

Transforming Health and Dental Care with Artificial Intelligence: Exploring Opinions from Dentists of Gujarat

Received: 11 February 2023, **Revised:** 15 March 2023, **Accepted:** 19 April 2023

Megha Patel

Professor and Head, Department of Pediatric and Preventive Dentistry, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India. Email: meghapatel@karnavatiuniversity.edu.in

Chhaya Patel

Reader, Department of Pediatric and Preventive Dentistry, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India. Email: chhayapatel@karnavatiuniversity.edu.in

Rohan Bhatt

Professor, Department of Pediatric and Preventive Dentistry, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India. Email: additionaldirectorksd@karnavatiuniversity.edu.in

Saumya Goyal (Corresponding Author)

Post Graduate Student, Department of Pediatric and Preventive Dentistry, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India. Email: saumyagoyal04@gmail.com Contact: 8758198938

Disha Makwani

Senior lecturer, Department of Pediatric and Preventive Dentistry, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India. Email: dishamakwani@karnavatiuniversity.edu.in

Foram Patel

Senior lecturer, Department of Pediatric and Preventive Dentistry, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India. Email: foram@karnavatiuniversity.edu.in

Keywords

Artificial Intelligence, Awareness, Pediatric Dentistry, Perception, Gujarat dentists, Machine learning

Abstract

Background: Artificial intelligence (AI) is at the foundation of recent technological advancements. It has found significant applicability in today's health-care systems around the world. A machine capable of physical manipulation and powered by an intelligent algorithm would be the ideal dental assistant for executing technique-sensitive treatments in a time efficient and affable manner.

Aim: To assess the knowledge and awareness of Artificial Intelligence in healthcare and its applicability in dentistry among General and Specialist dentists of Gujarat.

Methodology: An online survey was conducted among 1000 randomly selected dental professionals registered in Gujarat State Dental Council. It consisted of 15 closed-ended validated questions. The survey gathered information regarding participants' recognition of AI in Healthcare, their opinions on its applications, future implications, risk and barriers in the Indian Healthcare system. A gentle reminder was sent twice and after adequate responses, descriptive and inferential statistical analysis were carried out using SPSS V20 software.

Results: The concept of AI was familiar amongst 75.78% respondents. Majority of BDS and MDS felt that AI can be best used to prevent oral cancer however pediatric dentists opted AI for evaluating risk of caries ($p=0.000$). The use of AI as superior means was reported by Pediatric Dentists (37.5%) in assessing root anatomy and locating orifices while BDS and MDS selected AI in designing prosthesis. Chances of injuries and errors was selected as first risk by 67.8% and cost effectiveness and lack of infrastructure as the most common limiting factor (36.46%) by the studied sample.

Conclusion: Majority of the dentists were aware about the potential benefits of applying AI as a preventive, diagnostic and treatment tool in dental practice. Despite its numerous benefits, some of the most pressing uncertainties limiting its use were chances of errors and economic considerations.

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1. Introduction

Artificial intelligence (AI) is a broad term encompassing the ability of machines and technology to execute human-like tasks. According to "Barr and Feigenbaum," artificial intelligence (AI) is the area of computer science concerned with creating an intelligent computer system that illustrates attributes associated with intelligence in human behaviour, understanding language, learning, reasoning, problem solving, and so on ^[1]. Its primary objective is facilitating automated learning without the need for user intervention.^[2] In our daily lives, we use Google's smart search, iPhone's virtual assistant speech recognition and knowledge management and products like Google Maps to assist us commute effectively in cities. Because of breakthroughs in computer and informatic technologies, sophisticated technology such as deep neural networks and machine learning can now be implemented in health information systems.^[3]

AI technology is a machine translation analyser that efficiently performs basic activities.^[4] Deep learning systems, one of the AI technologies can aid with disease diagnosis, treatment and outcome projection in a wide range of medical circumstances.^[5,6] AI has been successfully applied in medical digitalization, including malignancy, colon growths, prostate cancer, hip joint problems, bone age assessment, caries diagnosis, colour selection, removable partial denture design, temporomandibular disorders, oral and maxillofacial disorder treatment, maxillary sinusitis, root morphology, periodontal diseases, oral carcinoma, periapical lesions, radiolucent lesions, cystic lesions, and debonding of dental crowns.^[7,8]

There are differences of opinion among the scientific community with regard to AI in dentistry. The main differences are with data, privacy, security, and ethical concerns. Few are also of view regarding the accountability of machine errors. Currently, more concerns are about ambiguous standards, and policymakers and healthcare professionals must seek legal clarification. AI misrepresentation may lead to unjustified fears. So far, most research has focused on the perception of AI among medical professionals or students of medicine and dentistry, with only a few focusing on dental practitioners.

Therefore, this study aimed to address the research gap by evaluating the awareness of use of Artificial Intelligence in healthcare and its future applications and limitations among General and Specialist dentists of Gujarat.

