



Review

Teledentistry: Building a Bridge Between Patient Care and Technology – A Narrative Review

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Abstract.

Background: Digital dentistry has transformed oral health care, with telecommunication at the forefront during the pandemic. With the use of network technology, remote consultations, personalized treatments, and greater access to care have become possible, especially in underserved areas. Despite the initial slow adoption, due to regulatory, cultural, and technological barriers, the use of teledentistry was highly accelerated during the global pandemic, highlighting its value in delivering safe, contactless, and widespread care. **Objectives:** The study aims to examine recent advancements and post-COVID-19 trends, benefits, barriers to teledentistry adoption in marginalized areas, focusing on improving access to digital healthcare. The objective is to identify current trends of teledentistry among a broad spectrum of the population. **Methods:** A thorough literature search used keywords such as “Tele dentistry, Digital Healthcare, Remote Dental Care, Underserved Populations, Health Equity, Virtual Oral Health, Barriers to Access and Socioeconomic Disparities”. across databases including PubMed, Science Direct, and Google Scholar. 38 articles published in English were selected, with a focus on literature from 2020 onwards. **Results:** The pandemic highlighted teledentistry's role in bridging healthcare gaps in rural areas through remote consultations. The programs were initiated in several countries like the US, India, Qatar and Pakistan have reported positive results. However, barriers like poor internet, limited training, lack of reimbursement, digital illiteracy, patient skepticism, and fear of job displacement have been found to hinder tele dentistry's adoption. **Conclusion:** Despite its promise, teledentistry faces hurdles. Addressing these disparities is crucial to ensuring equal access to quality dental care for all. Improving internet accessibility, simplifying technology usage, and implementing comprehensive training programs for dentists are essential steps. **Keywords:** Teledentistry, Digital dental care, Underserved populations, Dental care accessibility, Healthcare barriers.

1. Introduction

In recent times, the dental field has experienced a revolution due to the rise of digital dentistry. The use of computer-controlled elements in procedures has transformed how dental experts deliver care to patients and have created opportunities to enhance essential oral health services, such as improving diagnostic precision, simplifying treatment processes, and enhancing treatment outcomes and patient satisfaction¹.

A crucial aspect of this transformation is teledentistry - a subset of dentistry that harnesses technology to connect patients with dental providers, particularly becoming popular post-COVID-19 outbreak^{2,3}. Tele dentistry is an evolving field with extensive implications. It involves data exchange through phone lines, mobiles, fax machines, computers and videoconferencing². Also called e-dentistry, it now encompasses the use of patient records as well as clinical videos, and 3D digital images for diagnosis and consultation.

With the incorporation of state-of-the-art technologies, it has become possible to shift from one treatment fits all to a more personalized health care model. The ability to collect and process vast amounts of patient data, coupled with the advancements in artificial intelligence and machine learning with tailored online consultations, has enabled dental professionals to adapt treatment plans and oral healthcare solutions to the unique needs and preferences of individuals³.

Teledentistry facilitates remote dental care in resource-limited areas with the use of technology^{2,4}. It allows effective triaging of patients, improves clinical outcomes, and reduces waiting lists and missed school days for children⁵. Moreover, by leveraging digital tools and platforms, teledentistry can overcome geographical barriers, improve access to care, and enhance the overall quality of dental services, addressing oral health disparity and eliminating financial obstacles such as travel time and enhancing access to dental services and fostering collaboration among dental experts⁶.

The aim of the study is to uncover new directions, important benefits, and potential barriers to the adoption of digital healthcare solutions in rural, low-income, and marginalized areas, particularly following the COVID-19 pandemic, and to explore and identify the challenges that must be addressed to improve its effectiveness to achieve equal access to dental care for all.

In the following sections of this review article, the objective is to identify current trends of teledentistry, its origin, its applications, potential benefits, current trends and perceived shortcomings.

2. Methodology

A comprehensive literature search was carried out across PubMed, Elsevier, and Google Scholar for English-language papers published between 2020 and 2024. The search approach included the following keywords: “Tele dentistry”, “Digital Healthcare”, “Remote Dental Care”, “Underserved Populations”, “Health Equity”, “Virtual Oral Health”, “Barriers to Access” and “Socioeconomic Disparities”.

