

# Artificial Intelligence-Enabled Teledentistry for Early Oral Disease Detection and Clinical Triage in Underserved Populations: Current Evidence, Implementation Challenges, and a Proposed Care Pathway

**Gurpreet Kaur\***

*Senior Dental Surgeon, AlHilal Medical Centres and Hospitals, Manama, Kingdom of Bahrain*

**\*Corresponding Author:** Gurpreet Kaur, Senior Dental Surgeon, AlHilal Medical Centres and Hospitals, Manama, Kingdom of Bahrain.

**Received:** September 25, 2026; **Published:** October 09, 2026

## Abstract

**Background:** Teledentistry has expanded opportunities for remote oral-health consultation, screening, monitoring, education, and referral. In parallel, artificial intelligence (AI), including machine-learning and deep-learning approaches, is increasingly being investigated for dental image analysis, disease detection, risk assessment, and clinical decision support. Combining AI with teledentistry may provide new approaches to early oral-disease screening and prioritization, particularly for populations facing geographic, socioeconomic, mobility, or workforce-related barriers to conventional dental services.

**Objective:** This narrative review examines current and emerging applications of AI-enabled teledentistry for early oral-disease detection and clinical triage, with particular consideration of underserved and vulnerable populations. It further discusses diagnostic limitations, implementation barriers, ethical and legal considerations, and proposes a human-in-the-loop clinical pathway for responsible integration of AI-assisted remote screening into dental care.

**Methods:** Relevant literature was identified through PubMed, with priority given to systematic and scoping reviews, diagnostic-accuracy studies, clinical investigations, and recent literature addressing artificial intelligence, teledentistry, oral health, remote screening, and underserved populations. The literature was assessed narratively according to clinical application, diagnostic limitations, implementation considerations, and relevance to underserved populations. As this is a narrative review, no formal systematic review protocol, meta-analysis, or quantitative pooling of results was undertaken.

**Results and Discussion:** Current literature demonstrates increasing investigation of AI for analysis of oral photographs, including caries, plaque and gingival conditions, while teledentistry provides mechanisms for remote acquisition and professional interpretation of patient information. Recent studies have begun to investigate these technologies together. Potential applications include remote caries screening, preliminary assessment of periodontal and gingival conditions, oral-lesion triage, dental-trauma assessment, and prioritization of patients for professional evaluation. However, diagnostic performance under controlled conditions does not necessarily establish effectiveness in heterogeneous community populations. Image quality, dataset representativeness, algorithmic bias, false-positive and false-negative findings, privacy, cybersecurity, professional accountability, regulatory requirements, digital literacy, and unequal access to technology remain important considerations.

**Conclusion:** AI-enabled teledentistry may provide a useful adjunct to conventional dental services by supporting remote screening and prioritization. Its most appropriate near-term role may be human-supervised decision support rather than autonomous diagnosis. Clinical validation in diverse populations, standardized image-acquisition protocols, transparent governance, professional oversight, and integrated referral pathways are required before widespread implementation. A human-in-the-loop pathway connecting remote data acquisition, AI-assisted assessment, dentist verification, risk stratification, referral, definitive examination, and follow-up is proposed.

**Keywords:** Artificial Intelligence; Teledentistry; Dental AI; Oral Disease Screening; Dental Caries; Preventive Dentistry; Underserved Populations; Remote Dental Care; Clinical Decision Support; Health Equity

**Citation:** Gurpreet Kaur. "Artificial Intelligence-Enabled Teledentistry for Early Oral Disease Detection and Clinical Triage in Underserved Populations: Current Evidence, Implementation Challenges, and a Proposed Care Pathway". *EC Dental Science* 25.10 (2026): 01-11.

## **Introduction**

Digital technologies are increasingly influencing the delivery of oral healthcare. Among these developments, teledentistry and artificial intelligence have received particular attention because they address different components of the dental-care pathway. Teledentistry enables communication, consultation, monitoring, and exchange of clinical information across geographic distance, whereas AI provides computational methods capable of analyzing images and other clinical data and supporting classification or prediction tasks [1-4].

The convergence of these technologies has created the possibility of AI-enabled teledentistry, in which remotely obtained photographs, radiographs, clinical histories, questionnaires, or other information may undergo AI-assisted analysis before or in conjunction with professional dental review [3,5].

