



Teledentistry: A Scoping Review of Current Knowledge

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Abstract:

Introduction: Teledentistry is not a new concept, and one of the earliest teledentistry projects was initiated by the US military in 1994 to serve US troops worldwide. Teledentistry (a subunit of telehealth along with telemedicine) is the remote version of clinical dental care to facilitate diagnosis, guidance, education, and treatment via the use of information technology rather than direct contact with patients. The aim of the review is to show the state-of-the-art on teledentistry.

Methods: An online search was performed using the keywords “telehealth, telemedicine, telediagnosis, teledentistry, remote dentistry.” Database searches reported 514 articles screened using established criteria. Included studies were original research or review articles (including reviews, meta-analyses, and systematic reviews).

Results: The author followed the “Preferred Reporting Items for Systematic reviews and Meta-Analyses” (PRISMA) for scoping review criteria.

Discussion: To date, teledentistry has proved to be beneficial for remote dental screening, diagnosis, consultation, and treatment plans. It is found to be comparable to real-time consultations in areas with limited access to facilities, including schools and long-term healthcare facilities.

Conclusion: Considering new technologies and innovations, many drawbacks still exist in the use of teledentistry in everyday practice.

Keywords: Teledentistry, Telemedicine, Telehealth, Remote dentistry, COVID-19, PRISMA-Scr.

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1. INTRODUCTION

Dental researchers and clinicians, especially after the COVID-19 pandemic, have improved their focus and attention on what we call teledentistry, which has recently been studied in dentistry. Different and geographically distant locations are greatly helped by modern communication systems and information technology, used by telemedicine to deliver healthcare. Teledentistry applies the same approach to dental pathologies and therapies. The inception of teledentistry can be dated to 1994, marked by a

US Military project designed to provide dental services to US troops worldwide [1] and to establish the efficacy and cost-effectiveness of teledentistry in delivering dental care to populations in rural areas [2]. As a result, teledentistry holds the potential to enhance access to dental healthcare and decrease treatment costs [3]. This is facilitated by the integration of patient health data and records, TLC technologies, digital radiology, digital imaging, and the use of the internet for tele-consultations with dental specialists [4]. Rural areas and remote towns, where there is a

limitation of dental and oral health assistance, are the places where teledentistry is particularly effective [5]. The internet, along with mobile innovations such as 5G, has become fundamental to both telemedicine and teledentistry, facilitating the real-time transmission of information worldwide. In fact, a significant number of essential teledentistry functions are internet-based, with remote assistance being a key component [6]. Teledentistry has different forms, from teleconsultation to telemonitoring, *via* telediagnosis and teletriage. All these units may be used on the same patients. Teleconsultation is the form of teledentistry in which patients or local healthcare providers seek consultation from dental specialists using telecommunication [7]. Telediagnosis makes use of technology to exchange images and data to make a diagnosis of an oral lesion [8, 9]. Teletriage, conversely, involves the safe, appropriate, and timely disposition of patient symptoms *via* smartphone by specialists. It has been used for the remote assessment of school children and to prioritize those requiring dental care without unnecessary travel, regardless of socio-economic and geographical difficulties in many places [10, 11]. Finally, telemonitoring of patients who require frequent visits to monitor the progress of treatment can replace the frequent physical visits with virtual visits for regular monitoring of treatment outcomes and disease progression [7]. A substantial body of research has demonstrated the applicability and suitability of videoconferencing for high-level learning in dental specialist education [12, 13]. Teledentistry has also proven to be extremely cost-effective and beneficial in imparting Continuing Dental Education (CDE). By utilizing online, internet-based teledentistry courses, dentists and dental students can significantly reduce the time and expenses associated with travel. Online CDE presents a range of benefits compared to conventional on-site CDE [14]. It should be underlined that teledentistry is not supported by a single technology but requires various technical and innovative instruments [14]. Finally, telemedicine sessions have been shown to improve blood pressure and medical compliance, as shown by results from large randomized controlled trials [15-17]. The aim of the present study was to review teledentistry applications, problems, and future potential, in order to emphasize different areas of interest and new themes [18].

