

A COMPREHENSIVE REVIEW OF TELEDENTISTRY: EXPLORING ITS APPLICATIONS, CHALLENGES AND FUTURE POTENTIAL.

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ABSTRACT

Teledentistry, a transformative advancement in telemedicine, leverages technology to provide remote dental care and education, overcoming the barriers of in-person visits. Conceptualized in 1989 and officially defined in 1997, teledentistry has become essential in addressing the growing need for dental professionals, especially in underserved and rural areas.

Despite its advantages, widespread adoption is hindered by inadequate technology, gaps in digital literacy, data security concerns, and limited insurance coverage. The absence of in-person evaluation also raises concerns about diagnostic accuracy in complex cases. However, teledentistry bridges these gaps through real-time consultations, store-and-forward technology, and remote monitoring. Its integration across specialties—orthodontics, periodontics, prosthodontics, pediatric dentistry, and oral surgery—enhances accessibility, collaboration, and patient outcomes. Digital platforms also drive early detection and prevention, particularly in pediatric care.

Teledentistry is reshaping oral healthcare, offering a more inclusive, patient-centered approach by overcoming technological, financial, and regulatory challenges.

Definition of Teledentistry

Teledentistry is a subdivision of telemedicine that utilizes technology to offer remote dental consultations and education without physical patient presence. It involves exchanging patient information, images, and records for diagnosis, treatment planning, and patient care from a distance ¹. Teledentistry was first defined in 1997 as "the use of video-conferencing technologies to diagnose and provide treatment advice remotely," integrating telecommunications with dental sciences. This approach helps to address challenges related to geographic barriers, enabling the delivery of oral healthcare ^{2,3}.

Brief History and Evolution

Although the term “teledentistry” was formally coined in 1997, this concept began to take shape earlier, during a conference in 1989 about dental informatics, where experts started brainstorming on how digital tools could transform or change dental practice and education ⁴. In 1994, the U.S. Army's Total Dental Access Project achieved a significant milestone in understanding teledentistry. This initiative successfully demonstrated the feasibility of providing dental care to remote areas while reducing overall costs ⁵. The scope and relevance of teledentistry in modern dentistry expanded with the progress in digital imaging, telecommunications, the internet, and artificial intelligence ³.

Importance and Relevance

Teledentistry has become increasingly important as a solution to overcoming barriers to oral healthcare. It provides an efficient mechanism to deliver dental services in underserved and rural areas, where access to professional dental care is limited. Given the global shortage of dentists, which is projected to worsen in the coming decade, teledentistry has become a more dependable solution. Moreover, it enables professional communication and collaboration between general dentists and specialists for better patient service. It also offers unique opportunities for integrating oral health into the larger healthcare system to improve the continuity of care ³.

Types of Teledentistry

Three main types of teleconsultation methods are primarily used in teledentistry:

1. **Real-Time Consultation:** Consultation through live video communication between dental professionals and patients, allowing for immediate diagnosis and treatment recommendations.
2. **Store-and-Forward Technology:** In this method, Clinical data, such as radiographs, photographs, and records, are collected and transmitted for evaluation later.
3. **Remote Monitoring:** Oral health care is provided to patients remotely, often in a hospital or home-based setting ⁵.

Benefits

Teledentistry offers several advantages that help to address patient dental care, including improved accessibility for remote patients, cost reduction by minimizing travel and office expenses, enhanced collaboration between practitioners and specialists, and educational opportunities for both patients and dental professionals.

Applications

Teledentistry has broad usages across dental specialties:

1. **Pediatric Dentistry:** Among young children in a particularly underserved population, screenings for dental caries have proven to be very effective.
2. **Oral and Maxillofacial Surgery:** This helps with preoperative planning and promises timely and accurate interventions with remote consultations⁶.
3. **Orthodontics:** This helps dentists take appropriate action to improve patient outcomes by consulting orthodontists rather than providing unnecessary referrals⁷.
4. **Periodontics:** Periodontal treatment and post-surgical monitoring in rural areas have been effectively facilitated through remote consultations.

5. **Prosthodontics:** Teledentistry has been used to develop treatment plans for patients requiring oral rehabilitation, particularly in sparsely populated areas.

The above applications demonstrate a wide range of usability of teledentistry in effectively addressing oral health needs ^{3,5}.

TELEDENTISTRY IN CLINICAL PRACTICE

Teledentistry facilitates interdisciplinary care by enabling remote collaboration between specialists, which is especially valuable in complex cases requiring input from multiple dental professionals. This collaborative approach improves treatment outcomes and ensures timely care, particularly for people in rural or isolated areas, overcoming geographical barriers to dental access⁸.

The Role of Teledentistry in Pediatric Dentistry and Early Diagnosis and Prevention

Teledentistry is gaining importance in preventive dentistry by utilizing digital platforms such as messaging, apps, and video consultations. It has also demonstrated effectiveness in reducing dental issues such as plaque, gum inflammation, and white spot lesions, often outperforming traditional in-person care⁹. This essential modern tool provides care to underserved areas with limited access to pediatric specialists and offers significant benefits in monitoring, diagnosing, and preventing dental problems.