This development may be particularly relevant for populations in which conventional access to dental professionals is constrained. Recent literature has specifically considered teledentistry in rural settings and combinations of teledentistry and AI for vulnerable communities [6,7]. Nevertheless, technological feasibility should not automatically be interpreted as evidence of improved access, better clinical outcomes, or reduced oral-health disparities.

Image-based applications represent a particularly important area of development. AI systems have been investigated for detecting dental caries from oral photographs [8,9], and more recent evidence has examined smartphone-based approaches [10]. Deep-learning methods have also been investigated for detecting plaque and gingivitis from oral photographs [11].

These developments raise an important clinical question: rather than attempting to replace a dentist or establish definitive diagnoses remotely, could AI be incorporated into teledentistry primarily to identify risk, prioritize professional review, and facilitate appropriate referral?

This narrative review examines the evidence and emerging applications of AI-enabled teledentistry for early oral-disease detection and clinical triage. Particular attention is given to underserved populations, clinical safety, implementation challenges, and the importance of professional oversight. A human-in-the-loop pathway is proposed for integrating AI-assisted remote screening with conventional dental examination and care.

## **Teledentistry as a platform for remote oral healthcare**

Teledentistry encompasses the use of information and communication technologies to support dental consultation, assessment, monitoring, education, and aspects of care at a distance [1,2]. Remote dental interactions may occur synchronously through real-time communication or asynchronously through store-and-forward systems. In the latter approach, clinical histories, photographs, radiographs, or other information can be collected at one location and subsequently reviewed by a dental professional.

The COVID-19 pandemic accelerated interest in remote healthcare models, including teledentistry [12]. However, the relevance of teledentistry extends beyond pandemic-related circumstances. Digital dental workflows have been discussed as potential mechanisms for remote contact between patients and dental professionals and between general practitioners and specialists [13].

An evidence-gap map published in 2024 examined teledentistry in relation to health and educational outcomes, illustrating both the breadth of research in this area and the continuing need to identify areas where evidence remains limited [14]. Teledentistry should therefore not be regarded simply as video consultation. Its broader potential includes remote screening, specialist consultation, postoperative monitoring, oral-health education, referral, and collection of diagnostic information.

The reliability of remote assessment nevertheless depends upon the quality and completeness of the information transmitted. This limitation becomes particularly important when photographs obtained by patients, caregivers, community health personnel, or mobile devices are used for clinical assessment.

### **Integration of artificial intelligence with teledentistry**

AI encompasses computational techniques capable of performing classification, prediction, pattern recognition, and other tasks using data. Machine learning and deep learning have become particularly prominent within dental AI research.

Batra, *et al.* specifically reviewed AI in teledentistry and described opportunities for combining AI with remote dental care, education, research, and related innovations [3]. Subsequent literature has increasingly examined patient-centered and clinical aspects of AI-powered teledentistry [5].

In a potential remote-care workflow, an individual could provide structured clinical information together with photographs or other dental images. An AI system might then assist in image-quality assessment, identify suspicious features, generate a preliminary risk category, or prioritize the case for professional review.

The critical distinction is between AI-assisted screening and autonomous diagnosis. A screening system is intended to identify individuals who may require further evaluation. Definitive diagnosis, by contrast, may require direct clinical examination, radiographic investigation, palpation, periodontal measurements, vitality testing, biopsy, histopathology, or other procedures that cannot necessarily be reproduced remotely. For this reason, AI-enabled teledentistry may currently be more appropriately conceptualized as a clinical decision-support and triage system than as a replacement for conventional dental diagnosis.

### **Remote image acquisition: The foundation of AI-assisted screening**

Image acquisition is central to many proposed AI-teledentistry applications. Smartphones offer an attractive mechanism because of their widespread availability and increasingly capable cameras. Nevertheless, an image suitable for personal communication is not necessarily suitable for clinical analysis.

Variables such as illumination, focus, distance, camera angle, saliva, soft-tissue obstruction, tooth visibility and image resolution may influence the information available to both clinicians and algorithms.

Tareq, *et al.* investigated deep-learning approaches for caries assessment using non-standardized photographs and reported development of a computer-vision system for predicting dental cavitations [9]. Such work is particularly relevant to teledentistry because remote images are unlikely to be acquired under the same standardized conditions as photographs taken in a dental clinic.

Similarly, Huang, *et al.* evaluated smartphone-acquired photographs for assessment of traumatic dental injuries in a multicenter diagnostic-accuracy study [15]. Although this represents a different dental condition, it demonstrates the broader potential of smartphone imagery within remote dental assessment.