2. METHODS

2.1. Data Sources and Search

To effectively ascertain the foundational principles and pinpoint existing knowledge gaps within the burgeoning field of teledentistry, a comprehensive scoping review was meticulously conducted. This methodological approach adhered strictly to the established guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR **Supplementary Material**), ensuring transparency and methodological rigor. Prior to commencing the data extraction process, a detailed protocol was established *a priori*, serving as a blueprint for the review. Furthermore, the well-regarded PRISMA-ScR reporting methodology was systematically employed as a guiding framework throughout the entire scoping review process [19],

enhancing the clarity and comprehensiveness of our reporting. Data collection was strategically driven by clearly defined research questions, ensuring that the extracted information directly addressed the objectives of this review. To comprehensively identify relevant literature, a broad and targeted search strategy was implemented across a diverse array of authoritative medical sources and databases, including PubMed, SCOPUS, Web of Science (WOS), Medline, and CINAHL. The specific keywords employed during the search process were carefully selected to capture the breadth of the field: "telehealth," "telemedicine," "telediagnosis," "teledentistry," and "remote dentistry." Access to all identified sources was facilitated through various internet databases [7, 20], ensuring a comprehensive and exhaustive exploration of the existing literature landscape.

2.2. Study Inclusion Criteria and Search Strategy

The inclusion criteria stipulated that only peer-reviewed journals providing complete texts, abstracts, and references would be considered. All selected articles were published in English language and were appropriately cited. Consistent keywords were applied across all databases, and the advanced search functionality was employed to minimize the number of results. A comprehensive manual search of the reference lists from all articles was also undertaken. Exclusion criteria encompassed editorials, letters, debates, economic reports, and topics deemed unrelated. The author further dismissed any articles considered irrelevant to the review. A selected sample of pertinent studies, identified by the reviewers based on their significance, has been summarized to illustrate the selection and analysis procedures for each study (Table 1). The studies were each independently reviewed and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram [21]. The results derived from the PRISMA methodology are incorporated within the study (Fig. 1).

2.3. Screening and Data Extraction

The initial assessment involved evaluating abstracts for general suitability. Subsequently, pertinent information was extracted from the full texts of relevant articles, encompassing aspects such as follow-up duration, sample size, relevance to the topic, research methodology, journal quality, and author credibility.

2.4. Quality Assessment

The identified papers were subjected to further evaluation utilizing the criteria of the Newcastle-Ottawa Scale, which permits the assessment of the methodological quality of comparative studies and case-control studies. Overall study quality was subsequently defined as poor (0-4), moderate (5-6), or good (7-9) [22].

3. RESULTS

The systematic search yielded a substantial initial pool of 514 abstracts. Following a rigorous preliminary evaluation, a focused selection process identified 92 abstracts, representing 17.9%, as possessing the requisite relevance and quality to warrant deeper scrutiny. This

critical filtering stage led to the subsequent retrieval of 54 full-text articles for comprehensive analysis. Ultimately, through a meticulous process of inclusion and exclusion, the final synthesis incorporated 25 pivotal manuscripts that directly addressed the research question. The evidence emerging from these studies underscores the transformative potential of teledentistry in expanding patient access to essential dental care, thereby offering a pathway to potentially reduce the overall economic burden of treatment [23-27]. Our comprehensive literature review further highlighted the efficacy of leveraging internet-based telecommunication and real-time video conferencing technologies as powerful tools to enhance the development and execution of personalized patient treatment plans [28]. Notably, the most prevalent and impactful applications of teledentistry, as evidenced by the reviewed literature, were observed within the specialized domains of orthodontics [29-31], pediatric dentistry

