AI-Enhanced Radiographic Caries Detection in Children

A Scoping Review of Diagnostic Accuracy, Early Detection, and Clinical Integration

Zareba, Murphy, Root, Vinson, Burch

St. Christopher's Hospital for Children
A PARTNERSHIP OF TOWER HEALTH AND DREXEL UNIVERSITY

Introduction

Dental caries remains one of the most prevalent chronic diseases of childhood, contributing to pain, infection, and impaired quality of life. Early detection of approximal and occlusal lesions is essential to prevent progression and avoid invasive treatment. Bitewing radiographs are central to this process, yet radiographic interpretation is subject to considerable inter-observer variability, particularly for early enamel lesions. These diagnostic challenges are amplified in pediatric patients, whose mixed dentition, thinner enamel, and variable cooperation can compromise radiographic quality.

Artificial intelligence (AI), particularly convolutional neural networks (CNNs), has shown strong potential to enhance radiographic interpretation. Early studies demonstrated that CNNs can detect caries on bitewing radiographs with accuracy comparable to dentists[5]. Subsequent work expanded on these findings, showing that CNNs can match or exceed clinician performance across diverse datasets. Systematic reviews further support the diagnostic value of AI-based caries detection, highlighting consistent performance across imaging conditions and model architectures.

Despite these advances, the applicability of AI systems to pediatric radiographs remains unclear. Most models are trained on adult datasets, raising concerns about anatomical mismatch when applied to primary or mixed dentition. A focused synthesis of AI-based caries detection in pediatric contexts is therefore essential to guide safe and effective clinical integration.

Purpose

The purpose of this study was to conduct a scoping review evaluating the diagnostic accuracy, early detection capabilities, and clinical integration of AI-enhanced radiographic caries detection systems in pediatric populations.

Study Design & Methods

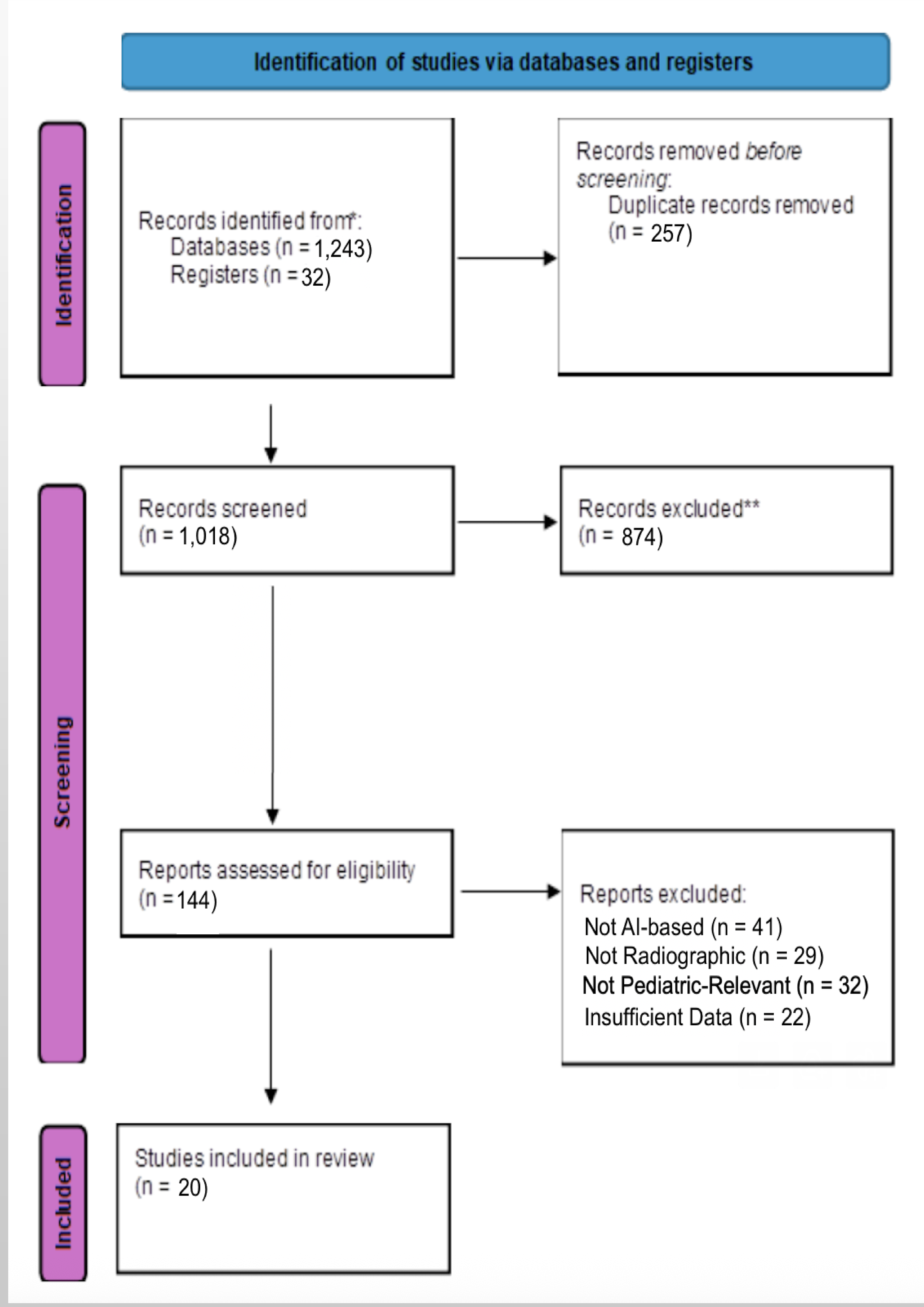
This scoping review followed the PRISMA-ScR framework to search through PubMed, Scopus, Web of Science, and Google Scholar.

