World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

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The Role of Digital Technology in the Early Diagnosis and Prediction of Early Childhood Caries: A Literature Review

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World Journal of Advanced Research and Reviews, 2025, 28(03), 1618–1627

Publication history: Received 11 November 2025; revised on 20 December 2025; accepted on 22 December 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.28.3.4223

Abstract

Early Childhood Caries (ECC) is a common multifactorial disease in children under six years old and is associated with considerable adverse effects on oral health, growth, development, and quality of life. Early detection of ECC is challenging because initial lesions are often subclinical and difficult to identify using conventional diagnostic methods. This study aimed to review and synthesize current evidence on the role of digital technology, particularly artificial intelligence (AI), in supporting the early diagnosis and prevention of ECC. A literature review was conducted using international databases, including Pubmed, Scopus, ScienceDirect and ResearchGate focusing on peer-reviewed English-language articles published within the last five years. Studies involving children under six years of age that applied AI-based technologies for ECC diagnosis or risk prediction were included. The analysis of ten selected articles demonstrated that machine learning and deep learning models, such as convolutional neural networks, vision transformers, and ensemble learning methods, achieved high accuracy, sensitivity, and specificity in detecting advanced carious lesions and predicting ECC risk based on clinical, behavioral, socioeconomic, salivary, and genetic data. However, limitations were consistently observed in the detection of early non-cavitated lesions. Overall, the findings indicate that AI-based digital technologies serve as effective clinical decision support tools that enhance diagnostic accuracy, risk stratification, and preventive planning for ECC. Although AI cannot replace conventional clinical examination, its integration into pediatric dental care holds strong potential to support earlier, more targeted, and personalized prevention strategies for treating dental caries in young children.

Keywords: Early Childhood Caries; Digital technology; Artificial Intelligence; Machine learning; Deep learning; Diagnosis; Prediction

1. Introduction

Early Childhood Caries (ECC) describes the presence of dental caries in children younger than six years, indicated by decayed, missing due to caries, or filled primary teeth[1]. Dental caries is a non-communicable disease characterized by the loss of tooth mineral resulting from the activity of acid-producing microorganisms within the oral biofilm. *Streptococcus mutans* is the main bacterium responsible for caries development, while other species such as *Lactobacilli, Actinomyces,* and *Candida albicans* also contribute to its progression [2]. Globally, approximately 48% of preschool-aged children experience ECC, and more than 573 million children do not receive adequate dental care. This condition has significant effects on children's growth and development, nutritional status, and quality of life, as well as that of their families [1].

ECC is influenced by various factors, including children's dietary patterns, parental feeding practices, and exposure to cariogenic microorganisms [3,4]. A history of caries in parents also increases the risk of ECC in children [3]. Other risk factors include excessive sugar consumption and poor oral hygiene [2,4]. Clinically, ECC is characterized by dull white

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spots on the enamel due to demineralization, which may progress to cavitation if left untreated [2,4]. Diagnosis is established through visual assessment, clinical examination, and radiographic evaluation, particularly in children with high-risk factors [4,5]. Early detection is essential, as it can prevent progression to more severe forms of ECC (severe ECC) [4,5].

Primary teeth play an essential role in aesthetics, speech, mastication, and space maintenance for permanent teeth; therefore, their health must be preserved [6]. Preventive strategies for ECC include reducing sugar intake, improving daily oral hygiene behaviors, increasing caregiver awareness, and the application of fluoride-based preventive measures [7,8]. The use of fluoride varnish or fluoride mouth rinses has been proven effective in reducing caries incidence in children. Because ECC treatment is relatively costly and has a high recurrence rate, primary prevention is considered the main focus. The Centers for Disease Control and Prevention (CDC) classifies disease prevention into three levels: primary prevention to stop the initial occurrence of diseases, secondary prevention for the early identification of diseases, and tertiary prevention to slow down disease progression [9].