2. Materials and Method

This was a descriptive, cross-sectional questionnaire based study. An online survey using Google forms was conducted among 1000 randomly selected dental professionals registered in Gujarat State Dental Council. It consisted of 15 validated questions. The questions included were close ended with either Yes/No or multiple choice or preference-based responses making them distinct and easy to respond. The survey gathered information regarding participants' demographics in first part and in second part it collected responses regarding their recognition of AI in healthcare, its applicability in dentistry, future consequences, potential risks and barriers involved with use of AI in their everyday clinical practice. 702 responses were obtained after two gentle reminders.

Statistical analysis

All the responses of the participants were noted in the spreadsheet and transferred to the Statistical Package for Social Sciences (SPSS) version 20.0 for detailed analysis.

3. Results

During the study period 702 dentists of Gujarat completed the survey, giving a 70.2% response rate. The demographic distribution (Table 1) shows that female (63.81%) respondents were more as compared to male (36.18%), General dentists were more as compared to specialists and most of the respondents were having <5 years of experience in clinical practice (56.98%).

Knowledge and Awareness regarding AI in healthcare (Table 2).

Majority of the respondents (75.78%) were familiar with the use of AI in healthcare ($p=0.000$). Improving the care/ diagnostic ability beyond current boundaries of human performance was preferred as the most potential benefit of AI (54.70%) followed by use of AI in management of patient and medical resources (21.65%).

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Applicability of AI in dentistry

The best use of AI as preventive tool was in preventing oral cancer by biomarker identification and blood signature analysis as reported by 49.46% BDS and 42.20% MDS whereas 39.28% pediatric dentists preferred AI in assessing the risk of caries in children as best preventive tool ($p=0.000$). The best diagnostic ability of AI was asked to be selected in order of preference. Predicting the course and time of dental caries in children was selected as first preference by 76.06% of the dentists, 67.52% selected radiographically imaging the decayed lesion or periodontal disease as third preference and detecting maxillofacial abnormalities as fifth preference was selected by 73.5% ($p=0.004$) (Table 3).

Regarding best applicability of AI in treatment planning, majority of BDS (39.24%) and MDS besides pediatric dentists (37.61%) demonstrated a significant incline towards 3D tooth preparation or designing prosthesis (RPD/CD), however the pediatric dentists opted assessing the root anatomy/ locating canal and apical foramen position in endodontics as best application of AI in treatment planning ($p=0.000$).

Risks and challenges of applying AI in Indian Healthcare

The respondents were asked to select the risk of applying AI in healthcare in order of preference. Chances of injuries and error was ranked as first preference by 67.8% dentists ($p=0.000$) whereas Nirvana Fallacy was chosen as 6th preference by 83.19% of total participants ($p=0.405$). When asked about the barriers of AI application in Health care all three groups significantly reported Cost effectiveness/Investment and Infrastructure ($p=0.016$) as its limiting factors. (Table 4)

Future of AI in healthcare (Table 5)

Majority participants in all three groups were of the opinion that AI will help doctors in off-loading and allow them to spend more time engaging with patients directly, when asked about the effect of AI on Doctor Patient relationship ($p=0.249$). 53.76% BDS and 44.95% MDS were of the opinion that AI will cause

patient engagement in seeking healthcare via Biosensor/ smart watches- providing patients relevant recommendations. However, the pediatric dentists (50%) differed in their opinion that by sending message alerts to consciously draw patient attention, AI can best seek patient engagement. When inquired about making AI as a part of learning for Undergraduate and Postgraduate students in dental colleges, all three groups gave consent ($p=0.018$).

AI and Healthcare according to years of clinical practice.

According to all three groups (<5 years, 5-10 years and >10 years), the most appropriate potential benefit of AI in Healthcare was reported as improving the care/ diagnostic ability beyond current boundaries of human performance ($p=0.037$) (Graph 1). Also, AI as a preventive tool in oral cancer detection was the most common preference amongst all the groups ($p=0.001$) (Graph 2). Regarding barriers towards application of AI in Indian health care, 39.5% ($n=158$) people with experience <5 years and 37.19% ($n=90$) people with experience of 5-10 years were of the opinion that it is due to Cost effectiveness/Investment and Infrastructure. However, 41.37% ($n=24$) respondents with >10 years of experience opted for the Absence of AI regulatory authority in India (Graph 3). All three groups showed a significant belief that AI can help doctors in off-loading and allow them to spend more time engaging with patients directly followed by AI's ability to reach patients through telemedicine ($p=0.023$) (Graph 4). Graph 5 shows risks of applying AI in Indian Health care according to years of experience of practice. Majority of participants were of the opinion that Chances of injuries and error was the most preferred reason ($p=0.092$) and least preferred was Nirvana Fallacy-trusting the judgement of AI over human intelligence ($p=0.000$). In our study 53.5% ($n=214$) in <5 years of experience and 61.98% ($n=150$) in 5-10 years of experience group were of the opinion that AI could also be best used for Comparing pre / post treatment changes by assessing the photographs. However, 78.33% ($n=47$) of dentists with more than 10 years of experience were of a different opinion according to whom AI could be best utilized for data record keeping of patients (Graph 6).

