

# Applications of teledentistry in dental practice: a systematic review<sup>1</sup>

## Aplicaciones de la teleodontología en la práctica odontológica: revisión sistemática<sup>1</sup>

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### Abstract

**Introduction:** access to dental services in rural and remote areas is a problem still to be solved; for this purpose, a new alternative known as teledentistry has emerged. Through the application of information and communications technologies (ICTs), teledentistry promotes prevention, diagnosis, and treatment. This study aimed to determine the impact of teledentistry applications on clinical practice in different specialties based on the current evidence in the literature. **Methods:** two reviewers conducted a literature search in PubMed, EMBASE, EBSCO, ScienceDirect and LILACS databases until August 2019, to identify studies published in English, Spanish and Portuguese. Studies containing interventions applied to teledentistry, published in the last six years and available in full text were included. Bias risk was assessed through validated criteria according to each study type. **Results:** the search strategy retrieved 1028 articles, 24 of which were selected for evaluation. Twenty-three articles were cross-sectional studies and only one study was quasi-experimental. Seventeen studies (70.8%) considered teledentistry as an alternative to diagnosing and treating oral diseases in rural areas and health centers through mobile devices and clinical photographs. Most studies had moderate to high bias risk. **Conclusion:** while there is evidence on the use of teledentistry in the various fields of dentistry, it is important to keep in mind that since this is a novel tool that seeks to support access to health services in remote areas, the obtained results are preliminary, and further research with quality publications is necessary to evaluate the effectiveness of this tool.

### Keywords:

teledentistry,  
health promotion,  
diagnosis, oral  
health, distance  
education

### Resumen

**Introducción:** el acceso a los servicios odontológicos en zonas rurales y remotas es una problemática que aún no está resuelta, por lo que se ha introducido la teleodontología, a través de la aplicación de tecnologías de la información y la comunicación (TICs) por medio de la prevención, diagnóstico y tratamiento. El objetivo del presente estudio consistió en determinar el impacto de las aplicaciones de la teleodontología desde las diferentes especialidades a partir de la evidencia. **Metodología:** dos revisores realizaron una búsqueda en las bases de datos PubMed, EMBASE, EBSCO, ScienceDirect y LILACS para identificar estudios publicados en inglés, español y portugués. Se incluyeron estudios que contenían intervenciones en teleodontología, publicados en los últimos seis años y en texto completo. La calidad de los artículos se evaluó teniendo en cuenta el diseño del estudio. **Resultados:** se identificaron 1028 artículos, y se incluyeron 24 artículos para su evaluación. Veintitrés de estos artículos eran estudios transversales y un solo estudio fue de intervención. Diecisiete estudios (70,8%) presentaron la teleodontología como una alternativa para diagnósticos y tratamientos de enfermedades bucales en zonas rurales mediante dispositivos móviles, consultas y fotografías. La mayoría de los estudios presentaban un riesgo de sesgo de moderado a alto. **Conclusión:** pese a que existe evidencia sobre el uso de la teleodontología en los diferentes campos de la odontología, es importante tener en cuenta que, dado que esta es una herramienta novedosa que busca apoyar el acceso a los servicios de salud en zonas remotas, se hace necesario realizar una nueva búsqueda de evidencia con mejor calidad en la publicación.

### Palabras claves:

teleodontología,  
promoción  
de la salud,  
diagnóstico, salud  
oral, educación a  
distancia

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## INTRODUCTION

Telemedicine refers to the provision of medical care with Information and Communication Technologies (ICTs) to conduct diagnostics, consider treatments, prevent diseases, and strengthen the network of professionals and research activities in rural and hard-to-reach communities.<sup>1,2</sup> Similarly, in dentistry, an innovative method called teledentistry has been developed, providing clinical care through electronic dental records and remote ICTs as an opportunity to raise awareness, promote education and provide patients with professional services.<sup>3-6</sup>

