ARTIFICIAL INTELLIGENCE IN PEDIATRIC DENTISTRY BEFORE THE 21ST CENTURY: A HISTORICAL REVIEW OF LITERATURE

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LITERATURE REVIEW

ABSTRACT

Artificial Intelligence (AI) has been prominently used in the field of healthcare since the 20th century. The last decade has seen an exponential rise in its applications in the field of pediatric dentistry. This historical review attempts to explore the use of AI before the 21st century in the field of pediatric dentistry. A search strategy was carried out across four relevant databases. 35 articles published in the English language before 2000 that met the inclusion criteria were screened. 8 studies were sought for retrieval, out of which full-text was available for only 3 articles. The included studies revealed the use of AI in pediatric dentistry in the sub-fields of histology, dental trauma, and behavior guidance.

Keywords: *Artificial Intelligence, Pediatric Dentistry, Historical Article, Questionnaire, Decision Tree*

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INTRODUCTION

The imitation game of 1950 by Alan Turing, and the 1956 Dartmouth conference are supposed to be the two timepoints that define the birth of artificial intelligence (AI). A stagnant phase followed from the 1970s till the 1990s, when development of AI came to a standstill. This era is termed as AI Winter. The boom of the World Wide Web reignited the interest in AI. Simultaneous technological advances that more prominently flourished in the 2010s, led to the advent of AI Spring.[1]

The earliest use of AI in healthcare can be traced back to 1972, when an expert system called 'MYCIN' was developed by Stanford University to identify bacteria and recommend suitable antibiotics accordingly. The nidus of AI application in dentistry is hazy and is postulated to begin in the late 1980s. The specialized field of pediatric dentistry is no stranger to AI.

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Machine learning has been a catalyst in assessment of age, identifying landmarks, growth estimation, cephalometry, teeth identification, diagnosing cavities, and making orthodontic evaluations.[2]

Recent systematic reviews on the application of AI in pedodontics have included studies published between 2009 to 2023. Thus, the objective of this paper is to review the prevalence of AI in pediatric dentistry before the 21st century.

METHODS

To satisfy our objectives, we report our search strategy in accordance with the PRISMA-S guidelines.[3] The databases chosen for our search included PubMed, Global Index Medicus (GIM), TRIP, and ScienceDirect. Table 1 lists down the search strategy used in each database along with the application of limits. None of our search strings were previously used or reported. All search strategies were first run in April 2024. An updated search was rerun in July 2024. The advanced search bar was opted for whenever possible.

DATABASE	SEARCH STRATEGY	LIMITS	HITS
PubMed	(("artificial intelligence"[tiab]) OR ("ai"[tiab]) OR ("machine learn*"[tiab]) OR ("deep learn*"[tiab])) AND ("dent*"[tiab]) NOT ("amelogenesis imperfecta"[tiab]) NOT ("apnoea index"[tiab])	Time: Till 2000 Language: English	33
Global Index Medicus	(artificial intelligence) AND (pediatric dentistry)	Time: Till 2000	0
IEEE Explore	pediatric dentistry AND machine learning AND artificial intelligence	Search: Full text & Metadata	1
ScienceDirect	(“Artificial intelligence”) AND (“pediatric dentistry”)	Time: Till 2000	2

Table 1 Search strategy

Each author in this paper was allotted a database to run the search strategy. KS accessed PubMed MedNar, whereas KP accessed GIM and ScienceDirect. The search results that met the inclusion criteria (filters/limits) were then de-duplicated. Both researchers simultaneously performed the title and abstract screening. A final screening was done to identify all papers with full-text availability.

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RESULTS

After the application of limits, a total of 35 articles were identified that were published in the English language till the year 2000. 33 of these articles were available on PubMed, whereas 2 results were displayed on ScienceDirect. None of the 35 articles were duplicate. Title and abstract screening excluded the two results from ScienceDirect due to lack of relevance. During the abstract screening of results on PubMed, the authors realised that the acronym 'AI' has been used to describe several facets that are not relevant to our study. These have been summarized in Figure 1.