A future AI-teledentistry platform could therefore include an image-quality checkpoint before disease classification. If an image is blurred, incomplete, poorly illuminated, or otherwise unsuitable, the system could request image reacquisition rather than attempting to produce a potentially unreliable clinical output.

### **AI-assisted dental caries screening**

Among potential applications, dental caries currently has one of the stronger evidence bases for AI analysis of oral photographs. Moharrami, *et al.* conducted a systematic review specifically evaluating AI models for detecting dental caries on oral photographs [8].

This provides an important evidence foundation because photographic analysis is considerably more compatible with remote screening than technologies requiring specialized equipment.

Tareq., *et al.* additionally demonstrated development of a deep-learning approach for visual caries assessment using non-standardized photographs [9]. More recently, Acosta., *et al.* systematically reviewed the diagnostic accuracy and feasibility of AI-driven smartphone imaging for caries detection [10]. A 2026 umbrella review further synthesized 17 systematic reviews and concluded that, despite promising experimental diagnostic performance, substantial heterogeneity, limited external validation, and other methodological limitations constrain clinical generalizability and support continued use of AI primarily as decision support rather than stand-alone diagnosis [26]. Together, these publications demonstrate increasing convergence between AI image analysis and technologies suitable for remote dental screening.

A preliminary diagnostic-accuracy study published by Karawia., *et al.* in 2026 compared ChatGPT-based assessment and teledentistry with dentist examination for detecting dental caries [16]. This is notable because it moves the research question beyond algorithm development toward comparison with professional clinical assessment.

Nevertheless, performance reported by an algorithm on a selected image dataset does not necessarily indicate equivalent performance when patients take photographs themselves. Similarly, identification of visually apparent cavitated lesions does not establish that all stages of caries can be reliably detected remotely. The absence of tactile examination and, when clinically required, radiographic information also limits what can be inferred from photographs alone.

Therefore, a safer clinical objective is identification of potential caries requiring professional assessment rather than definitive diagnosis of dental caries. Such a distinction reduces the risk of presenting remote AI output as equivalent to comprehensive clinical examination.

### **Plaque, gingivitis and periodontal assessment**

AI-assisted analysis of visible oral conditions is not limited to dental caries. Moharrami., *et al.* systematically reviewed deep-learning approaches for detecting dental plaque and gingivitis from oral photographs [11]. Automated analysis of visible plaque and gingival characteristics could potentially contribute to remote preventive programs.

Coy., *et al.* also investigated machine-learning methods for scoring intraoral plaque using non-standardized images [17]. These developments may eventually support personalized preventive interventions, particularly where repeated images can be obtained longitudinally.

Periodontal diagnosis, however, presents additional challenges. Comprehensive periodontal assessment may require probing depths, clinical attachment measurements, bleeding assessment, mobility evaluation, radiographic findings, and consideration of systemic and behavioral risk factors. An oral photograph cannot provide all these parameters.

AI-enabled teledentistry should therefore avoid representing photographic identification of gingival inflammation as equivalent to comprehensive periodontal diagnosis. Its more defensible role is screening, preventive monitoring and identification of individuals who should undergo professional periodontal evaluation.

### **Oral lesions and oral-cancer triage**

Early professional evaluation of suspicious oral lesions is clinically important, making oral-lesion triage an attractive potential application of teledentistry. Santana., *et al.* specifically addressed integration of AI with teledentistry in relation to oral-cancer diagnosis

in Brazil [18]. This demonstrates interest in combining remote dental systems and computational technologies for potentially serious oral conditions.

The PubMed record available for that article does not contain an abstract; therefore, detailed conclusions about diagnostic performance should not be attributed to the paper without examination of its full text.

The conceptual application nevertheless warrants attention. A patient, community healthcare worker, or dental professional could obtain an image of an oral lesion and transmit it through a secure platform. An AI system could potentially assist in identifying cases requiring priority review, followed by assessment by a dental professional or oral-medicine specialist.

The purpose should be expedited triage rather than definitive remote diagnosis. Many benign and potentially malignant oral conditions can share visual characteristics. Definitive assessment may require clinical history, palpation, serial observation, adjunctive investigation, biopsy and histopathological evaluation. Consequently, false-negative results in this area could have particularly serious implications. Human professional review and clearly defined urgent-referral pathways are therefore essential components of any AI-assisted oral-lesion screening system.