This concept was first implemented in dentistry in 1997 by Cook,<sup>4</sup> who used video conferencing for diagnosis and remote treatment consultations, and managed to exchange clinical information and images.<sup>7</sup> Currently, this alternative is still in development as a promising tool to identify the presence of injuries and perform teleconsultation in school programs, rural areas, and areas with limited access through different devices such as smartphones, portable x-rays, social networks, and in various specialties such as endodontics, oral surgery, periodontics, and public health, proving to be more efficient and with high demand in the provision of health services, thus reducing inequality in dental clinical care.<sup>8,9</sup>

Globally, research projects like the ones conducted by Kale S, Kakodkar P, Shetiya SH<sup>10</sup> in India assessed mothers' abilities for health education regarding the diagnosis of tooth decay, using smartphone photographs, which were sent through a social network. Each child's diagnosis was requested, with significant changes for mothers, who made improvements in the diagnosis of their children's dental condition.

In Latin America, specifically in Brazil, Fonseca et al<sup>11</sup> evaluated the correct diagnosis of the presence of oral lesions and diagnoses conducted remotely through digital images obtained with a cell phone, showing improved efficiency and higher demands in the provision of health services and a decrease in inequalities in dental clinical care.<sup>12,13</sup> In Colombia, the concept of telehealth was implemented through Law 1419 of 2010, as a means of supporting the General System of Social Security in Health (Sistema General de Seguridad Social en Salud, SGSSS), in order to support health service providers in terms of equity in care, improved access to health services, and quality of life in vulnerable areas.<sup>14</sup>

However, the implementation and applicability of telehealth to date is still inconclusive because the development and application of these remote methods are recent, and therefore teledentistry is still unknown to many professionals, preventing the population from receiving the benefits of these practices. Therefore, a systematic review of the literature was conducted to determine the impact of teledentistry applications in various specialties in clinical practice based on available scientific evidence.

## METHODS

A systematic search of the literature was conducted to describe and summarize the information available on the applications of teledentistry, following the PRISMA-P guidelines (2015).<sup>15</sup>

### Eligibility Criteria

Eligible studies were independently selected by two reviewers who used titles and

abstracts, including descriptive analysis, cross-sectional studies and/or interventions in relation to teledentistry, published in the period 2013 to August 2019, available in full text in English, Spanish or Portuguese. Other study types, such as literature reviews, systematic reviews, or documents submitted as editorials or books were excluded.

## Search Strategy

Eighteen bibliographic searches were carried out using the PubMed, EMBASE, EBSCO, ScienceDirect and LILACS databases from 2013 to August 2019. These searches were carried out through the combination of the following keywords: “teledentistry AND education distance”; “teledentistry AND health promotion”; “teledentistry AND oral health”; “teledentistry AND NOT telemedicine”; “teledentistry OR telehealth AND health promotion AND oral health”; “telehealth AND telemedicine AND teledentistry”; “teledentistry AND oral health”; “tele-

medicine AND teledentistry”; “telemedicine AND oral health”; “teledentistry AND health promotion OR oral health”; “teleodontolog a AND educaci n a distancia”; “teleodontolog a AND salud oral”. The search strategy was adapted for each database.

## Selection of studies and data extraction

For the selection of studies, two authors examined the publications' titles independently and in duplicate based on the eligibility criteria; then the abstracts were accessed, deciding which articles to include. In the second evaluation stage, the articles were obtained in full text and evaluated by the two authors, who agreed by consensus on the final inclusion.

The selected articles were broken down in an evidence table (Table 1). The first reviewer extracted each full text, while the second reviewer independently verified the extracted data and resolved the discrepancies generated at this stage.

