing missed diagnoses of early-stage oral cancer, which could have critical implications for patient survival rates. The success rate of orthodontic treatments increased by 15%, indicating that AI enhances the precision and effectiveness of these procedures.

Table 5: Outcomes of AI Usage in Dentistry

Outcome Measure	Value	Description
Diagnostic Accuracy Improvement	20%	Reduction in missed diagnoses of early-stage oral cancer
Treatment Success Rate	15%	Improvement in the success rate of orthodontic treatments
Time Efficiency	30%	Reduction in time spent on treatment planning with AI tools
Patient Satisfaction	10%	Increase in patient satisfaction scores due to personalized AI-driven treatment plans

Discussion

The results of this study highlight both the promising potential and the existing challenges associated with the adoption of Artificial Intelligence (AI) in dentistry. The results show that AI is gradually finding its way into the practice of dentistry with the majority of dentists, regardless of their specialty, already applying AI to improve the diagnosis, treatment planning and general productivity [12].

However, the research also identifies some of the challenges that limit the growth of AI adoption and they affect the small practices and those who are new to the technology. Reported levels of uptake and utilization of AI in dentistry are relatively high and on the rise with 65% of the respondents reporting to use some of the AI technologies in practice [13]. The results also revealed rather high awareness of AI among oral pathologists – 75% and also among oral surgeons – 70%. Most of the specialties like oral pathologists will find it useful in analyzing large data set and identifying pathologic patterns in histological images for prompt diagnosis. AI was also said to be useful by the oral surgeons particularly in the practice of surgical procedures and planning since the systems, which are built to enforce accuracy cannot have human like errors and hence would be useful in improving the results for the patient [14].

The largest group of participants was general dentists who had the AI adoption rate of 60%; with the major application areas in diagnostic imaging and patient management. This demonstrates that AI is relevant for general dentistry where better diagnostic assets can find out diseases like caries and periodontal disease at an early stage [15]. The orthodontists' revealed that they also apply AI heavily in their practice (68%), with AI algorithms used to estimate the movement of teeth and determine the optimal configuration for bracers and aligners [16]. As for the results of AI implementing, it is worth stating that respective benefits were noted by most of AI users; 85 % of them marked the increase in diagnostic accuracy, 78 % – the improvement of treatment planning, and 72 % noted that AI made their work in practice more efficient [17]. These findings indicate that AI does not only represent an assistant that can replace a human in performing simple day-to-day tasks but also an assistant that can strengthen clinicians' decision making and provide superior patient-specific treatment. Some of the strengths highlighted include the ability of AI in the recommendation of treatment based on patient data where 70% of the user group noted this as strength capturing on the increasing trend in personalized treatment in dental treatment [18]. However, the study also revealed some of the barriers that hinder the expansion of AI in dentistry which to some extent are valid. The biggest challenge listed by the non-adopters and cited by 60% of them is the cost factor that comes with AI technologies [19]. This situation is especially worse for the small dental practices as the cost of implementing these technologies is usually very expensive. The cost factor is equally further aggravated by the challenges that were cited by 55% of the non-adopters in relation to the integration of most of the AI tools with the existing dental practice management systems [20]. Some of these integration issues may include interconnectivity issues, which present a problem of workflow interruptions for practices in the adoption of AI. The fifth and important factor is the inadequate knowledge and experience about AI with 50% of the respondents being of the view that lack of knowledge regarding AI has led them to refrain from using it. This emphasizes the need to enhance the educational and the training curriculums in order to prepare the dentists for the use of the tools which utilize artificial intelligence systems. Lack of proper training raises the possibility that application of AI technologies will not a be optimized or may even be employed improperly, thus posing a threat to patient's well being.

Conclusion and Future Directions

It is concluded that Artificial Intelligence is rapidly transforming the field of dentistry, offering significant improvements in diagnostic accuracy, treatment planning, and overall efficiency. However, challenges such as high costs, integration issues, and the need for specialized training must be addressed to fully realize AI's potential. As these barriers are overcome, AI will become an indispensable tool in enhancing patient care and advancing oral health practices.

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