



Review Article

Teledentistry: A comprehensive review of clinical applications, benefits, and challenges

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Abstract

Teledentistry is now an essential aspect of modern oral healthcare delivery, allowing for remote consultation, diagnosis, prevention, and treatment planning through digital media. First used to expand access in disadvantaged areas, it has now transformed into an ambidextrous tool possessing established applications in detection of caries, orthodontic evaluation, surveillance for oral malignancy, and oral healthcare for the elderly. There is evidence that teledentistry obtains diagnostic accuracy comparable to that of traditional chairside methods, besides ensuring cost-effectiveness and maximizing workforce use. During the COVID-19 pandemic, teledentistry helped ensure continuity of care, infection prevention, and remote follow-up for patients. Despite its established benefits, barriers like data protection concerns, digital divide, and uneven regulatory environments remain in the way. Opportunities for the future include the use of artificial intelligence (AI), mobile health technologies, and interprofessional telehealth platforms to establish teledentistry on a sustainable basis for hybrid models of denting care. This review confluences current evidence for the efficacy, challenges, and prospects associated with teledentistry, besides yielding valuable insight for its role in shaping transformed global oral healthcare delivery.

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1. Introduction

Oral health is a significant public health issue across the globe, and dental caries, periodontitis, oral malignancy, and malocclusion notably escalate the total disease burden.¹⁻⁴ Despite clinical advances in dentistry, access inequities in care continue and unevenly impact rural groups, the elderly, and socioeconomically disadvantaged groups.^{6,9,14} Professional bodies and the World Health Organization have emphasized the requirement for novel and economical solutions for these concerns and for enhancing distribution mechanisms of oral care.

Teledentistry represents a distinct subset of telemedicine, employing information and communication technologies (ICT) to facilitate remote dental consultations, diagnoses, preventive measures, and patient education.^{1,2,8,40} Initially introduced in the 1990s, teledentistry has undergone significant evolution through the incorporation of digital imaging, mobile health applications, electronic health

records, and video conferencing platforms.^{19,39} It has found application in various fields of dentistry, such as caries detection,^{3,21,29} orthodontic triage,^{12,23} oral cancer monitoring,^{15,22} geriatric dental care,²⁴ and maxillofacial follow-up.⁴² The COVID-19 pandemic acted as a catalyst for the widespread adoption of teledentistry globally, as the necessity for infection control compelled the implementation of remote consultations and ensured continuity of care.^{5,13,17,13,25,32,37,38} Research conducted in Canada, Southeast Asia, and Europe illustrated that teledentistry alleviated service disruptions, enhanced patient safety, and preserved professional oversight throughout periods of lockdown.^{13,25,39,43}

Various systematic reviews and cost analyses stress that teledentistry delivers diagnostic precision like traditional in-person assessments, while simultaneously lessening costs and enhancing manpower allocation.^{1,3,20,24,29,36,47} Challenges, however, still linger, like infrastructural deficits, variations in digital literacy, differences in regulations, and issues in

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matters of confidentiality and medico-legal responsibilities.^{33,34,35,45} Despite these, teledentistry is acquiring traction not only as an supplementary measure prompted through the pandemic, yet more importantly, an enduring cornerstone of the digital shift in health. It is the aim of this review to contain an all-inclusive summation of the evidence behind the uses, advantages, drawbacks, and points for the future of teledentistry, strictly based on published research and systematic reviews.

2. Materials and Methods

The current review was conducted in the form of a narrative synthesis of the published literature relating to teledentistry, solely based on the references outlined in the aggregated bibliography (n = 48). They included systematic reviews, randomized controlled trials (RCTs), observational studies, feasibility studies, economic evaluations, and practice-based papers that had been published in the years 2001 through 2024. By maintaining methodological rigour, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was also followed as an adjunct referencing framework for the study selection and study reporting.⁴

2.1. Eligibility criteria

1. **For inclusion:** Reviews and studies that assessed clinical use of teledentistry, diagnostic precision, cost-benefit, patient and provider attitude, or population health effects. Both pre-pandemic and COVID-19 period studies were included.
2. **For exclusion:** Grey literature, non-peer-reviewed journals, editorial opinions without back data, and non-relevant studies for teledentistry were excluded.

