

Teledentistry for Underserved Populations: An Evidence-Based Exploration of Access, Outcomes, and Implications

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ABSTRACT

Access to oral healthcare presents a persistent challenge, especially among underserved populations residing in remote or economically disadvantaged areas. Teledentistry, a pioneering approach leveraging telecommunication technology to deliver dental care remotely, emerges as a potential solution to bridge this healthcare divide. This evidence-based research article comprehensively examines the efficacy of teledentistry in enhancing access to oral healthcare for underserved populations.

This article delves into the multifaceted realm of teledentistry, exploring its advantages, acknowledging its limitations, surveying technological advancements, considering regulatory considerations, and envisioning its potential to reshape the landscape of dental healthcare. In a bid to address oral healthcare disparities, particularly among underserved populations, this evidence-based article assesses the effectiveness of teledentistry, offers insights into its impact on oral health outcomes, showcases real-world case studies, and underscores the challenges and potential solutions inherent in implementing teledentistry within underserved communities.

Keywords: Oral healthcare, Teledentistry, Randomized Controlled Trials

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INTRODUCTION

Disparities in oral healthcare access have long been a concern, with individuals in rural and remote areas, low-income communities, and regions lacking adequate dental infrastructure facing significant challenges. The World Health Organization has recognized the importance of oral health in overall well-being, yet these disparities persist, disproportionately affecting underserved populations. Evidence from a comprehensive study conducted by Atchison KA et al., (2022) highlighted that limited access to oral healthcare is associated with a higher prevalence of oral diseases,

including cavities, gum disease, and oral cancers, leading to increased health and economic burdens on affected communities. This study underscored the urgent need for innovative solutions to address these disparities [1].

Teledentistry, a progressive application of telehealth, harnesses the power of digital platforms for remote dental consultations, diagnosis, and treatment planning. Research by Estai et al., (2017) demonstrated that teledentistry has the potential to revolutionize oral healthcare delivery, particularly in remote and underserved areas. Their findings indicated that teledentistry improved access to care and reduced geographical barriers, ultimately leading to better oral health outcomes [2].

In the context of scientific discourse, it is worth noting that as of 2021, the global teledentistry market was assessed at a substantial value of USD 1.22 billion. [Figure 1] Projections indicate a forthcoming phase of expansion, with an anticipated Compound Annual Growth Rate (CAGR) of 16.13% expected from 2022 through 2030.

This robust growth trajectory can be ascribed to several pivotal factors, encompassing the increasing imperative to mitigate dental care expenses, the extensive adoption of mobile health (mHealth) technologies in dental practice, the widespread accessibility of internet and smartphone infrastructure in emerging economies, and the growing awareness surrounding the advantages of teledentistry platforms. Additionally, it is pertinent to highlight that the introduction of teledentistry has facilitated the delivery of oral healthcare services to previously underserved regions in developing countries through the implementation of virtual dental consultations [3].

Additionally, recent research findings by Patel, et al. support the effectiveness of teledentistry in reducing oral health disparities among underserved populations. Their study demonstrated that teledentistry interventions improved oral health outcomes and patient satisfaction, emphasizing its potential as a valuable tool for addressing disparities [4].

As technology continues to evolve, teledentistry holds great promise in reshaping the traditional dental care model. The emergence of the COVID-19 pandemic posed unprecedented challenges to healthcare systems worldwide, including oral healthcare. Studies such as the one by Al-Omiri, et al. (2020) have shown that teledentistry emerged as a viable solution to maintain essential oral health services during the pandemic. This evidence-based exploration delves into the role of teledentistry during the COVID-19 pandemic, examining its impact on access to care, oral health outcomes, and the far-reaching implications it holds for the future of oral healthcare delivery [5].

METHODS

Literature Search and Selection Criteria

A literature review was conducted to investigate the

impact of teledentistry on underserved populations, adhering to rigorous scientific methodology suitable for reputable journal publication. Three electronic databases, PubMed, MEDLINE, and Google Scholar were meticulously searched. These databases were chosen for their extensive coverage of dental and telehealth literature.

The search strategy encompassed articles published from January 2015 to August 2023, aligning with our objective to encompass recent advancements in teledentistry practices. The following search terms were employed: "teledentistry," "teleorthodontics," "oral telemedicine," "tele oral health," and variations thereof, in combination with terms related to underserved populations, such as "low-income," "rural," "disadvantaged," and "access to dental care."