Three hundred twenty-five articles were identified in Google Scholar, 259 articles in Elsevier and 189 in PubMed, of which 38 were included in the narrative review. The studies were selected based on the following inclusion criteria:

- Studies between 2020 and onwards were considered to ensure inclusion of recent advancements.
- Consideration of only English language articles were made.
- This study focuses on teledentistry, telemedicine and digital health treatment in underprivileged populations.
- Both original research (clinical trials, observational studies, etc.) and review articles were considered in the literature review.

The exclusion criteria included:

- Non-English articles were omitted to maintain language uniformity in data interpretation.
- Studies published prior to January 2020 were excluded to concentrate on contemporary evidence.
- Research that did not specifically investigate underserved demographic groups (such as rural, economically disadvantaged, or systematically marginalized people) was excluded.
- Preliminary conference proceedings, unpublished articles, and non-peer-reviewed sources were omitted to maintain academic standards.

The initial selection procedure implemented a dual-stage method. First, titles and summaries were examined to locate possibly pertinent studies. Subsequently, a thorough evaluation of the complete text of the chosen publications was conducted. Articles were judged based on their applicability to the research subject, methodological validity, and meaningful impact on teledentistry. To ensure academic excellence in this narrative review, the SANRA (Scale for the Assessment of Narrative Review Articles) framework, created by Baethge et al. (2019), was utilized⁷. This framework offered standardized guidelines for appraising article justification, suitable scope determination, and quality appraisal, particularly appropriate for non-systematic review approaches. Following this methodical process, relevant data was abstracted and grouped into primary thematic domains encompassing comparative studies, measures of clinical efficacy, and critical appraisals of benefits and drawbacks.

3. Eminence of Teledentistry

Teledentistry was formally developed in 1989 as part of dental informatics, funded by the Westinghouse Electronics Systems Group in Baltimore⁷. The first practical implementation was by the U.S. Army for consultations with patients located at distances of 100 miles from dental setups⁸.

In 1994, the US Army's Total Dental Access Project⁹ aimed at improving patient care, dental education and communication between dentists and dental laboratories demonstrated the utility of teledentistry in extending dental care to distant and rural areas and offering data required for deeper analyses.

With the advent of the internet and low-cost technology available globally, teledentistry evolved from NASA's and the military's projects in the late 1900s to worldwide delivery at every doorstep¹⁰. Additionally, with the explosion of medical websites and more than 360,000 articles published annually⁹, dental practitioners have increased access to the web for healthcare related purposes and consultations.

The shift, however, from traditional consultations was slow and limited to conferences due to regulatory barriers¹¹, lack of reimbursement policies¹², and resistance to change among healthcare providers and patients¹³. It is interesting to note here that the COVID-19 pandemic actually facilitated in achieving the current levels of widespread adoption of tele dentistry^{6,14,15}. The necessity of telehealth was already present but underemployed, with gradual adoption before the pandemic. The international lockdowns promoted urgent demand and significant investments in telehealth solutions globally, acting as a catalyst in increasing the adoption curve significantly forcing a behavioral and cultural shift towards remote healthcare^{12,15,16}. Digital facilities were developed to reduce the infection spread and clinic crowding by facilitating contactless patient and peer connection, aiding in more appropriate utilization of health care services in underserved areas^{17,18,19}.

4. Teledentistry and the COVID-19 Pandemic

The COVID-19 pandemic led to a major hazard to healthcare management systems across the world. It made it difficult to access dental care for the masses⁹. However, studies show that tele dentistry managed an outstanding 300% increase in dental consultations during lockdown¹⁸. This was mainly due to the elimination of barrier factors such as patients' financial constraints, unfamiliarity with speciality settings, language barrier, fear, travel distance and concerns of safety^{18,19}.

Remote dental services provided by various tele dentistry clinics included specialized phone or video consultation, triage, remote examination, screening for symptoms, patient education and monitoring, dental hygiene, follow-up of treatment and management²⁰. The infrastructure used to deliver the services included internet, telephone, smartphone with better camera resolution, video calling, SMS, email, electronic prescribing, electronic referral system, electronic patient record, patient management system^{20,21}.

