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Original Article

A bibliometric analysis of teledentistry published in the category of dentistry, oral surgery and medicine

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Abstract *Background/purpose:* Telemedicine has gained the popularity during COVID-19 pandemic. "Teledentistry" as the dental application of telemedicine was also with increased attention. The bibliometric analysis was employed to examine the global research trends and the current implementation status of teledentistry.

Materials and methods: Titles and subjects were searched in the Web of Science database by using the keywords "teledentistry OR oral telemedicine OR dental telemedicine OR telemedicine in dentistry" in the category of Dentistry, Oral Surgery & Medicine. Documents were collected from the establishment date up to December 31, 2023. Microsoft Excel was used for the descriptive and statistical analyses. The data were exhibited with visualization by VOS-viewer.

Results: A total of 146 articles were identified for bibliometric analysis. An upward trend in the number of publications was evident. The statistical analysis indicated a notable increased teledentistry publications affected by COVID-19 pandemic ($P < 0.01$). The applications of teledentistry were mainly related to clinical practice (89.73%), such as oral and maxillofacial surgery, orthodontics, dental caries, oral mucosal lesions, and dental emergencies. For geographic distributions, the United States lead with 46 publications (34%) by corresponding authors listed in the article. The keyword network analysis highlighted the prominent research areas and the changes influenced by the pandemic and technological development, respectively.

Conclusion: This bibliometric study provided an overview of the progress, trends and current directions for teledentistry in the fields of dentistry, oral surgery and medicine.

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Introduction

Teledentistry was first defined by Cook as “the practice of providing treatment advice and diagnosis using video conferencing technology over long distances” in 1997.¹ Since then, teledentistry has been defined in various ways. In 2020, the American Dental Association has stated the issues on teledentistry that telemedicine refers to a variety of technologies and strategies for providing virtual medical, health, and educational services, with teledentistry being the application of telemedicine systems and methods in dentistry.² World Health Organization also delimited teledentistry as the uses of information and telecommunication technology to provide oral healthcare services between an oral healthcare provider and a patient/recipient or other health care providers, who are separated by distance in 2021.³

The emergence of the coronavirus disease (COVID-19) imposed the significant constraints that disrupted conventional healthcare practices. During COVID-19 pandemic, the dental professions adopted teledentistry rapidly and extensively to provide the excellent applications in first visit or follow-up visits in the field such as oral medicine, oral radiology, and domiciliary dental care.^{4–7} Taken together, telemedicine acts as an effective tool for dental service during COVID-19 pandemic.⁸ In addition to the issue of COVID-19, teledentistry was not widely discussed the details. Therefore, the development trends of teledentistry, the most substantial advancements in clinical applications, and the impacts still need further evaluation.

Bibliometrics and visualization have been conveyed the imperative technique of scientific research evaluation for providing the valuable information about future researches.⁹ Through the bibliometric analysis, researchers can easily analyze the trends of articles or books in the specific fields from past to present. The aims of this study were to explore the development trends, application status, and future prospects of teledentistry from a macro perspective using the results of bibliometric analysis.

Materials and methods

Search strategy

The bibliometric search was processed for the analysis of teledentistry. All the literatures were extracted from the established date of Web of Science core collection (Clarivate Analytics, Philadelphia, PA, USA) to December 31, 2023. The search strategy employed keywords “teledentistry OR oral telemedicine OR dental telemedicine OR telemedicine in dentistry” in the category of Dentistry, Oral Surgery & Medicine for title and subject indexing. Relevant literatures on teledentistry were manually screened by the first author. Initially, titles as well as abstracts were reviewed. The literature not relevant to the topic was excluded. Subsequently, a full-text review was conducted for each extracted article. The exclusion criteria were set as: (1) the inability to access the full text, (2) the content not primarily focused on teledentistry, (3) the incomplete information about authors and their affiliations, and (4) the conference abstracts. If there was inconsistency in the

inclusion criteria for the literature, it was discussed by two reviewers to decide whether to include or exclude it.

