Proceedings of ICBioMed 2025 Symposium: AI for Healthcare: Advanced Medical Data Analytics and Smart Rehabilitation
DOI: 10.54254/2753-8818/2025.AU27118

Teledentistry: Bridging Global Oral Health Gaps Through Digital Innovations

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Abstract. Teledentistry, the integration of digital technologies into oral healthcare, has emerged as a transformative solution to address global disparities in dental access. With 69% of dentists concentrated in Europe and the U.S. serving only 27% of the global population, teledentistry bridges gaps through remote diagnosis, consultation, and education. This review highlights key applications including rural outreach programmes that achieve high diagnostic concordance with in-person exams, artificial intelligence (AI)-powered postoperative monitoring that reduces follow-ups, cross-border specialist consultations, and virtual reality (VR)-enhanced dental education that improves learning outcomes. Core technologies such as high-resolution imaging, secure data systems, and AI diagnostics demonstrate reliability comparable to traditional methods, though challenges like internet reliability and reimbursement policies persist. Economic analyses suggest cost savings, but evidence quality remains low. While patient satisfaction is high, particularly in underserved regions, yet older adults face adoption barriers. This review synthesizes teledentistry's applications in diagnosis, consultation, education, and postoperative care, evaluating its clinical and economic value, identifying implementation barriers, and proposing strategies for standardized adoption.

Keywords: Teledentistry, AI diagnostics, digital dentistry.

1. Introduction

The integration of digital technologies into dentistry marks a crucial shift in how oral care is delivered and accessed. Traditional dental care often depends on patients traveling to clinics, which is difficult in regions with very few dentists. According to the World Health Organization, nearly 69% of dentists work in Europe and the United States, yet these areas represent only a quarter of the world's population. In Africa, one dentist may serve more than forty thousand people [1]. This uneven distribution makes oral health one of the most unequal areas of medicine, as regions with the most acute shortages are projected to experience the fastest population growth over the next 75 years. Teledentistry has been developed to reduce these barriers, with tools like mobile imaging, real-time communication, and secure record sharing to overcome those systematic barriers. The idea was first applied in specific groups such as the military and remote villages, but it gained much broader attention during the COVID-19 pandemic, which exposed vulnerabilities in conventional

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dental diagnosis. The COVID-19 pandemic accelerated teledentistry adoption by 400% when face-to-face care was limited, emphasizing its critical role in bridging gaps in dental care [2].

Three main elements make this approach possible. First, high-quality imaging tools such as intraoral scanners and smartphone cameras allow accurate pictures of teeth and gums. Research confirms these devices are just as accurate as traditional methods, with studies showing they can even spot early signs of cavities [3]. Second, secure data systems protect patient information while improving communication. Studies show weaknesses in current dental records, like missing patient details or gaps in security, highlighting the need for strong encryption and strict privacy laws [4]. Finally, AI diagnostics bring smart analysis to remote care. Tools like convolutional neural networks (CNNs) are proving highly accurate at detecting tooth decay, often catching issues that humans might miss [5]. Together, these tools make remote care practical, even though challenges like weak internet or limited training still exist.

Teledentistry is being used in four main areas to improve dental care and education. Firstly, remote consultations help extend services to areas with very few dentists. With studies in Zimbabwe and Nigeria showing 85-90% diagnostic accuracy and 92% patient satisfaction for remote consultations, although poor internet coverage still limits reach [6]. Secondly, mobile apps that track healing after treatment reduce the need for in-person visits. Post-operative apps reduce in-person follow-ups by 15% through AI-powered monitoring tools like Bluetooth-enabled toothbrushes, which can monitor recovery [7]. Thirdly, countries with few specialists, such as Libya, benefit from collaborations with European universities, while China has used 5G to support remote implant surgeries. These models expand access but also face challenges like unstable internet and inconsistent regulations. Finally, virtual reality (VR) is showing strong results in dental education. A randomized trial with 50 students, those trained with VR outperformed peers who received traditional instruction in tooth arrangement [8].

Despite these successes, barriers remain [9]. Rural internet coverage is uneven, reimbursement for app-based monitoring is unclear, and VR tools are expensive [7]. Overall, evidence supports teledentistry as a way to reduce gaps in care but scaling it will require stronger infrastructure and supportive policy. This review aims to summarize the current applications and technological advancements of teledentistry in diagnosis, consultation, education, and postoperative follow-up, to inform its standardized implementation and future development, and to discuss the challenges, emerging trends, and potential strategies.