The advancement of digital technology in dentistry has significantly transformed clinical practice, research, and disease prevention, while enhancing accuracy, efficiency, and patient comfort in diagnostic and treatment processes. Innovations such as intraoral scanning, cone beam computed tomography (CBCT), and quantitative light-induced fluorescence (QLF) allow for early detection of dental lesions without radiation exposure, support more accurate diagnoses, and promote non-invasive approaches to caries prevention [10].

One of the most prominent innovations in digital technology is the use of artificial intelligence (AI), especially machine learning (ML) and deep learning (DL) [11,12]. Machine learning (ML), as a field within artificial intelligence (AI), enables the analysis of large amounts of data (social and economic) to predict healthcare demands, identify disease trends, and recognize populations at higher risk [13]. Based on data obtained through machine learning, AI can recognize complex patterns to generate automated diagnoses and support clinical decision-making [11]. Meanwhile, deep learning (DL) allows simulation models to learn complex data at varying levels of abstraction and assists computers in forming complex concepts from simple data. Among deep learning approaches, Convolutional Neural Networks (CNNs) have demonstrated high effectiveness in image-based dental caries detection by autonomously learning and extracting relevant features from dental imaging data [12].

The utilization of digital technology and AI has a significant impact on patients' quality of life by accelerating diagnostic and treatment processes, enhancing communication between dentists and patients, and expanding access to dental healthcare services, particularly in resource-limited areas [14]. In addition, digital technology supports greater patient involvement in treatment decision-making, as patients can more easily understand treatment options through digital simulations and visualizations. This has the potential to improve patient compliance and satisfaction, which are crucial in the early prevention of dental caries in children [15].

The objective of this study is to explore the role of digital technologies in facilitating early diagnosis and preventive strategies for Early Childhood Caries (ECC).

2. Methods

This study was conducted as a literature review to examine the role of digital technologies, particularly artificial intelligence (AI), in supporting the early diagnosis and risk prediction of Early Childhood Caries (ECC). Literature searches were conducted using international online databases, including Pubmed, ScienceDirect, Scopus and ResearchGate. The search strategy employed combinations of keywords such as "early childhood caries," "artificial intelligence," "machine learning," "deep learning," "diagnosis," and "prediction." To maintain the relevance of the evidence base, this review included only English-language, peer-reviewed publications released within the past five years.

Eligible studies included those involving children younger than six years that utilized AI-driven digital technologies for the diagnosis or prediction of ECC and reported performance metrics such as accuracy, sensitivity, specificity, or the area under the receiver operating characteristic curve. Both observational studies and systematic reviews were considered, while studies not focusing on ECC, not using AI-based approaches, or unavailable in full-text format were excluded.

The included studies were analyzed qualitatively by grouping them into diagnostic and predictive domains. Diagnostic studies primarily utilized image-based analysis, intraoral scans, saliva-based assessments, or spectroscopic data combined with machine learning or deep learning models, whereas predictive studies integrated clinical, behavioral, socioeconomic, or genetic variables to estimate ECC risk. Relevant data were extracted and summarized in structured tables, followed by a descriptive synthesis to evaluate the contribution of AI-based digital technologies to ECC diagnosis, early detection, and preventive decision-making in pediatric dental care.

3. Results

A total of 208 articles were found based on the search results from four databases. Ten publications were chosen for this study after being screened in accordance with the inclusion and exclusion criteria, consisting of five articles addressing diagnostic variables and five articles addressing predictive variables.