3. Review Study Type

1. **Systematic Reviews and Meta-analyses:** Multiple systematic reviews synthesized evidence on clinical outcomes, utilization, costs, and diagnostic accuracy.^{1-3,8,29,36,47}
2. **Randomized Controlled Trials (RCTs):** RCTs assessed orthodontic screening and triage in all sources of referral.²³
3. **Observational and Comparative Studies:** Numerous investigations have juxtaposed teledentistry with traditional examination techniques among paediatric, orthodontic, and geriatric demographics.^{18,21,22,26-31}
4. **Feasibility and Pilot Projects:** First experiments in child caries detection and cell phone monitoring systems.^{15,28,30}
5. **Economic Analysis:** Cost-effectiveness analysis for residential aged care services and rural teledentistry programs.^{20,24,47}
6. **COVID-19 Driven Studies:** Research examining role of teledentistry in service continuity, infection control, and patient/provider perspectives during the pandemic.^{5,13,17,25,32,37-39,42,43}

4. Data Retrieval and Integration

1. Studies carried out were classified under five themes:
2. Clinical efficacy and accuracy of diagnosis
3. Varied applications in specializations
4. Public health effects and care access
5. Economic evaluations
6. Virus pandemic-inspired applications and potential

The outcomes were narratively synthesized due to study population, outcome, and design heterogeneity.

5. Uses of Teledentistry

1. **Diagnostic accuracy and clinically effectiveness:** One of the major fields of research for teledentistry is its diagnostic reliability compared to conventional chairside evaluations. Several studies show that virtual evaluations with digital imagery have diagnostic accuracy comparable to face-to-face evaluations, particularly for detection of caries in paediatric groups.^{3,21,29,30} Teledentistry in preschool age groups has been effective in identifying caries in a timely basis and allowing for distant prioritization for treatment needs.^{21,26,28} There was support from a systematic review confirming teledentistry achieved adequate sensitivity and specificity for multiple dental lesions, thus supporting its clinical value.^{1,3,29}
2. **Orthodontic applications:** Orthodontics was among the first fields to take up teledentistry. Telemonitoring enables orthodontists to make preliminary screenings, sort out cases for emergency attention, and make follow-ups.^{12,23} A randomized controlled trial established that orthodontic referral triaging conducted from a distance helped increase the efficiency of specialist services in avoiding pointless face-to-face assessments.²³ The application of smartphone-assisted, peripheral immersion imaging systems improved accessibility even more and decreased patient travel burdens.¹²
3. **Monitoring for oral cancer and mucosal lesions:** Teledentistry has been useful in the early detection and follow-up of oral malignancy and other mucosal lesions. Trials conducted using mobile health (mHealth) platforms and intraoral cameras established its potential for identifying potentially malignant disorders and minimizing delayed diagnosis.^{15,22} Televised community-based screening for oral mucosal lesions enhanced convenience for high-risk groups, facilitating their referral to specialist services.^{15,22}
4. **Paediatric and school-based dental care:** School-based programs integrating teledentistry have been effective in enhancing the availability of preventive services for dentists and allowing for the earliest possible detection of child oral disorders.^{18,26,28}

Comparative studies indicated that intraoral photographs from school locations offered consistent diagnostic data for dentists.¹⁸ Furthermore, initial studies utilizing preschool age groups supported that teledentistry could potentially eradicate barriers in terms of parental involvement and geographical accessibility.^{28,30}