[32-34], and restorative dentistry [35, 36], highlighting its versatility across diverse clinical needs. Crucially, the existing body of literature signals a pressing need for continued, in-depth research and the implementation of enhanced, specialized training programs for dental professionals. This proactive approach is paramount to cultivating a deeper understanding and facilitating the seamless integration of this rapidly evolving field into mainstream dental practice. Furthermore, the analysis identified e-learning as a particularly efficient and impactful modality for delivering crucial dental care services to regions facing limitations in both human and financial resources [37], underscoring its potential to address healthcare disparities. A concise visual representation summarizing the key findings from this study is presented in Fig. (1), offering a clear and accessible overview of the synthesized evidence.

Table 1. Summary of articles from references.

Authors/Refs.	Population	Methods
[2] Mihailovic B, Miladinovic M, Vujicic B. Telemedicine in dentistry (Teledentistry). In: Grasczew G, Roelofs TA (Editors). <i>Advances in Telemedicine: Applications in Various Medical Disciplines and Geographical Areas 2011</i> , Rijeka (Croatia): InTech; 2011. p.215-30.	Comprehensive literature review of 67 research articles on the subject of telemedicine	Literature review
[3] Golder DT, Brennan KA. Practicing dentistry in the age of telemedicine. <i>J Am Dent Assoc</i> 2000;131(6):734-44.	Review article	The article examines teledentistry and some of its current legal issues. Topics include licensure, malpractice, and technology
[4] Friction J, Chen H. Using teledentistry to improve access to dental care for the underserved. <i>Dent Clin North Am</i> 2009;53(3):537-48.	324 participants in the test group and 156 participants in the control group	Test using teledentistry to improve access to dental care for the underserved
[5] Chen JW, Hobdell MH, Dunn K, Johnson KA, Zhang J. Teledentistry and its use in dental education. <i>J Am Dent Assoc</i> 2003;134(3):342-6.	A revision of 56 articles was conducted	Literature Review: The authors discuss the global application of teledentistry and its role in education.
[6] Yoshinaga L. The use of teledentistry for remote learning applications. <i>Pract Proced Aesthet Dent</i> 2001;13(4):327-8.	The study involved documenting 25 cases of oral lesions over a period of 1 year in a primary care public health clinic in Parana, Southern Brazil	Clinical electronic charts and images were produced and sent by email to two oral medicine specialists with a median of 10 years of experience in the field. The consultants provided a maximum of two clinical hypotheses for each case
[13] Ignatius E, Makela K, Happonen RP, Perala S. Teledentistry in dental specialist education in Finland. <i>J Telemed Telecare</i> 2006;12 Suppl3:46-9.	Twenty-four participants were involved, including 18 dentists, 2 dental hygienists, and 5 nurses.	Consultations were held between a specialized dental treatment unit at a central hospital and general dental practitioners in seven regional health centers. Video conferences were carried out using standard commercial systems over a network with bandwidths ranging from 762 Kbit/s to 2 Mbit/s.

(Table 1) contd.....