Mobile technology and internet usage have also created new opportunities for patient education, especially for children, who are becoming increasingly adept at using digital devices. These platforms raise awareness about oral hygiene and help maintain communication with parents to guide them on essential preventive measures and behavior management¹⁰.

Teledentistry offers several benefits for pediatric oral health care. Virtual consultations can reduce the need for travel, making it easier for children and parents to attend appointments without interrupting daily routines¹¹. Dentists can use video consultations to triage patients, provide follow-up care, and share treatment plans with intraoral images. Additionally, virtual visits can lessen dental anxiety, as it allows parents and children to learn more about necessary procedures and available options before in-person appointments¹².

Moreover, teledentistry plays a crucial role in preventive care, particularly for children at high risk of dental caries. This remote monitoring allows for the early detection of non-cavitated lesions, as adjunct dental personnel can capture intraoral images for dentist evaluation. These images help in the assessment of caries risk and monitoring of oral health along with enabling the creation of personalized prevention plans. Early diagnosis of non-cavitated lesions is key to preventing progression to cavitated lesions, and teledentistry facilitates timely interventions such as sealants or minimally invasive restorations¹³.

The application of CAMBRA (Caries Management by Risk Assessment) strategies, which emphasize early detection and treatment of dental issues through personalized care plans, is used in teledentistry, specifically for screening children remotely and offering guidance on preventive practices like toothbrushing, interdental cleaning, and fluoride use both practitioners and patients save time and resources, especially in underserved areas^{14,15}.

Teledentistry provides a unique opportunity to use tools like video modeling, in which children watch peers cope with dental procedures. This method has been shown to alleviate anxiety and improve coping mechanisms¹². This remote counseling allows dentists to support patients and their families in a less stressful and more convenient manner.

The Role of Teledentistry in Oral Medicine

Teledentistry plays an essential role in oral medicine, offering dental professionals and specialists a means to address complex oral health concerns. This scoping review aims to consolidate existing research regarding the technical specifications of teledentistry services and security aspects, along with guidelines on standardized methods for oral cavity photography in this context.

Teledentistry leverages technology such as computers, telecommunications, digital imaging devices, and software to support remote diagnosis and treatment recommendations⁸. These tools have been applied in various fields such as healthcare, education, and public health due to their ability to extend access to remote areas, reducing time and costs for patients¹⁶.

Studies also report positive clinical outcomes from using virtual images and radiographs for remote consultations in diagnosing oral lesions. While teledentistry shows promise, face-to-face evaluations remain the most reliable for definitive diagnosis. However, high-resolution clinical images and comprehensive case summaries can significantly aid in prioritizing referrals, particularly in cases of suspected malignancy¹⁷.

Notably, some studies have demonstrated successful applications of teledentistry in oral medicine. For example, Bradley M et al. showcased its use in a community dental service in Belfast, Northern Ireland, with a prototype teledentistry system⁴, and Torres-Pereira C et al. suggested that remote diagnosis using digital images via email is an effective alternative for assessing oral lesions¹⁸.

Regarding biopsy results, most consultations stemmed from clinical suspicions of malignancy; however, several lesions were benign, often resulting from irritative or infectious factors such as pyogenic granulomas and traumatic fibromas. These findings align with studies that demonstrate teledentistry's effectiveness as a screening tool for early oral cancer detection¹⁹.

Teledentistry enables specialists in remote monitoring and management of oral lesions. This is fundamental for malignant and potentially malignant conditions, making early detection and diagnosis more feasible.

Role of Teledentistry in Oral and Maxillofacial Surgery and Periodontics

Teledentistry has proven to be effective in oral and maxillofacial surgery. For example, Duka M et al. found that the remote evaluation of impacted or semi-impacted third molars using telemedicine yielded comparable results to in-person clinical assessments⁶. Rollert MK et al. also highlighted the reliability of telemedicine consultations for patients undergoing dentoalveolar surgery. The ability to conduct preoperative evaluations remotely is particularly valuable for cases in which patient transport is challenging or costly.

Aziz SR and Ziccardi VB noted that smartphones provide oral and maxillofacial surgeons with quick, accessible digital images, enhancing the efficiency of specialty consultations. Furthermore, a web-based teledentistry consultation system used by the U.S. Department of Defense demonstrated that the most commonly requested specialties for remote consultations were oral surgery, prosthodontics, and periodontics^{20,21}.

At Fort Gordon, Georgia, a successful case demonstrated remote post-operative care in which a periodontist supervised suture removal from 150 miles away. This approach highlights the efficiency and cost-effectiveness of telemedicine in the context of oral surgery.