Table 1 Results of literature studies for diagnostic variables

References	Study Design	Sample Size	Digital Technology Used	Performance Materics	Outcomes	Author conclusion
Hashim et al., 2025	cross-sectional analytical study	104 children saliva sample	Laser-induced breakdown spectroscopy (LIBS) + Artificial Neural Network (ANN)	Accuracy (91.8% for multivariate, 92.7% for spectroscopic data)	LIBS demonstrated high effectiveness in predicting caries risk with good accuracy based on saliva characteristics.	Combining LIBS with AI opens new possibilities for ECC screening via telehealth, enhancing accessibility for early detection
Al-Namankany, 2023	Systematic review	6 study reviewed	Machine learning models (e.g., CNNs, XGBoost, AutoML)	AUC (0.74-0.85), Sensitivity (68.8%-92%), Specificity (86%-95%)	Machine learning techniques showed consistent and accurate results in detecting early childhood caries.	AI models hold promise for improving ECC detection, but further research is necessary to standardize their use in clinical practice.
Schwarzmaier et al., 2024.	cross-sectional study	143 dental images	AI-based image evaluation tool (deep learning)	Accuracy (97.2%), Sensitivity (68.8% to 98.5%), Specificity (86.1% to 99.4%), AUC (0.834 to 0.964)	High accuracy in detecting caries across various severity levels, with the best performance in dentin cavities.	The AI model performs well across varying caries severity stages. Further external validation with larger and diverse datasets is recommended.
Felsch M et al., 2023	cross-sectional study	18,179 dental images	Vision transformer-based AI model	Precision (0.99), Recall (0.99), F1 Score (0.77-0.82)	The transformer-based model showed excellent diagnostic performance in	The vision transformer technology offers superior detection accuracy for caries and could

					detecting caries and MIH, particularly for dentin cavities.	be a more effective alternative to CNNs for future applications.
Jones et al., 2025	cross-sectional study	216 participants, 4396 teeth	Intraoral scan data with Attention U-Net deep learning	Precision (0.78), Recall (0.66), Specificity (0.96)	The model performed excellently in detecting advanced caries.	The AI model shows promise, especially for later-stage lesions, but further improvements are necessary for early caries detection.

Table 2 Results of literature studies for prediction variables

References	Study Design	Sample Size	Digital Technology Used	Performance Materics	Outcomes	Author conclusion
Sadegh-Zadeh et al., 2022	Cross-sectional study	780 parents with children under 5 years	Machine Learning: DT, XGBoost, KNN, LR, MLP, RF, SVM (linear, RBF, polynomial, sigmoid)	Accuracy: Range from 92% (DT) to >97% (RF and MLP); evaluated using Leave-One-Out and K-fold cross-validation	Identified key risk factors like sugary foods, not attending regular dental visits, and parental socioeconomic level	Machine learning models, particularly RF and MLP, effectively predict ECC risk and enable targeted preventive programs
Al-Namankany, 2023	Systematic review	6 studies analyzed	AI-driven diagnostic tools (CNN, AutoML)	High sensitivity and specificity, AUC values from 0.74 to 0.90	Improved clinical decision-making, targeted preventive measures	AI holds potential for personalized ECC management
Hasan et al., 2025	Cross-sectional study	724 mothers with children under 6 years	Machine Learning (RF, XGBoost, RFC)	AUC-ROC: 0.77, Accuracy: 72%, Sensitivity: 80%	Identified risk factors: plaque score, brushing frequency, maternal education	ML model effectively predicts ECC in a low-resource setting
Park et al., 2021	Cross-sectional study	4195 children aged 1-5 years	XGBoost, Random Forest, LightGBM, Logistic Regression	AUC: 0.774–0.785, Misclassification: 0.235	ECC risk prediction models were comparable to traditional methods	ML models can aid in predicting and preventing ECC with targeted interventions
Zaorska et al., 2021	Case-control study	95 children (48	Neural Networks (ANNs)	Sensitivity: 90%, Specificity: 96%, AUC: 0.970	Identified SNPs as strong	Neural networks and SNP analysis

		caries and 47 caries-free)			predictors for ECC	offer substantial tools for early ECC prevention

4. Discussion

Dental caries is a condition with a multifactorial etiology characterized by the demineralization of dental hard tissues, namely enamel, dentin, and cementum, and may occur in both primary and permanent dentitions [23]. Early Childhood Caries (ECC) affects children younger than six years and is defined by the presence of one or more carious primary teeth, including both cavitated and non-cavitated lesions, primary teeth lost as a result of caries, or teeth that have been restored. Beyond oral health, ECC is associated with adverse effects on children's physical growth and development, as well as nutritional status and oral health–related quality of life for both children and their families. Furthermore, children with caries are known to have lower school attendance rates and suboptimal academic performance [1]. Globally, the prevalence of ECC remains high, with estimates reaching 49% among preschool children, with the lowest prevalence reported in Greece at 19.3% and the highest in the Philippines at 98% [24].

