

# Impact of Teledentistry Programs on Dental Service in Rural Areas: A Systematic Review

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## Abstract

**Aim.** To assess the evidence on the impact of teledentistry (TD) programs on dental service in rural areas. **Methods.** Five databases (PubMed/Medline, Scopus, Embase, Ovid MEDLINE and ScienceDirect) were screened until August 2018 to find English papers on the impact of TD programs in dental service in rural zones. Titles and abstracts were systematically organized in spreadsheets of Microsoft Excel® software. Repeated titles from different databases were eliminated and those that seemed to fulfill inclusion criteria or presented limited information to be categorized were downloaded in PDF format for full-text reading. The most relevant methodological data were extracted and presented in a table. Also, the methodological quality of included studies was assessed by using an adaptation of New Castle Ottawa Scale. **Results.** Database searching resulted in 50 papers but only 4 fulfilled inclusion criteria and remained for qualitative analysis. Regarding methodological quality of included studies, they have high risk of bias. TD studies focused on dental diagnosis (n=2 studies) and dental treatment planning (n=2 studies) in children or adults. *In vivo* mouth recording was the main method used on TD programs, comparing the outcomes (n=2 studies) or not (n=2 studies) with physical consultation. Selected studies revealed that TD has a positive impact in terms of dental diagnosis, treatment planning on rural communities but more studies are necessary. **Conclusions.** TD programs seem to have a positive impact on dental service in rural areas but further evidence is required to use it as a feasible and economic tool to improve communication, diagnosis, dental treatment planning.

**Keywords:** Teledentistry, rural areas, dental service, oral health, systematic review.

## INTRODUCTION

The access to health services is a fundamental right that aims to improve the quality of life of people. According to World Health Organization (WHO), health services must be timely, efficient, effective, universal, easy to access, inclusive, equitable and it must be of quality. Despite several strategies and policies implemented by governments, there are still deficiencies and inequities in the provision of health services between rural and urban areas [1,2]. This phenomenon may be related to lower economic investment, lack of trained personnel or limited access routes. Technological tools such as internet services, smartphones, cameras or mobile applications used on telemedicine (TM) made possible to optimize the diagnosis and patients treatment, facilitating remote communication between health professionals in distant hospitals, cities, countries or continents. Other advantages of TM involve the access to specialized service/consultation with a good cost-effective balance in major medical fields [3]. There is strong evidence showing a positive impact of TM in health services on different populations [4,5], confirmed by improvement in the quality of service and patient experience [6].

Oral health maintenance is also important to preserve general health of individuals due to some oral conditions have a negative impact on the different dimensions (physical, physiological and social). For example, the loss of teeth due to dental caries and periodontal disease affects the basic functions of eating, communication, smiling. Consequently, it decreases self-esteem, social interactions and the individual's own quality of life [7]. There is evidence suggesting that periodontal diseases such as gingivitis or periodontitis are related to low birth weight [8], myocardial infarction and heart failure [9]. Therefore, oral health services should fulfill the same ideal characteristics proposed by WHO, independently of the type of community, rural or urban. Like TM, teledentistry (TD) is an alternative service model that

integrates dentistry and technological tools such as internet services, fax, scanners, digital imaging (extraoral, intraoral, laboratorial, radiographs, medical reports), audio and video-conferencing technologies by “Real Time consultation” or “Store and forward method” [10]. Cost savings is another advantage of TD programs, being determinant on the feasibility [11,12]. According to a national-level cost model for school dental screening in Australia, the costs of TD models can represent only 30% of traditional face to face model [13]. This would permit an economic option to remote communication/education among dental professionals, diagnosis, treatment planning and access to specialized consultation to people who have limited access to health services or economic limitations [14]. Different systematic reviews on the validity [15], accuracy [16] or benefits [17] of this modality have been conducted on different scenarios, having a high acceptability among dental professional and patients [17]. Nonetheless, there is no consensus based on TD studies exclusively conducted on rural areas from different countries. This knowledge will permit to identify its impact and feasibility to be used in a large scale, leading to develop joint strategies between system engineers and health personnel to diminish disparities in oral health services. Therefore, the aim of this study was to review and critically analyze the literature on the impact of TD programs on dental service in rural areas.

## MATERIALS AND METHODS

This systematic review was structured following all items listed on the Preferred Reported Items for Systematic Reviews and Meta-analysis (PRISMA) [18]. The question of this retrospective research was: are TD programs effective strategies in rural areas?.

### Selection criteria

There were included papers published in English language assessing the impact of TD in oral health service among patients (no distinction by age or sex) who belong to rural areas from different parts of the world. They were included if exclusively assessed the impact of TD and/or compared with physical evaluation, focusing on goals such as education, diagnosis, treatment planning. Studies that aimed to exclusively evaluate cost-savings of TD programs, systematic reviews, comprehensive reviews, congress abstracts and editor letters were not considered in this study.