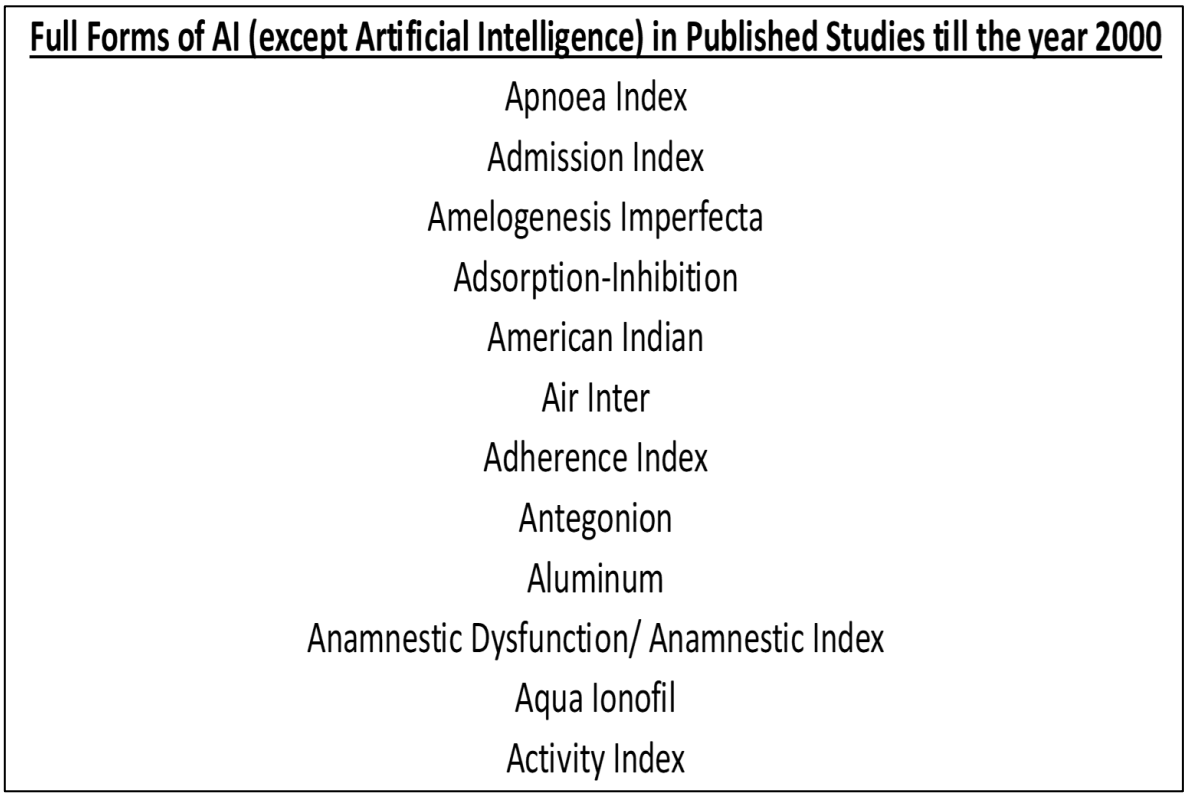

Figure 1 Full forms of AI (except Artificial Intelligence) in published studies till the year 2000

Thus, every result wherein the full form of AI was not artificial intelligence was excluded. Furthermore, two studies that were of interest to this review did not have an abstract available and were hence eliminated. A total of six articles met the inclusion criteria on PubMed. However, full text was available for only three articles. A flow diagram of studies to be included in these analysis is revealed in Figure 2.

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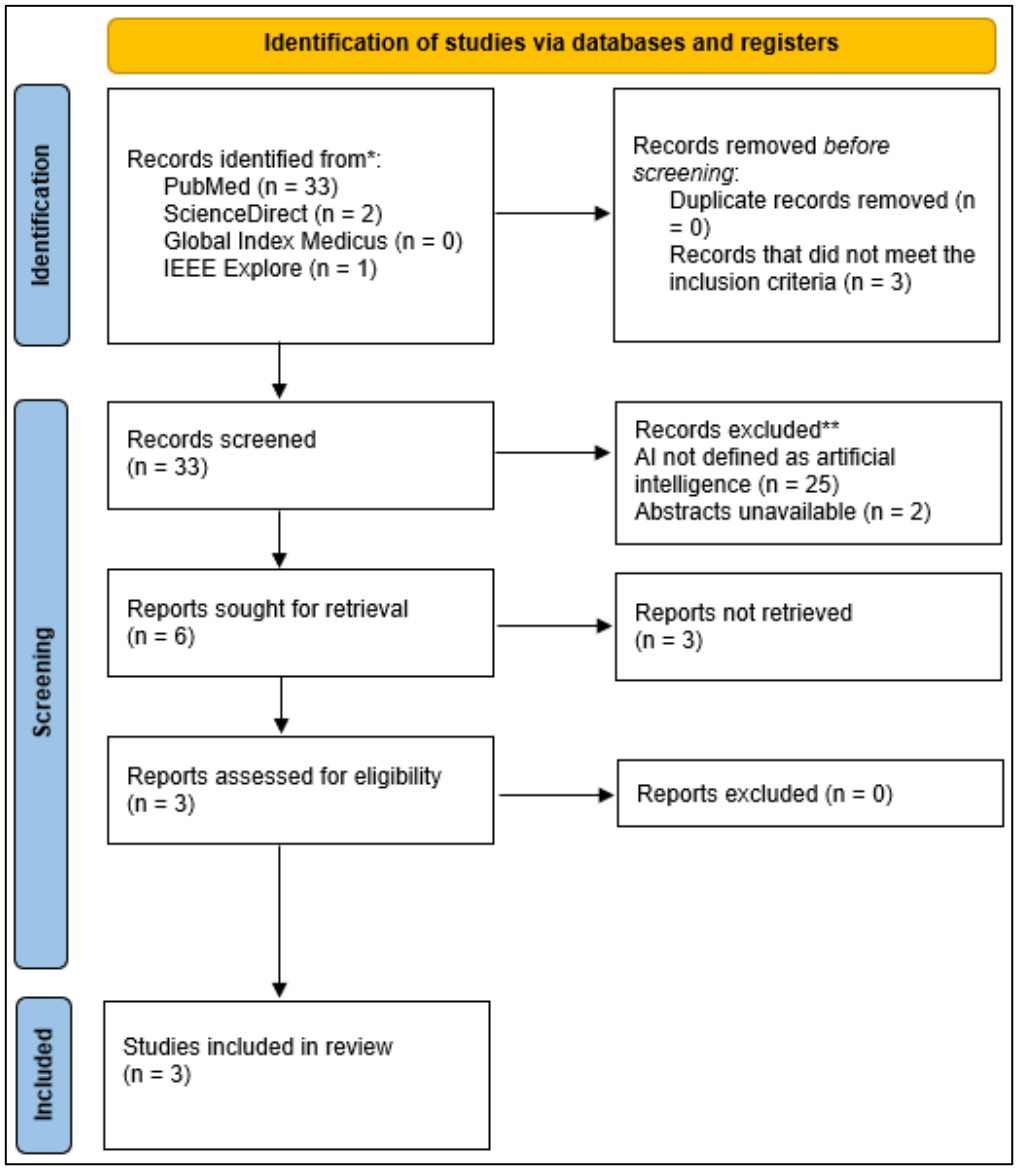