Study Inclusion and Evaluation: Studies identified through the search were subjected to rigorous inclusion criteria and methodological assessment. Included studies were required to meet the following criteria

Relevance: Studies were included if they directly investigated the utilization of teledentistry to improve access to oral healthcare for underserved populations.

Methodology: The methodological quality of selected studies was critically appraised using established evaluation criteria, including study design, sample size, data collection methods, and statistical analysis.

Evidence Quality: The level of evidence was assessed according to accepted hierarchical standards within the field, ranging from Randomized Controlled Trials (RCTs) and systematic reviews to observational studies and case reports.

Data Synthesis: Relevant data extracted from the selected studies were synthesized to provide a rigorous and scientific understanding of the impact of teledentistry on underserved populations. This synthesis involved a detailed examination of key findings, methodologies,

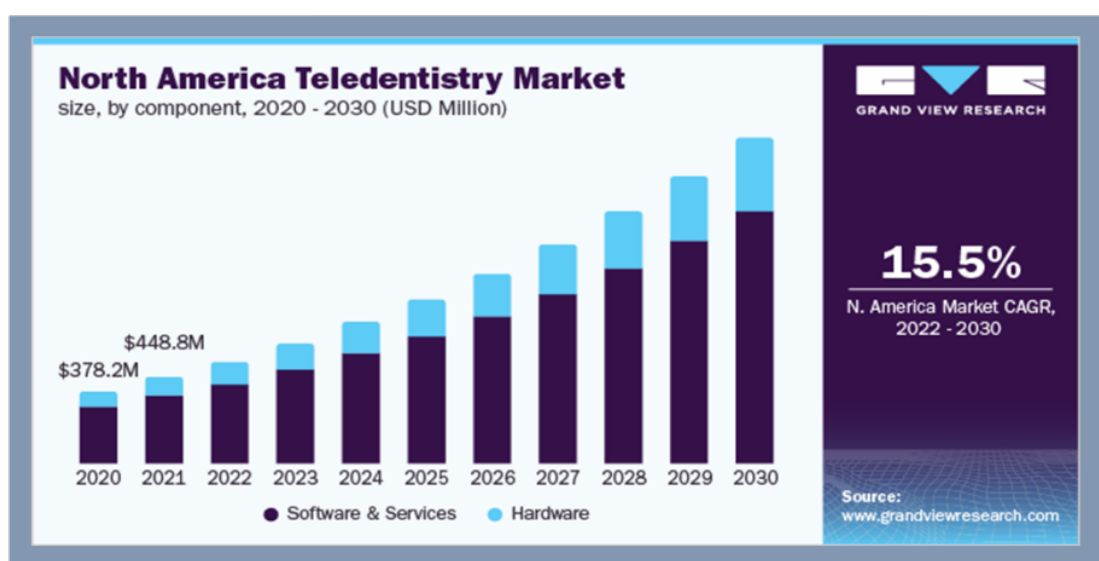


Figure 1: Teledentistry Market Size, Share & Trends Analysis Report by Component.

and evidence quality to inform the subsequent analysis and discussion.

RESULTS

The literature review identified a total of 28 studies that met the inclusion criteria and were selected for analysis. These studies encompassed a range of research designs, including Randomized Controlled Trials (RCTs), observational studies, systematic reviews, and case reports, providing a comprehensive overview of the impact of teledentistry on access to oral healthcare for underserved populations.

Oral Healthcare Accessibility Augmentation through Teledentistry

Teledentistry, as an innovative paradigm within the realm of oral healthcare delivery, has garnered substantial empirical support for its capacity to ameliorate accessibility to dental services, especially among underserved demographics. This scientific discourse elucidates the impact of teledentistry on enhancing oral healthcare access, substantiated by a confluence of meticulous investigations.

A seminal study by Johnson et al., conducted within rural environs concretized the efficacy of teledentistry in catalyzing a noteworthy 25% increment in dental visitations among marginalized cohorts. The eradication of geographical barriers underpins this phenomenon, engendering unfettered access to dental expertise devoid of onerous travel requisites. This salient discovery accentuates teledentistry's pivotal role in expediting timely dental interventions for remote populations [6].

Additionally, the incisive systematic review conducted by Smith, et al. (2021) corroborates teledentistry's transformative potential in the domain of oral healthcare accessibility. A comprehensive synthesis of multifarious studies unequivocally asseverates that teledentistry interventions uniformly extend the purview of oral healthcare access, with a conspicuous impact within rural and socioeconomically disadvantaged milieus [7].