2. Clinical applications and implementation of teledentistry

Teledentistry is revolutionizing oral healthcare delivery, enabling efficient oral health screening in underserved regions by combining community health workers (CHWs) with remote dental expertise. CHWs capture intraoral images using smartphones or portable scanners, which are transmitted to dentists for diagnosis and evaluation. A study by Steinmeier et al. demonstrated that intraoral scans (IOS) achieved 78–95% agreement with clinical exams for detecting dental conditions (e.g., caries, restorations), though periodontal assessments were less accurate. The model has high efficiency (3.17 minutes per scan) and reduces geographic barriers, particularly in Africa and Asia, where dentist shortages are a severe problem. Challenges persist, including limited internet infrastructure and training for CHWs, but store-and-forward systems mitigate connectivity gaps. IOS-based remote screening can effectively triage patients for most dental conditions, despite limitations in image resolution for calculus detection [10]. While this approach addresses diagnostic gaps in rural areas, similar technological innovations are now being adapted for personalized home care.

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Building on community screening models, AI-powered smartphone applications enable real-time self-monitoring of preventive care for elderly populations. These innovative systems can analyze intraoral selfies to detect plaque and gingivitis, providing instant feedback and personalized care instructions [11]. The technology is particularly effective for short-term oral hygiene maintenance, with studies showing significant reductions in plaque indices when used consistently. For elderly patients, video-guided instructions help overcome mobility challenges while maintaining preventive care standards. However, posterior tooth surfaces are difficult to image reliably, and long-term adherence tends to decrease in the absence of regular professional follow-up. The technology works best when combined with periodic clinician oversight, creating a hybrid care model. Despite these challenges, AI-powered monitoring offers a practical solution for aging populations with limited access to traditional dental care due to inconveniences. This shift toward patient-centered technology is simultaneously transforming postoperative management to reduce clinical boundaries.

Mobile postoperative platforms are streamlining recovery management. Mobile applications like ExoDont streamline postoperative dental care by automating medication reminders and wound-care instructions, significantly reducing the need for in-person follow-ups [12]. Digital tools are proving especially useful after treatment. Mobile apps can deliver reminders for pain medication, antibiotics, and oral hygiene, reducing common problems like missed doses or confusion about instructions. Field trials show strong results (mean score: 4.6/5) for improving adherence, with functionality rated 4.5/5, although engagement scored lower (3.5/5) due to its non-interactive design. Even with this drawback, apps like ExoDont have helped reduce complications such as infection and dry socket while cutting clinic visits. Its three-tier architecture ensures secure data handling, with an admin panel for clinicians to customize patient-specific plans. Future iterations could integrate more symptom tracking features to further reduce unnecessary appointments. By turning routine recovery steps into digital protocols, they give patients clearer guidance and dentists more reliable follow-ups.

The study by Moghbeli et al. demonstrates how teleconsultation systems bridge gaps in dental care by enabling real-time collaboration between dentists, radiologists, and specialists across geographic boundaries [13]. Their conceptual model highlights critical requirements for international teleconsultations, including secure patient data transmission, diagnostic image sharing (87.5% deemed essential), and dedicated interfaces for specialist input. 5G technology enhances these systems by supporting high-resolution image transfers (e.g., OPG radiographs) and low-latency video consultations, essential for complex cases like implant planning or oral pathology. The study notes that such systems reduce unnecessary referrals by 30% while maintaining diagnostic accuracy compared to in-person evaluations. However, challenges remain in standardizing data formats and ensuring equitable access in resource-limited regions.

3. Economic value, clinical performance, and regulatory challenges of teledentistry

Teledentistry demonstrates significant cost-saving potential compared to traditional in-person care, particularly in reducing indirect expenses such as travel and time for patients. According to the systematic umbrella review by Scheerman et al, teledentistry is often perceived as cost-effective, with studies highlighting reductions in travel time and waiting lists [14]. However, the evidence remains largely assumptive due to the critically low quality of existing reviews, which rely on descriptive or low-quality studies rather than robust economic evaluations. For instance, asynchronous (store-and-forward) models are noted as less costly than real-time consultations, yet conclusions are constrained by methodological flaws in primary research. High initial costs for advanced technologies like AI or VR tools are also cited as barriers. High-quality experimental

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studies, such as RCTs or factorial designs, are requiredto validate cost-effectiveness claims and address other factors in intervention types and outcomes.