**Table 1.** Characteristics of included studies

First author	Year	Country	Context	Population involved	Research design	Outcome (Area to evaluate)	Tool used
AlKlayb <sup>18</sup>	2017	Saudi Arabia	Doesn't report	Mothers	D	Oral health	Mobile app (iTeethey™)
Bhatt <sup>19</sup>	2018	India	Rural area	Adults	C	Oral cancer / Cervical cancer	Interview
Birur <sup>20</sup>	2019	India	Industrial zone	Adults	A	Oral cancer	Mobile app
Boringi <sup>21</sup>	2015	India	University	Dental professionals and students	D	Knowledge and beliefs	Questionnaire
Daniel <sup>22</sup>	2017	United States	Schools	Children	D	Tooth decay	Photographs
Almeida <sup>23</sup>	2017	Brazil	University	Children and adults	DT	Dentoalveolar trauma	Photographs
Estai <sup>24</sup>	2017	Australia	Rural area	Dentists, dental students, dental therapists, nurses	D	Tooth decay	Questionnaire
Estai <sup>25</sup>	2016	Australia	Doesn't report	Adults	DT	Oral diseases	Mobile app
Estai <sup>26</sup>	2016	Australia	Dental clinic	Children and adults	DT	Tooth decay	Mobile app
Giradeau <sup>27</sup>	2017	France	Prison	Prisoners	DT	Oral health	Camera (Soprocure®)
Haron <sup>28</sup>	2017	Malaysia	Doesn't report	Adults	DT	Oral cancer	Mobile device
Jung <sup>29</sup>	2018	South Korea	University	Adults	DT	Tooth decay	Digital Fluorescence (QLF-D)

First author	Year	Country	Context	Population involved	Research design	Outcome (Area to evaluate)	Tool used
Kohara <sup>30</sup>	2018	Brazil	University	Teeth extracted, Children	DT	Tooth decay	Mobile device
Martin <sup>31</sup>	2016	United States	Doesn't report	Dental Professionals	D	Telehealth	Questionnaire
McFarland <sup>32</sup>	2017	United States	Rural area	Students in dentistry, oral health, and other health professions	D	Teledentistry	Questionnaire
McLaren <sup>33</sup>	2016	New York	Rural area	Children	D	Teledentistry	Teledentistry consultation
McLaren <sup>34</sup>	2016	New York	University	Children	D	Dental treatments	Teledentistry consultation
Morosini <sup>35</sup>	2014	Brazil	Prison	Adolescents	DT	Tooth decay	Photographs
Paixao <sup>36</sup>	2018	Brazil	Health centres	Teleconsulting	D	Teledentistry	Database
Puhorit <sup>37</sup>	2017	India	Rural area	Children	DT	Tooth decay	Camcorder
Roxo <sup>38</sup>	2017	Australia	Distance education	Dentists, nurses, dietitians	A	Oral cancer	Virtual course
Skandarajah <sup>39</sup>	2017	India	Health centre	Adults	PB	Oral cancer	Mobile microscope
Van Hilsen <sup>40</sup>	2013	United States	Doesn't report	Teeth extracted	QE	Tooth decay	Midwest Caries IDTM (MID), Visual Photo Examination (CAM), Cross-polarization Optical Coherence Tomography (CP-OCT).
Vinayagamorthy <sup>41</sup>	2019	India	Rural area	Adults	O	Oral cancer	Mobile App (WhatsApp)

D: Descriptive; DT: Diagnostic Test; A: Analytical; CE: Quasi-experimental; O: Observational; C: Qualitative

Source: by the authors

The selected aspects for each article are classified by first author, country, context, study sample, study design, outcome, and tool used for the application of teledentistry.