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Table 1: Demographics

Gender	No.	Percentage
Female	448	63.81
Male	254	36.18
Education	No.	Percentage
BDS	372	52.99
MDS	218	31.05
Pediatric Dentist	112	15.95
No. of years in dental practice	No.	Percentage
<5 years	400	56.98
5-10 years	242	34.47
>10 years	60	8.54

Table 2: Awareness of AI among Doctors as per specialization

Questions	Responses	Total n=702 (%)	Education			P value
			BDS (n=372) (%)	MDS (n=218) (%)	Pediatric Dentist (n=112) (%)	
Familiar with the concept of Artificial Intelligence and its uses in Health care.	Yes	532 (75.78%)	258 (69.35%)	170 (77.98%)	104 (92.85%)	0.000
	No	86 (12.25%)	58 (15.59%)	24 (11.01%)	4 (3.57%)	
	May be	84 (11.96%)	56 (15.05%)	24 (11.01%)	4 (3.57%)	
The most appropriate potential benefit of AI in Health care	Automating drugs in medical practice	78 (11.11%)	46 (12.36%)	24 (11.01%)	8 (7.14%)	0.424
	Democratizing medical knowledge & excellence	88 (12.53%)	52 (13.97%)	26 (11.92%)	10 (8.92%)	

Journal of Coastal Life Medicine

	Improving the care/ diagnostic ability beyond current boundaries of human performance	384 (54.70%)	200 (53.76%)	116 (53.21%)	68 (60.71%)	
	Management of patient and medical resources	152 (21.65%)	74 (19.89%)	52 (23.85%)	26 (23.21%)	

Table 3: Knowledge of applicability of Artificial Intelligence

Questions	Responses	Total n=702 (%)	Education			P value
			BDS (n=372) (%)	MDS (n=218) (%)	Pediatric Dentist (n=112) (%)	
AI can be best used as a Preventive tool	Assess the risk of caries in children	166 (23.64%)	74 (19.89%)	48 (22.01%)	44 (39.28%)	0.000
	Predict the incubation zones of pathogenic plaque biofilm	120 (17.09%)	60 (16.12%)	42 (19.26%)	18 (16.07%)	
	Predict the size of unerupted teeth	116 (16.52%)	54 (14.51%)	36 (16.51%)	26 (23.21%)	
	Prevent oral cancer by biomarker identification and blood signature analysis	300 (42.73%)	184 (49.46%)	92 (42.20%)	24 (21.42%)	
AI can be best used as a diagnostic tool (select in order of preference)	Predict the course and time of dental caries in children (1st Pref)	534 (76.06%)	286 (76.88%)	164 (75.22%)	84 (75.00%)	0.004
	Predict the necessity of extractions during orthodontic treatment (2nd Pref)	470 (66.95%)	270 (72.58%)	132 (60.55%)	68 (60.71%)	0.010
	Radiographically image the decayed lesion or periodontal disease (3rd Pref)	474 (67.52%)	276 (74.19%)	138 (63.30%)	60 (53.57%)	0.006

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	Detection and classification of malocclusion (4th Pref)	546 (77.77%)	304 (81.72%)	164 (75.22%)	78 (69.64%)	0.000
	Detect maxillofacial abnormalities like facial clefts, bony lesions, BRONJ (5th Pref)	516 (73.50%)	290 (77.95%)	154 (70.64%)	72 (64.28%)	0.018
	Detect and classify impacted/ supernumerary teeth (6th Pref)	534 (76.06%)	304 (81.72%)	160 (73.39%)	70 (62.50%)	0.000
AI can be best used in treatment planning	3D tooth preparation or designing prosthesis (RPD/CD) for the patient	248 (35.32%)	146 (39.24%)	82 (37.61%)	20 (17.85%)	0.000
	Analysis of space loss in mixed dentition	114 (16.23%)	46 (12.36%)	44 (20.18%)	24 (21.42%)	
	Assessing the root anatomy/ locating canal and apical foramen position in endodontics	204 (29.05%)	92 (24.73%)	70 (32.11%)	42 (37.50%)	
	Caries excavation and restoration by nanobots	136 (19.37%)	88 (23.65%)	22 (10.09%)	26 (23.21%)	

Table 4: Risks and Barriers of Apply AI in Indian Health care as per specialization of Dentists

Questions	Responses	Total n=702 (%)	Education			P value
			BDS (n=372) (%)	MDS (n=218) (%)	Pediatric Dentist (n=112) (%)	
Risks of applying AI in Indian Healthcare	Chances of injuries and errors (1st Pref)	476 (67.80%)	280 (75.26%)	134 (61.46%)	62 (55.35)	

