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RESEARCH ARTICLE

FROM TELL-SHOW-DO TO BEHAVIOUR BOTS: GAUGING THE CLINICAL ADOPTION AND HURDLES OF ARTIFICAL INTELLIGENCEIN PEDIATRIC DENTISTRY ACROSS KERALA

Sreelekshmi M S[1], Anandaraj.S[2], Sageena George[3] and Deepak Jose[2]

1. Post Graduate Student, Department of Pediatric and Preventive Dentistry, PMS College of Dental Science and Research, Kerala.
2. Professor, Department of Pediatric and Preventive Dentistry, PMS College of Dental Science and Research, Kerala.
3. Head of the Department and Professor, Department of Pediatric and Preventive Dentistry, PMS College of Dental Science and Research, Kerala.

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Abstract

Background:-Managing children's behaviour during dental treatment is an important part of pediatric dental practice. Dental anxiety and fear can make treatment difficult and may affect cooperation between the child and the dental team. Conventional behaviour guidance techniques remain important, but advances in artificial intelligence (AI) and digital technologies have introduced additional approaches for distraction, communication, education, and behavior guidance. However, informati on regarding the awareness and actual use of these technologies among pediatric dentists in Kerala is limited.

Aim:-To assess the awareness, familiarity, perceived effectiveness, utilization, educational needs, and barriers related to AI and digital technologies used for behaviour guidance among pediatric dentists in Kerala, India.

Materials and Methods:-A cross-sectional descriptive survey was conducted among pediatric dental professionals in Kerala, including private practitioners, academicians, and postgraduate residents. The questionnaire was distributed electronically through professional and academic networks, and 40 complete responses were obtained and included in the final analysis. Data were collected using an online questionnaire consisting of five sections: demographic characteristics, awareness and familiarity with AI, identification and use of digital technologies, perceived effectiveness and educational needs, and barriers to adoption. Descriptive statistics were used to summarize the responses.

Corresponding Author:-Anandaraj. S
Address:-Professor, Department of Pediatric and Preventive Dentistry, PMS College of Dental Science and Research, Kerala.

Results:-This survey evaluated the integration of AI and digital technologies for behaviour guidance in pediatric dentistry, revealing a predominantly young demographic (51.7% under 30) with moderate AI familiarity (51.7% somewhat familiar). VR/AR distraction tools were the most commonly reported digital technologies (88.6%), while the reported use of AI-based tools was lower. 71.8% of respondents noting that digital tools could potentially benefit emergency or uncooperative patients**.**89.2% of respondents perceived that these technologies could potentially help reduce children's fear and anxiety and improve cooperation, widespread clinical adoption remains restricted by a limited awareness of commercial tech (82.8%) and a lack of clinical training (72.4%). To address these barriers, 75.8% of respondents support incorporating AI and digital behaviour-guidance training directly into postgraduate dental education.
Conclusion:-Pediatric dentists in Kerala showed considerable awareness and a positive perception of AI and digital technologies for behaviour guidance, but actual clinical utilization was limited. Improved awareness, practical training, affordable technologies, adequate infrastructure, and evidence-based guidelines may help increase appropriate adoption of these technologies in pediatric dental practice.

Introduction:-

Securing a child's cooperation in the dental chair is a complex process that requires clinical skill, patience, communication, and an understanding of child psychology. Dental anxiety and fear may lead to uncooperative behaviour, difficulty in completing treatment, and avoidance of future dental visits. Behaviour guidance is therefore an important component of pediatric dental practice. Conventional approaches include tell-show-do, positive reinforcement, distraction, communication techniques, voice control, and, when indicated, pharmacological approaches such as nitrous oxide sedation and general anesthesia[1]

The development of digital technologies has introduced new non-pharmacological approaches for managing dental anxiety and improving cooperation. Virtual reality (VR), augmented reality (AR), digital games, mobile applications, and other interactive technologies can distract children from the clinical environment and provide an engaging experience during dental treatment[2,3,4,5]. Studies evaluating VR in pediatric dentistry have reported reductions in anxiety and pain during different dental procedures[5,6]