An MeSH-based search was completed to search for the following key terms:

- Artificial Intelligence
- Deep Learning
- Dental Caries
- Radiographic Detection
- Pediatric Dentistry
- Diagnostic Accuracy

Studies were included if they evaluated AI or machine learning for dental caries detection, used radiographic imaging (bitewing, periapical, panoramic, or CBCT), included children/mixed-age populations applicable to pediatric care, or were peer-reviewed studies

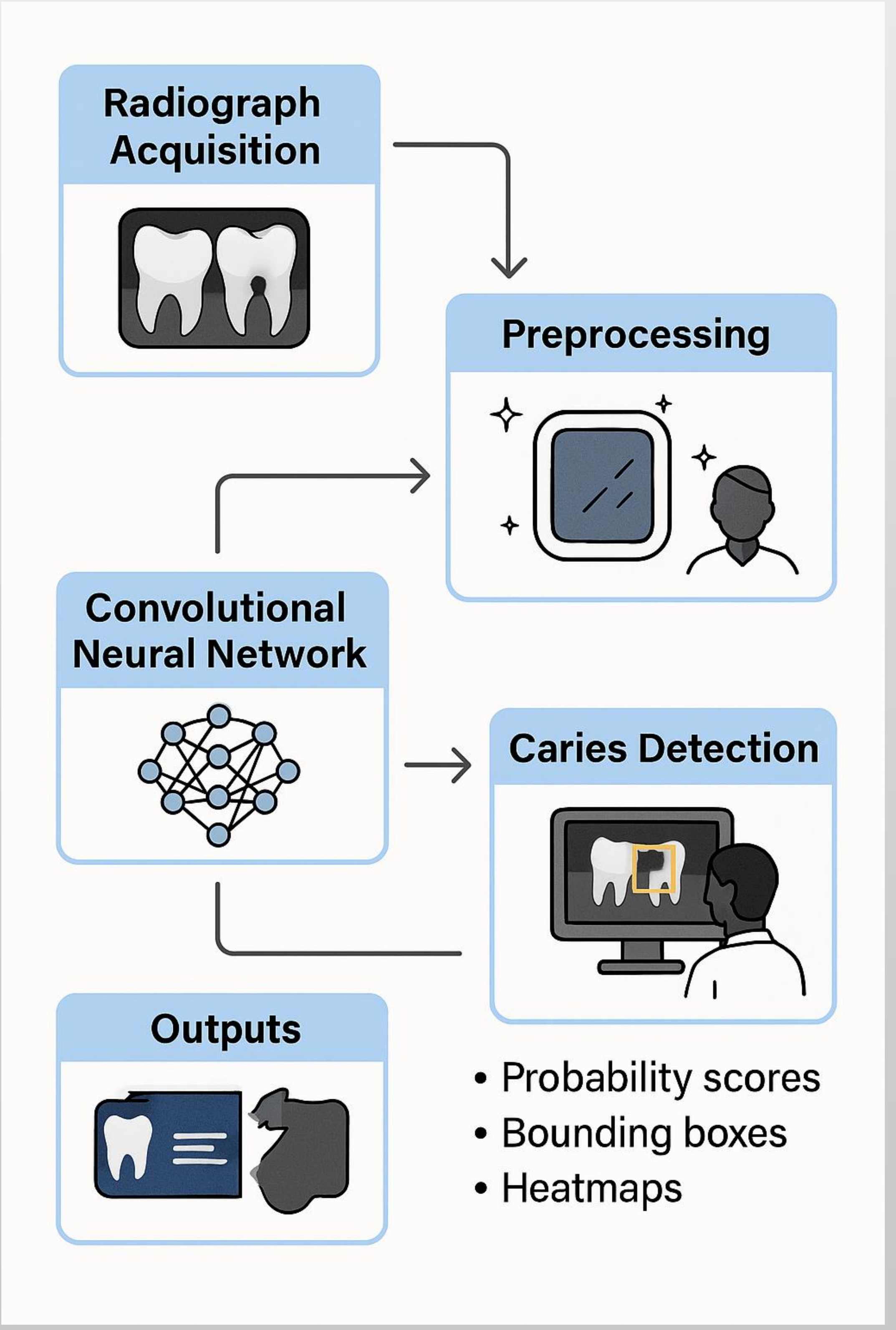
Studies were excluded if they were non-radiographic AI studies, Non-AI caries detection studies, studies with low-quality evidence (case reports, editorials, or narrative reviews), and studies without extractable diagnostic accuracy data. Other reasons for exclusion include AI model type, imaging modality, sample size, reference standard, and performance metrics.



Results

CNN-based models dominate the literature. Lee et al. first demonstrated that CNNs could detect caries on bitewing radiographs with accuracy comparable to dentists. Schwendicke et al. expanded on this by showing that CNNs can match or exceed clinician performance across multiple datasets[6]. Moran et al. reported high classification accuracy for approximal lesions using CNNs trained on annotated bitewings. ForouzeshFar et al. found similarly strong diagnostic performance for enamel and dentin lesions.

Systematic reviews confirm that deep learning models consistently outperform traditional machine learning approaches and often rival clinician performance Across studies, CNN-based systems demonstrated a sensitivity range of 0.78–0.89, a specificity range of 0.80–0.90, and an accuracy range of 0.82–0.88. These values are comparable to or exceed general dentist performance.



Discussion

This scoping review highlights the growing potential of AI-assisted caries detection in pediatric dentistry. CNN-based models demonstrate promising accuracy, particularly for proximal and dentin lesions. Systematic reviews confirm that deep learning systems consistently outperform traditional approaches and may reduce diagnostic variability. These findings suggest that AI could serve as a valuable adjunct to clinician interpretation, especially in cases where early enamel lesions are subtle or radiographic quality is compromised.

Despite these advances, several challenges remain. Most AI models are trained on adult radiographs, raising concerns about generalizability to primary teeth and mixed dentition. Pediatric radiographs often exhibit greater anatomical variability, overlapping structures, and motion artifacts, all of which may reduce model performance. Additionally, the heterogeneity of imaging protocols, annotation standards, and ground-truth definitions across studies complicates direct comparison and limits the ability to generalize findings to real-world pediatric settings.