Journal of Coastal Life Medicine

(Select in order of preference)						
	Risk of data fragmentation via various AI systems (2 nd Pref)	502 (71.50%)	290 (77.95%)	140 (64.22%)	72 (64.28%)	0.000
	Concerns for patient privacy (3 rd Pref)	488 (69.51%)	268 (72.04%)	154 (70.64%)	66 (58.92%)	0.001
	Bias & inequality in application to the patients (4 th Pref)	520 (74.07%)	286 (76.88%)	150 (68.80%)	84 (75.00%)	0.011
	Professional resignation-decreased human knowledge and capacity when used for long term (5 th Pref)	564 (80.34%)	308 (82.79%)	168 (77.06%)	88 (78.57%)	0.093
	Nirvana Fallacy- trusting the judgement of AI over human intelligence (6 th Pref)	584 (83.19%)	318 (85.48%)	178 (81.65%)	88 (78.57%)	0.000
The barriers/ challenges of applying AI in Indian Health care	Absence of AI regulatory authority in India	156 (22.22%)	66 (17.74%)	56 (25.68%)	34 (30.35%)	0.405
	Cost effectiveness/Investment and Infrastructure	256 (36.46%)	152 (40.86%)	74 (33.94%)	30 (26.78%)	0.016
	Inadequate framework to ensure security, quality & accuracy of AI solutions.	106 (15.09%)	52 (13.97%)	32 (14.67%)	22 (19.64%)	
	Socio cultural acceptance-trust issues/ fear of AI replacing humans	184 (26.21%)	102 (27.41%)	56 (25.68%)	26 (23.21%)	

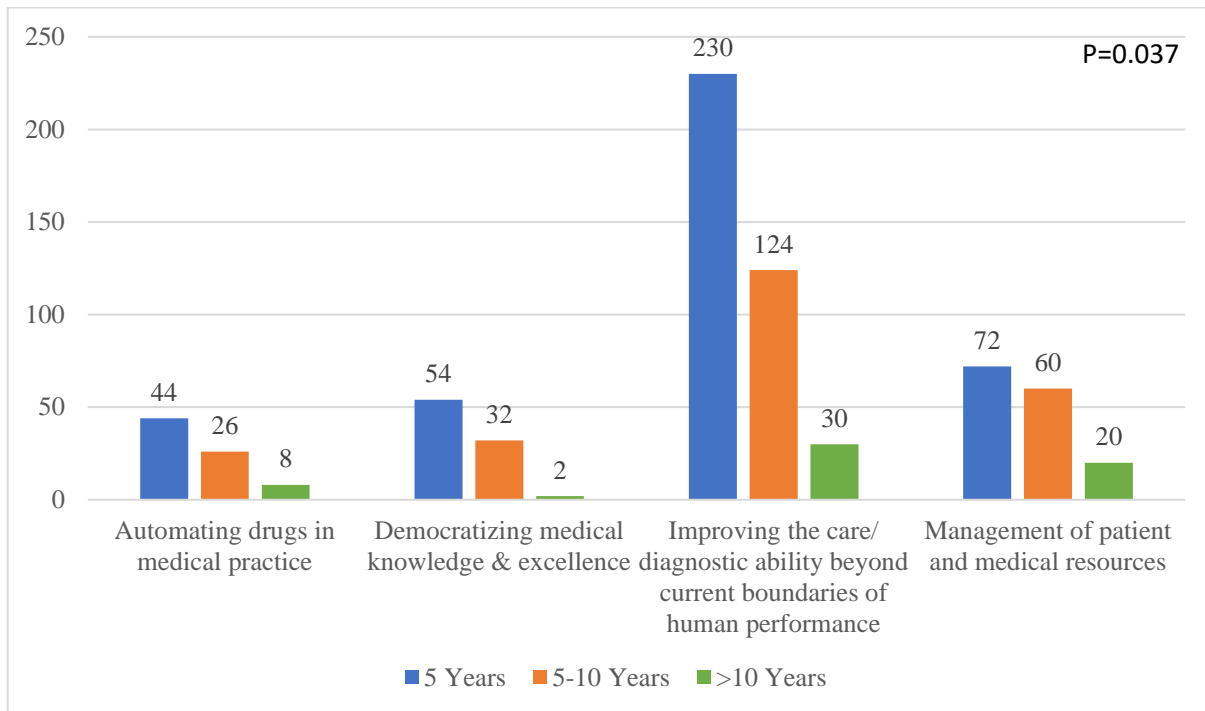
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Table 5: Future of AI in Healthcare as per specialization of Dentists