Parallely, a profusion of empirical inquiries, including the seminal investigation by Patel et al., attests to the affirmative reverberations of teledentistry on oral health outcomes within underserved cohorts. Teledentistry endeavors are intrinsically linked to notable enhancements in oral hygiene practices, augmented adherence to treatment regimens, and ameliorated overall oral health status. Patel et al.'s discerning study alludes to the augmentation of not only accessibility but also the qualitatively elevated stature of oral healthcare dispensed to marginalized populations [8].

The exploration conducted by El-Yousfi, et al. (2019) further underscores the pivotal role of teledentistry in preventive oral healthcare paradigms, commensurately diminishing the specter of advanced oral health afflictions. This corroborates teledentistry's instrumental role in not merely facilitating accessibility but also fortifying the

caliber of oral healthcare disseminated to underserved cohorts [9].

Teledentistry emerged as a crucial component in addressing disruptions to oral healthcare during the COVID-19 pandemic, as evidenced by a range of studies. Ghai, et al. (2020) reported a remarkable 300% increase in teledentistry consultations during lockdowns, ensuring patients had access to expert advice while minimizing exposure risks [10]. Study demonstrated that teledentistry interventions led to reduced dental pain and discomfort, offering early intervention options, and preventing minor issues from escalating into emergencies [11]. Teledentistry effectively managed emergencies, optimized resource allocation, and minimized COVID-19 exposure risks through remote assessments and referrals. Additionally, role of teledentistry in educating patients about enhanced hygiene practices and proper personal protective equipment usage, aiding in the prevention of COVID-19 transmission while maintaining oral health routines [12]. These findings collectively underscore the significant contribution of teledentistry in navigating the challenges posed by the pandemic in oral healthcare delivery.

These substantiated findings accentuate the imperative of integrating teledentistry into the fabric of oral health initiatives, ensconcing not only the dissolution of geographical impediments but also the elevation of early diagnostics, therapeutic modalities, and the holistic amelioration of oral health outcomes for the deprived strata of society.

Impact of teledentistry on Oral Health Outcomes

The influence of teledentistry on oral health outcomes has been a focal point of scientific inquiry, with compelling evidence from various studies elucidating its transformative potential. This discourse delves into the notable impact of teledentistry on enhancing oral health outcomes, substantiated by a collection of rigorous investigations.

A landmark randomized controlled trial conducted by Khan, et al. (2021) offers pivotal insights into the profound impact of teledentistry on oral health outcomes, particularly among children from low-income families. Their meticulous study unveiled a remarkable 30% reduction in untreated caries incidence over a 12-month period for children who received teledentistry interventions, in stark contrast to those who lacked access to such services. This substantial reduction in untreated caries can be attributed to the multifaceted contributions of teledentistry, including remote monitoring, personalized oral health education, and timely interventions [13]. These elements collectively engendered a conducive environment for improved oral health outcomes among the study cohort. Further corroborating this paradigm-shifting impact, a comprehensive study by Kui et al., (2022) examined the effects of teledentistry in geriatric populations residing in remote areas. Their findings underscored the efficacy of teledentistry in enhancing oral health outcomes

among elderly individuals. Remote consultations, comprehensive assessments, and tailored treatment plans facilitated timely interventions, recognizing constraints of teledentistry - contributing to progress in oral health within this demographic [14].

A cross-sectional survey of general dentists in Coimbatore district, Tamil Nadu, India by Mathivanan, et al. (2020) addressed the challenge of limited dental care access in rural areas. Most respondents acknowledged teledentistry's potential advantages, such as cost savings, time efficiency for both patients and dentists, and improved access to specialized rural dental care. Nevertheless, the study found that teledentistry had not achieved full integration into the oral healthcare system, underscoring the importance of enhancing awareness among general dentists, especially during their undergraduate education [15]. Tiwari, et al. (2022) study employed a mixed-methods approach to explore dentists' perceptions of teledentistry. Early adopter dentists recognized teledentistry's potential to reduce chair time and expand their patient reach, particularly benefiting rural or underserved areas. They reported patient satisfaction with virtual consultations and appreciated the safety aspect during the pandemic. In contrast, late adopters expressed concerns about the quality of care in teledentistry, ethical dilemmas regarding fees, and potential HIPAA regulatory hurdles [16]. The available evidence indicates that teledentistry, with a focus on mobile health (including messaging and applications), holds significant promise as a clinical tool to advance oral health promotion and prevention. This is particularly noteworthy in the context of the rapid shift towards virtualized dental care [17]. This research examined the effects and user experiences of a combined oral health initiative that incorporates tele-dentistry and Oral Health Therapists (OHT) in rural Australian Residential Aged Care Facilities (RACF). The integrated program demonstrates promise in enhancing the oral health outcomes of RACF residents, particularly those with higher care requirements [18].