Study selection and data extraction

First, the clinical practice and dental education by using teledentistry were evaluated. Second, eight main fields of dental clinical application were divided based on the research content including oral and maxillofacial surgery, orthodontics, caries detection, oral mucosal manifestation, dental emergency, restorative dentistry, oral facial pain, and others. Third, the specific research subjects were divided into three subject groups, namely children, the elderly, and the residents of rural areas. All classification processes were conducted twice independently by the first author, and the results were then subjected to a Kappa test for the consistency. In case of inconsistency between the results, the author would discuss with the other author for the final classification.

Statistical analysis and visualization

The included literatures were recorded in Microsoft Excel for the descriptive analysis. The network visualization maps were generated by using VOSviewer version 1.6.20. In this study, the consistency assessed by Kappa statistics was around 95%.

Results

The search strategy and results are presented in the flow chart (Fig. 1). After rigorous screening procedures, a total of 146 articles were identified for further bibliometric analysis. As illustrated in Fig. 2, there is an upward trend in the number of teledentistry publications. The higher peaks of publications were found in 2021 and 2022 with 28 and 29 articles, respectively.

In addition, all articles were divided into two periods based on the year 2020 when the World Health Organization declared COVID-19 as a global pandemic. There were 56 articles published from 2001 to 2019. However, there were up to 90 articles published during the pandemic-affected period from 2020 to 2023. A *P*-value of 0.0056 was obtained from Mann–Whitney *U* test that indicated a significant increased teledentistry publications affected by COVID-19 pandemic.

Compared to dental education ($n = 15$, 10.27%), dental clinical applications were accounted for the majority of teledentistry publications ($n = 131$, 89.73%). The top five most common clinical application fields were oral and maxillofacial surgery ($n = 22$), orthodontics ($n = 19$), caries detection ($n = 13$), oral mucosal manifestations ($n = 12$), and dental emergencies ($n = 6$). In addition, a total of 20 documents were found by targeted specific research groups: 16 articles focus on children, 2 articles for elderly, and 2 articles for the residents in remote area.

The geographic distributions calculated based on corresponding authors were illustrated in Fig. 3. In terms of countries, the United States of America had the highest number of teledentistry publications. In terms of continents, North America ($n = 51$, 34.93%) had the highest