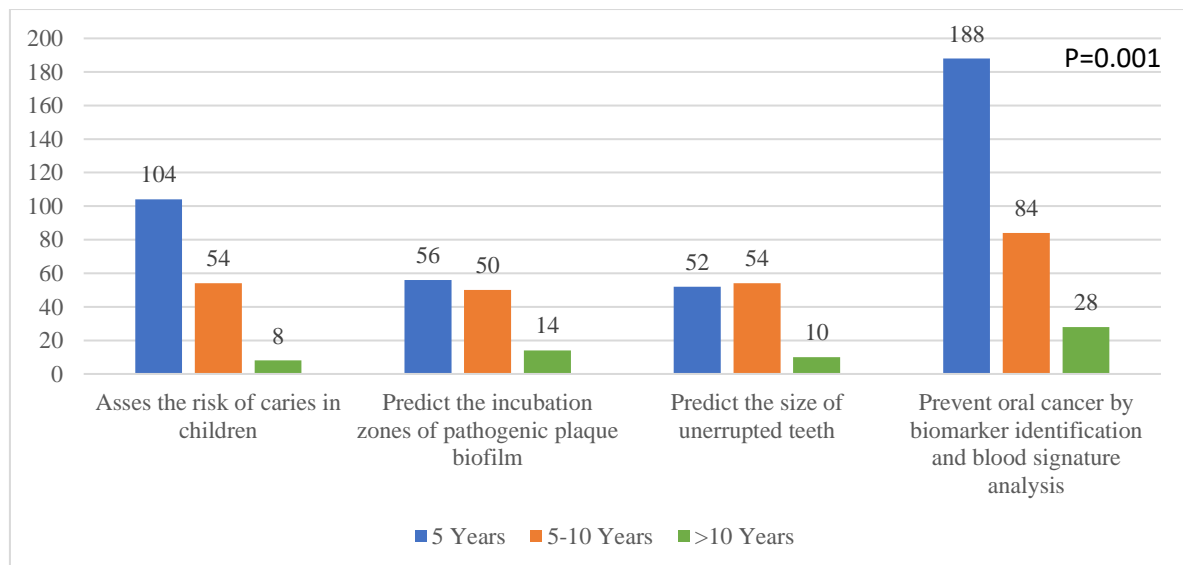
Questions	Responses	Total n=702 (%)	Education			P value
			BDS (n=372) (%)	MDS (n=218) (%)	Pediatric Dentist (n=112) (%)	
AI and Doc-Patient relationship	Help doctors in off-loading and allow them to spend more time in engaging with patients directly	324 (46.15%)	180 (48.38%)	88 (40.36%)	56 (50.00%)	0.249
	Provide richer and specific data for patient treatment option	178 (25.35%)	88 (23.65%)	60 (27.52%)	30 (26.78%)	
	Through telemedicine more patient reachability and definite access to health care	200 (28.49%)	104 (27.95%)	70 (32.11%)	26 (23.21%)	
AI for patient engagement in seeking healthcare	Biosensor/ smart watches- providing patients relevant recommendations	338 (48.14%)	200 (53.76%)	98 (44.95%)	40 (35.71%)	0.003
	Nudging patient behaviour by social media	112 (15.95%)	58 (15.59%)	38 (17.43%)	16 (14.28%)	
	Sending message alerts- to consciously draw patient attention	252 (35.89%)	114 (30.64%)	82 (37.61%)	56 (50.00%)	
AI as a part of learning for Under and Post graduate students in dental colleges	Yes	500 (71.22%)	314 (84.40%)	178 (81.65%)	8 (07.14%)	0.018
	No	28 (03.98%)	20 (05.37%)	4 (01.83%)	4 (03.57%)	

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	May be	174 (24.78%)	38 (10.21%)	36 (16.51%)	100 (89.28%)	
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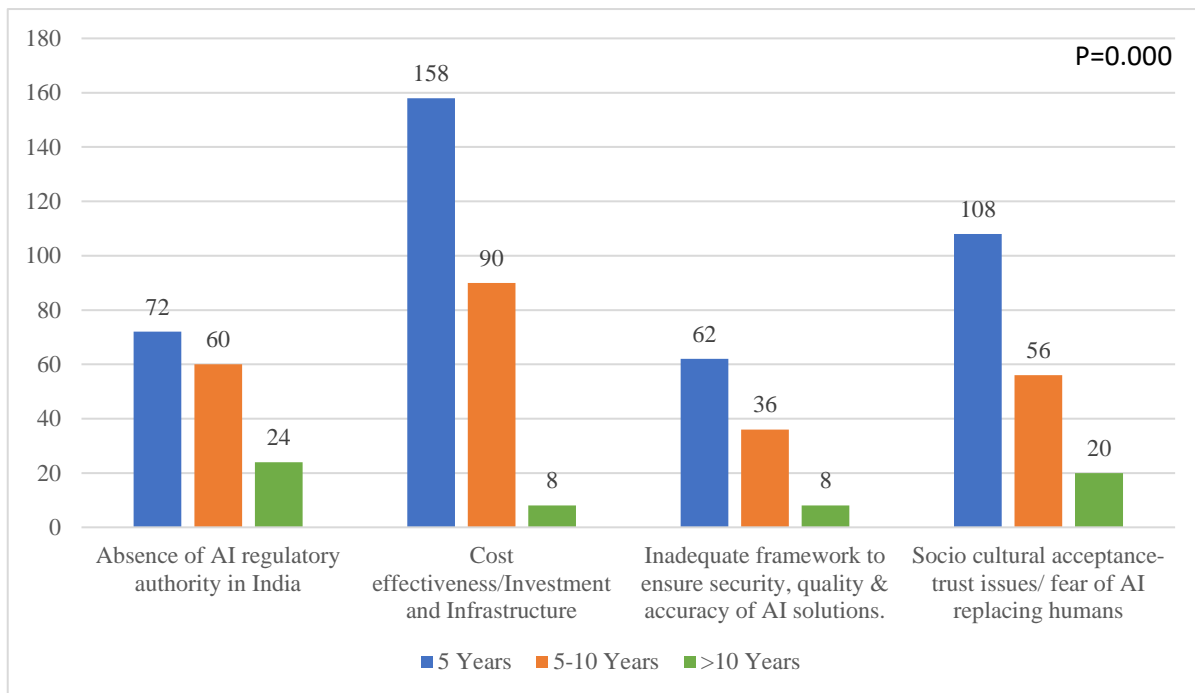