COVID-19, a paradoxical bliss, has forced improvement in healthcare by extending its reach to distant areas despite the digital divide^{21,22}. Due to the rapid epidemiological interventions and surveillance worldwide, teledentistry initiatives in marginalized areas have gained traction and expanded. For example, the Virtual Dental Home (VDH) program in California²³, remotely provides oral examinations, diagnosis, and care planning under the supervision of licensed dentists. In Qatar, a teledentistry project established during the COVID-19 pandemic, provides remote consultations, diagnosis, and decision-making for treatment through a dedicated hotline (National Conference of State Legislatures) - Teledentistry: Connecting Rural Communities to Dental Care²⁴. Saudi Arabia's Seha Virtual Hospital also offers telehealth and teledentistry consultations, remote monitoring, and virtual orthodontic care^{25,26}. In rural areas of India, teledentistry programs use mobile health units and digital technologies for oral health education, screenings and consultations⁷.

Similarly, the Bangladesh Teledentistry Initiative connects rural patients with dental professionals for consultations, diagnosis, and follow-up care⁸. These programs exemplify providing and improving essential healthcare services for marginalized communities, enhancing their overall health outcomes and bridging the gap caused by geographic and economic disparities with the use of technology²⁷.

5. The Digital Healthcare Divide

The development of new healthcare models, including teledentistry, would customarily involve a gradual process of stakeholder engagement, pilot testing, and assessment to ensure long-term sustainability^{28,29}. Unfortunately, the urgency of the pandemic has led to a "jump of several digital years," leaving many disadvantaged communities without the foundational groundwork of adequate consultation and evaluation prior to the implementation of new tele-dental initiatives^{30,31}.

This void in the globalization of oral health care^{32,33} has led to a higher prevalence of oral diseases in resource-limited areas due to infrastructural limitations and financial barriers^{23,34}. Along with that, poor socioeconomic environment and individual characteristics such as educational background and physical disability also contribute to minimal, need-based visits to dentists by these vulnerable groups^{17,35,26}.

Without addressing these factors, such programs may fail to meet their full potential and address the long-term needs of disadvantaged communities effectively.

6. Implementation Barriers to Teledentistry

Despite the wide recognition of the potential benefits of teledentistry, there are a vast number of factors that hinder the adoption and implementation of the technological advancement. The following sections discuss some of those issues and provide possible solutions to mitigate them.

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6. 1 Personal Factors

Due to inadequate utilization of tele dentistry methods and hesitation, brought on by a lack of knowledge and skill, the potential benefits of tele dentistry for disadvantaged populations may be restricted^{9,19,37}. This hesitation has been attributed to the dentists' fear that telemedicine would make them lose their jobs and lessen their physical presence in hospitals. It is also compounded by the circumstance that the foundational curriculum for the Bachelor of Dentistry in Pakistan has no preparatory courses for navigating teledentistry^{31,38}.

Additionally, during the pandemic, the lockdown boosted the practice of telemedicine because the strict implementation of SOPs forced the practitioners to utilize digital consultations, however, without the necessary skills to assimilate teledentistry into everyday practice, dentists in

marginalized areas are resorting back to traditional practice ^{39,40}.

The ease of traditional practice also far outweighs the nuances of navigating 2D images for diagnosis and uncertainty in online consultations. Tele dentistry is unable to undertake hands-on operations and interventions. It lacks thorough assessments, as some illnesses require an in-person examination to be fully diagnosed ¹⁷. Thus, motivation for such dentists to practice teledentistry is lacking, especially in areas with limited dental professionals, incentives, career development opportunities, and support systems ⁴⁰.

The patients' response also plays a role in the continuing usage of digital facilities. Marginalized households are usually less equipped or less educated and lack financial capability to pay for such consultations ^{31,41}. Moreover, research highlights patients' dissatisfaction with diagnosis on pictures and the lack of physical examination along with concerns about their information being shared over the Internet ^{34,39}, and they would prefer to discuss their condition with the dentist in person. Awareness campaigns and cultural understanding to effectively communicate and counsel the population are required in such cases ⁴².