Early Childhood Caries (ECC) has multifactorial causes and is primarily triggered by an imbalance in the oral microbiota resulting from the activity of cariogenic bacteria that are acidogenic and aciduric, particularly *Streptococcus mutans* and *Streptococcus sobrinus.* ECC is also frequently associated with poor dietary patterns and inadequate oral health maintenance behaviors [25]. In early childhood, the oral bacterial flora is still developing and the immune defense system has not yet fully matured, allowing caries to progress rapidly [25]. This process is exacerbated by additional risk factors such as inappropriate bottle-feeding practices, particularly the use of bottles containing sweetened liquids before bedtime, the transition from natural to artificial nutrition, and the shift from liquid to semi-solid foods [25]. The frequency of sugar consumption, plaque accumulation, reduced protective function of saliva, prolonged acid exposure, and low socioeconomic conditions collectively contribute to the initiation and progression of ECC [26].

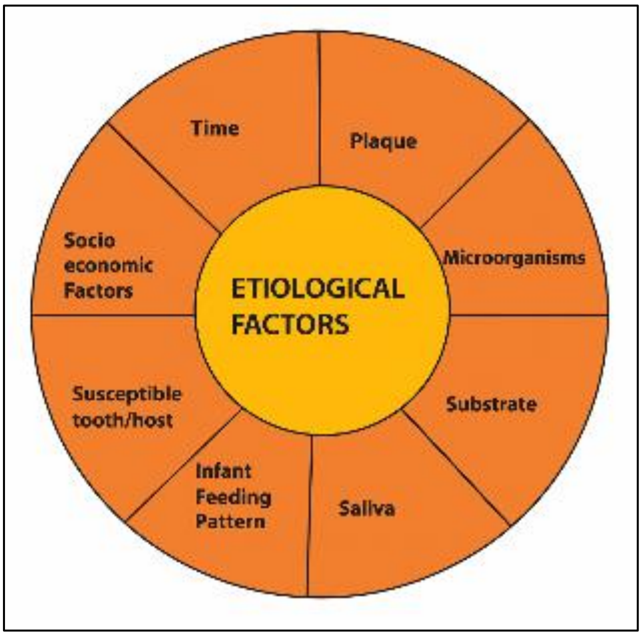

Figure 1 Etiological factors of Early Childhood Caries (ECC) [26]

The pathogenesis of dental caries is characterized by mineral loss (demineralization) and erosion of the hard dental tissues resulting from a marked decrease in pH within plaque-covered areas [25]. This process begins with the vertical transmission of cariogenic microorganisms such as *Streptococcus mutans* and *Streptococcus sobrinus* from mother to child, as well as horizontal transmission among family members [26]. These microorganisms ferment simple carbohydrates, particularly sucrose, into organic acids that significantly lower the local pH [27]. Repeated acid production, in conjunction with the presence of risk factors, creates an increasingly acidic microenvironment in which the buffering capacity of saliva is insufficient to neutralize the condition. As a result, an imbalance in the microbial ecosystem (dysbiosis) occurs, promoting the dominance of aciduric bacteria and accelerating demineralization without adequate remineralization, thereby initiating white spot lesions that may subsequently progress to cavitated defects [28].