### Bias risk in individual studies

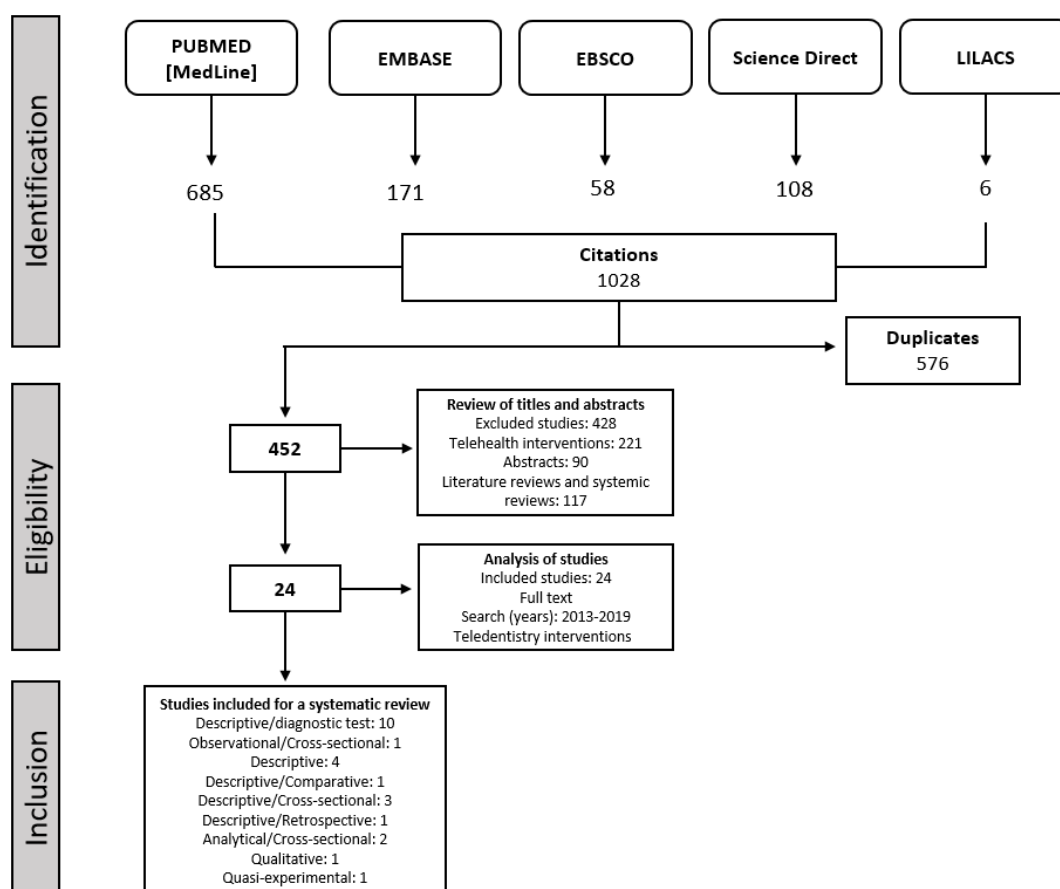
Bias risk was assessed according to each study type, verifying cross-sectional studies through a checklist by the Agency for Healthcare Research and Quality (AHRQ)<sup>16</sup> and randomized clinical trials through the list of items for publication of the Cochrane Collaboration Tool.<sup>17</sup>

## RESULTS

The search strategy identified 1028 articles, of which 24 were included in this systematic review (Figure 1). There were 23 cross-

sectional studies and 1 intervention study. Each study is detailed in Table 1.

Most studies were conducted in the United States and India, as well as in countries in South America, Asia, and Oceania. As for population type, the rural area was predominant. In terms of the intervened population, eight studies were performed in adults, four in children, two in children and adults, and one in adolescents. Other studies were in students, dental professionals, and other health-related professions; there were in vitro studies (teeth removed), and studies conducted in prisoners and teleconsultation. Concerning the area to evaluate, eight studies indicated tooth decay as the main outcome, followed by oral cancer with six studies. Finally, in determining the tool used for each study, an application or a mobile device was used in eight studies.



**Figure 1.** Flowchart of assessed studies per PRISMA

Source: by the authors

## Results of cross-sectional studies

In total, seventeen (70.8%) of the 24 evaluated studies mentioned teledentistry as an alternative method in rural areas, health centers, and prisons for diagnosing and treating oral diseases such as oral cancer, tooth decay, and dentoalveolar trauma through different means such as applications and mobile devices: iTeethey™, WhatsApp, Remote-I, mobile microscope, digital fluorescence (QLF-D), Soprocare photo camera®, teledentistry consultations, and clinical photographs by dentists, specialists and health professionals such as nurses and nutritionists. Similarly, one study

identified knowledge and beliefs about teledentistry from college in students and dental professionals, and six studies assessed the applicability and use of teledentistry for health promotion and disease prevention during consultation, through questionnaires, interviews and databases in children, mothers and other adults.