5. **Special care and geriatric dentistry:** Use of teledentistry in residential aged care facilities has been applied in providing preventive and diagnostic dentistry services for older adults who have low mobility.^{20,24} Costing revealed that teledentistry helped in cutting the cost-of-service delivery while service quality was retained.²⁴ Results mirror its contribution in resolving oral health inequities affecting older and dependent adults.
6. **Teledentistry and its impacts on access to healthcare and public health:** Teledentistry has been very influential in public health. Its implementation has been aimed at targeting marginalized and rural populations, reducing geographic barriers, and enhancing workforce distribution.^{6,9,14,40} They documented the potential of teledentistry in Southeast Asia and Australia in complementing healthcare services and aiding in community engagement.^{13,25,39} Broad reviews have also recognized access to healthcare as one key advantage that teledentistry is associated with.^{8,40}
7. **Pandemic-induced applications:** Teledentistry was taken up rapidly during the COVID-19 pandemic in the form of an adjunct for ensuring continuity of dental care with minimal risks of infection.^{5,13,17,25,32,37,38,39,42,43} Remote consultations, triage for emergencies, follow-up of maxillofacial patients, and patient education were enabled.^{25,32,42} Patient and provider questionnaires reflected high degrees of satisfaction and acceptance, even if diagnostic deficiencies and technological issues evoked concerns.^{37,38} Teledentistry was thus cemented in its role as an essential adjunct to traditional dentistry in the pandemic times. Cost-Effectiveness and.
8. **Optimization of workforce:** Economic evaluations highlight the potential of teledentistry in reducing costs and improving the deployment of dental staff.^{20,47,24} In regional and aged care settings, teledentistry proved equally cost-effective and resource-optimal.^{20,24} An umbrella review also supported that teledentistry is economically effective alongside increased accessibility and patient satisfaction.⁴⁷

6. Discussion

Accumulating evidences on teledentistry indicates that it has transitioned from an experimental adjunct to a practical and sustainable instrument for the delivery of oral health. Findings from the diagnostic, therapeutic, and public health arenas all together establish its contribution to the progress of equitable access to care for dentistry, specifically for vulnerable and underserved groups.

1. **Clinical effectiveness and diagnostic reliability:** Consistent evidence confirms that teledentistry delivers diagnostic reliability equivalent to traditional dental exams. Systematic reviews establish high validity in the detection of caries, periodontal disease, and orthodontics.^{1,2,3,8,29,36} For paediatric groups, several studies confirmed validity of teledentistry in caries detection and treatment triage, noting its potential for widescale screening.^{18,21,26,28,30} For one comparative study, intraoral photos taken in schools yielded diagnostic results closely paralleling in-person evaluations, thus extending the clinical practice of dentists and hygienists into school and community settings.¹⁸ Likewise, trials of feasibility established high inter-examiner agreement when caries were examined through remote image.^{21,28} Together, these results strongly confirm that teledentistry is more than just an interim substitute but a clinically effective process for the delivery of oral diagnostics.^{3,29,30}
2. **Teledentistry in dental specialties:** Teledentistry has been employed in many of the specialties of dentistry. It is employed in orthodontics for initial screening, case prioritization, and for followup, and thus serves to minimize unnecessary referral and maximize clinical efficiency.^{12,23} Teledentistry triage was supported in a randomized controlled trial to reduce specialist orthodontic service bottlenecks.²³ Teledentistry has been helpful in oral oncology, too, in that it enhances observation for potentially malignant lesions. Teledentistry pilots using population settings and mobile health platforms upheld its value for referral and for detection at an earlier time, particularly in high-risk groups.^{15,22} Teledentistry has been valuable in the maxillofacial specialty, also, in that it contributes to follow-up consultation and continuity care for surgical patients.⁴²
3. **Public health significance and equitable access:** Highest value addition in teledentistry is in closing access gaps. Oral service scarcity is common in rural and remote areas, and teledentistry is used to breach such barriers.^{6,9} Southeast Asian and Australian studies showcased its complementarity with community health infrastructure, leading to enhanced coverage and continuity of care.^{13,25,39} Teledentistry was feasible and cost-effective in residential aged care, which is constrained by mobility and workforce issues, yet

ensuring timely diagnosis and prevention interventions.^{20,24} This is its key public health role, given that oral ailments have high prevalence among socio-economically disadvantaged groups.^{6,14}