### Search strategy

Five databases (PubMed/Medline, Scopus, Embase, Ovid MEDLINE and ScienceDirect) were screened until August 2018 without restriction in publication year to find eligible papers. We combined the following related terms “teledentistry”, “dental telehealth”, “oral telehealth”, “dental telecommunication”, “rural patients”, “rural zone”, rural

community” and “rural areas” according to style on each database, as shown in table 1. Repeated hits from different databases were eliminated and remaining titles/abstracts were read in detailed taking into consideration established selection criteria. Potentially eligible papers were downloaded and read in PDF format (full-text version). Also, we read the list of reference from included papers to find other results that could be missed on previous searching strategies.

**Table 1.** Searching strategies adapted to different databases.

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#### PubMed/Medline

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(((((("teledentistry") OR "dental telehealth" OR "oral telehealth" OR "dental telecommunication") AND ("Rural patients" OR "Rural population" OR "Rural zone" OR "Rural community" OR "Rural areas"))))))

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#### Scopus

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TITLE-ABS-KEY ((((((("teledentistry") OR "dental telehealth" OR "oral telehealth" OR "dental telecommunication") AND ("Rural patients" OR "Rural population" OR "Rural zone" OR "Rural community" OR "Rural areas"))))))

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#### Embase

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('teledentistry' OR 'dental telehealth' OR 'oral telehealth' OR 'dental telecommunication') AND ('rural patients' OR 'rural population' OR 'rural zone' OR 'rural community' OR 'rural areas')

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#### Ovid MEDLINE

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('teledentistry' OR 'dental telehealth' OR 'oral telehealth' OR 'dental telecommunication') AND ('rural patients' OR 'rural population' OR 'rural zone' OR 'rural community' OR 'rural areas')

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#### ScienceDirect

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(((((("teledentistry") OR "dental telehealth" OR "oral telehealth" OR "dental telecommunication") AND ("Rural patients" OR "Rural population" OR "Rural zone" OR "Rural community" OR "Rural areas"))))))

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#### Data extraction

The most important methodological aspects were extracted from included studies. Data included first author name, publication year, country, rural zone, sample size (n), population group, TD strategy and instrument, telepresenter professional, treatment phase, comparison with physical examination and author conclusions. Later, they were tabulated on Microsoft Excel® spreadsheets (Microsoft Corporation, Redmond, Washington, USA).