Building on the question of cost-effectiveness, another critical aspect of teledentistry's viability lies in its clinical performance and patient reception. Teledentistry demonstrates high diagnostic reliability and patient satisfaction, particularly in rural and remote settings. Studies report an 89% concordance between teledentistry and in-person diagnoses for conditions like oral lesions and molar pathologies. Patient satisfaction is notably high (63–78% "very satisfied"), driven by reduced travel time, prompt treatment, and cost savings [15]. However, diagnostic accuracy varies for subtle lesions, possibly dropping sensitivity. Younger patients and those in underserved areas report higher satisfaction, while older adults face technological barriers [16]. Despite limitations, teledentistry is considered reliable for triage and routine consultations, though hybrid models may be needed for complex cases.

Teledentistry is reliable for triage and routine consultations, but complex cases still require in-person visits or hybrid models. Widespread adoption will depend on solving difficult legal and financial issues. Teledentistry presents significant legal and reimbursement challenges that must be addressed for its safe and effective integration into dental care. Key legal concerns include that in many regions, dentists must be licensed where the patient is located, which restricts cross-border consultations [17]. Malpractice liability is another critical issue: once a remote consultation begins, the dentist is responsible for meeting the same standard of care as in person. Failure of diagnosis or referral can create malpractice risks. Data privacy and security also pose substantial risks; digital transmission raises risks of unauthorized access. Encryption and secure storage are essential safeguards [18]. Informed consent is vital, ensuring patients understand the risks, benefits, and technological limitations of remote consultations. Technological failures, from poor image quality to equipment, can affect treatment and create questions of shared liability between providers and manufacturers. On the financial side, insurance coverage for teledentistry remains inconsistent. Many systems do not reimburse virtual consultations, making adoption less sustainable. Solutions will require clear regulations, standardized protocols, clear legal definitions, and insurance reforms that cover remote dental care while protecting patients and providers alike.

4. Future directions and policy responses of teledentistry

The future of teledentistry depends on strong digital infrastructure and equitable access on technology. Reliable internet and 5G are vital for smooth video consultations and real-time imaging [19]. Additionally, AI-enhanced intraoral scanners can now detect problems early, reducing the need for clinic visits. These innovations, such as integrating IoT-connected devices, such as smart toothbrushes that provide real-time feedback, may soon make preventive care more personalized and efficient. However, without better broadband access and affordable tools, these benefits will remain limited to wealthier regions.

Virtual reality is becoming a key part of dental training, letting students practice procedures in a safe, controlled setting [20]. The successful adoption of teledentistry depends on comprehensive training for dental professionals and greater public awareness. Adding VR to dental curricula prepares new professionals for both remote care and advanced diagnostics. At the same time, public awareness campaigns are necessary to address patient hesitancy and promote trust. Patients who understand teledentistry's cost savings and convenience are more likely to use it. Partnerships between dental associations and media platforms could spread these messages effectively, ensuring that both practitioners and patients are well-informed and confident in using teledentistry solutions.

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Beyond education and technology, clear rules and incentives will determine whether teledentistry becomes a permanent part of healthcare. Governments should establish consistent regulations on licensing, malpractice, and privacy, while insurers need to expand reimbursement policies. Subsidizing digital scanners and teledentistry platforms for low-income clinics would also close gaps in underserved areas. Additionally, a global framework could further standardize practices across borders [21]. With these measures, teledentistry could move from experimental programs to a recognized part of modern health systems.

5. Conclusion

Teledentistry is already proving effective in extending dental care, particularly for people who live in underserved regions. Applications such as rural outreach, AI-supported recovery care, international consultations, and VR-based training all show encouraging results, with diagnostic accuracy reaching 89% and patient satisfaction is consistently high. The technology relies on three main elements: high-quality imaging, secure data sharing, and AI-based analysis, which together improve efficiency and reduce geographic barriers. Yet challenges remain. Diagnostic sensitivity is lower for subtle conditions, older adults engage less with digital tools, and insurance policies lag behind practice. Moving forward, future research should focus on stronger cost-effectiveness studies, better integration of platforms, and consistent reimbursement policies. Investments in infrastructure and training for both patients and providers will also play a central role. With these steps, teledentistry has the potential to reduce of the most persistent inequalities in healthcare and make oral health more accessible worldwide.

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