Artificial intelligence (AI) is another rapidly developing technology in healthcare and dentistry. AI refers to computer systems capable of performing tasks that normally require aspects of human intelligence, such as pattern recognition, prediction, classification, and decision-making.[7] Machine learning (ML) is a branch of AI that uses algorithms to identify patterns from data, while deep learning (DL) uses multilayered neural networks to analyse complex datasets. AI has been investigated in dentistry for image analysis, diagnosis, treatment planning, prediction, and patient management.[7,8]

In pediatric dentistry, AI applications have been studied in areas such as early childhood caries detection, tooth identification, prediction of dental disease, radiographic analysis, and treatment planning.[9,10]The systematic review of AI applications in pediatric dentistry reported promising results but also highlighted limitations in study quality, external validation, and clinical implementation.[9]AI has also been proposed for behaviour guidance, personalized communication, natural language processing, and oral-health education in children.[11]

Several interactive technologies may be useful for pediatric behaviour guidance. VR uses immersive visual and auditory experiences to divert a child's attention from the dental environment. AR combines digital content with the real-world environment and can provide interactive experiences during dental procedures. Gamification and oral-health applications can make dental education more engaging. Chatbots and natural language processing systems may provide information and communication before dental visits. AI-based systems may also have the potential to assist in assessing anxiety and developing personalized behaviour-guidance strategies.[11]

Although these technologies are developing rapidly, their routine use depends on clinician' s awareness, confidence, training, cost, infrastructure, and perception of their clinical usefulness. Previous surveys among dental professionals have demonstrated increasing awareness of AI but also identified important barriers related to knowledge, training, cost, ethics, and access to technology.[12,13,14] Recent studies specifically involving pediatric dental professionals in India have similarly reported positive perceptions of AI along with significant knowledge gaps and barriers to implementation.[14,15]

However, there is limited information regarding how pediatric dentists in Kerala perceive and use AI and digital technologies specifically for behaviour guidance. Understanding their current level of awareness, actual utilization, perceived benefits, and barriers is important for planning appropriate educational and clinical strategies.

Therefore, the present study was conducted to assess the awareness, familiarity, perceived effectiveness, utilization, educational needs, and barriers related to AI and digital technologies for behaviour guidance among pediatric dentists in Kerala, India.

Materials and Methods:-

Study design and setting:-

A cross-sectional descriptive survey was conducted among pediatric dental professionals in Kerala, India. The questionnaire was distributed electronically through professional and academic networks during the study period. As participation in individual questionnaire items was not mandatory, the number of valid responses varied across items. Percentages were therefore calculated based on the valid responses for each item. As the questionnaire was disseminated through multiple professional and academic channels, the exact number of individuals who received the questionnaire could not be reliably determined; therefore, a response rate was not calculated.

The survey was conducted anonymously, and no personally identifiable information, including names or contact details, was collected. Participation was voluntary, and participants were informed about the purpose of the study before completing the questionnaire. Submission of the completed questionnaire was considered to indicate informed consent to participate. Participants could discontinue participation before submitting their responses. The collected data were treated confidentially, used solely for research purposes, and access to the data was restricted to the research team.

Study participants:-

Participants were identified and recruited through professional and academic networks across Kerala, India. The target population included pediatric dentists, academicians, and postgraduate residents involved in pediatric dental practice. A non-probability convenience sampling technique was used. Pediatric dental professionals who were willing to participate and completed the questionnaire were included, while non-eligible participants and incomplete responses were excluded. A total of 40 complete responses were included in the final analysis. Participation was voluntary, and responses were collected anonymously.

Questionnaire:-

A structured, investigator-developed questionnaire was prepared to assess awareness, familiarity, utilization, perceived effectiveness, educational needs, and barriers related to the use of artificial intelligence (AI) and digital technologies for behaviour guidance in pediatric dentistry. The questionnaire was developed based on the objectives of the present study and a review of the relevant literature concerning AI and digital technologies in dentistry and pediatric behaviour guidance. The technologies were considered in two broad categories: AI-based technologies and non-AI digital technologies. AI-based technologies included AI-powered chatbots, natural language processing (NLP)-based applications, and AI-based emotion or anxiety-detection tools. Non-AI digital technologies included virtual reality (VR), augmented reality (AR), and gamification-based applications when used without an explicit AI component.For questions on technology use and barriers to adoption, participants were allowed to select multiple options, whereas other questions required a single response.