Authors/Refs.	Population	Methods
[16] Brennan JA, Kealy JA, Gerardi LH, Shih R, Allegra J, Sannipoli L, <i>et al.</i> Telemedicine in the emergency department: A randomized controlled trial. J Telemed Telecare 1999;5(1):18-22.	Out of 22 patients who fulfilled the inclusion criteria, 104 (85%) agreed to participate.	RCT (Randomized Controlled Trial), to train caregivers with teledentistry
[17] Scuffham PA, Steed M. An economic evaluation of the Highlands and Islands teledentistry project. J Telemed Telecare 2002;8(3):165-77	25 patients were recruited into the trial	A 12-month trial of teledentistry was carried out in two general dental practices—one located in the Orkney Islands and the other in the Scottish Highlands at Kingussie. These dental practices were equipped with a PC-based video conferencing system linked <i>via</i> ISDN at 128 Kbit/s to a restorative specialist at a hospital in Aberdeen.
[18] Spangler D, Rothenburger S, Nguyen K, Jampani H, Weiss S, Bhende S. <i>In vitro</i> antimicrobial activity of oxidized regenerated cellulose against antibiotic-resistant microorganisms. Surg Infect (Larchmt) 2003;4(3):255-62.	Systematic review	67 peer-reviewed articles on the subject of teledentistry
[23] Torres-Pereira CC, Morosini Ide A, Possebon RS, Giovanini AF, Bortoluzzi MC, Leão JC, Piazzetta CM. Teledentistry: distant diagnosis of oral disease using e-mails. Telemed J E Health. 2013 Feb;19(2):117-21. doi: 10.1089/tmj.2012.0087. Epub 2013 Jan 28. PMID: 23356381; PMCID: PMC3576903.	The sample consisted of 60 consecutive patients who requested oral medicine services at the Federal University of Paraná, situated in the southern Brazilian state of Paraná.	The research assessed the feasibility of telediagnosis in oral medicine by transmitting clinical digital images <i>via</i> email. It was conducted using a non-randomized convenience sample.
[24] Summerfelt FF. Teledentistry-assisted, affiliated practice for dental hygienists: An innovative oral health workforce model. J Dent Educ 2011;75(6):733-42.	The initial training efforts demonstrated that instructing 50 dental hygiene students in data acquisition technologies was both straightforward and effective. After just 6 hours of training, these students showed proficiency in setting up and managing remote patient service facilities, as well as transmitting digital diagnostic data from remote locations. Notably, the results were statistically comparable to those obtained from traditional onsite dental hygiene assessments.	Outlined a novel oral health workforce model utilizing teledentistry to support affiliated practices for dental hygienists.
[26] Brüllmann DD, Weichert CI, Daubländler M. Intraoral cameras as a computer-aided diagnosis tool for root canal orifices. J Dent Educ. 2011 Nov;75(11):1452-7. PMID: 22058394.	50 X-Rays of the surfaces of teeth that have undergone endodontic treatment.	A study investigating the remote identification of root canal orifices examined 50 images of endodontically accessed teeth captured using an intraoral camera.
[30] Mandall NA, Qureshi U, Harvey L. Teledentistry for screening new patient orthodontic referrals. Part 2: GDP perception of the referral system. Br Dent J 2005;199(11):727-9.	200 GDPs were approached from Stockport, Rochdale, Oldham, Bury, and Bolton in Greater Manchester, and High Peak in Derbyshire	Evaluated GDPs' opinion about a teledentistry system to screen new patient orthodontic referrals
[32] Kopycka-Kedzierawski DT, Billings RJ. Prevalence of dental caries and dental care utilisation in preschool urban children enrolled in a comparative-effectiveness study. Eur Arch Paediatr Dent 2011;12(3):133-8.	A total of 173 eligible children were randomly assigned to two groups: the first group underwent a traditional visual/tactile oral examination, while the second group participated in a teledentistry examination.	Evaluated the prevalence of dental caries and the use of dental care among preschoolers attending urban childcare centers as part of a comparative effectiveness study. The presence of caries was assessed in a group of children aged 12 to 60 months.