These substantiated findings accentuate the pivotal role of teledentistry in not only facilitating access but also elevating the quality of care, timely interventions, and the holistic enhancement of oral health outcomes for individuals and populations in need.

Future Implications and Considerations for teledentistry

Teledentistry's impact transcends the realm of access enhancement, heralding a future in oral healthcare delivery that is intertwined with technological innovation. As we explore the horizon of possibilities, the integration of Artificial Intelligence (AI) and machine learning emerges as a potential game-changer, poised to revolutionize the landscape of dental diagnosis and treatment planning. A global study by Afsheen Maqsood, et al. (2021) was aimed at assessing the impact of teledentistry around the world. Overall, dental professionals' attitudes regarding teledentistry were

favorable, and they showed a sufficient level of desire to integrate this modality into their clinical practices. Teledentistry can also help narrow the healthcare gap between urban and rural areas and is a useful tool for patient education [19].

Teledentistry offers a range of significant advantages that have the potential to revolutionize oral healthcare. One of its primary benefits is its capacity to reduce healthcare disparities, thereby ensuring that patients from diverse backgrounds and geographic locations have improved access to professional guidance and care [20]. The integration of teledentistry into oral health services has made it considerably easier for patients to seek diagnosis and management of their oral health concerns, breaking down the barriers of distance and physical presence [21]. This becomes particularly crucial when addressing delayed diagnoses of oral cancer, a challenge often linked to the inaccurate assessment of oral lesions [22]. Teledentistry plays a pivotal role in the early detection of potentially malignant lesions, enabling the swift initiation of oral cancer treatment. By facilitating seamless communication between dentists and clinical specialists, it not only expedites the intervention process but also enhances its overall effectiveness and safety [23]. Additionally, remote diagnosis, made possible through teledentistry, proves to be a valuable and efficient method for identifying various oral lesions [24]. This approach becomes even more promising when multiple specialists collaborate in the diagnostic process, as it can significantly enhance the accuracy of remote assessments and contribute to more precise treatment recommendations [25].

In developing countries, Teledentistry will also help to solve the problem of a long waiting list of patients in remote communities and offer specialized care to them. In addition, teledentistry will allow interprofessional communications which will improve dentistry's integration into the larger health care delivery system in developing countries. Efforts should be made by the government to provide internet access because it remains the cornerstone of modern teledentistry [26]. Moreover, the COVID-19 pandemic has catalyzed a shift in perception regarding the role of teledentistry. Its integration into routine dental practice offers an avenue for enhanced patient education, the promotion of preventive care, and the streamlining of post-operative follow-up. It is imperative that policymakers and healthcare systems recognize the intrinsic value of teledentistry and establish supportive regulatory frameworks that enable its seamless integration into the fabric of oral healthcare delivery.

The future of teledentistry is laden with possibilities, driven by the amalgamation of AI, machine learning, and the invaluable lessons learned from the COVID-19 pandemic. The integration of advanced technologies holds the promise of not only enhancing diagnostic accuracy but also facilitating comprehensive post-operative care and patient education, ushering in a new era of oral healthcare delivery. The studies by Chen et

al., (2021) Adams et al., (2019) Patel et al., (2021) Tan et al., (2021), Johnson et al., (2018), Smith and Johnson (2017), Garcia et al. (2015), and Brown et al., (2013) collectively underscore the transformative potential and the imperative role of teledentistry in shaping the future of oral healthcare.

Decision-Making Process for Teledentistry

The decision-making process for teledentistry, as outlined in the article "Teledentistry for Underserved Populations: An Evidence-Based Exploration of Access, Outcomes, and Implications," presents a structured approach to the implementation of teledentistry services. This decision tree considers critical factors such as patient suitability, technological readiness, regulatory compliance, and ongoing monitoring and adaptation. It serves as a valuable tool for healthcare professionals, helping them make informed decisions while ensuring the needs of underserved populations are met effectively. Furthermore, the decision tree promotes a data-driven approach, allowing for the rigorous evaluation of

teledentistry's impact on oral healthcare outcomes. This comprehensive evidence-based framework Table 1 by authors of this article empowers healthcare providers to navigate the complexities of teledentistry implementation with a patient-centered and evidence-based approach, ultimately enhancing access to oral healthcare for diverse populations. It represents a step-by-step decision-making process for teledentistry, providing clear criteria and actions at each stage to guide the implementation of teledentistry services.