Role of Teledentistry in Endodontics

Teledentistry has also proven valuable in endodontics. Brullmann D et al. demonstrated that remote evaluation could accurately identify root canal orifices from images of endodontically accessed teeth. Zivkovic D et al. showed that telecommunication-based diagnosis could identify

periapical lesions in anterior teeth, offering cost-effective solutions for urgent care. Additionally, studies, including Baker WP 3rd et al., have shown no significant difference in the accuracy of diagnosing periapical lesions when using conventional radiographs compared to those transmitted via telecommunication systems²².

Role of Teledentistry in Orthodontics

Teledentistry has become an important tool in orthodontics as well. According to Berndt F et al., interceptive orthodontic treatments provided by trained general dentists and overseen remotely by orthodontic specialists can significantly reduce the severity of malocclusions in children, particularly when referral to a specialist is not feasible²³. Further studies, such as those by Stephens CD and Cook J, found that teledentistry improves the accessibility to orthodontic advice for general dental practitioners and patients⁷. Additionally, Cook J et al. found that teledentistry reduced unnecessary orthodontic referrals by providing general dental practitioners with quick specialist consultations²⁴.

Teledentistry also helps address minor orthodontic emergencies, such as appliance discomfort, which can be resolved remotely, reducing unnecessary visits and reassuring patients. Mandall NA's study on teledentistry for orthodontic referrals confirmed that decisions based on clinical photographs matched those from in-person evaluations, further validating teledentistry's effectiveness in orthodontics²⁵.

In summary, teledentistry offers significant potential across various dental specialties, improving access to care, supporting remote consultations, and aiding early diagnosis and treatment. Continued research and developing standardized protocols will be essential for optimizing its integration into routine dental practice.

TELEDENTISTRY FOR SPECIAL POPULATIONS

Teledentistry plays a significant role in comprehensive community outreach programs. Often implemented in schools or nursing homes, participants receive thorough examinations and treatment plans while staff are utilized more efficiently based on patient needs. Through an almost decade-long pilot program, The University of the Pacific has demonstrated that this method of engagement is as effective as in-person examinations²⁶.

Teledentistry in the Elderly Population

Over the past fifty years, significant advancements in both preventive and restorative oral care have allowed older adults to keep more of their natural teeth. Additionally, the number and proportion of older adults has increased considerably. As a result, the demand for oral health services among this group has risen, necessitating the thorough management of complex dental issues including periodontal diseases, cavities, root caries, dry mouth, oral mucosal disorders, and cancers of the mouth and throat. These oral health issues can be influenced or worsened by other underlying health conditions. Access to dental care is a major concern for many older individuals, particularly those in institutional settings, long-term care facilities, or rural areas.

Oral health is a vital component of overall well-being and has a significant impact on quality of life. Healthcare systems will need to address the needs of many patients who have suffered from chronic untreated diseases, including oral health conditions. Maintaining oral health is essential, particularly in preventing and treating conditions that could lead to edentulism, among the elderly²⁷. Unmet oral health needs are prevalent among older populations, highlighting the importance of improving access to dental care. Additionally, oral diseases may contribute to or

exacerbate inflammatory and infectious processes at a systemic level, potentially worsening the health of individuals with comorbidities²⁸.

The global pandemic has created a distinct chance to rethink traditional dental care approaches. Elderly individuals, particularly those who are frail or institutionalized, often face barriers to accessing standard dental treatment. Factors like limited mobility and fear of SARS-CoV-2 have further hindered older adults from seeking care in dental clinics. To enhance care quality for those with reduced autonomy and living in institutions, Teledentistry could serve as a viable solution for providing dental health services to older adults during and beyond the pandemic. Dental professionals and policymakers must reconsider current practices and anticipate future needs, recognizing the opportunities emerging in the aftermath of this crisis².

Teledentistry in Other Underserved Communities

Racial and ethnic minorities, individuals with mental or physical challenges, and those from low-income families, especially children, disproportionately face limited access to dental care. In rural areas, several barriers prevent people from receiving dental care, including geographic isolation, poor infrastructure, adverse weather conditions, lack of public transportation, poverty, absence of health insurance, and a shortage of dentists to the population. These challenges are further compounded by the scarcity of specialty and subspecialty dentists.

By facilitating teleconsultations with specialists from larger communities, local dentists can more easily provide their patients with access to specialty care. Teledentistry also extends affordable care to underserved populations, particularly those in rural areas, at a reasonable cost. This review emphasizes the importance of teledentistry across various dental specialties and its role in supporting underserved populations.

The Institute of Medicine's report, "Improving Access to Oral Health Care for Vulnerable and Underserved Populations," recommends teledentistry as a solution to overcome traditional geographic barriers to care for rural and underserved communities. Currently, teledentistry is primarily used for screening, treatment planning, and providing limited diagnostic, preventive, and restorative services by dental auxiliaries and primary care providers in remote areas, all within their scope of practice²⁹.

Increasing access to oral health care for underserved populations has been a key focus in discussions about improving public oral health. Teledentistry is an innovative solution for expanding access to both general and specialty dental services, particularly in rural and underserved communities³⁰.