### **Dental trauma and other remote applications**

Remote dental assessment may also be useful when patients experience traumatic injuries or other conditions requiring rapid decisions regarding urgency. Huang, *et al.*'s multicenter investigation of smartphone-acquired photographs for traumatic dental injuries demonstrates the feasibility of studying mobile-health approaches in this setting [15].

Teledentistry could potentially help distinguish cases requiring immediate dental attention from those suitable for scheduled assessment, although clinical safety protocols would be essential.

Another example comes from Lanzetti, *et al.* who conducted a pilot investigation using teledentistry and AI to assess dental erosion among competitive swimmers [19]. This study is valuable conceptually because it demonstrates application of AI and teledentistry together for a defined oral-health problem rather than discussing the combination only theoretically. These examples indicate that the future scope of AI-enabled teledentistry may extend beyond a single disease.

### **Applications in rural, vulnerable and underserved populations**

One of the strongest rationales for teledentistry is its potential use when conventional dental services are difficult to access. Nakao and Kotani's 2026 scoping review specifically examined teledentistry utilization in rural areas and identified studies addressing screening, pathological diagnosis, oral-health support, and specialist referral [6].

Drafta, *et al.* considered teledentistry, AI and hybrid models in relation to oral health among vulnerable communities [7]. Recent literature has also explored AI within public-health dentistry [20]. Older populations represent another potential beneficiary group. Beltrán, *et al.* described a teledentistry care model for older populations in remote Chilean settings using satellite communication technology [21].

These examples support further investigation of remote oral-health systems in populations experiencing access barriers. However, a paradox must be acknowledged. The communities most likely to experience inadequate access to dental services may also experience limited internet connectivity, inadequate access to appropriate devices, lower digital literacy, language barriers, or difficulty using smartphone applications.

Thus, digital technology can potentially reduce one form of inequality while introducing another. For this reason, claims that AI-enabled teledentistry reduces oral-health disparities should be made only when supported by appropriate outcome evidence. At the present stage, a more scientifically defensible conclusion is that these technologies may provide mechanisms for extending screening and professional consultation, but their effect on sustained access and oral-health equity requires further evaluation.

| Study                              | Design                                | Primary Relevance                                             | Interpretation                                                                              |
|------------------------------------|---------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Moharrami, <i>et al.</i> 2024 [8]  | Systematic review                     | AI detection of caries from oral photographs                  | Supports photographic AI screening; does not establish autonomous diagnosis.                |
| Tareq, <i>et al.</i> 2023 [9]      | Model-development study               | Deep learning for caries on non-standardized photographs      | Relevant to real-world remote image variability.                                            |
| Acosta, <i>et al.</i> 2026 [10]    | Systematic review                     | AI-driven smartphone imaging for caries                       | Directly relevant to mobile remote screening.                                               |
| Moharrami, <i>et al.</i> 2025 [11] | Systematic review                     | Deep learning for plaque and gingivitis from oral photographs | Supports preventive/gingival screening applications.                                        |
| Mulder, <i>et al.</i> 2024 [14]    | Evidence gap map                      | Teledentistry health and education outcomes                   | Highlights breadth of evidence and remaining gaps.                                          |
| Huang, <i>et al.</i> 2024 [15]     | Multicenter diagnostic-accuracy study | Smartphone photographs for traumatic dental injuries          | Supports feasibility of remote photographic assessment.                                     |
| Karawia, <i>et al.</i> 2026 [16]   | Preliminary diagnostic-accuracy study | AI/teledentistry compared with dentist examination for caries | Moves evidence toward direct clinical comparison.                                           |
| Lanzetti, <i>et al.</i> 2024 [19]  | Pilot investigation                   | AI and teledentistry for dental erosion                       | Example of integrated AI-teledentistry use.                                                 |
| Nakao and Kotani, 2026 [6]         | Scoping review                        | Teledentistry in rural areas                                  | Supports rural screening, diagnosis support and referral discussion.                        |
| Drafta, <i>et al.</i> 2025 [7]     | Review                                | Teledentistry, AI and vulnerable communities                  | Directly relevant to underserved-population implementation.                                 |
| Bittar, <i>et al.</i> 2026 [26]    | Umbrella review                       | AI for dental caries detection across imaging modalities      | Highlights heterogeneity and methodological limitations; supports decision-support framing. |

Table 1: Selected evidence relevant to AI-enabled teledentistry.