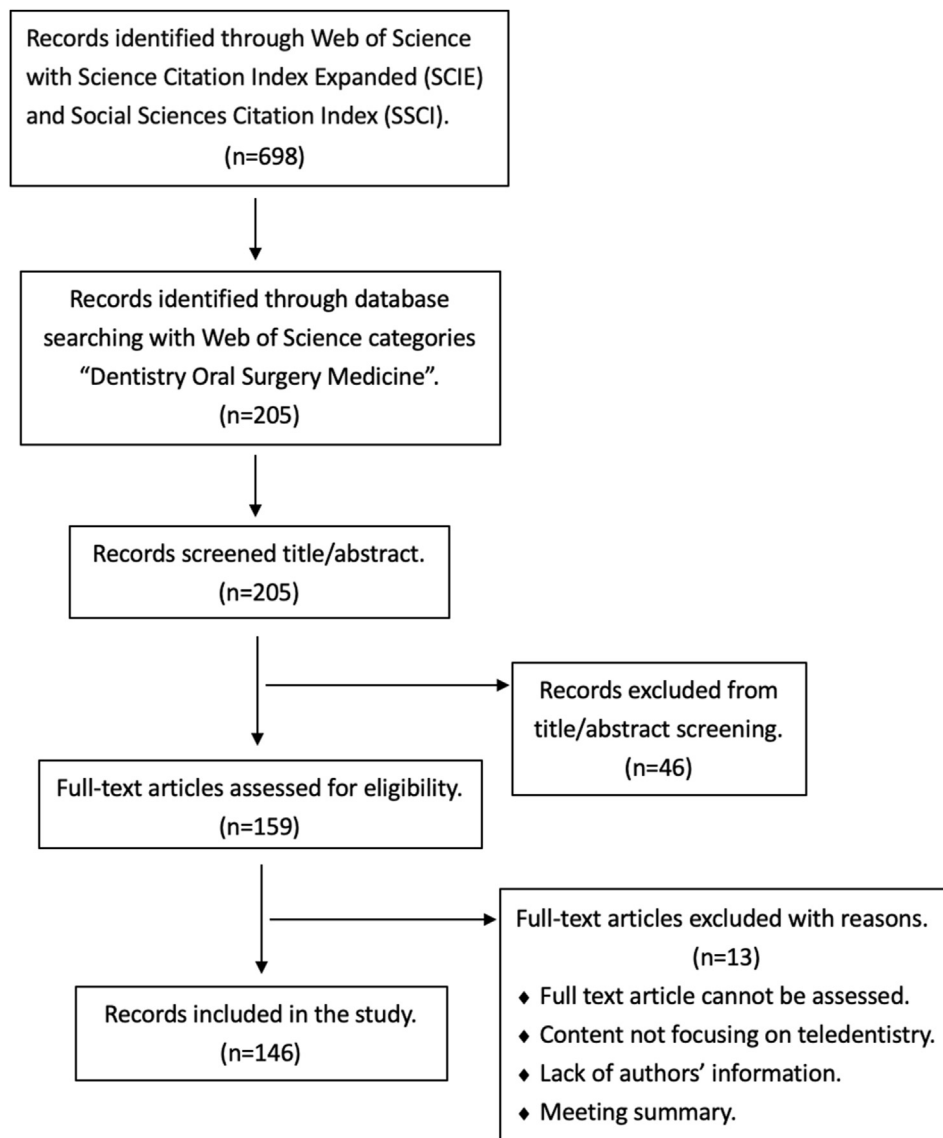


Figure 1 Systematic flowchart of the process and criteria for literature screening.

number of publications, followed by Europe ($n = 39$, 26.71%), Asia ($n = 20$, 13.70%), and Central and South America ($n = 20$, 13.70%).

The top five journals with the most published articles related to teledentistry are presented in Table 1. A total of 51 articles were published by these five journals, accounting for 34.9% of all published documents. Our results also revealed that 4 teledentistry articles published in Journal of Dental Sciences were captured in this study.^{4–6,8}

The top ten most cited articles are presented in Table 2. The majority are original articles and the research direction is related to clinical practice. A randomized controlled clinical trial on orthodontics by Mandall et al.¹⁰ in 2005 received the highest citation count ($n = 448$) among teledentistry-related literature in the WoS database. It also has the highest number of average citation per year ($n = 23.57$) since publication.

Keyword analysis was conducted by VOSviewer. Fig. 4A illustrates the keyword co-occurrence network, with four

clusters presented. The chronological development of keyword co-occurrence network is shown in Fig. 4B. Keywords related to orthodontics appeared around 2017, and the more popular emerging keywords in the past two years are COVID-19, oral cancer, and oral medicine.

Discussion

In the past, the discussion about teledentistry was limited. On the technical level, the constraint of teledentistry could be related to the limited technological development and accessibility at that time. Furthermore, unlike in other medical fields, dental healthcare often requires the direct interaction between dentists and patients for the instrument-based procedures. Consequently, teledentistry was not widely favored by dental professionals when physical consultations were feasible. Islam et al.¹¹ also observed that the dental field was slower in adopting the