Teledentistry, as part of broader telehealth services, aids in identifying cases, directing patients to the appropriate level of care, managing diseases, and providing patient education. Some patients using teledentistry may continue preventive care locally, while others may be referred to a dentist for in-person treatment. Overall, teledentistry improves access, lowers costs, and enhances oral health outcomes for those who utilize the service. It also holds the potential to reduce the oral health disparities between rural and urban populations³.

Teledentistry in Individuals with Disabilities

The statement, "Any disabled person has the right to benefit from the full solidarity of the national community, which, as part of this national duty, guarantees access to essential care recognized for all citizens and ensures the full exercise of citizenship," comes from the law on the rights, opportunities, participation, and citizenship of disabled individuals, enacted on February 11th, 2005. However, in practice, this promise remains unfulfilled. There is limited research on this

issue, particularly regarding oral care, yet the available studies consistently highlight a significant public health concern regarding the oral health of individuals with disabilities. For example, Dorin et al. reported that only 3.4% of 8,401 children and adolescents with disabilities were free of oral health issues. It is widely acknowledged that the oral health of individuals with disabilities worsens with age and is significantly poorer than that of the general population. Recent international studies underscore the inadequate state of dental care for this group, revealing higher rates of untreated dental issues and insufficient oral hygiene practices among this group. This population is recognized as being at high risk for dental diseases. In addition to traditional risk factors, contributing factors include medication use, neuro-motor and sensory impairments, comorbidities, and behavioral changes. These factors can make it difficult for caregivers to assist with oral hygiene and complicate the provision of dental treatment. Non-cooperative behavior in some individuals with disabilities further necessitates a preventive approach to avoid the worsening of oral health³¹.

As previously noted, the oral health of disabled individuals is a significant public health concern. This issue is not new, and French policymakers and stakeholders have already proposed various measures to address it. For example, an oral consultation is recommended when the patient first enters a facility and annually thereafter. Unfortunately, this initial consultation is rarely conducted due to several challenges, including a lack of oral health knowledge among healthcare professionals in disability facilities, difficulties in arranging for on-site dental visits, and logistical complications in transporting patients and medical staff to dental offices³².

Teledentistry in Medically Compromised Patients

Telehealth offers the potential to reach a wide range of individuals, particularly those with weakened immune systems, pre-existing medical conditions, or family responsibilities like child care, by minimizing unnecessary contact and supporting physical distancing. Acknowledging this potential, the Federal Communications Commission (FCC) allocated substantial funding to support medical providers and health institutions in expanding telehealth services during the COVID-19 pandemic³³. The shift from in-person visits to teledentistry enables oral health providers to minimize infection risks while continuing to offer essential services, including triaging orofacial issues, follow-up care, screenings, and oral health promotion. This is particularly beneficial for older adults and individuals who are home-bound or living in long-term care facilities—populations highly vulnerable to severe complications from COVID-19.

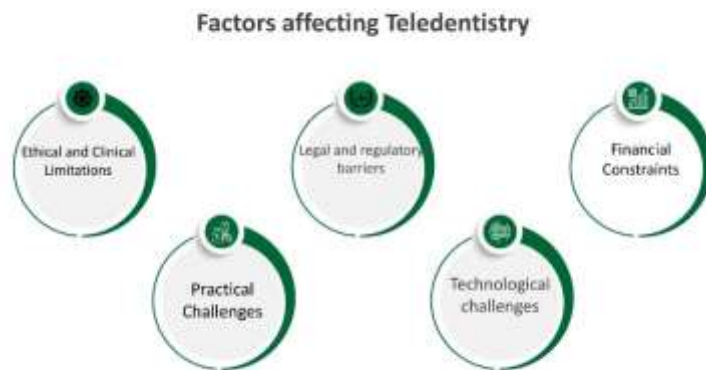
Patients were advised to avoid hospital, dental, and other medical facilities visits due to the risk of cross-infection. The dental environment, in particular, has proven to be a significant source of transmission, as many dental procedures involve the generation of aerosols and droplets that can carry harmful microorganisms. This exposes dentists to infection from patients, which they may subsequently transmit to their families. Consequently, many dentists have reported heightened levels of fear and anxiety. To mitigate these risks, new consultation models should be encouraged to minimize direct contact between dentists and patients.

In today's world, high-speed mobile data and the internet enhance communication between dentists and patients. With the widespread use of smartphones, laptops, and various video conferencing tools, "teledentistry" has emerged as an innovative way to provide dental care remotely³⁴. This approach has revolutionized traditional methods, offering virtual consultations and follow-ups instead of in-person clinical evaluations. It has proven particularly valuable during the COVID-19 lockdown, reducing the need for patients to visit dental clinics unless necessary. This narrative

review aims to highlight the significance of teledentistry for both general and specialized dentists in managing dental emergencies during the lockdown³⁵.