Proposed human-in-the-loop AI-enabled teledentistry pathway

Based on the applications and limitations identified above, a clinically conservative model is proposed. The model deliberately places dental professional verification between AI output and clinical action. The algorithm is therefore not the final decision-maker. This approach also recognizes that screening and diagnosis represent different stages of healthcare delivery. The pathway begins with structured remote information and image acquisition, followed by an image-quality checkpoint before AI-assisted screening. AI output is then reviewed by a dental professional, who determines risk category and the appropriate referral pathway. Definitive diagnosis and treatment remain the responsibility of qualified dental professionals, while remote monitoring is used only when clinically appropriate.

### **Clinical safety and diagnostic accuracy**

Diagnostic performance is fundamental to responsible AI deployment. A false-positive result can lead to unnecessary anxiety, referral, cost, and use of clinical resources. A false-negative result can be more consequential if it provides false reassurance and delays treatment. Sensitivity and specificity should therefore be interpreted according to the clinical purpose of the system and the consequences of error.

Another concern is dataset shift. An AI model developed using images from one population, camera type, clinical environment, age group, or disease distribution may not perform identically when deployed elsewhere. This issue is particularly important when technologies are proposed for underserved populations. A system intended to improve access should be validated in the populations in which it will actually be used. External validation, prospective evaluation and real-world implementation studies are therefore important priorities.

### **Ethical, legal and privacy considerations**

Ethical implementation of AI-enabled teledentistry extends beyond diagnostic accuracy. Rahim., *et al.* reviewed the potential, challenges and ethical dimensions of AI in dentistry [22]. More recently, Kaushik and Rapaka specifically considered ethical, legal and economic issues associated with AI-driven teledentistry [23].

Patient privacy requires appropriate protection of dental photographs, radiographs, medical histories and identifying information during acquisition, transmission, storage and analysis. Patients should receive appropriate information about the role and limitations of AI where required by the applicable clinical and regulatory framework.

Professional accountability should be clearly defined when AI recommendations influence referral or treatment pathways. Training datasets that inadequately represent different ages, populations, oral conditions, imaging devices or clinical environments may contribute to unequal performance. Dental professionals should understand the intended use and limitations of systems sufficiently to interpret outputs responsibly. These considerations support human oversight and a human-in-the-loop model.

### **Implementation barriers**

Even a diagnostically accurate AI system cannot improve healthcare if it cannot be integrated into clinical practice. Németh., *et al.* examined dentists' experiences and attitudes concerning digital healthcare and teledentistry and reported areas of limited awareness, including AI and teledentistry technologies [24]. More recent research has continued to examine utilization patterns and implementation barriers in dental practice [25].

Potential barriers include technical infrastructure, software costs, interoperability, clinician training, reimbursement, professional acceptance, data protection requirements, internet access, patient digital literacy, workflow disruption and uncertainty regarding regulation.

Implementation research should therefore examine not merely whether an algorithm works but whether the complete pathway works. That pathway includes the patient, image-acquisition process, software, AI model, dental professional, referral system, definitive examination, treatment and follow-up.

### **Research priorities**

Several research priorities emerge from the current evidence. Prospective studies should evaluate AI-assisted teledentistry under real-world conditions rather than exclusively on retrospectively selected datasets. Standardized protocols for smartphone and intraoral image acquisition should be developed and validated.

Studies should include populations representative of intended deployment settings, including rural communities, older adults, children, individuals with disabilities and populations experiencing socioeconomic barriers. Future investigations should compare AI-assisted teledentistry with teledentistry alone and conventional pathways to determine whether AI provides meaningful incremental benefit rather than merely adding technological complexity.

Outcome measures should extend beyond algorithm accuracy and may include referral appropriateness, time to professional assessment, treatment completion, patient satisfaction, cost, clinician workload, access to services and oral-health outcomes. Economic evaluations are needed to establish whether remote AI-assisted screening is cost-effective at the level of healthcare systems and communities. Equity should be treated as a measurable outcome rather than an assumed consequence of technological innovation.

## **Discussion**

The convergence of AI and teledentistry represents an important development within digital oral healthcare. Current evidence indicates active investigation of AI for photographic detection of dental caries [8-10], plaque and gingival conditions [11,17], as well as expanding investigation of remote dental assessment [6,14-16]. At the same time, emerging studies and reviews are increasingly examining AI and teledentistry as an integrated concept [3,5,7,19,23].

The evidence nevertheless supports caution. The performance of a computer-vision model does not itself demonstrate that deployment will improve patient outcomes. Likewise, the existence of a telecommunication platform does not establish that underserved individuals will obtain definitive dental treatment following remote screening.