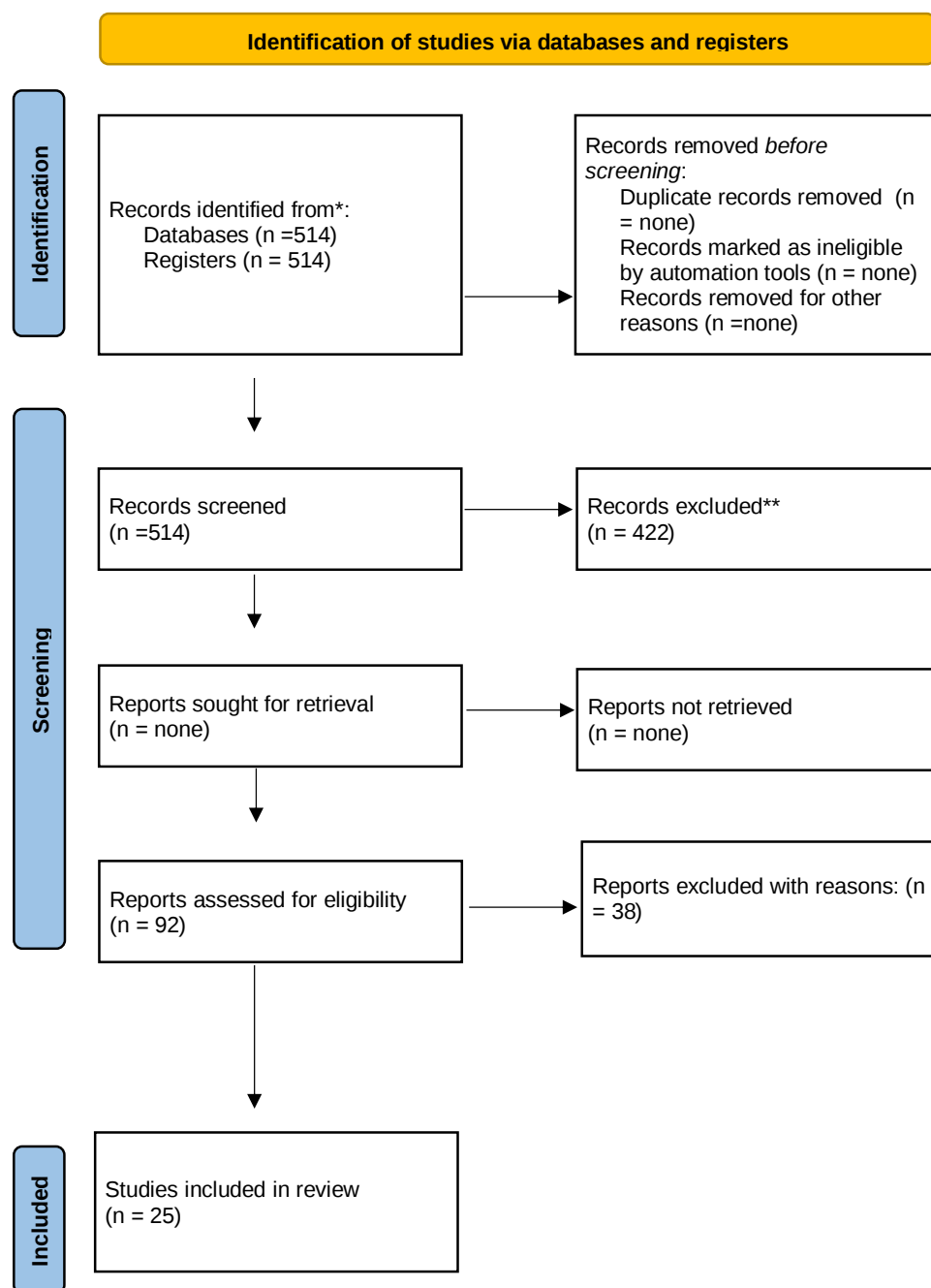


Fig. (1). PRISMA flow diagram.

4. DISCUSSION

The aim of the present study was to review teledentistry-based studies regarding worldwide application, patient-oriented support, dental innovation, and dental education. In areas far from cities, many people living in towns and villages may need dental assistance, but there are often few dental offices and limited staff, so patients may require remote contact and consultation [38]. On the other hand, technical problems, legal issues, and privacy concerns

are aspects that may need greater attention in the future. Unfortunately, the efficacy of teledentistry can be compromised by technological constraints, such as suboptimal internet speeds or unreliable service. These impediments are frequently more pronounced in many developing countries and rural regions, where the infrastructure required for implementing teledentistry is deficient. A dependable communication infrastructure, characterized by adequate bandwidth, is indispensable for the successful adoption of teledentistry practices. Moreover, patient

privacy must be protected at all costs, similar to other telemedical information [39, 40]. Medical and dental education may benefit from telemedicine and teledentistry. In fact, both can be very effective tools for providing CDE to dental caregivers. Considering the costs of in-person education, including travel, lodging, and food, tele-education can be considered a highly innovative and valuable medium to use [41, 42].