CHALLENGES AND LIMITATIONS OF TELEDENTISTRY

The integration of teledentistry introduces various challenges and limitations that need to be addressed to establish its credibility as a viable alternative to conventional dental care. Recognizing these obstacles is crucial for dental professionals and industry stakeholders aiming to leverage technology to enhance patient access and the effectiveness of care. A key reason for the hesitation among many dental practitioners to adopt teledentistry revolves around five primary areas of concern³⁶.



Ethical and Clinical Limitations

Ethical aspects of healthcare are intrinsically linked to the quality of care delivered. The commitment to providing high-quality healthcare is an ethical obligation, informed by the principles of beneficence (doing good) and nonmaleficence (avoiding harm). Meeting ethical standards in healthcare requires respect for patient autonomy and the promotion of fairness. Furthermore, the concepts of "good" or "high-quality" care must be evaluated from an ethical standpoint, considering not only technical outcomes but also patient-centered factors such as dignity, access, and equity³⁷.

Teledentistry faces substantial ethical dilemmas, including the necessity of protecting patient confidentiality, obtaining informed consent, and navigating complex licensing regulations. To guarantee the provision of quality care within teledentistry, it is essential to tackle access inequalities, uphold ethical principles, and address challenges to patient engagement³⁸.

A significant limitation is the lack of physical examinations, which can undermine the effectiveness of assessments conducted through virtual consultations. This deficiency raises concerns about the risk of misdiagnosis or incomplete treatment plans. For instance, periodontal diseases may remain undetected in a virtual examination, as the subtleties of a physical examination are often crucial for early detection. Additionally, poor-quality imaging may result in overlooked signs of early cavities, highlighting the difficulties dental professionals face in delivering comprehensive care through digital means. Consequently, in-person visits are still necessary, especially in complex situations requiring thorough physical assessments for accurate diagnosis and treatment³⁹.

Practical Challenges

Despite the potential advantages of teledentistry, it also encounters several practical challenges inherent to its online format. Many dental issues, such as swelling, severe decay, soft tissue lesions, loose teeth, and compromised prosthetics, often necessitate in-person evaluations for precise diagnosis and treatment planning. These challenges underscore the importance of adequate training for dental professionals in effectively utilizing teledentistry tools. However, resistance to adopting new technologies can obstruct implementation efforts and slow progress in this area. Furthermore, a major obstacle to the successful integration of teledentistry is the insufficient technical proficiency among dental staff. If practitioners lack the necessary skills and confidence to utilize these digital tools, they may be hesitant to transition to a digital-first approach. Overcoming these challenges necessitates the development of comprehensive training programs and ongoing support systems to assist dental professionals in adapting to the rapidly changing technological landscape of the field³⁹.

Moreover, while it is vital to prioritize privacy and confidentiality, telehealth service providers must also ensure the accuracy, security, and integrity of the data being transmitted. The emergence of new digital platforms may require adjustments in healthcare providers' professional roles, potentially necessitating further training to manage these changes effectively. Additionally, the traditional healthcare model, which emphasizes interpersonal relationships, fosters trust, respect, and mutual understanding. The transition to telehealth alters this dynamic, raising concerns about whether electronic communications can uphold the same level of confidentiality and trust as direct interactions⁴⁰.

Legal and Regulatory Barriers

The legal framework regulating healthcare practices significantly impacts telehealth, as all medical activities must adhere to the legal and ethical standards of their respective jurisdictions. Since teledentistry often crosses jurisdictional boundaries (including state and international lines), it can create challenges related to licensure. In certain countries, such as Australia, Brazil, and several European regions, providing services across state lines is typically allowed, enabling licensed healthcare professionals to operate nationwide. However, practitioners must verify the specific regulations and requirements set by the relevant governing authority in the jurisdiction where they plan to practice. In contrast, teledentistry regulations can differ significantly in other regions and are often managed at the state, regional, or provincial level.

A notable challenge involves confirming the credentials of healthcare providers. In addition to obtaining informed consent from patients, consultations should include clear communication regarding the qualifications of the healthcare professional, assisting patients in understanding how to verify those credentials. However, validating professional qualifications can become more complex in a teledentistry context, as there may not be a straightforward method to confirm the credentials of providers delivering care remotely⁴⁰.

Healthcare providers encounter several difficulties in securing reimbursement for teledentistry services. The varied coverage policies and reimbursement criteria across different states pose significant obstacles to the financial sustainability of teledentistry. The Centers for Medicare & Medicaid Services (CMS) have established specific regulations and limitations that complicate the reimbursement landscape for telehealth services. Additionally, many private insurance

companies have yet to implement comprehensive coverage for telemedicine services, further complicating matters for healthcare providers⁴⁰.

While telemedicine services provide convenience, they also raise concerns regarding security and privacy, as patient information is transmitted online. The healthcare sector has historically been susceptible to data breaches due to its handling of sensitive information. The adoption of electronic health records (EHRs) and other forms of protected health information (PHI) in telemedicine increases the risk of data-related issues^{40,41}.