Conclusion

AI-assisted caries detection shows strong potential to enhance diagnostic accuracy and early lesion identification in pediatric dentistry. Continued development of pediatric-specific datasets and clinical validation studies will be essential for safe and effective implementation.

References

1. Pitts NB. Diagnostic tools and measurements—impact on appropriate care. *Monogr Oral Sci*. 2009;21:1-15.
2. Hintze H, Wenzel A, Danielsen B. Behaviour of approximal carious lesions assessed by clinical examination, bitewing radiography and subtraction radiography. *Caries Res*. 1999;33(3):199-207.
3. Espelid I. Radiographic diagnoses and treatment decisions on approximal caries. *Community Dent Oral Epidemiol*. 1986;14(5):265-270.
4. Espelid I, Tveit AB. Clinical and radiographic assessment of approximal carious lesions. *Acta Odontol Scand*. 1986;44(1):31-37.
5. Lee JH, Kim DH, Jeong SN, Choi SH. Detection and diagnosis of dental caries using a deep learning-based convolutional neural network algorithm. *J Dent*. 2018;77:106-111.
6. Schwendicke F, Golla T, Dreher M, et al. Convolutional neural networks for dental image diagnostics: a scoping review. *J Dent*. 2019;91:103226.
7. Moran M, Faria M, Giraldi G, et al. Classification of approximal caries in bitewing radiographs using convolutional neural networks. *Sensors*. 2021;21(15):5192.
8. ForouzeshFar P, Safaei AA, Ghaderi F, Hashemikamangar SS. Dental caries diagnosis from bitewing images using convolutional neural networks. *BMC Oral Health*. 2024;24:211.
9. Devlin H, Yuan J, Fernando S, et al. Artificial intelligence for caries detection: evaluation of a deep learning system. *Dentomaxillofac Radiol*. 2021;50(8):20210055.
10. Zhang K, Liu X, Shen J, et al. Deep learning–based caries detection on dental radiographs: a systematic review. *Dentomaxillofac Radiol*. 2020;49(7):20190279.
11. Kositbowornchai S, Siriteptawee S, Plermkamon S, et al. Accuracy of radiographic caries detection: a systematic review and meta-analysis. *Caries Res*. 2021;55(2):113-123.
12. Pinto GS, Araújo MW, Braga MM, Mendes FM. Radiographic diagnosis of dental caries: systematic review and meta-analysis. *J Dent*. 2019;83:1-9.
13. Wenzel A. Radiographic modalities for diagnosis of caries in a historical perspective: from film to machine-intelligence supported systems. *Dentomaxillofac Radiol*. 2021;50(5):20210010.
14. Espelid I, Mejare I, Weerheijm K. EAPD guidelines for use of radiographs in children. *Eur J Paediatr Dent*. 2003;4(1):40-48.
15. Cantu AG, Gehrung S, Krois J, et al. Detecting caries lesions of different radiographic extension on bitewings using deep learning. *J Dent*. 2020;98:103351.
16. Ali Öncel A, Ayan E. Convolutional neural network applications in dental diagnostics: a focused review on bitewing-based caries detection. *Arch Comput Methods Eng*. 2025;32:1-27.
17. Sharifi F, Ghadimi N, Sharifi V, Anvarirad N. Caries detection using deep learning and convolutional neural networks from radiographic images. *World J Biol Pharm Health Sci*. 2025;22(2):359-368.
18. Mahizha SI, Annrose J, Angelo JMC, et al. Deep convolutional neural networks for early detection of interproximal caries using bitewing radiographs: a systematic review. *Evid Based Dent*. 2025;26:xx-xx.
19. Wang Y, He S, Chen H, et al. Artificial intelligence for dental caries detection: a systematic review and meta-analysis. *J Evid Based Dent Pract*. 2023;23(2):101842.
20. Schwendicke F, Cejudo Grano de Oro J, Garcia Cantu A, et al. Artificial intelligence for caries detection: value of data and information. *J Dent Res*. 2022;101(10):1150-1157.