6. 2 Managerial Factors

One critical factor is the absence of clear reimbursement models or regulatory frameworks for teledentistry services to ensure patient safety and the delivery of high-quality care ⁴³. Sustaining teledentistry initiatives requires securing partnerships and sustainable funding through institutional boards, insurance coverage, and government support to cover the initial setup and ongoing operational costs ^{44,45}. Considering that for small private clinics, setting up teledentistry services out of pocket is a financial burden with minimal investment returns due to the high costs of telehealth hardware and software, especially in underserved areas like rural Pakistan and India ³¹.

Another challenge is the cost of the telemedicine equipment and the payment of the tele dental oral healthcare professional ³⁷. The question of "who pays the tele dentistry service provider?" has been an unanswered one as the majority of studies on teledentistry have been covered by grants and terminated on exhaustion of funds ⁴⁶.

It is important to note that countries have started taking steps to mitigate the financial burden. In Australia, the government provides financial incentives and subsidies through extended medicare discounts. Canada and the United States offer grants and funding opportunities through the Health Resources and Services Administration and the Ontario Teledentistry Network ⁴⁷. However, in developing countries, the implementation of such efforts is either still ongoing or yet to start.

Teledentistry integration into the health care system is only possible through the collaboration of organizational institutions with local dentists, clinics, and hospitals for an efficient data-sharing system, seamless coordination, efficient referrals, follow-up care, patient information and record continuity ⁴.

Some examples of such integrated systems are of the VDH program in California ⁴⁸ which partners with various institutions such as schools, Head Start Centers, and community clinics

providing preventive and early intervention services under remote supervision resulting in decreased ER visits. Integrated care is supported by the use of secured electronic medical records (EMRs), which facilitate the sharing of patient data ⁴⁹.

The Ontario Teledentistry Network in Canada ⁵⁰ links dental offices, hospitals, and public health units, improving telecommunication for a large population, reducing patient travel with information shared between physicians and specialists ^{51,52}.

The Queensland Teledentistry initiative (Australian Ministry of Welfare and Health) ⁵³, a collaboration between remote area health services and urban dental specialists in Australia, uses secure online portals to gather data and conduct primary checks before handing them over to experts, which has increased accessibility to specialized treatments by patients; decreased waiting times; improved effectiveness of oral medicine generally ⁵⁴.

6. 3 Technological Factors

Reliable and high-speed internet connectivity and, ensuring that both dental professionals and patients have access to the necessary equipment, such as computers, cameras, and dental instruments, is crucial for the successful implementation of teledentistry ^{4,55,56}.

The technology used in teledentistry should also be user-friendly for both providers and patients with comprehensive technical support and troubleshooting assistance for smooth operation ^{4,56}. Difficult-to-navigate systems can create significant barriers to the continued use of tele dentistry services in areas where digital literacy may be lower ^{57,58}.

The success of teledentistry in rural areas depends on addressing technical requirements, infrastructural barriers, and training needs for dental professionals¹⁷. Promoting digital literacy to enhance the acceptance and utilization of teledentistry services should also be considered. Cybersecurity and data privacy are also important considerations for the long-term sustainability of teledentistry ⁵⁵.

India's Digital India program is focused on improving Internet connectivity in rural areas through projects like BharatNet for the implementation of teledentistry ⁷. Brazil's Health Ministry has initiated digital literacy programs for healthcare professionals and the public ⁵⁹. The European Union has also put in place rules like the General Data Protection Regulation (GDPR) to ensure privacy and security of data in telehealth services, enhancing trust and encouraging adoption of teledentistry, benefiting patients and medical practitioners in rural regions ^{56,60}.

7. Teledentistry Project of the Students of CMH Multan

In light of the evidenced advantages, a teledentistry camp was held by the house officers of the Combined Military Hospital Multan, Institute of Health Sciences, Pakistan. The idea of the camp was to offer remote consultations, providing diagnoses and oral hygiene advice, highlighting technology's role in improving dental care access for underserved areas (Figures 1 and 2).



Figure 1. A house officer is conducting a remote dental consultation, demonstrating oral hygiene technique via a digital device for patient education.