Technological Challenges

Telemedicine faces challenges stemming from inadequate technological access, particularly in rural or economically disadvantaged areas. Individuals lacking access to computers, smartphones, or reliable internet connections may struggle to participate in teledentistry appointments, limiting their healthcare access. Additionally, elderly patients, who may be less familiar with technology, might encounter challenges navigating telemedicine services.

Technical difficulties or interruptions in internet service during a telemedicine appointment can hinder healthcare providers' ability to accurately assess patients, potentially resulting in misdiagnoses. Diagnostic errors can negatively impact both patients and healthcare practitioners, leading to inappropriate treatments and increased costs. Moreover, these disruptions can obstruct telemedicine sessions, preventing patients from receiving necessary care⁴¹.

Some patients may experience difficulties with digital tools or feel uncomfortable using telecommunication resources, leading to reduced engagement and diminished trust in teledentistry services³⁹.

Financial Constraints

Regulations are essential for securing the financial support necessary for the effective implementation and ongoing success of teledentistry. Financial challenges encompass not only reimbursement for healthcare services but also the costs associated with adopting telehealth technologies. Establishing and maintaining telehealth requires investments in technological infrastructure and training on how to use these technologies. Healthcare providers lacking the financial resources or capabilities to implement telehealth may face significant obstacles, resulting in further barriers to patient access⁴⁰.

ARTIFICIAL INTELLIGENCE AND FUTURE TRENDS IN TELEDENTISTRY.

Artificial intelligence (AI), a branch of computer science, aims to design systems or machines capable of executing tasks that normally require human intelligence⁴². The incorporation of AI into teledentistry could profoundly transform dental care, teaching, research, and distant innovations. By developing machine learning algorithms, including deep learning, predictive models can be created to assess the risks of oral health disorders, detect complications, and classify patients. With the help of these models, patients can independently diagnose dental conditions, take preventative action, or treat them in their early stages⁴³. This strategy, which aims to enhance oral health outcomes through earlier diagnosis and better patient satisfaction, is especially beneficial in underprivileged areas with limited access to dental practitioners⁴⁴.

Advantages of AI in Teledentistry

Through improved diagnostic precision, quicker clinical results, and easier access to care for underserved communities, artificial intelligence (AI) in teledentistry holds the potential to revolutionize dentistry or dental care. By utilizing AI technologies like deep learning, predictive analytics, and treatment planning, teledentistry can provide efficient, personalized dental care at reduced costs, leading to increased patient satisfaction. These developments open new avenues for preventive oral care in addition to removing the obstacle to universal dental treatment⁴⁵.

APPLICATION ASPECTS	AI IN TELEDENTISTRY
Use as a Diagnostic Tool	<ul style="list-style-type: none"> *AI-powered predictive models for oral health risk assessment. *Machine learning algorithms for dental disease diagnosis. *AI-assisted screening of dental radiographs.
Use in Remote Consultation	<ul style="list-style-type: none"> * Smart device-based remote screening and diagnosis * AI-enabled triage systems for dental patients

Limitations of artificial intelligence in teledentistry

Artificial Intelligence (AI) is highly dependent on advanced computer science. Critical issues include data protection, extraction quality, and consistency. The storage of these vast data volumes demands substantial investment in data-sharing systems or cloud infrastructure. Ensuring a consistent format for data collection from the outset is essential to reduce variability and improve accuracy⁴⁶.

ChatGPT in Teledentistry.

One significant example of AI's widespread adoption is ChatGPT, a conversational AI chatbot developed by OpenAI. Since its release in November 2022, ChatGPT has garnered substantial attention, thanks to its user-friendly interface. As a large language model (LLM), it is trained on vast amounts of human-written text, enabling it to respond to a wide range of inquiries and perform various text-based tasks⁴⁷. In the realms of dentistry and healthcare, ChatGPT holds great promise, with potential applications in treatment planning and patient monitoring related to dental health and hygiene⁴⁸. However, the effectiveness of these applications depends on the availability of accurate, current, and unbiased data. While ChatGPT can deliver quick answers, concerns around its reliability, transparency, and the accuracy of its information are especially pertinent when addressing health-related topics, particularly when compared to traditional search engines⁴⁷.

AI-powered teledentistry holds the potential to augment the expertise of even the most experienced or overworked clinicians. While current teledentistry applications serve as supplements rather than replacements for in-person consultations, AI can drive a transition from a curative approach to a predictive and preventive personalized care model. This transformative shift, which will continue to evolve, positions AI to assist clinicians, educators, and researchers across all aspects of dentistry⁴².

CONCLUSION

Teledentistry is an option to overcome the access barriers some people face in receiving oral health care, especially in rural and underserved regions with limited access to dental professionals. As the global shortage of dentists is expected to increase, teledentistry provides an effective way to deliver essential care while fostering collaboration between general dentists and specialists, thereby improving patient outcomes. It also supports prevention by allowing early identification

and ongoing monitoring of oral health problems, which can help avoid more complex treatments in the future. The three main methods of teledentistry- real-time consultations, store-and-forward technology, and remote monitoring- offer key benefits such as improved access, lower costs, and increased cooperation between professionals. Also, its applications span several dental specialties, including pediatric dentistry, orthodontics, and periodontics, and address a wide range of patient needs. While challenges such as digital access and legal restrictions remain, the integration of AI could further improve diagnostic accuracy and care delivery. Overall, teledentistry is shaping the future of dental care, making it more accessible, preventive, and efficient.