Graph 1: The most appropriate potential benefit of AI in Healthcare

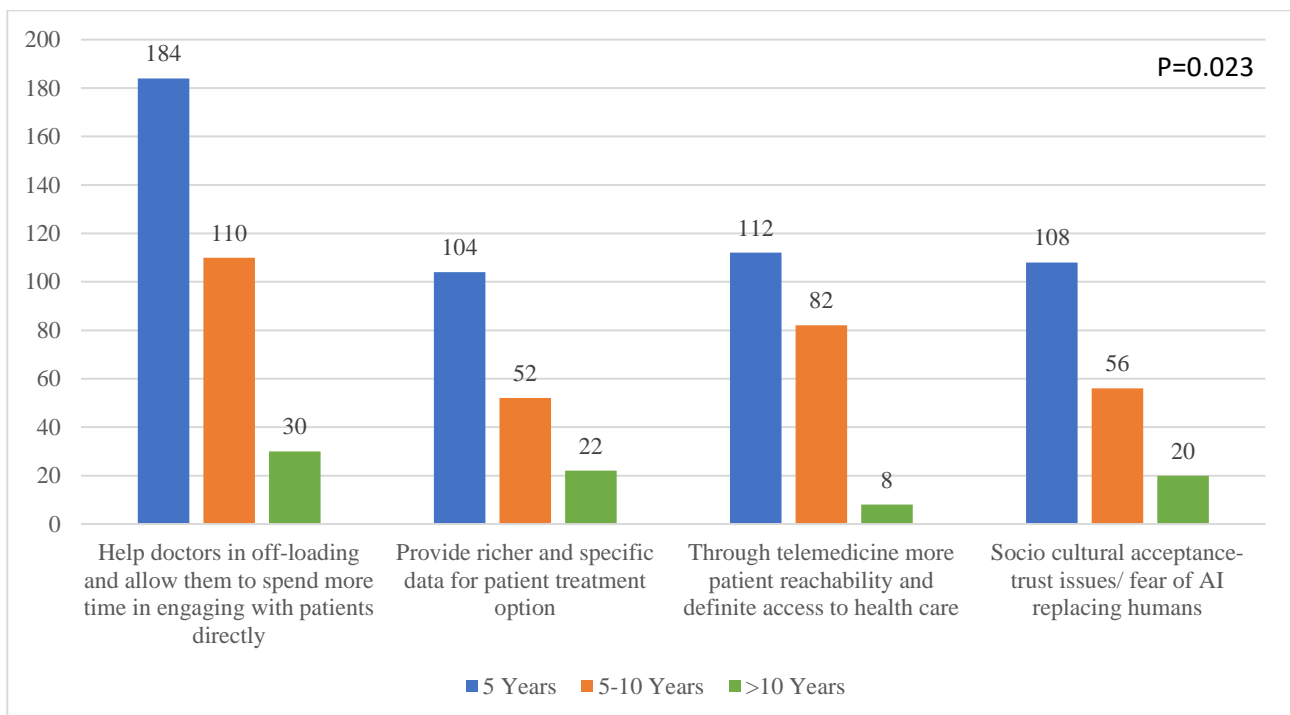


Graph 2: AI best used as a Preventive tool

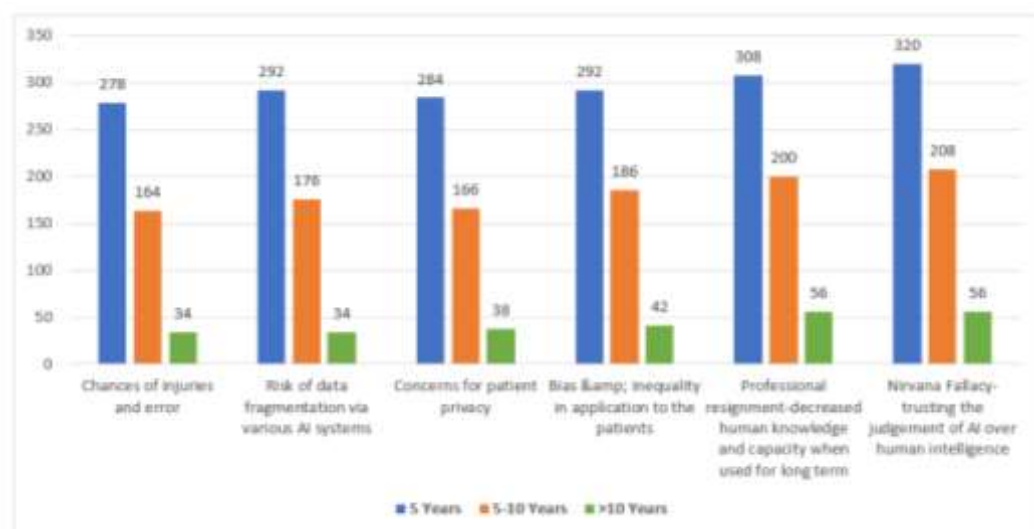
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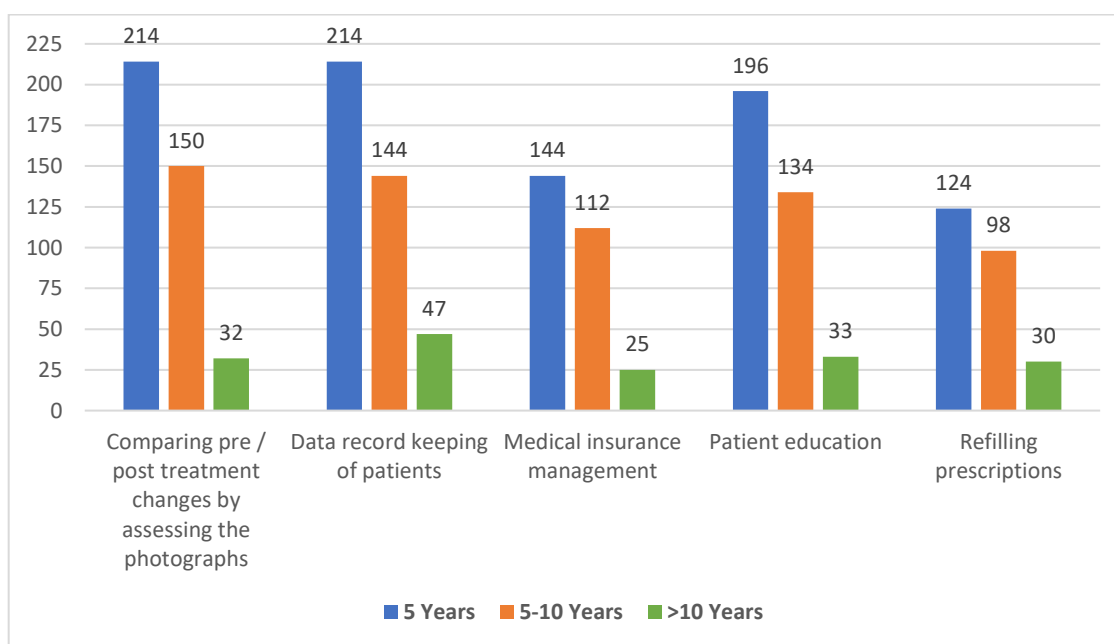
Graph 3: The barriers/challenges of applying AI in Indian Health care



Graph 4: AI and Doc- Patient relationship



Graph 5: The risks of applying AI in Indian Health care (select in order of preference)



Graph 6: The other applications of AI (multiple choice)

4. Discussion

Every healthcare personnel bears responsibility for innovation that leads to improved therapy and wellbeing of patients with increased ease and accessibility and without it, no progress can be made. Artificial intelligence is routinely being utilized in varied aspects of our daily life including the medical field, but is still in the teething phase in dentistry. Socio demographic variables, state law and policies, education, IT skills and many other factors affect the adaptability and acceptability of the population to the

new advancement or technology. To the best of our knowledge, this was the first of its kind survey that addressed the awareness and perception of dentists of Gujarat regarding applicability, barriers and risk of AI in dental practice and this makes this study unique.

Our study revealed that the majority of respondents were conscious of the usefulness of AI in healthcare and dentistry which is in contrast to Oh et al., 2019's survey of Korean medical practitioners, which concluded that only 5.9% were familiar with the concept of AI. A bibliometric study by B. X. Tran et

Journal of Coastal Life Medicine

al., 2019, claimed that the combination of AI, big data, and highly parallel computational approaches seems to have the potential to provide a revolutionary manner of delivering evidence-based individualized medicine.[10] In our survey, 54.7% of all participants, regardless of educational background or years of experience in dentistry practise, believed that clinical treatment and diagnostics might be fundamentally transformed with the assistance of artificial intelligence.