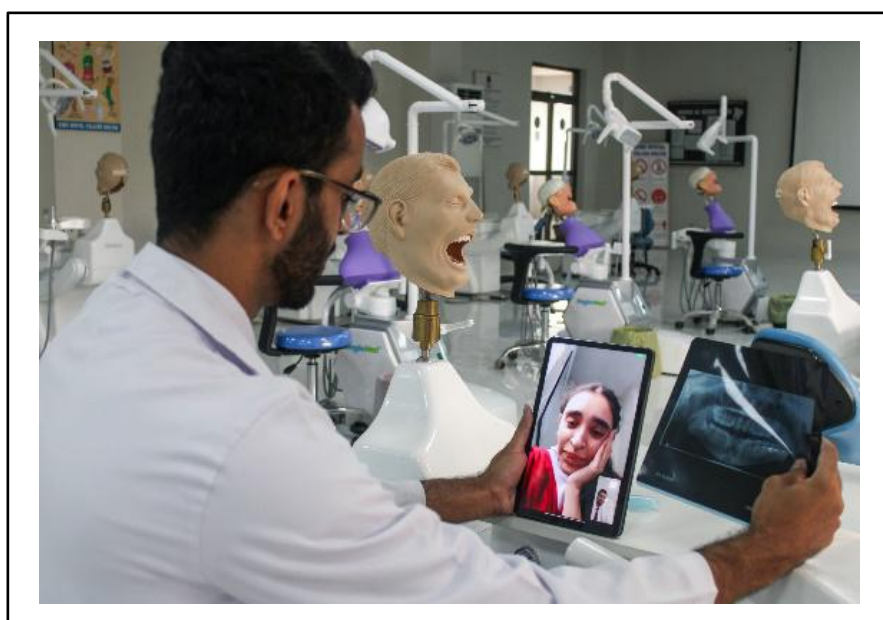


Figure 2. A dental professional is using a tablet and to conduct a remote consultation for a patient, correlating patient symptoms remotely with an accessible radiograph.

The populations of the surrounding villages of Multan (Bosan and Shujahbad) were targeted, where there is a lack of access to healthcare services and some limited telecommunication infrastructure is available. Our volunteers showed up with cell phones and tablets / or the staff was trained to use their phones for video consultations. On this end, the expert was guiding the patients through the video consultations.

Around 500 consultations were carried out and the feedback from the stakeholders was encouraging. The practice also identified the potential improvement areas such as training of the healthcare professionals for the technology and access to the internet. CIMS Multan is determined to make teledentistry consults as an ongoing practice and expand the healthcare

outreach to remote and vulnerable populations.

8. Limitations and Future Directions

This review provides important perspectives by concentrating on literature published since 2020 and emphasizing underrepresented populations; however, there were some limitations. The literature search narrowed the focus to recent studies ensuring their relevance, but it might have overlooked essential foundational or longitudinal insights from earlier research. Additionally, while focusing on underserved groups improves targeted relevance, it could restrict the broader applicability of the findings to different populations or healthcare environments. As a narrative review, the study is vulnerable to selection bias. Moreover, the lack of studies from low-income areas—due to shortcomings in digital infrastructure or research funding—might impact the global relevance of the conclusions.

To fill these gaps, additional research is necessary to identify the best methods, legal frameworks, costs, and advantages of teledentistry in underserved populations^{9,17}. Comprehensive global studies should examine its efficacy compared to traditional practices and evaluate its practicality across various healthcare environments, including the effects of telemedicine advancements and provider adoption^{17,18,39}. Furthermore, exploring the most effective telehealth technologies, their influence on oral health results and patient contentment, as well as the associated training requirements, is crucial for enhancing implementation. Equally significant is discovering strategies to mitigate resistance or doubt among stakeholders to promote broader acceptance and integration^{17,19}.

These endeavors should be supported by organized educational programs, including the incorporation of teledentistry into dental education and the provision of certified workshops and seminars, to establish fundamental skills and stimulate interest among both current and future professionals.

9. Conclusion

Teledentistry has shown strong potential as an accessible, efficient, and patient-centric approach to reducing the gap in demand for healthcare. Its rapid growth during the COVID-19 pandemic highlighted the advantages it offers in diagnosing and planning treatments, as well as in preventive care. The programs initiated in several countries like the US, India, Qatar and Pakistan have reported positive results. However, the lack of appropriate training, insufficient reimbursement models, infrastructural gaps, and the digital divide, hinder the widespread adoption of the technology. Despite the challenges in technology, training, and regulation, its advantages in enhancing accessibility, affordability, and patient outcomes are clear as shown in Figure 3. It shows a comparison of the advantages and disadvantages of teledentistry.