## Results of intervention studies

One quasi-experimental study was found, which evaluated and compared the visual and infrared detection methods to identify early non-cavitated ex vivo demineralization through three tests to detect

occlusal demineralization: Midwest Caries ID™ (MID), visual photographic examination (CAM), and cross-polarization optical coherence tomography (CP-OCT) on teeth removed 1 to 2 weeks apart. The teeth were then sectioned, and each lesion's depth was confirmed, reporting that MID and CP-OCT were helpful in detecting the presence of demineralization, though not in the depth of

the injury. It also did not present diagnostic values such as CAM for use in teledentistry.

### Bias risk analysis

Of the included studies, 95% had moderate to high bias risk. Table 2 shows the bias risk analysis for observational studies only. On the other hand, the only intervention study was considered to have low bias risk as shown in Table 3.

**Table 2.** Quality assessment according to the Agency for Healthcare Research and Quality (AHRQ)

Author	Source of information (survey, records, review)	Inclusion and exclusion criteria	Time period evaluated	Consecutive population	Reports other aspects of participants	Quality assessment	Exclusions of participants in the analysis	Assessment and control of confounding variables	Data collection response rate	Handling missing data in the analysis	Clarity in follow-up
Purohit, et al (2017)	+	+	+	+	-	-	-	-	+	-	N/A
Estai, et al (2015)	+	-	-	+	-	-	-	-	+	-	N/A
Roxo, et al (2017)	+	+	+	+	-	-	-	-	+	-	N/A
Paixao, et al (2018)	+	+	+	+	-	-	+	-	+	-	N/A
Vinayagamoorthy, et al (2019)	+	+	+	+	-	-	-	-	+	-	N/A
Girardeau, et al (2017)	+	+	+	+	+	-	-	-	+	-	N/A
Boringi, et al (2015)	+	-	-	+	+	-	-	-	+	-	N/A
Estai, et al (2016)	+	-	-	+	+	-	-	-	+	-	N/A
Skandarajah, et al (2017)	+	-	-	+	+	-	-	-	+	-	N/A
McLaren, et al (2016)	+	+	+	+	+	-	-	-	+	-	N/A
Kohara, et al (2018)	+	+	+	+	+	-	-	-	+	-	N/A
Bhatta, et al (2018)	+	+	+	+	+	-	-	-	+	-	+
Daniel, et al (2017)	+	+	+	+	-	-	-	-	+	-	N/A
Martin, et al (2016)	+	+	+	+	+	-	-	-	+	-	N/A
Jung, et al (2018)	+	+	+	+	-	-	-	-	+	-	N/A
Haron, et al (2017)	+	-	-	+	-	-	-	-	+	-	N/A
McLaren, et al (2017)	+	-	+	+	-	-	-	-	+	-	N/A
de Almeida, et al (2017)	+	-	+	+	-	-	-	-	+	-	N/A
Birur, et al (2019)	+	+	+	+	-	-	-	-	+	-	N/A
Alklaybsa, et al (2017)	+	+	+	+	-	-	-	-	+	-	N/A
Estai, et al (2016)	+	+	+	+	-	-	-	-	+	-	N/A
Morosini, et al (2014)	+	+	+	+	-	-	-	-	+	-	N/A
McFarland, et al (2017)	+	+	-	+	-	-	-	-	+	-	N/A

+ Yes: Meets the assigned item - No: Does not meet the assigned item N/A: Not applicable

Source: by the authors



**Table 3.** Quality assessment according to Cochrane Collaboration

Author	Random sequence generation	Concealing the assignment	Blinding participants and staff	Incomplete results data	Selective reports	Other bias
Van Hielsen, et al (2013)	+	+	+	+	-	N/A

+ Yes: Meets the assigned item - No: Does not meet the assigned item N/A: Not applicable

Source: by the authors

## DISCUSSION

The concept of teledentistry includes the combination of the use of computers, telecommunications technology, digital diagnostic imaging services, devices and software for oral health analysis and monitoring, through diagnosis and treatment recommendations in the distance.<sup>42</sup> All the aforementioned aids have been used in fields such as care, education, and public health due to easy access to remote areas, and reduced time and costs for patients.<sup>43</sup>

Two teledentistry methods are practiced nowadays: store and transmit and/or videoconferencing. However, its implementation is minimal, and a more frequent use of this modality in the diagnosis of pathological conditions is suggested.<sup>44</sup>