Detecting Early Childhood Caries (ECC) at an early stage remains difficult due to the subclinical nature of initial lesions. In efforts to overcome the limitations of conventional methods, digital technologies based on artificial intelligence (AI) have been employed to support the prediction of ECC risk. Through data-driven approaches such as machine learning, AI is capable of integrating demographic, behavioral, and maternal factors, including the child's age, socioeconomic status, toothbrushing habits, maternal age at childbirth, and maternal caries status, to estimate the probability of ECC occurrence and accurately and consistently classify children into specific risk groups [21,12]. This predictive approach enables the identification of high-risk children before the clinical manifestation of caries, thereby supporting the implementation of early preventive strategies and more targeted interventions. In addition to its predictive capabilities, AI has also been reported to play a role in the diagnosis of ECC, particularly through deep learning–based image analysis. Models such as convolutional neural networks are able to analyze intraoral photographs and radiographic images to detect very subtle early-stage carious lesions that are often overlooked during visual examination and conventional radiographic assessment, demonstrating higher sensitivity without a significant reduction in specificity [11]. Thus, the integration of AI in both the prediction and diagnosis of ECC not only enhances early accuracy and consistency but also supports a more preventive and personalized approach to the management of early childhood caries.

1.1. The Role of Artificial Intelligence in Supporting the Diagnosis of Early Childhood Caries (ECC)

Advances in artificial intelligence have substantially influenced the field of dentistry, including in supporting the diagnosis of early childhood caries. Numerous studies have demonstrated that AI is capable of improving the accuracy of caries lesion detection, accelerating the diagnostic process, and reducing inter-clinician subjectivity. In the study by Hashim et al. (2025), the integration of Laser-Induced Breakdown Spectroscopy (LIBS) with Artificial Neural Networks (ANN) demonstrated high effectiveness in predicting caries risk based on salivary characteristics, with an accuracy of 91.8-92.7%. This study highlights that the success of AI models depends not only on algorithmic performance but also on methodological transparency, data generalizability, and class bias evaluation. These findings are consistent with the study by Chen et al. (2022), which showed that Convolutional Neural Network algorithms applied to bitewing radiographs were able to detect proximal lesions with higher sensitivity than conventional visual examination, although false positives were still observed. In addition, a systematic review by Nzenwata (2024) emphasized the importance of implementing explainable AI so that diagnostic results can be understood by clinicians as well as patients' parents, thereby increasing trust in the technology.

A systematic review conducted by Al-Namankany (2023) highlighted AI as a decision support system that enhances diagnostic consistency, with findings indicating that AI is sufficiently accurate in detecting early childhood caries, particularly in advanced lesions. Deep learning technologies based on radiography and intraoral photographs are used to extract visual features such as changes in enamel color and texture, thereby assisting in the identification of early lesions that are often overlooked during conventional visual examination. In line with these findings, Uribe et al. (2021) emphasized the importance of integrating behavioral factors in children into caries risk prediction so that diagnosis is not solely image-based but also multifactorial in nature. Furthermore, Veseli et al. (2024) demonstrated the potential of AI-based smartphone applications to rapidly detect early childhood caries in community settings. This technology processes images of children's teeth captured using smartphone cameras and classifies the presence of caries lesions using deep learning algorithms, thereby expanding diagnostic access, particularly in areas with limited radiographic facilities. In addition, an umbrella review by Arzani et al. (2025) found that the accuracy of AI in caries detection was relatively consistent across various modalities, including radiographs, intraoral photographs, and intraoral scans, with high sensitivity for advanced lesions but remaining limited for early lesions. These findings reinforce Al-Namankany's perspective that further AI development is still required to effectively detect non-cavitated lesions.

Schwarzmaier et al. (2024) reported that AI performance was higher for advanced lesions than for early lesions because CNN models analyze radiographic pixel intensity to differentiate between healthy and carious teeth. However, limitations in detecting non-cavitated lesions were still observed, indicating the need for data augmentation and multimodal approaches to improve sensitivity. Consistent with these findings, a meta-analysis by Maniangat and Rezallah (2025) showed that AI sensitivity for early lesions remains low despite relatively high specificity. This study emphasized the importance of large datasets and high-quality annotations. In addition, Priyanka et al. (2025) stated that integrating multifactorial data such as age, diet, and socioeconomic status with clinical images can enhance AI capability in diagnosing early childhood caries, thus reducing reliance solely on visual analysis.