Integrating tele dentistry into dental education, developing sound policy frameworks, and advancing digital literacy are essential next steps for long-term contributions to the equitable delivery of dental care. While it cannot replace in-person dental visits, teledentistry is helpful in making dental treatment more equitable and focused on the patient needs.

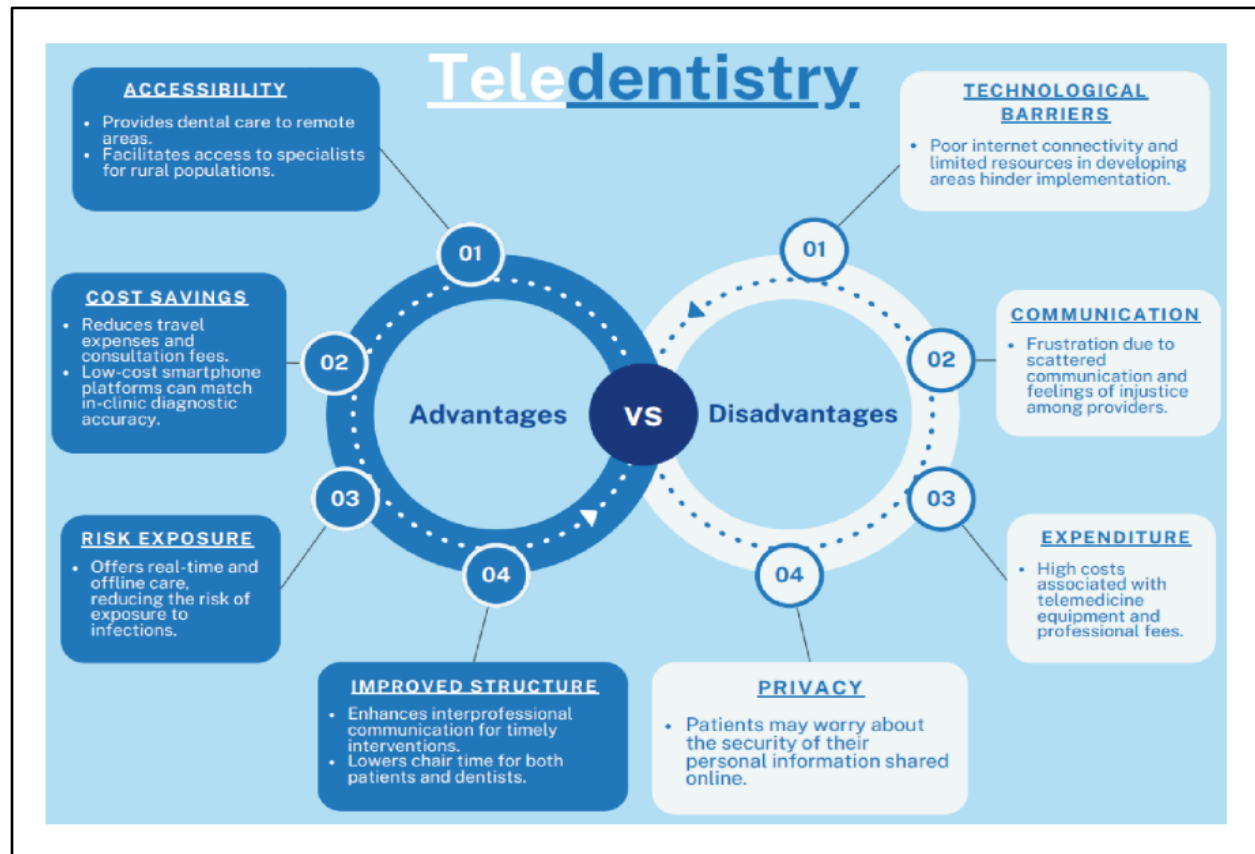


Figure 3. Comparative illustration of the disadvantages and advantages of teledentistry.

Abbreviation	Full Form
VDH	Virtual Dental Home

Declarations:

Supplementary Materials: Not applicable.

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