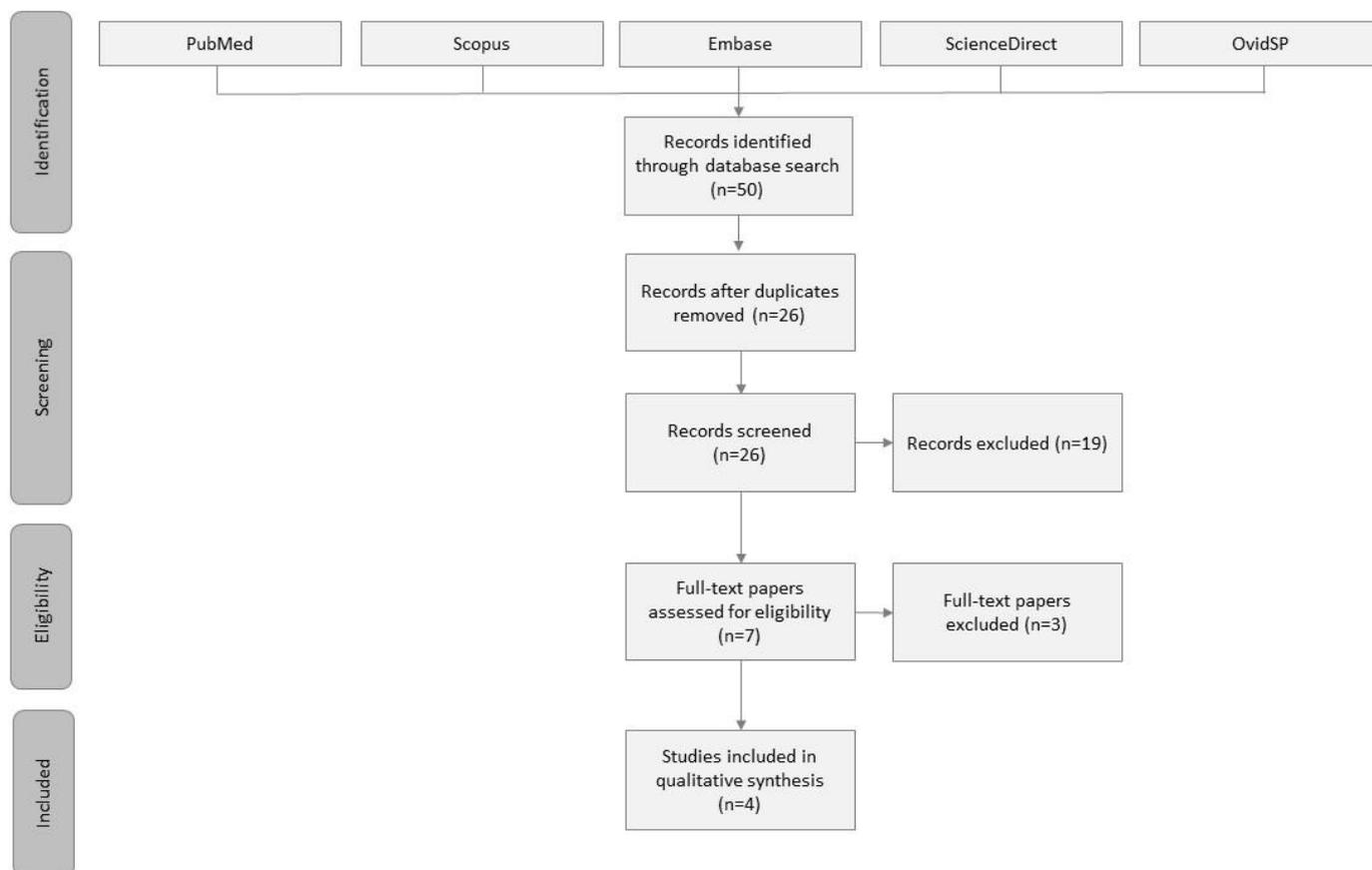
#### Risk of bias

Due to all included studies had a transversal methodological design; methodological quality was assessed by using an adaptation of New Castle Ottawa scale [19]. It consists on 7 domains (case definition, sample calculation, representativeness, confusion adjustment, determination of results, validity and non-response rate). assessed by positive or negative responses. Finally, individual risk of bias was calculated according to the number of “Yes”. Papers receiving 1 to 3 “Yes” were considered as high risk of bias while those that obtained between 4 and 8 “Yes” were judged as having low risk of bias.

## RESULTS

### Search and study selection

In total, 50 papers were found in five databases. After filtering the results, 24 studies were eliminated due to repetition and 26 studies remained for screening. Finally, only 4 papers fulfilled selection criteria [20, 21, 22, 23]. The complete search strategy and selection process is summarized in figure 1.



**Figure 1.** Flowchart showing database searching and selection process.

### Study characteristics

All included papers were published between 2016 and 2018 [20, 21, 22, 23]. They were mainly conducted on United States [20,22]. Only one study was conducted in Australia [23] and other one in rural areas of Bhopal district in India [21]. Regarding sample size, it varied from 116 to 251 participants, constituted by children (n=3 studies) and adults (n=1 study). Main TD strategies involved *in vivo* recording of oral cavity for diagnostic purposes by using intraoral cameras (IOC), smartphones and/or webcams. Only one study applied

TD for remote consultation to discuss about dental treatment planning in Finger Lakes region of New York State (United States) [22]. Regarding Telepresenter assistants, dentists, hygienists, dental assistants, dental residents, oral health therapist and community health workers were enrolled. From included studies, 2 compared TD program with physical examination while 2 studies did not perform a comparison (Table 2).

**Table 2.** Main methodological data extracted from included studies.

| Author (Year)            | Rural zone                            | Country   | Sample size (n) | Population Group | TD strategy and instrument  | Telepresenter assistant profesional   | Treatment phase  | Comparison with presencal examination? |
|--------------------------|---------------------------------------|-----------|-----------------|------------------|---|---|------------------|--|
| McLaren et al. (2016)    | Finger Lakes region of New York State | EEUU      | 251             | Children         | Diagnosis by <i>in vivo</i> recording with Tandberg 1700 HD Monitor, webcam and IOC | Dentists, hygienists, dental assistants and community health workers        | Dental treatment | No                                     |
| Purohit BM et al. (2017) | Rural areas of Bhopal district        | India     | 139             | Children         | Diagnosis by recording oral cavity using Sony Xperia camera, and LED flashlight.    | Three dentists assisted by a recording clerk.                               | Dental diagnosis | Yes                                    |
| McLaren S et al. (2017)  | Finger Lakes region of New York State | EEUU      | 251             | Children         | Dental consultation <i>in vivo</i> with Tandberg 1700 HD Monitor, webcam and IOC    | Pediatric dentistry faculty member or second-year Pediatric dental resident | Dental treatment | Yes                                    |
| Tynan A et al. (2018)    | Rural Queensland                      | Australia | 116             | Adults           | Diagnosis using an IOC  | Oral health therapist   | Dental diagnosis | No                                     |

### Risk of bias

According to New Castle Ottawa Scale adapted for cross-sectional studies, items such as case definition and validity were confirmed in all studies. Conversely, sample size

calculation, representativeness, confusion adjustment and non-response rate received a negative response. Finally, all included studies received 3 points which indicates high risk of bias.