Felsch et al. (2023) utilized Vision Transformers on large-scale intraoral photographs to detect caries lesions in children. This technology divides images into small patches and processes relationships between patches through attention mechanisms, enabling more comprehensive capture of complex visual patterns compared to conventional CNN-based approaches. The model achieved high accuracy, exceeding 90%, for dentin cavitated lesions, although delineation of early lesions remains challenging. Consistent with these findings, Kühnisch et al. (2021) reported AUC values ranging from 0.89 to 0.93 for pediatric intraoral photographs, with higher sensitivity for dentin lesions compared to enamel lesions. Furthermore, Alraeesi et al. (2024) demonstrated that the application of Vision Transformers to dental radiographs improved caries diagnostic efficiency by leveraging large and diverse datasets, although generalization to new data remains a challenge.

Meanwhile, Jones et al. (2025) applied Attention U-Net to pediatric intraoral scans for 3D image segmentation and classification of caries severity based on the ICCMS. Although high recall was achieved for advanced lesions, detection performance for early lesions remained limited, highlighting the need for multimodal integration. Similar findings were reported by Asci et al. (2024), who used U-Net Deep CNN on pediatric panoramic radiographs, achieving sensitivity above 90% for dentin lesions but experiencing reduced performance for early lesions. Alharbi et al. (2023) showed that Attention U-Net increased AUC values to 0.91-0.94 and improved sensitivity for small proximal lesions compared to standard U-Net, although limitations in detecting early enamel lesions persisted. A study by Zhang (2024) combined Attention U-Net within a multi-model approach and achieved overall accuracy above 90%, yet the pattern of reduced performance for early lesions remained consistent.

Based on the synthesis of these studies, it can be concluded that artificial intelligence has significant potential in supporting the diagnosis of early childhood caries. Various deep learning approaches, including Convolutional Neural Networks, Vision Transformers, and Attention U-Net, demonstrate strong capability in improving the accuracy of caries detection in children, particularly for advanced lesions and across multiple imaging modalities such as radiographs, intraoral photographs, and intraoral scans. Although AI performance varies depending on data type, methodology, and population characteristics, most studies consistently report limitations in detecting early lesions, particularly non-cavitated lesions. Therefore, future AI development should focus on integrating multifactorial data, adopting multimodal approaches, and conducting cross-population validation to ensure that this technology can be reliably and effectively implemented in pediatric dental practice.

1.2. The Role of Artificial Intelligence in Supporting the Prediction of Early Childhood Caries (ECC)

Based on the results presented in Table 2, study by Sadegh-Zadeh et al. (2022) demonstrated that various machine learning algorithms exhibit very high predictive capability in identifying the risk of Early Childhood Caries (ECC) in children under five years of age. By involving 780 parents with children, this study applied multiple models, including Decision Tree, Random Forest, Multilayer Perceptron, and Support Vector Machine, resulting in accuracy levels ranging from 92% to more than 97%. These findings indicate that machine learning approaches are capable of integrating multifactorial risk factors, including patterns of sweet food consumption, frequency of dental visits, and parental socioeconomic conditions. Accordingly, the results of this study emphasize the potential of AI in supporting comprehensive ECC risk prediction and underpin the development of more targeted preventive programs.

These results are complemented by a systematic review conducted by Al-Namankany (2023), which analyzed six studies related to the use of AI technology in the prediction and diagnosis of ECC. The review indicated that multiple AI-driven diagnostic approaches, including convolutional neural networks and automated machine learning models, consistently reported high sensitivity, specificity, and AUC metrics. Beyond demonstrating robust technical performance, the results emphasized the role of AI in improving clinical decision-making and facilitating the development of more personalized preventive strategies. Furthermore, the incorporation of this systematic review into the results table offers a broad perspective on current trends in AI applications for ECC management and underscores the clinical relevance of digital technologies.

Furthermore, Hasan et al. (2025) developed machine learning models based on Random Forest and XGBoost in a mother-child population in Bangladesh, involving 724 subjects. The developed models demonstrated relatively good performance, with an AUC-ROC value of 0.77, an accuracy of 72%, and a sensitivity of 80%. Although the accuracy was lower compared with several other studies included in the table, the relatively high sensitivity indicates the model's ability to identify children at risk of ECC, which is particularly important in the context of early screening. The main risk factors identified included plaque scores, toothbrushing frequency, and maternal education level, confirming that AI models are capable of capturing relevant behavioral and environmental determinants, especially in regions with limited dental healthcare resources.