4. **Impact of COVID-19 pandemic:** The COVID-19 pandemic acted as a catalyst for rapid and widespread adoption of teledentistry.^{5,13,17,25,32,37,38,39,42,43} Remote consultations ensured continuity of care when conventional dental services were restricted due to infection control protocols. For example, studies in Canada and Europe reported that teledentistry enabled safe triaging, management of urgent dental cases, and continuity of orthodontic and maxillofacial follow-up care.^{25,32,42} Patient and provider surveys during the pandemic revealed high levels of satisfaction, with participants valuing convenience and safety.^{37,38} However, these studies also identified limitations such as reduced diagnostic scope and dependency on image quality, suggesting that while teledentistry is effective, it cannot fully replace in-person care.^{38,43} The pandemic nonetheless positioned teledentistry as an indispensable component of resilient healthcare systems.^{39,43}
5. **Economic considerations and workload balancing:** Economic analyses offer additional rationale for teledentistry uptake. Audits in rural and aged care settings validated its cost-saving potential, minimizing service delivery, workforce stress, and travel cost reductions.^{20,24} Further, an umbrella review established consistent evidence for positive economic outcomes for teledentistry, in addition to patient access and satisfaction improvement.⁴⁷ Furthermore, demonstration projects like the Australian Queensland tele-dent-surgery model showcased effective, large-scale implementation for maximizing workforce usage in widely dispersed regions.²⁰ With teledentistry, dentists may supervise auxiliary personnel from a remote location, opening potential for task-shifting and improved resource allocation.^{20,24,47}

7. Barriers to Adoption of Tele dentistry

There is robust evidence for teledentistry both in clinical and economic justification, yet various barriers continue to remain that inhibit its universal uptake.

1. **Concern for data privacy and security:** Maintenance of patient data confidentiality is one of the key issues. Issues of encryption, safe storage, and medico-legal accountability continue to be heard.^{33,34,35,45} Unless strong policies and legislations are in place, both patients and practitioners would hesitate to adopt teledentistry whole-heartedly.
2. **Infrastructural challenges and digital divide:** Variations in internet accessibility, equipment availability, and technological expertise cause unevenness in the efficacy of teledentistry.^{33,34} Such inhibitions occur mainly in non-urban regions and in low- and middle-income nations, in which accessibility is limited even for healthcare.^{6,9,14,25,39}
3. **Technical and diagnostic problems:** Image resolution, camera resolution, and operator competence may drastically influence accuracy in diagnosis.^{18,29,30} Although teledentistry is consistent in the case of simple ailments like caries and orthodontic screening, high-level issues have a propensity to necessitate face-to-face assessment.^{3,21,29}
4. **Regulatory and reimbursement challenges:** Variations in national and regional regulations for telehealth delay consistent uptake.^{33,35} Once more, non-uniformity in common reimbursement models discourages inclusion in daily practice.^{35,45}
5. **Cultural and professional acceptance:** Dental professionals' resistance and patient mistrust towards digital media have been described in certain settings.^{34,39} To increase uptake beyond mediocre levels, adequate training, awareness programs, and professional reinforcement should be established.

7.1. Future of teledentistry

Teledentistry is subject to both technological, policy, and healthcare system advancements for its growth in the future.

1. **Artificial intelligence (AI) integration:** Artificial intelligence-facilitated diagnosis equipment could boost accuracy, reduce image interpretation manual effort, and support clinical decision-making.^{15,39,46} This could reduce provider workload and increase service scalability to its fullest potential.
2. **Teledentistry and mobile health (mHealth) and smartphone applications:** Smartphone applications and mobile imaging make teledentistry more assessable, especially in school settings and in rural regions.^{12,15,22,28,39} They make surveillance, patient education, and community-level early diagnosis easier.
3. **Interprofessional telehealth practice:** Teledentistry is not just compatible on wider telehealth platforms but also encourages interprofessional working for dentists, medical practitioners, and allied health professionals. This is more so for management of complex ailments like oral malignancy and age care.^{22,39,46}
4. **Hybrid models of care:** Post-COVID-19, hybrid care models combining in-person visits with virtual follow-ups are increasingly recognized as sustainable. Evidence suggests that teledentistry will remain an

essential adjunct to routine dental practice rather than a temporary solution.^{37-39,42,43}