REFERENCES

1. Clark GT. Teledentistry: What is it Now, and What Will it be Tomorrow? *J Calif Dent Assoc.* 2000;28(2):121–7.
2. Friction J, Chen H. Using Teledentistry to Improve Access to Dental Care for the Underserved. *Dent Clin North Am.* 2009;53(3):537–48.
3. Jampani ND, Nuthalapati R, Dontula BSK, Boyapati R. Applications of Teledentistry: A Literature Review and Update. *J Int Soc Prev Community Dent.* 2011;1(2):37–44.
4. Bradley M, Black P, Noble S, Thompson R, Lamey PJ. Application of Teledentistry in Oral Medicine in a Community Dental Service, N. Ireland. *Br Dent J.* 2010;209(8):399–404.
5. Chen JW, Hobdell MH, Dunn K, Johnson KA, Zhang J. Teledentistry and Its Use in Dental Education. *J Am Dent Assoc.* 2003;134(3):342–6.
6. Duka M, Mihailovic B, Miladinovic M, Jankovic A, Vujicic B. Evaluation of telemedicine systems for impacted third molars diagnosis. *Vojnosanit Pregl.* 2009;66(12):985–91.
7. Stephens CD, Cook J. Attitudes of UK consultants to teledentistry as a means of providing orthodontic advice to dental practitioners and their patients. *J Orthod.* 2002;29(2):137–42.
8. da Costa CB, Peralta FDS, Ferreira de Mello ALS. How has teledentistry been applied in public dental health services? An integrative review. *Telemed J E Health.* 2020;26(11):945–54.
9. Fernández CE, Maturana CA, Coloma SI, Carrasco-Labra A, Giacaman RA. Teledentistry and mHealth for promotion and prevention of oral health: A systematic review and meta-analysis. *J Dent Res.* 2021;100(9):914–27.
10. Sharma H, Suprabha BS, Rao A. Teledentistry and its applications in paediatric dentistry: A literature review. *Pediatr Dent J.* 2021;31(3):203–15.
11. Viswanathan A, Patel N, Vaidyanathan M, Bhujel N. Utilizing teledentistry to manage cleft lip and palate patients in an outpatient setting. *Cleft Palate Craniofac J.* 2021;58(1):1–6.
12. Wallace CK, Schofield CE, Burbridge LAL, O'Donnell KL. Role of teledentistry in paediatric dentistry. *Br Dent J.* 2021;25:1–6.
13. Brown LJ, Kaste LM, Selwitz RH, Furman LJ. Dental caries and sealant usage in U.S. children, 1988–1991: selected findings from the Third National Health and Nutrition Examination Survey. *J Am Dent Assoc.* 1996;127(3):335–43.
14. Van Hilsen Z, Jones RS. Comparing potential early caries assessment methods for teledentistry. *BMC Oral Health.* 2013;13:16.

15. Goffin G, Carter N, Widyarman AS, et al. Role of teledentistry in enabling improved oral care outcomes. *Br Dent J.* 2024;236(2):162–8.
16. Khan SA, Omar H. Teledentistry in practice: literature review. *Telemed J E Health.* 2013;19(7):565–7.
17. Flores AC, Lazaro SA, Molina-Bastos CG, de Guattini VLO, Umpierre RN, Gonçalves MR, et al. Teledentistry in the diagnosis of oral lesions: A systematic review of the literature. *J Am Med Inform Assoc.* 2020;27:1166–72.
18. Khoury ZH, Sultan AS. Tele-oral oncology: reinvigorating telemedicine in oral cancer care. *J Cancer Allied Spec.* 2020;6(1):e335.
19. Flores-Hidalgo A, Collie J, King S, Grant FT, Beasley NE, Moss ME, et al. The use of teledentistry in clinical oral and maxillofacial pathology practice: an institutional experience. *Front Oral Health.* 2023;4:1063973.
20. Aziz SR, Ziccardi VB. Telemedicine using smartphones for oral and maxillofacial surgery consultation, communication, and treatment planning. *J Oral Maxillofac Surg.* 2009;67:2505–9.
21. Rocca MA, Kudryk VL, Pajak JC, Morris T. The evolution of a teledentistry system within the Department of Defence. *Proc AMIA Symp.* 1999:921–4.
22. Brullmann D, Schmidtman I, Warzecha K, d’Hoedt B. Recognition of root canal orifices at a distance – A preliminary study of teledentistry. *J Telemed Telecare.* 2011;17:154–7.
23. Baker WP 3rd, Loushine RJ, West LA, Kudryk LV, Zadinsky JR. Interpretation of artificial and in vivo periapical bone lesions comparing conventional viewing versus a video conferencing system. *J Endod.* 2000;26:39–41.
24. Berndt J, Leone P, King G. Using teledentistry to provide interceptive orthodontic services to disadvantaged children. *Am J Orthod Dentofacial Orthop.* 2008;134:700–6.
25. Favero L, Pavan L, Arreghini A. Communication through telemedicine: home teleassistance in orthodontics. *Eur J Paediatr Dent.* 2009;10:163–7.
26. Mandall NA. Are photographic records reliable for orthodontics screening? *J Orthod.* 2002;29(2):125–7.
27. Suter N. Teledentistry applications for mitigating risk and balancing the clinical schedule. *J Public Health Dent.* 2020;80(S2).
28. Murray Thomson W. Epidemiology of oral health conditions in older people. *Gerodontology.* 2014;31(Suppl S1):9–16
29. Institute of Medicine (IOM) & National Research Council (NRC). Improving access to oral health care for vulnerable and underserved populations. 2011.
30. Kopycka-Kedzierawski DT, Bell CH, Billings RJ. Prevalence of dental caries in Early Head Start children as diagnosed using teledentistry. *Pediatr Dent.* 2008;30:329–33.
31. Dorin M, Moysan V, Cohen C, Collet C, Hennequin M. Évaluation des besoins de santé bucco-dentaire des enfants et adolescents fréquentant un institut médico-éducatif ou un établissement pour enfants et adolescents polyhandicapés, en France. [Evaluation of oral health needs in children and adolescents attending a medico-educational institute or an institution for children and adolescents with multiple disabilities, in France]. *Prat Organ Soins.* 2006;37:14.