A structured questionnaire was developed to assess five major areas:-

Demographic characteristics: age and professional background.
Awareness and familiarity: participant's familiarity with AI and related technologies.
Technology identification and utilization: awareness and use of VR, AR, gamification, anxiety-monitoring tools, chatbotsandNatural language processing (NLP) applications.
Perceived effectiveness and educational needs: perceived usefulness of AI and digital technologies for behaviour guidance and opinions regarding inclusion of AI training in postgraduate education.
Barriers to adoption: awareness, training, cost, infrastructure, technical concerns, privacy, parental resistance, and other practical limitations.

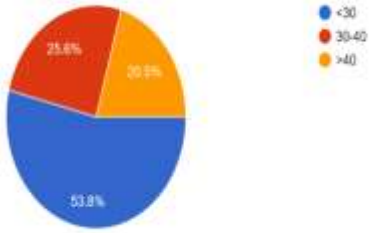
Data collection:-

The questionnaire was distributed electronically over a defined data-collection period. Responses were screened for completeness before analysis.

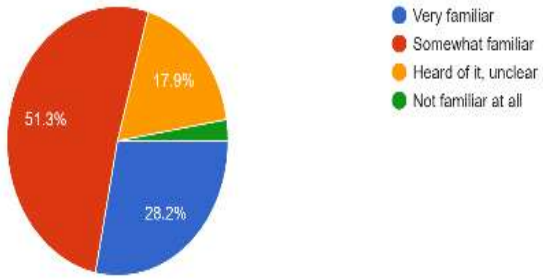
Statistical analysis:-
Data were analysed using descriptive statistics. Categorical variables were summarized as percentage. Inferential statistical analysis was not performed because of the small sample size and the variable number of valid responses across individual questionnaire items, which limited the statistical power and reliability of subgroup comparisons. The findings were therefore interpreted descriptively.

Results:-
A total of 40 responses were included in the analysis. Frequencies and percentages are presented based on the valid responses for each individual item.

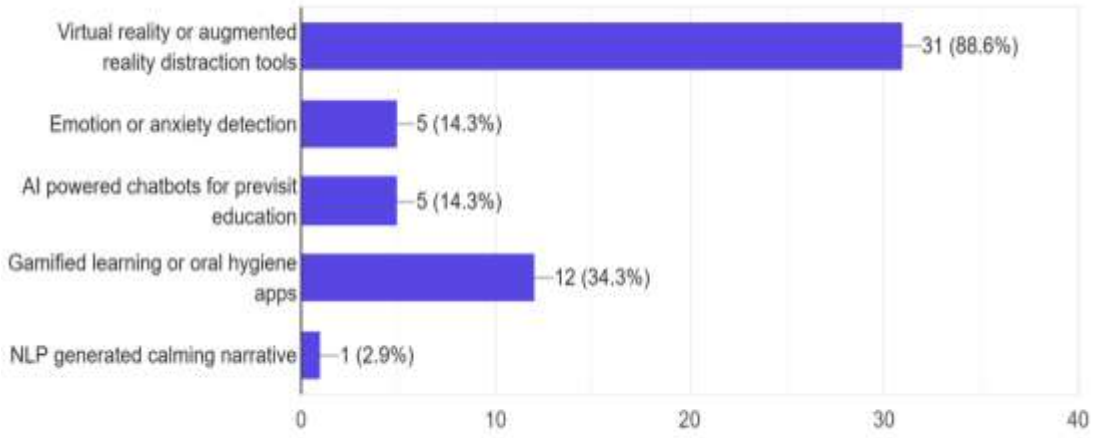
Demographic characteristics:-
The largest proportion of participants were below 30 years of age, accounting for 51.7% of respondents. Participants aged 30–40 years represented 27.6%, while 20.7% were above 40 years.



Awareness and familiarity with AI:-
More than half of the respondents (51.7%) reported being somewhat familiar with AI. A further 27.6% reported being very familiar with AI, while 17.2% had heard of AI but were unclear about its applications. Only a small proportion reported no familiarity with AI.These findings indicate that most participants had at least some awareness of AI, although a smaller proportion reported a high level of familiarity.