5. **Development and standardization of policy:** Setting global norms for privacy, consent, interoperability of data, and reimbursement is essential for long-term sustainability.^{33,35,45,47} Policymakers and professional groups should work together to achieve balanced incorporation in varying healthcare systems.
6. **Financial viability and optimization of resources:** Economic evaluations have proved teledentistry to be cost-effective.^{20,24,47} Large-scale upscaling of such models could potentially optimize distribution of the workforce, keep healthcare expenditures in check, and raise global oral health equity.

8. Conclusion

Teledentistry is among the greatest digital health revolutionizations in the provision of oral healthcare, bridging barriers in accessibility, improving efficiency, and enhancing diagnostic precision in diverse populations. Consensus evidence compiled in this review concludes that teledentistry is clinically effective for diagnostic use, namely for the detection of caries, orthodontic assessments, and surveillance for mucosal lesions. Application in paediatric, geriatric, and community programs reflects its promise for extension of care beyond customary clinical settings.^{18,20,24,26,28} Of relevance, systematic reviews, and comparisons all affirm that teledentistry-derived diagnostic precision is equivalent to that from traditional face-to-face examinations, affirming its role as an effective adjunct to customary practice.^{1,3,8,29,36} From the public health perspective, teledentistry has helped eliminate geographic and socioeconomic barriers in significant ways. When combined with school and aged-care programs, it has broadened outreach to vulnerable groups, such as children and the elderly.^{18,20,24,26,28,30} Adoption was hastened further due to the COVID-19 pandemic, which showed its potential in maintaining service continuity, infection control, and patient-provider communication during periods of mobility restriction. Patient satisfaction questionnaires conducted during the pandemic indicated high levels of acceptance, confirming its potential in future care models.^{37,38} Economic evaluations supporting feasibility and sustainability, and cost-effectiveness of teledentistry is established in both regional and aged-care settings.^{20,24,47} The cost and outcome umbrella review on teledentistry indicates its cost-reducing potential while enhancing patient access and satisfaction.⁴⁷ Further, optimisation of the workforce by remote supervision and task-shifting places teledentistry in the category of strategic solutions in response to global manpower shortages in oral healthcare.^{20,24,47} Beyond these benefits, sustained barriers prevent universal uptake. These include concerns regarding data privacy, non-standardized regulatory regimes, technological inequities, and cultural opposition from both providers and patients.^{33,34,35,39,45} Reliability of diagnosis may also depend on conditions of complexity and image

quality.^{18,29,30} Confronting these barriers necessitates unified policy intervention, infrastructural investments, and professional education programs. For the future, prospects of teledentistry look encouraging. Its confluence with artificial intelligence, mobile health programs, and interprofessional telehealth platforms is poised to robustly expand precision in diagnosis, scalability, and patient participation.^{12,15,22,39,46} Blended service models that leverage in-person consults and remote follow-ups promise to constitute routine practice, facilitating continuity, convenience, and economy.^{37-39,42,43} Above all, establishment of global norms for privacy, consent, and remuneration will be essential for ensuring that implementation is equitable and sustainable.^{33,35,45,47} Teledentistry, therefore, should now be regarded less as an adjunct or temporary innovation, but rather an essential constituent of updated oral healthcare architecture. Its potential to provide clinically precise, economically sustainable, and socially equitable dental services gives it transformative potential in addressing global oral health. Further research, policy advocacy, and technological innovation will constitute key determinants in unleashing full promise of teledentistry and embedding it in healthcare's core routines, regardless of location, all the world over.

9. Source of Funding

None.

10. Conflict of Interest

None.

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