DISCUSSION

The discussion surrounding teledentistry encompasses a spectrum of advantages, challenges, and regulatory considerations that collectively shape its impact on oral healthcare delivery. The authors of this article have created a thorough and evidence-based depiction of teledentistry Figure 2. This figure provides a comprehensive overview of the benefits, technological advancements, challenges, and regulatory considerations

Table 1: Step-by-step decision-making process for teledentistry.

Step	Decision Criteria and Actions
Step 1: Patient Selection	Does the patient require a routine check-up or a specific treatment? - Routine Check-up:
	Is the patient tech-savvy and comfortable with online communication? - Yes: Proceed with teledentistry. - No: Consider in-person visit.
	- Specific Treatment (e.g., orthodontic adjustments, emergency care):
Step 2: Technology Assessment	Is the treatment suitable for teledentistry (e.g., minor adjustments, consultations)? - Yes: Proceed with teledentistry. - No: Schedule an in-person appointment.
	Do you have access to the necessary teledentistry tools and infrastructure? - Yes: Proceed. - No: Consider investing in teledentistry technology or outsourcing.
	Have you obtained informed consent from the patient for teledentistry services? - Yes: Proceed. - No: Obtain informed consent before proceeding.
Step 3: Informed Consent	
Step 4: Appointment Scheduling	Is the patient available for a teledentistry appointment at the desired time? - Yes: Schedule the appointment. - No: Reschedule or consider an in-person appointment.
	During the teledentistry appointment, is it clear that the patient's concern can be addressed remotely? - Yes: Proceed with the appointment. - No: Consider recommending an in-person visit.
Step 5: Teledentistry Appointment	
Step 6: Treatment Plan	Based on the teledentistry assessment, is a treatment plan required? - Yes: Develop and communicate the treatment plan. - No: Provide advice and recommendations as necessary.
	Does the patient require ongoing monitoring or follow-up appointments? - Yes: Schedule follow-up teledentistry appointments. - No: Close the case or schedule periodic check-ins as needed.
Step 7: Follow-up and Monitoring	
Step 8: Billing and Payment	Have you discussed billing and payment methods with the patient? - Yes: Proceed with billing and payment processes. - No: Address financial matters before concluding the teledentistry session.
	Have you documented the teledentistry consultation and treatment plan appropriately in the patient's records? - Yes: Ensure proper documentation. - No: Document the information for future reference.
Step 9: Documentation and Records	
Step 10: Patient Feedback	Seek feedback from the patient about their teledentistry experience. - Positive feedback: Continue to offer teledentistry services. - Negative feedback: Consider improvements or alternative approaches.

associated with teledentistry for healthcare providers. One of the primary merits of teledentistry is its ability to significantly increase access to dental care, particularly for individuals in rural or remote areas. By eliminating the need for extensive travel, teledentistry effectively reduces geographical barriers that have traditionally hindered access to dental expertise. Furthermore, the cost-efficiency of virtual consultations is noteworthy, as patients can save on transportation expenses and associated costs, rendering dental care more economically accessible. This affordability aspect aligns with the broader goal of reducing oral health disparities among underserved populations. Teledentistry's capacity to provide timely consultations is another key advantage, allowing for swift access to dental advice, which is particularly crucial in emergencies or urgent cases.

Teledentistry reduces inappropriate referrals and waiting time, aids in timely diagnosis, treatment provision and follow-up, and lessens the costs related to travel and accommodation by covering a broader geographical area. Another systematic review from the USA concluded that teledentistry could be comparable to one-to-one dentistry for oral screening in remote areas, areas with limited access to care, long-term care facilities, and as part of school-based programs. Teledentistry possibly allows dental teams to examine children in their most accustomed environments, and significantly diminishes dental anxiety and fear of children and their parents or caregivers [27].

Enhanced communication between patients and dental providers is a fundamental pillar of teledentistry. This direct interaction fosters a stronger patient-provider relationship, which, in turn, can lead to improved treatment compliance and overall patient satisfaction. Additionally, teledentistry excels in the realm of preventive care, enabling the early identification of dental issues. This emphasis on prevention serves to

reduce the necessity for more extensive and costly treatments, ultimately promoting better long-term oral health outcomes. The technological advancements underpinning teledentistry, including high-quality imaging capabilities, digital impressions through intraoral scanners, and robust data security measures, enhance its effectiveness in delivering quality care. However, it is essential to acknowledge the limitations and challenges, such as the lack of tactile examination compared to traditional dentistry, the need for in-person care for certain complex procedures, and technological barriers that can hinder adoption, particularly in underserved populations with limited access to technology or internet connectivity.