Various preventive applications of AI have been tested in the field of dentistry by different practitioners. Romanini et al in 2020 tested a prototype for diagnostic aid during oral cavity examination.[11] The sample used for the device training and validation showed 78.89% accuracy in diagnosis of oral cancer. In our study 49.46% BDS and 42.20% MDS were of the opinion that AI was best suited for analysis of preventing oral cancer by biomarker identification and blood signature analysis which was also the most reported finding in the practitioners with more than 10 years. However, the majority of Pediatric dentists (39.28%) differed in their opinion and preferred the best use of AI as a preventive tool in assessing the risk of caries in children. This is corroborated by Park et al.,2021, who compared ML forecasting model for the assessment of early childhood caries to classic regression models.[12] Data from the Korea National Health and Nutrition Examination survey (2007-2018) were reviewed and analysed. ML-based forecast models, like conventional prediction models, were capable of detecting ECC, anticipate high-risk groups, and develop a treatment plan.

On panoramic radiographs, AI has proven to be a credible technology for evaluating the depth of dental cavities, diagnosing apical lesions, determining working length, grading dental arches, tooth segmentation, TMJ osteoarthritis, and identifying early osteoporosis in jaws. Rekow used a machine-learning technique to identify and classify dental restorations in panoramic radiographs. [13] Kuwada et al discovered that "DetectNet and AlexNet" appeared to be potentially useful in categorizing the presence of impacted supernumerary teeth on panoramic radiographs in the maxillary incisor region.[14] Using bitewing images, the artificial neural network (ANN) models achieved 97.1% accuracy, 95.1% precision, 94.3% specificity and sensitivity ranging from 85% to

99.6%.[15] Using the AI model "back-propagation neural networks," Sornam and Prabhakaran reported accuracy ranging from 85 to 100% in dental caries classification.[16] However, comparisons between studies were difficult due to methodological differences. In our study the majority of the dentists (76.06%) irrespective of education or clinical experience, chose AI as a diagnostic tool for anticipating the progression and duration of dental caries in children as first preference and the least preferred application was detection and classification of impacted/ supernumerary teeth.

To extract marginal lines more precisely, Zhang et al used a deep learning model study.[17] A total of 380 dental preparation models were used in this study. The data was extracted using sparse octree (S-Octree) CNNs. 97.43% of the results were accurate on average. AI's ability to overcome manual errors made it a good option for implementation due to its higher accuracy. This was in accordance with our study where 39.25% BDS and 37.61% MDS agreed that AI's application in treatment planning could be best used for 3D tooth preparation or designing prosthesis (RPD/CD) for the patient. However, 37.5% Pediatric dentists differed in their opinion by reporting AI as best for assessing the root anatomy/ locating canal and apical foramen position in endodontics. This dissent can be considerable research that has been available on application of AI in endodontics and Pediatric dentists have more treatment experience in the field of endodontic procedures for children.

The world of AI is transforming continuously with its growing popularity in the healthcare sector worldwide. India still seems to lack its ability to successfully launch stable, acceptable and cost-effective AI based applications. Some of the challenges for AI-driven healthcare include unstructured data sets, interoperability, a lack of open sets of medical data, and woefully inadequate analytics solutions which can work with big data. [18,19] There is a scarcity of high-quality datasets related to diseases and conditions prevalent in these settings, making it difficult to train AI algorithms for identifying risk factors or diagnosing diseases. Furthermore, in many Indian healthcare settings, health records are handwritten in local languages, making the process even more difficult. Besides this, because the Indian population is so diverse, datasets may contain cultural biases such as caste, sexuality,

Journal of Coastal Life Medicine

etc. [20] In our study majority of dentists irrespective of their specialization or years of experience felt that the most accepted risk of applying AI in health care was chances of injuries and error. However, when barriers were assessed, the majority of dentists with different qualifications were of the same belief that it was lack of cost effectiveness/investment and infrastructure, compared to 41 % of clinicians with experience >10 years who felt that it was due to absence of AI regulatory authority in India and hence is not being accepted and applied.

Drevenstedt et al. employed voice commands to record patients' documents and data, to schedule patients' visits, to notify patients regarding routine check-ups and to reschedule necessary dental appointments. [21] In our study, practitioners with <5 years and 5-10 years of experience were of the opinion that AI could also be best used for comparing pre / post treatment changes by assessing the photographs while dentists with more than 10 years of experience identified data record keeping of patients as other best use of AI. High-end computing solutions can surpass the numerous challenges associated with manual data handling. This in turn can benefit doctors and their team to spend more time with patients and this was also reflected in our study as one of the major factors. The dentists in our study perceived that AI can be of great help when it comes to precision medicine and can engage the patients more in seeking healthcare by sending patient relevant recommendations through biosensors or smartwatches.

Limitations of the Study

The study was confined to a limited demographic area with a limited number of participants. Also, selection bias cannot be ruled out because respondents may have been more focused on AI and expressed more positive views than nonparticipants and each participant may have had a different understanding of AI. Follow-up surveys and multicentre research should be conducted to further investigate these issues.

5. Conclusion

According to the findings of this survey, dental practitioners in Gujarat believe that applying AI to dentistry would be beneficial in uplifting the dental

care by making it more accurate, accessible and patient and doctor friendly.

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Journal of Coastal Life Medicine

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