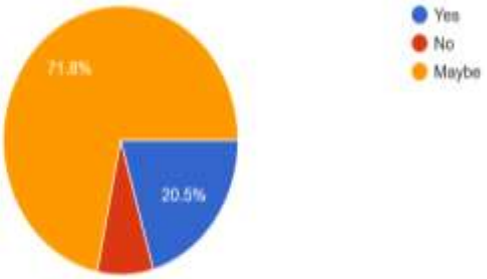
AI-based and digital technologies used for behaviourguidance:-
VR/AR distraction tools were the most commonly reported digital technologies, with 31 participants (88.6%) reporting their use**.** Gamified learning or oral-health applications were reported by 12 participants (34.3%). Emotion or anxiety-detection tools and AI-powered chatbots were each reported by 5 participants (14.3%). NLP-generated calming narratives were reported by 1 participant (2.9%).



These findings indicate that immersive and interactive technologies were more commonly used than newer AI-based communication and anxiety-monitoring tools.

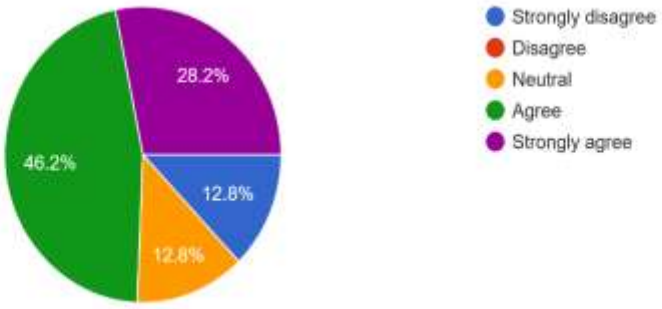
Use in emergency or uncooperative patients:-

When participants were asked whether AI could be useful during emergency treatment or with an uncooperative child, 71.8% selected "Maybe," while 20.5% selected "Yes." Only a small proportion selected "No." This suggests that although most participants were open to the possible use of AI in difficult clinical situations, many remained uncertain about its practical effectiveness.



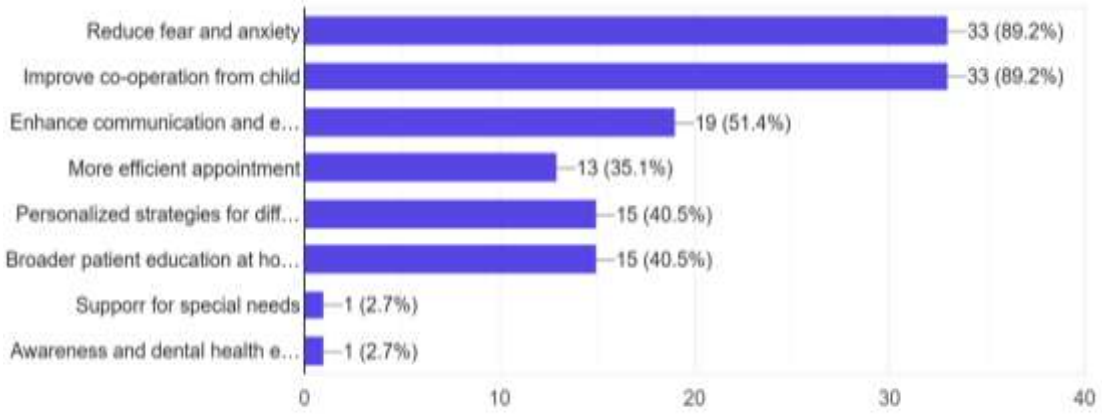
Educational needs:-

A majority of participants supported the inclusion of AI and digital behaviour-guidance training in postgraduate pediatric dental education. This finding suggests that pediatric dentists are interested in receiving structured education to understand and use emerging technologies in clinical practice.