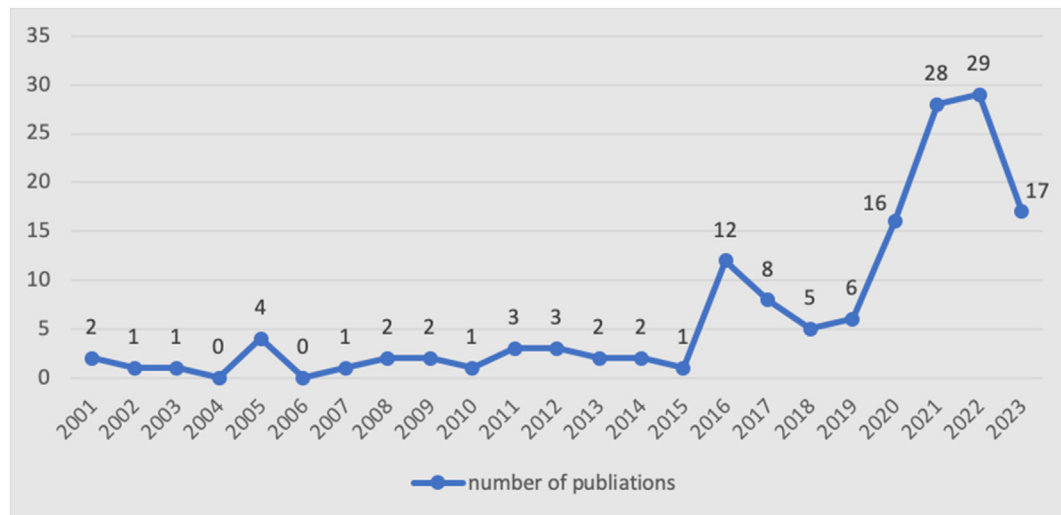


Figure 2 The trends of teledentistry publications from 2001 to 2023.

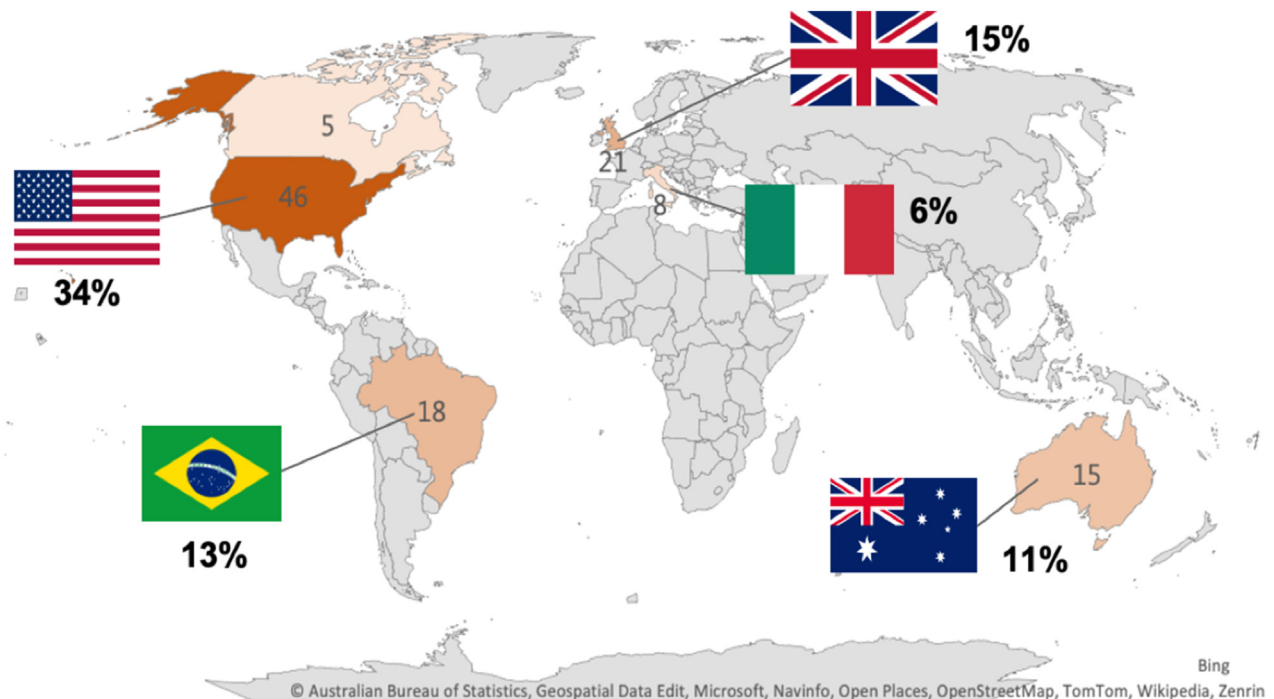


Figure 3 The global geographic distribution of publications related to teledentistry.

information and communication technology compared to other medical disciplines. During the COVID-19 pandemic period, teledentistry has gained the widespread acceptance. In agreement with our findings, it demonstrated a significant difference in average yearly publication rates of teledentistry publications from 2020 to 2023 after the outbreak of COVID-19.