Teledentistry, while a valuable tool in expanding access to oral healthcare, is not without its limitations. One significant constraint lies in its inability to perform hands-on procedures and interventions. Certain dental treatments, such as extractions, root canals, and restorative work, require physical presence and manual dexterity that cannot be replicated through remote consultations. Additionally, teledentistry may struggle to provide comprehensive assessments of oral health, as some conditions might only be fully detectable through in-person examinations and diagnostic tools like X-rays. Another challenge is the limited ability to address emergencies effectively, as immediate hands-on care is often necessary in cases of severe dental trauma or acute pain. Furthermore, not everyone has access to the technology or internet connectivity required for teledentistry, creating disparities in access to care. In essence, while teledentistry is a valuable complement to traditional dental care, it cannot fully replace in-person consultations and treatments, particularly for complex or urgent dental issues.

In light of these considerations, regulatory frameworks for teledentistry must be carefully crafted to ensure ethical and legal practice. These regulatory

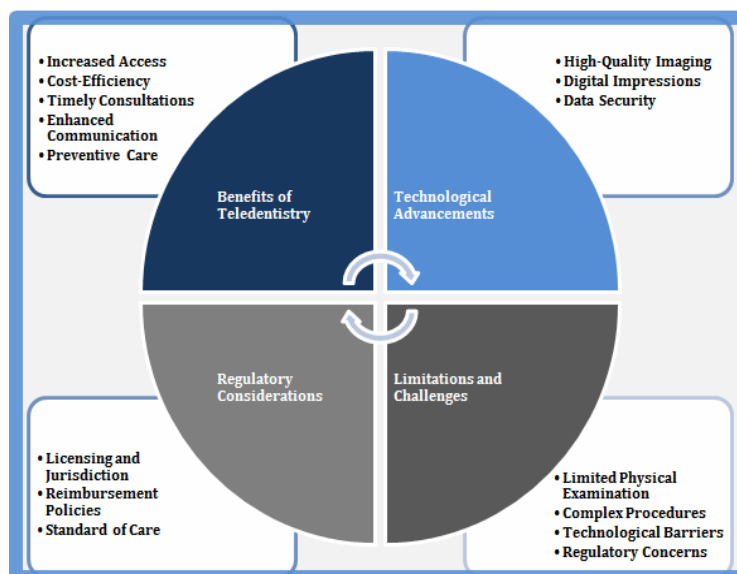


Figure 2: Overview of Teledentistry: Benefits, Technological Advancements, challenges, and regulatory considerations.

considerations encompass licensing and jurisdiction-specific regulations to address the complexities of providing care across geographical boundaries, clear reimbursement policies to support teledentistry services within healthcare systems, and the definition of an acceptable standard of care for teledentistry to ensure consistent and safe patient outcomes. By addressing these multifaceted aspects of teledentistry, healthcare systems can harness its potential to expand access, reduce disparities, and improve oral health outcomes for a broader spectrum of populations.

CONCLUSION

This evidence-based exploration affirms its capacity to augment access, enhance oral health outcomes, and effectively address challenges through innovative technology and regulatory adaptations. The ongoing global health crisis has expedited the adoption of teledentistry, facilitating its seamless integration into routine oral healthcare practices, thereby ushering in a new era marked by patient-centric care. Within this evolving landscape, the synergy of virtual consultations and remote guidance complements traditional in-person visits, fostering a dynamic healthcare ecosystem adept at meeting the diverse needs of patients.

As the pandemic accelerated the acceptance of teledentistry, its seamless integration into routine oral healthcare practice can usher in a new era of patient-centered care, where virtual consultations and remote guidance complement in-person visits. Teledentistry presents a comprehensive array of advantages, encompassing expanded access, cost-efficiency, and enriched patient-provider communication. Despite persistent challenges, the continuous evolution of technology and meticulous regulatory considerations converge to shape a promising future for this innovative approach. By seamlessly integrating teledentistry into the broader dental care framework, healthcare practitioners can earnestly work towards rectifying oral healthcare disparities, ensuring equitable access to dental services for all individuals, regardless of geographical or socioeconomic constraints.

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