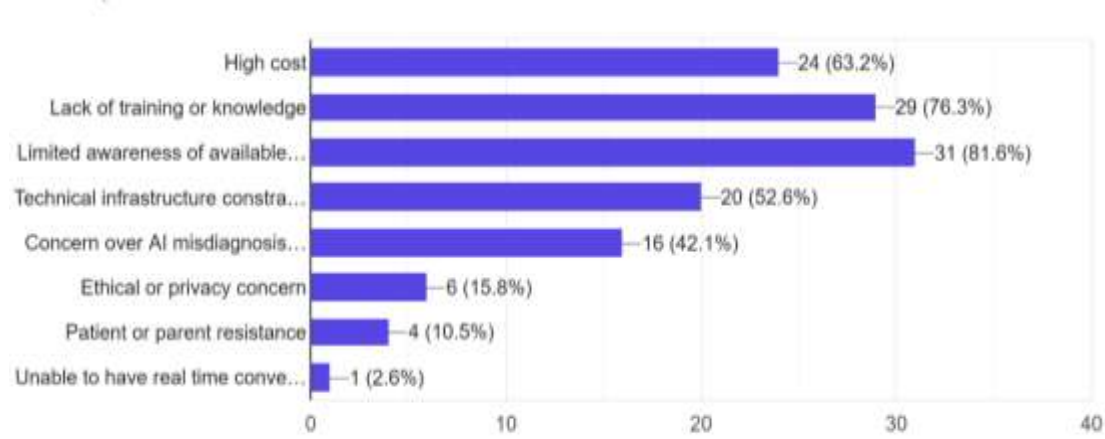
Expected benefits:-

The most frequently perceived potential benefits were the potential reduction of fear and anxiety and improvement in child cooperation, each reported by 89.2% of participants. Enhancement of communication was reported by 51.4% of participants. Personalized strategies for difficult cases and improved patient education were each identified by 40.5% of participants, while 35.1% identified improved appointment efficiency as a potential benefit.



Barriers to adoption:-

The most frequently reported barrier was limited awareness of available commercial technologies (82.8%). Lack of access to practical clinical training was reported by 72.4%. High equipment and procurement costs were reported by 55.2%, followed by infrastructure limitations (44.8%) and concerns regarding software or technical errors (41.4%). Privacy and ethical concerns were reported by 17.2%, while patient or parental resistance was reported by 6.9%. Only 3.4% identified slow or delayed conversational technology as a barrier.



Domain	Variable / Response	Percentage (%)
Demographic characteristics	Below 30 years	51.7
	30–40 years	27.6

	Above 40 years	20.7
Awareness and familiarity with AI	Very familiar	27.6
	Somewhat familiar	51.7
	Heard of AI but unclear about its applications	17.2
	Not familiar	3.5
AI-based and digital technologies used for behaviour guidance	VR/AR distraction tools	88.6
	Gamified learning/oral-health applications	34.3
	Emotion/anxiety-detection tools	14.3
	AI-powered chatbots	14.3
	NLP-generated calming narratives	2.9
Usefulness in emergency/uncooperative patients	Yes	20.5
	Maybe	71.8
	No	7.7
Expected benefits	Reduction of fear and anxiety	89.2
	Improvement in child cooperation	89.2
	Enhanced communication	51.4
	Personalized strategies for difficult cases	40.5
	Improved patient education	40.5
	Improved appointment efficiency	35.1
	Support for children with special needs	2.7
	Increased dental-health awareness	2.7
Barriers to adoption	Limited awareness of available commercial technologies	82.8
	Lack of access to practical clinical training	72.4
	High equipment/procurement cost	55.2
	Infrastructure limitations	44.8
	Concerns regarding software/technical errors	41.4
	Privacy and ethical concerns	17.2

	Patient/parental resistance	6.9
	Slow or delayed conversational technology	3.4
Educational needs	Support inclusion of AI/digital behaviour-guidance training in postgraduate education	75.8
	Other/not supportive	24.2

Discussion:-

Artificial intelligence (AI) and digital technologies are becoming increasingly relevant in healthcare and dentistry, with potential applications extending from diagnosis and treatment planning to patient education, communication, and behaviour guidance. [8,9,10] In pediatric dentistry, the use of these technologies is particularly relevant because children may experience fear, anxiety, and difficulty cooperating during dental treatment. Digital technologies such as virtual reality (VR), augmented reality (AR), gamification, chatbots, and other interactive applications may provide additional methods of distraction and communication, thereby complementing conventional behaviour guidance techniques. [2,3,4]AI may further support these approaches by allowing the development of personalized and interactive systems based on patient characteristics, communication patterns, and behavioural responses. [9,10,11]