In terms of application, teledentistry can be used in dental education through Web-based self-instruction and videoconference, and is also widely used in clinical practice. In oral and maxillofacial surgery, through the store-and-forward model of teledentistry, early diagnosis and intervention of oral malignant tumors can be improved.¹²

Additionally, teledentistry was applied to facial trauma, using images for immediate diagnosis and treatment guidance.¹³ "Teleorthodontics" has been utilized for monitoring patients undergoing orthodontic treatment and evaluating new patients, thereby helping to avoid unnecessary consultations until the appropriate timing for intervention.^{11,14} "Teliagnosis" employs imaging equipment for highly accurate remote diagnosis, widely applied in caries detection and the diagnosis of oral mucosal diseases.^{15,16} Caries detection, especially in early childhood caries, constitutes the main application of teledentistry in children.¹⁵

Despite the reduced manpower costs and less psychological pressure on children, teledentistry remains

Table 1 The top five journals listed by the number of teledentistry publications.

Rank	Journal	Journal ranking	Q ^a	Impact factor	Publication number
1	BMC Oral Health	40/91	2	2.9	12
2	British Dental Journal	46/91	3	2.6	11
2	Journal of Dental Education	57/91	3	2.3	11
4	Oral Diseases	19/91	1	3.8	9
5	Journal of Oral and Maxillofacial Surgery	69/91	4	1.9	8

^a Quartile: Q1 = 0–25%, Q2 = 25–50%, Q3 = 50–75%, Q4 = 75–100% from JCR 2022.

Table 2 The top ten most cited publications.

Rank	Article title	Journal	Journal ranking (JCR 2022)	Types of article	Number of citations	Average citations pre year
1	Teledentistry for screening new patient orthodontic referrals. Part 1: A randomised controlled trial. (Mandall et al., 2005)	British Dental Journal	46/91	Original article	448	23.57
2	Teledentistry: A key component in access to care. (Daniel et al., 2014)	Journal of Evidence-Based Dental Practice	22/91	Review	92	9.2
3	WhatsApp: a telemedicine platform for facilitating remote oral medicine consultation and improving clinical examinations. (Petruzzi et al., 2016)	Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology	40/91	Original article	92	11.5
4	Teledentistry and its use in dental education. (Chen et al., 2003)	Journal of the American Dental Association	18/91	Review	90	4.28
5	Effect of intervention using a messaging app on compliance and duration of treatment in orthodontic patients. (Li et al., 2016)	Clinical Oral Investigations	28/91	Original article	83	10.37
6	Comparing potential early caries assessment methods for teledentistry. (Van Hilsen et al., 2013)	BMC Oral Health	40/91	Original article	73	6.63
7	Telemedicine using smartphones for oral and maxillofacial surgery consultation, communication, and treatment planning. (Aziz et al., 2009)	Journal of Oral and Maxillofacial Surgery	69/91	Case report	72	4.8
8	Application of teledentistry in oral medicine in a community dental service, N. Ireland. (Bradley et al., 2010)	British Dental Journal	46/91	Original article	72	5.14
9	Using teledentistry to provide interceptive orthodontic services to disadvantaged children. (Berndt et al., 2008)	American Journal of Orthodontics and Dentofacial Orthopedics	37/91	Original article	71	4.43
10	Teledentistry from a patient perspective during the coronavirus pandemic. (Rahman et al., 2020)	British Dental Journal	46/91	Original article	66	16.5