Figure 2 Prisma flow diagram

A summary of articles that were excluded in the final screening round is given in Table 2. The studies that were included for our review are outlined in Table 3.

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YEAR	AUTHOR(S)	SUMMARY	REASON FOR EXCLUSION
1990	Zusman SP	-	Abstract not available
1991	Mackin N, Sims-Williams JH, Stephens CD	-	Abstract not available
1986	Ralls SA, Cohen ME, Southard TE	Computer assisted dental diagnosis. No mention of study design or relevance to pediatric dentistry in particular.	Full-text not available
1995	Zhang X, Cai F, Liu F, Bao X, Liu Y	Medical examination system that uses artificial intelligence and is designed for persons who wish to obtain higher professional posts in healthcare	Full-text not available
1999	Farman AG, Farman TT	Description of "RVG-ui" that uses a charged couple device, making it superior over traditional direct exposure peri-apical radiographs in terms of speed of image acquisition, reduction of radiation dose, storage of images, and data retrieval. The use of AI in this system has been described for diagnosing proximal caries.	Full-text not available

Table 2 Reasons for exclusion of studies after final screening

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YEAR	AUTHOR(S)	AI SYSTEM USED	FIELD OF PEDIATRIC DENTISTRY	SUMMARY
1996	Nilsson T, Lundgren T, Odelius H, Sillen R, Noren JG	Inductive learning and neural network analysis	Histology	Co-variations between different elements in the enamel of human deciduous molars could be identified. Commonly observed co-variations included sodium and chlorine, potassium and fluoride, and magnesium and strontium.
1998	Robertson A, Sillen R, Noren JG	Inductive learning and neural network analysis	Dental Trauma	Functional, Personal, and Social effects of patients' oral situation following dental trauma in patients between 7-19 years of age as per their results from a questionnaire.
1999	Klingberg G, Sillen R, Noren JG	Induction Analysis	Behavior Guidance	Analysing the relation between dental fear and anxiety, and behavior management problems.

Table 3 Included studies in the final data synthesis

DISCUSSION

The three studies included in our study were published between 1996 to 1999.[4-6] Notably, two authors, Jorgen G. Noren and Rudolf Sillen were a part of all the included studies. Thus, every included study had University of Gothenburg as one of the affiliations. None of the included studies featured an artificial intelligence system that had a direct clinical intervention.

The primary method of machine learning in the included studies was by induction. Through induction, relationships between variables (symbolic input) can be an output in the form of information (graphical representation).

There are methodological similarities in the studies published between 1996 and 1998. A workflow pattern can be derived wherein the authors use an inductive analysis program (XpertRule Analyser, Attar Software Ltd., Lancashire, UK) to analyse data that was presented as a spreadsheet which in turn was generated by either Microsoft Excel 3.0 or Graph-in-the-box Windows 3.0. The results from the inductive analysis are presented as decision trees or knowledge trees. A neural network analysis was used to verify the results of the induction analysis. This ensured that the decision trees are split in accordance with different attributes such that each factor is related to the other in hierarchy.

Pruning of data is to reduce the effect of outliers on the results generated through neuronal networks. This further facilitates accuracy in statistical testing and helps in normalization of data. This was a common step carried out in all included studies.

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based on the results of our included studies, AI systems using inductive learning and neural networks could successfully reveal co-variations between elements in the enamel of the human deciduous molar (accuracy: 95%), conclude from the subjective experiences of patients with a history of dental trauma to have physical and emotional complications, and to understand that dental fear stems primarily due to non-dental reasons and is not directly linked to behavior management problems.

Reflections from these pre-21st century studies shed light on the volume of technological advances that has occurred in the last two decades. Machine learning has now a subset called deep learning which is a form of knowledge acquisition for machines that is derived through multi-layered neural networks and large, clustered datasets (also known as big data). Moreover, machines now have the ability of unsupervised learning, wherein they can identify patterns without an input of additional variables.

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