The present study specifically evaluated the awareness and use of AI and digital technologies for behaviour guidance among pediatric dentists in Kerala. The findings provide an overview of the current level of familiarity with AI, the types of technologies being used in clinical practice, their perceived usefulness, expected benefits, educational requirements, and barriers to implementation. Understanding these factors is important because awareness of emerging technologies does not necessarily translate into their routine clinical use. It helps to identify the existing gap between interest in AI and its practical application in pediatric dental practice. This information may be useful in planning appropriate training programs and developing strategies for the safe, effective, and evidence-based integration of AI and digital technologies into pediatric dentistry.

Most participants had at least some familiarity with AI. More than half were somewhat familiar with AI, while 27.6% were very familiar. This suggests that AI has gained substantial recognition among pediatric dental professionals. Similar findings have been reported in recent Indian studies. Naik et al. surveyed 400 pediatric dental professionals and found that 65% were aware of AI applications in pediatric dentistry, although knowledge gaps and barriers related to cost, ethics, and training were identified.[15]Santhosh et al. also reported favourable perceptions of AI among Indian pediatric dentists and emphasized the importance of awareness and training for successful implementation.[14]

The present findings also indicate that awareness does not necessarily result in clinical use. More than half of the participants had never used digital technology with a patient, while only a small proportion reported regular use. This difference between awareness and implementation is important. AI and digital technologies may be attractive to clinicians, but practical adoption requires appropriate training, access to suitable equipment, technical support, and evidence demonstrating clinical benefit. [7,12,15]

71.8% “Maybe” response regarding AI and digital technologies for emergency or uncooperative patients indicates uncertainty about their applicability. As the reasons were not explored, factors such as limited experience or training cannot be confirmed. This may reflect the need for further evidence and hands-on experience before routine adoption, particularly as behaviour guidance must be individualized according to the child and treatment context.[1]
The most commonly reported expected benefits in the present study were reduction of fear and anxiety and improvement in cooperation. This is consistent with the findings of clinical studies evaluating VR and other digital distraction methods. [6] However, these technologies should be considered adjunctive methods rather than replacements for established behaviour guidance. The American Academy of Pediatric Dentistry recommends individualized behaviour guidance based on the child's developmental level, treatment needs, previous experiences, and clinical circumstances.[1]

The present study found that the major barriers to adoption were limited awareness of available technologies and lack of practical training. This finding is consistent with recent Indian studies. Naik et al. identified knowledge gaps

and lack of training as important challenges to AI integration among pediatric dental professionals.[15] Santhosh et al. similarly highlighted the need for improved awareness and training among Indian pediatric dentists.[14] These findings indicate that continuing dental education and postgraduate training may have an important role in improving responsible adoption of AI and digital technologies. Cost was another important barrier identified in the present study. Advanced VR equipment, software subscriptions, computers, cameras, and other digital infrastructure may increase the initial cost of implementation. For private dental practices, particularly smaller practices, the cost of equipment may discourage adoption even when clinicians perceive the technology as useful. Infrastructure limitations were also reported by a considerable proportion of participants.

Digital behaviour-guidance systems may require suitable computers, stable internet connectivity, compatible software, maintenance, and trained staff. Without adequate infrastructure, even clinicians who are willing to use the technology may find routine implementation difficult. Concerns regarding software and technical errors were reported by 41.4% of participants. Such concerns are important because AI-based systems may produce incorrect or inconsistent outputs. AI should therefore not be considered an independent decision-maker in pediatric dentistry. Clinical decisions should remain under the responsibility of the pediatric dentist, who should evaluate the child's individual needs and critically interpret any technology-assisted information. [7,8,11] Privacy and ethical concerns were reported less frequently than awareness, training, cost, and infrastructure. However, these issues remain important. AI systems may collect patient information, images, behavioural data, or audio recordings. Appropriate safeguards for data protection, informed consent, transparency, and responsible use are therefore necessary before these systems are incorporated into routine clinical care. [7,8]