A large population-based approach was demonstrated in the study by Park et al. (2021), which analyzed data from more than 4,000 children aged 1-5 years using various machine learning algorithms, including XGBoost, Random Forest, and LightGBM, and compared them with traditional logistic regression. The results showed that all models exhibited relatively similar AUC values, ranging from 0.774 to 0.785, with a misclassification rate of 0.235. These findings indicate that although the performance of machine learning is comparable to conventional statistical methods, AI technology still offers advantages in managing multivariate and non-linear data. Therefore, the results of this study support the use of AI as an assistive tool in ECC prediction and in identifying groups of children at high risk who may benefit from preventive interventions.

In addition to approaches based on clinical and behavioral factors, Zaorska et al. (2021) introduced a biological approach through the use of artificial neural networks based on single nucleotide polymorphisms (SNPs) in a case-control study involving 95 children. The developed model demonstrated very high performance, with a sensitivity of 90%, specificity of 96%, and an AUC of 0.97. These results indicate that integrating genetic data with AI technology can significantly enhance the predictive capability for ECC. Accordingly, this study broadens the perspective of AI application in ECC risk prediction by emphasizing more personalized and precision-oriented approaches within pediatric dental care.

Overall, the synthesis of studies presented in the table indicates that artificial intelligence technology has strong capability in supporting the prediction and diagnosis of Early Childhood Caries (ECC) through complex and multifactorial data analysis. These findings align with the general understanding of the role of artificial intelligence in healthcare, where AI functions as an advanced analytical tool capable of simultaneously processing non-linear and multivariate data. This is consistent with the study by Alowais et al. (2023), which stated that the primary advantage of AI lies in its ability to integrate diverse clinical and non-clinical data sources to improve risk assessment accuracy and disease detection, conceptually supporting the predictive and diagnostic results reported in this table.

Although most studies included in the table demonstrate promising performance, variations in accuracy, sensitivity, and AUC values across studies indicate that AI model performance is strongly influenced by population characteristics, data quality, and the algorithmic approaches employed. These findings align with the perspective that artificial intelligence is not yet capable of fully replacing clinical examination, but instead serves to complement and enhance clinicians' diagnostic processes. This is in line with the study by Tun et al. (2025), which emphasized that AI-based systems are most effective when used as clinical decision support systems, where AI-generated results still require interpretation and validation by healthcare professionals before being applied in clinical practice. Accordingly, the results presented in this table reinforce the position of AI as a complementary technology that supports, rather than replaces, clinical judgment in the management of ECC.

5. Conclusion

Early Childhood Caries (ECC) is a multifactorial disease with a persistently high global prevalence and far-reaching consequences that extend beyond oral health to affect children's growth, development, quality of life, and social and academic functioning. Its development results from complex interactions among biological, behavioral, environmental, and socioeconomic factors, driven by oral microbial dysbiosis, frequent sugar consumption, and limited protective mechanisms such as saliva, leading to progressive demineralization of dental hard tissues. A major challenge in ECC management is the early detection of initial, often subclinical, lesions. In this context, artificial intelligence (AI) has demonstrated substantial potential in supporting both the diagnosis and risk prediction of ECC through advanced machine learning and deep learning approaches capable of integrating clinical, behavioral, demographic, and even genetic data. Evidence consistently shows that AI achieves high accuracy in identifying advanced carious lesions and in predicting high-risk children, although its performance remains limited for detecting early non-cavitated lesions. Therefore, AI is best used as a clinical decision support tool that complements, rather than replaces, conventional clinical examination, with future development focusing on multifactorial data integration, multimodal approaches, and cross-population validation to enable earlier, more targeted, and personalized prevention and management of ECC.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there are no conflicts of interest associated with this research.

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