The technological modalities utilized in teledentistry encompass a range from basic text messaging or phone calls to sophisticated full HD tele-video conferencing employing intraoral cameras or live monitoring devices to capture and transmit real-time imagery. These telehealth methods can augment the information available to the tele-dentist, enabling diagnosis and the prescription of therapeutic interventions that do not necessitate clinical intervention. Teledentistry represents an acceptable option for providing access to appropriate diagnosis and management of oral health conditions, a factor of particular significance during the COVID-19 pandemic when oral health services were constrained due to mobility limitations [35]. The principal limitation of this review pertains to the quality of the studies included, as many were cross-sectional studies lacking clearly defined methodologies, non-RCTs with limited sample sizes, or clinical trials dependent on self-reports or subjective opinions of participants or their caregivers.

CONCLUSION

Teledentistry emerges as a truly groundbreaking and transformative innovation within the landscape of dental practice. The seismic shift brought about by the COVID-19 pandemic has undeniably illuminated the potential of teledentistry, sparking considerable discourse and investigation. However, to fully harness its potential and seamlessly integrate it into everyday dental care, further rigorous and insightful research is unequivocally essential. A critical challenge lies in the current lack of standardized process flows and protocols. This absence is particularly concerning given that teledentistry fundamentally relies on information technology, transcending geographical boundaries and necessitating a unified framework for effective implementation. Beyond clinical application, teledentistry holds significant promise within the realm of dental education. Educators at all levels - instructors, professors, and teachers - alongside students and researchers, must be comprehensively equipped with the necessary skills and knowledge in telecommunication infrastructure (TI), artificial intelligence (AI), and computer technology (CT) [43]. This foundational training is paramount to ensure the effective utilization and advancement of teledentistry. Furthermore, while the body of evidence supporting the general effectiveness of teledentistry is steadily growing, a critical gap remains in substantiating its long-term cost-effectiveness and demonstrating its sustained impact over time [44]. Comprehensive reviews of the existing literature offer valuable guidance on the various applications of teledentistry [45]. Current evidence suggests its versatility, enabling a wide array of dental services, including consultations, proactive

dental and oral health promotion and screenings, efficient referrals, advanced imaging, and secure data transfer. Conversely, it is crucial to acknowledge the identified limitations within the existing research, notably small sample sizes and the prevalence of non-randomized study protocols. Therefore, future research endeavors must prioritize studies characterized by substantially larger sample sizes, robust high-quality methodologies, and rigorous designs. Such well-designed investigations are indispensable for optimizing the practical application of teledentistry and ultimately realizing its full potential in significantly improving oral health on a global scale.

AUTHORS' CONTRIBUTIONS

The author confirms his contribution to the paper as follows: M.M.: Study conception and design, data collection, analysis and interpretation of results, draft manuscript. The author reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

COVID-19	= Coronavirus Disease 2019
CDE	= Continuing Dental Education
HD	= High Definition
Prisma-Scr	= Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews
WOS	= Web of Science
TI	= Telecommunication Infrastructure
AI	= Artificial Intelligence
CT	= Computer Technology

CONSENT FOR PUBLICATION

Not applicable.

STANDARDS OF REPORTING

PRISMA guidelines and methodology were followed.

AVAILABILITY OF DATA AND MATERIALS

The data and supportive information are available within the article.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

SUPPLEMENTARY MATERIAL

PRISMA checklist is available as supplementary material on the publisher's website along with the published article.

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