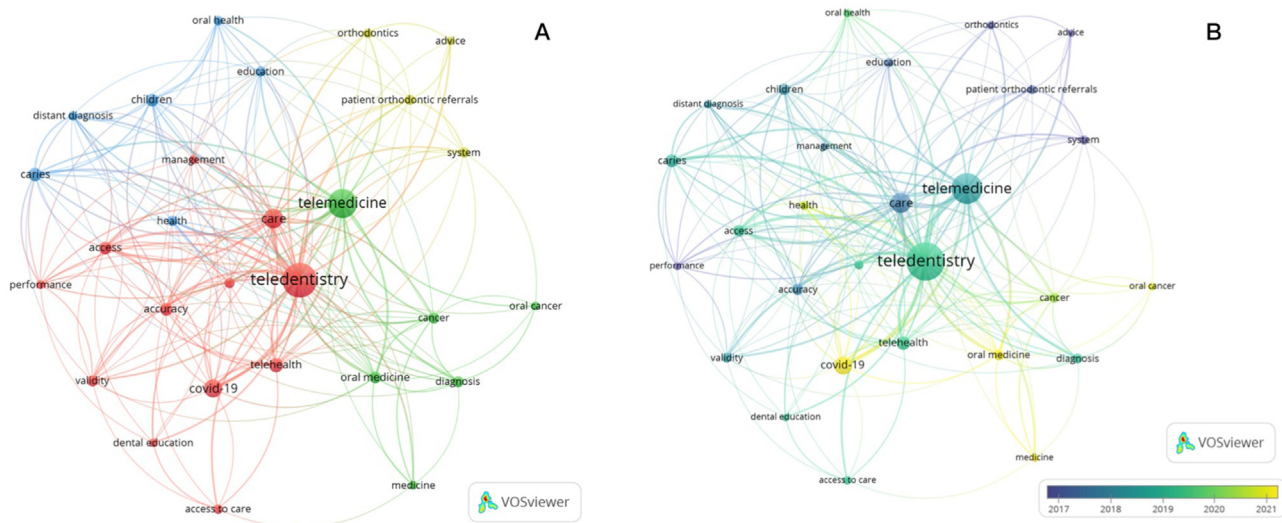


Figure 4 VOSviewer network visualization map of keyword co-occurrence. (A) Network visualization for clustering results. (B) Overlay visualization for chronological analysis.

effective in diagnosis. For elderly patients with physical disabilities, teledentistry can eliminate the inconvenience and discomfort of movements. With an aging population, it can also reduce the cost of care.¹⁷ Although there is limited literature, teledentistry still holds potential in addressing the unequal distribution of medical resources between urban and rural areas. In remote areas with limited access to medical resources, teledentistry holds immense value as the most cost-effective and quickest method to bridge the urban-rural oral health gap.^{18,19} Dental professionals could provide medical resources through information and images transmitted by primary healthcare workers in local communities. Teledentistry can also be applied to international medical collaboration. This approach provides an excellent opportunity to reduce disparities in oral health between countries.

It is worth noting that teledentistry requires technological infrastructure, which is more readily available in most developed countries, potentially affecting the global publication profile. Additionally, the policies and practice guidelines for teledentistry vary across countries, influencing its development differently across nations.²⁰ For example, in countries like the United States, where policy development is more advanced, only a few state governments have proposed comprehensive policies for teledentistry.¹² The relevant policies and regulations set by governments will be crucial factors in the future development of teledentistry.

Several studies exploring the application of teledentistry during the pandemic have been published, with COVID-19 evident in the keyword network, showcasing its influence on the evolution of teledentistry. Keyword evolution over time is also associated with advancements in technology and imaging equipment. The latest keywords, oral cancer and oral medicine, both require higher image clarity. With the advancement of relevant technologies, teledentistry has greater potential for application.

This study still has certain limitations, including potential neglect in literature inclusion due to language,

database selection, and search structures. Bibliometric analysis extracted from Web of Sciences, articles published in Scopus, Google Scholar, and non-dentistry, oral surgery and medicine journals were excluded. In addition, the blind spot of screening articles only for title and subject indexing in bibliometric analysis may miss some important associated articles. For example, only 4 teledentistry articles published in Journal of Dental Sciences were extracted.^{4–8} However, one important perspective “The implication of COVID-19 pandemic on domiciliary dental care”⁷ indicated the conduction of teledentistry as a good tool to deliver domiciliary dental care was not included in this analysis. In addition, the bibliometric study cannot analyze the presence of bias or quality of evidence in the included studies.

In conclusion and within the above limitations, our analyses provide an overview on the development and potential future growth of teledentistry. The research map on teledentistry is expected to help researchers further explore the teledentistry more efficiently. Teledentistry is poised to become an important part of the future dental industry.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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