Pentapati et al evaluated the reliability of an intraoral camera in teledentistry for the detection of oral diseases through an examiner who was trained and calibrated in an intraoral camera to take videos of the oral cavity, against clinical examination to evaluate cavities, bacterial plaque, calculus, dental wear, and fluorosis in children, reporting significantly higher values with the use of the intraoral camera than with clinical examination ( $p = 0.001$ ), by means of the Spearman correlation coefficient.<sup>45</sup>

Similarly, Purohit et al evaluated the reliability of videography to detect tooth decay among 12-year-old schoolchildren in a rural Indian

region through clinical examinations using the decayed, missing and filled teeth index (DMF-t) and a standardized video recording of the oral cavity. Sensitivity (0.86) and specificity (0.58) values were calculated for videographic evaluation of tooth decay, and concordance was evaluated using the Bland-Altman graph, concluding that teledentistry can be used as an alternative for dental cavity detection and for consultations in remote or hard-to-reach areas.<sup>37</sup>

Torres-Pereira et al evaluated the applicability of tediagnosis in oral medicine through the transmission of clinical images by email to two specialists, using two clinical hypotheses for each case, which were compared with the biopsy results, showing that in 80% of cases at least one specialist provided the correct diagnosis, showing that the use of information technology provides an acceptable rate of correct diagnoses, thus supporting its application as a tool for detecting oral diseases.<sup>46</sup>

Regarding users' satisfaction with the use of applications and mobile devices in teledentistry, Estai et al evaluated users' acceptance of a teledentistry model using Remote-I, a store and transmit telemedicine platform, to assist in the detection of oral diseases transmitted directly from the application to the server, finding out that users showed optimism towards the use of the teledentistry system, and positively evaluated the items in terms of content and quality of service.<sup>24</sup>

However, to achieve efficiency and quality standards in teledentistry, it is necessary to adequately train professionals and insist in instant response to avoid careless service, educating dentists in the practice of teledentistry, including information on legal, ethical and technological implications, as well as clinical methods for patient care.

The findings of this systematic review show that, while the use of teledentistry is recent, there are some studies evaluating the knowledge, perceptions, and attitudes in teledentistry among dental students, general dentists and specialists, as well as the use of applications, mobile devices and intraoral cameras for oral health education and diagnosis of oral diseases such as tooth decay, periodontitis, and oral cancer, as well as the adherence to recommendations provided by dentists. This provides an important source of information and advice for health policy makers, service managers and clinicians, resulting in increased access to health services and dental consultation.<sup>47</sup>

Most evaluated studies have multiple limitations, and even though this review was limited to the use of teledentistry in recent years, there appears to be scarce use of this technology. This review found out that there are only a few studies that help identify good quality standards, since most studies did not show prior evaluations, and there was only one experimental study, showing that the degree of scientific evidence is currently poor.

Similarly, while teledentistry has a high potential for addressing needs in the rural population or in remote areas, the findings of this review show that more than half of the evaluated studies were performed in urban areas rather than rural environments, or did not report the location where they were conducted, and most studies were

developed in the U.S., Europe, Asia and Australia. This may be due to economic factors (financing), poor access to networking in rural areas, or because the studies are in their pilot stage; it is therefore necessary to conduct further studies with a significant sample and related follow-up studies in Latin American countries.

## CONCLUSION

This review helped determine the impact of teledentistry in different dental areas. However, most revised studies showed limitations in terms of short-term use of teledentistry and low level of evidence due to the methods and results obtained. It is therefore necessary to conduct further studies to evaluate the efficacy and follow-up of teledentistry services for consultation, diagnosis, and recommendations in dental treatment, as it may be a viable alternative in the reduction of time, transfers, and costs.

## AUTHORSHIP STATEMENTS

All persons who meet authorship criteria are listed as authors of this document, and all authors certify that they have participated in its planning, design, and development, as well as in the interpretation of results. In addition, each author critically reviewed the paper, approved its final version and agreed with its publication. No responsible signature of the document has been omitted and the criteria for scientific authorship are met.

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## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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