32. Surabian S. Developmental disabilities and understanding the needs of patients with mental retardation and Down Syndrome. *J Calif Dent Assoc.* 2001;29:415-23.
33. Federal Communications Commission (FCC). FCC fights COVID-19 with \$200M; adopts long-term connected care study. Washington (DC); 2020.
34. Matusitz J, Breen GM. Telemedicine: its effects on health communication. *Health Commun.* 2007;21(1):73–83.
35. Ahmed MA, Jouhar R, Ahmed N, Adnan S, Aftab M, Zafar MS, et al. Fear and practice modifications among dentists to combat novel coronavirus disease (COVID-19) outbreak. *Int J Environ Res Public Health.* 2020;17(8).
36. Shuborna N, Islam S, Jahan S, Hoque Apu E, Bin Noor O, Chowdhury MT. Editorial: Teledentistry: Limitations and Challenges.
37. Marckmann G, Schildmann J. Qualität und Ethik in der Gesundheitsversorgung [Quality and ethics in healthcare]. *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz.* 2022;65(3):335-341. [German]
38. Malpe M, Choudhari SG, Nagtode N, Muntode Gharde P. Beyond the Chair: Exploring the Boundaries of Teledentistry. *Cureus.* 2024 Jun 13;16(6):e62286.
39. Mohamed AM, Ahmed F, Gondi KM, Salem KA, Mohammed OB, Peeran SW. Knowledge, Attitude, and Practice of Teledentistry in Periodontal Diagnosis Among Dental Interns at a College in Sebha, Libya: A Cross-Sectional Questionnaire Study. *Cureus.* 2024 Apr 15;16(4):e58330.
40. Mariño RJ, Zaror C. Legal issues in digital oral health: a scoping review. *BMC Health Serv Res.* 2024 Jan 3;24(1):6.
41. Fahim A, Saleem Z, Malik KA, et al. Exploring challenges and mitigation strategies towards practicing Teledentistry. *BMC Oral Health.* 2022;22(1).
42. Mallineni SK, Sethi M, Punugoti D, Kotha SB, Alkhayal Z, Mubarak S, et al. Artificial intelligence in dentistry: A descriptive review. *Bioengineering.* 2024;11(12):1267.
43. Batra P, Tagra H, Katyal S. Artificial Intelligence in Teledentistry. *Discoveries (Craiova).* 2022 Sep 30;10(3):153.
44. Pedroso CM, Warnakulasuriya S, Santos-Silva AR. Teledentistry in the detection of oral potentially malignant disorders and oral cancer in the Latin American region: a review of literature with current possibilities. *Explore Digit Health Technol.* 2024;2:291–301.
45. Kaushik R, Rapaka R. A Patient-Centered Perspectives and Future Directions in AI-powered Teledentistry. *Discoveries.* 2024;12:e199.
46. Huang YK, Hsu LP, Chang YC. Artificial intelligence in clinical dentistry: The potentially negative impacts and future actions. *J Dent Sci.* 2022 Oct;17(4):1817-1818.
47. Eggmann F, Blatz MB. ChatGPT: Chances and Challenges for Dentistry. *Compend Contin Educ Dent.* 2023 Apr;44(4):220-224.
48. Alhaidry H, Fatani B, Alrayes J, Almana A, Alfhaed N. ChatGPT in Dentistry: A Comprehensive Review. *Cureus.* 2023;15.