An important finding was the high level of interest in educational training. Most participants supported the inclusion of AI and digital behaviour-guidance training in postgraduate education. This is consistent with the increasing recognition that future dental professionals will require basic AI literacy. Training should not be limited to operating a particular device. It should also include understanding the capabilities and limitations of AI, interpretation of AI-generated outputs, data privacy, ethical considerations, and appropriate clinical decision-making. [8,11,15] The present findings are also relevant when compared with the existing evidence on AI in pediatric dentistry. Current research has primarily focused on diagnosis, image analysis, caries detection, prediction, and treatment planning rather than direct AI-based behaviour guidance [9,10,11] Therefore, the positive perception of AI for behaviour guidance in the present study should be interpreted as an indication of clinician interest and perceived potential rather than proof of clinical effectiveness.

Overall, the findings indicate a gap between awareness and reported implementation of AI and digital technologies among pediatric dental professionals in Kerala. The findings are broadly consistent with previous Indian studies regarding the importance of awareness, training, and barriers to implementation. [14,15] Differences between studies may be explained by variations in participant characteristics, geographic setting, professional experience, access to technology, educational exposure, and the rapidly changing nature of AI. Importantly, the perceived benefits reported in the present study represent clinicians' perceptions and should not be interpreted as demonstrated clinical effectiveness. Structured training, affordable technologies, adequate infrastructure, technical support, and evidence-based clinical guidelines may help address the gap between awareness and implementation. Future studies should evaluate these technologies using standardized clinical outcomes in children, including validated measures of anxiety, behaviour, pain, and treatment completion.

The findings highlight the need for structured AI and digital technology training in postgraduate pediatric dental education. Training should include practical use of VR/AR and other digital tools, patient selection, integration with conventional behaviour guidance, AI literacy, data privacy, and ethical considerations. In clinical practice, these technologies should be used as individualized adjuncts rather than replacements for established behaviour-guidance techniques. Their use should consider the child's needs, available infrastructure, cost, technical support, and data-protection requirements. The findings suggest an emerging transition from conventional approaches such as Tell-Show-Do towards technology-assisted behaviour guidance. However, the concept of "Behaviour Bots" should be understood as representing the emerging potential of AI-enabled interaction rather than the current standard of pediatric dental care. Appropriate adoption will depend on evidence of clinical effectiveness, practitioner training, affordability, infrastructure, and the development of clear evidence-based guidelines.

Limitations:-

The study has several limitations. The sample was limited to 40 pediatric dental professionals in Kerala, which may restrict generalizability and introduce selection bias. As the questionnaire was distributed through multiple

professional and academic networks, the response rate could not be calculated and non-response bias cannot be excluded. Reliance on self-reported awareness, perceptions, and technology use may have introduced self-reporting and recall bias, while the questionnaire requires further validation for reliability and validity. The cross-sectional design provides only a snapshot of current perceptions and cannot establish causal relationships or changes over time. Furthermore, perceived benefits were not supported by objective clinical outcomes and should not be interpreted as demonstrated clinical effectiveness. Larger, multicentric and longitudinal studies using validated instruments and objective clinical measures are warranted.

Future Research:-

Future studies should move beyond perception-based surveys to multicentric clinical studies involving larger samples. Research should use validated anxiety and behaviour measures and assess clinical outcomes such as pain, treatment completion, and patient satisfaction. Safety, technical reliability, privacy, and cost-effectiveness should also be evaluated. Randomized controlled trials would provide stronger evidence regarding the clinical effectiveness and appropriate use of these technologies.

Conclusion:-

Pediatric dentists in Kerala demonstrated considerable awareness and positive perceptions regarding the potential role of AI and digital technologies in behaviour guidance, although reported clinical utilization was limited. The findings highlight the need for greater awareness, practical training, affordable technologies, and adequate infrastructure to support appropriate adoption. As this was a cross-sectional survey based on clinician's perceptions and self-reported use, the findings do not establish clinical effectiveness. Further multicentric clinical studies are needed to evaluate the effectiveness, safety, and cost-effectiveness of these technologies in pediatric dental practice.

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