The central challenge is therefore not simply to connect AI to a smartphone camera. It is to connect screening to professional verification, referral, definitive diagnosis, treatment and follow-up. This distinction is the basis of the proposed human-in-the-loop pathway.

Such a model could be particularly suitable for community screening programs. Images and structured clinical information could be collected remotely, AI could support initial prioritization, and dental professionals could verify the information before determining the appropriate referral pathway. The approach could potentially allow professional resources to be directed toward patients according to clinical need while preserving the dentist's role in clinical decision-making.

However, implementation should proceed only alongside validation, governance, privacy protection, professional training and mechanisms ensuring that a referral actually results in access to appropriate dental care.

## **Conclusion**

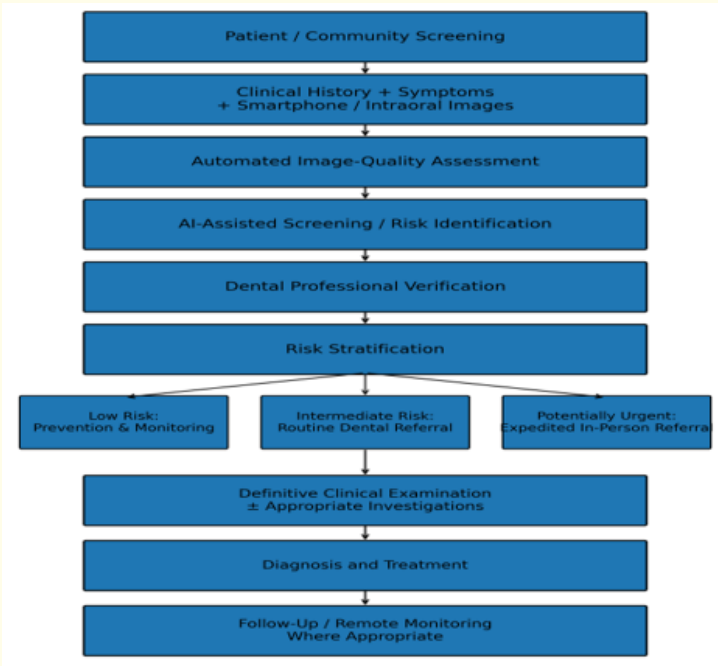
AI-enabled teledentistry is an emerging approach with potential applications in oral-health screening, preliminary risk assessment and clinical triage. Evidence concerning AI analysis of oral photographs is expanding, particularly for dental caries, plaque and gingival conditions. Research is also increasingly examining smartphone imaging, remote dental assessment and integration of AI with teledentistry.

Its most clinically appropriate role at present may be as an adjunct to dental professionals rather than an autonomous diagnostic system. A human-in-the-loop model is proposed in which remotely acquired patient information undergoes quality assessment and AI-assisted screening, followed by dental professional verification, risk stratification and appropriate referral. Definitive diagnosis and treatment remain connected to conventional professional care.

Future research should prioritize prospective clinical validation, diverse and representative populations, standardized image acquisition, privacy and security, economic evaluation, professional accountability, and measurement of actual patient and access

outcomes. AI-enabled teledentistry should ultimately be evaluated not according to technological sophistication alone, but according to whether it safely and effectively connects individuals to appropriate oral healthcare.

Figure 1 shows proposed human-in-the-loop AI-enabled teledentistry screening and triage pathway. Figure 1 placement: Inserted here in the manuscript; final figure prepared at 300 dpi.



*Figure 1: AI supports screening and prioritization, while a dental professional verifies the output before clinical action.*

**Conflict of Interest**

The author declares no conflict of interest.

**Funding Support**

No external funding was received for this work.

**Ethical Approval**

Not applicable. This article is a narrative review and does not report research involving human participants or animals.

**Informed Consent**

Not applicable.

**Data Availability**

No new datasets were generated or analyzed for this narrative review.

## Author Contribution

Gurpreet Kaur conceived the review topic, developed the clinical framework, interpreted the literature, and approved the final manuscript.

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**Citation:** Gurpreet Kaur. "Artificial Intelligence-Enabled Teledentistry for Early Oral Disease Detection and Clinical Triage in Underserved Populations: Current Evidence, Implementation Challenges, and a Proposed Care Pathway". *EC Dental Science* 25.10 (2026): 01-11.

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**Volume 25 Issue 10 October 2026**

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