**Table 3.** Risk analysis of bias based on an adaptation of New Castle Ottawa Scale

| Author (Year)            | Selection       |                    | Comparability      |                      | Determination of the result   |          |                    | Score (0-8) |
|--------------------------|-----------------|--------------------|--------------------|----------------------|---|----------|--------------------|-------------|
|                          | Case definition | Sample calculation | Representativeness | Confusion adjustment | Determinati-on of result  | Validity | Non-respon-se rate |             |
| McLaren et al. (2016)    | Yes             | Not                | Not                | Not adjusted         | Compliance rate with dental treatment after TD consultation                       | Yes      | Not                | 3           |
| Purohit BM et al. (2017) | Yes             | Not                | Not                | Not adjusted         | Reliability of TD method in dental caries diagnosis                               | Yes      | Not                | 3           |
| McLaren S et al. (2017)  | Yes             | Not                | Not                | Not adjusted         | Accuracy of predicting dental treatment modalities for live-video TD consultation | Yes      | Not                | 3           |
| Tynan A et al. (2018)    | Yes             | Not                | Not                | Not adjusted         | Development and implementation of integrated model of TD                          | Yes      | Not                | 3           |

### Summarized results

McLaren et al., (2016) [20] showed that compliance rates for completed comprehensive dental treatment were high, ranging from 56% to 100%. Live-video TD consultations conducted among rural paediatric patients were feasible options to increase dental treatment compliance rates when treating complex paediatric dental cases. Purohit BM et al., (2017) [21] concluded that TD examinations were comparable to

clinical examination for dental caries screening among school children. TD tools can be effectively used for remote consultation and treatment planning. McLaren et al., (2017) [22] showed that TD consultations facilitated high treatment completion rates and improved the access to specialty dental care while decreasing treatment time. In addition, TD improved oral health of rural pediatric patients. Tynan A *et al.*, (2018) [23] concluded that there was an improvement of oral care plan and a minimisation of need for residents to

attend an oral health care facility., besides financial and social cost savings.

## DISCUSSION

The aim of this systematic review was to critically analyze the literature on the impact of TD programs on dental service in rural areas. This specific approach is due to people who belong to rural communities are negatively impacted by inequalities in access and quality of health service as compared to urban areas [24, 25]. Nonetheless, some inequalities related to access may be overcome by using internet services, smartphones and mobile applications, generally involved on TD programs. In this systematic review, 4 papers [20, 21, 22, 23] met inclusion criteria but the first ones were published in 2016, indicating that implementation of TD in rural areas and its impact on diagnosis, treatment planning or oral health education is a recent research field compared to TM studies conducted on similar populations [26, 27]. Probably, it can be explained by limited access to internet services or by the fact that people prefer traditional models in some medical areas which necessarily implies physical contact with health professional [28]. Difficulties on implementing TD on rural zones may be associated to the fact that patients believe on their "inactive" role in health-disease process and they trust health professionals have a significant responsibility on this process [29]. It should be highlighted that most of included studies were conducted on United States which could be associated to provision of high quality services to population, including more vulnerable patients [30]. Conversely, no English studies conducted on Latin American or African countries were found which must call attention among researchers due to social inequities and poor quality of health services in these populations [31, 32, 33]. Different health care members can be involved in TD programs. Besides dentists, hygienists, dental assistants, dental residents, oral health therapist and community health workers located in rural areas participated in the studies included in this systematic review. As shown in Summerfelt's study, members such as dental hygienists could digitally save and transmit diagnostic data to remote dentists to determine diagnosis and treatment planning. Also, inside the scope of practice, they could provide basic promotion and preventive services to patients [34].

Overall, selected studies showed that TD programs had a positive impact on diagnosis and/or treatment planning in rural populations. It is widely known that early diagnosis plays an important role on disease history due to it facilitates prevention and early management of prevalent diseases such as dental caries [35], periodontitis [36] and oral cancer [37]. Dental caries remains as the most prevalent oral condition around the world, representing a public health problem [38]. Visual examination has been considered as the gold standard method to diagnose caries lesions at different stages [39]. Nevertheless, digital photography, video-recording and TD play an important role on the early diagnosis and treatment planning of dental caries, being in some cases superior or similar than visual inspection as demonstrated by other authors, [40, 41] and confirmed in the current systematic

review. Digital images (including those obtained by IOC) have been successfully used by other authors to assess changes in oral mucosal pathology [42], dental restorations quality [43], detection of root canal orifices [44], diagnosis of calculus, tooth wear, fluorosis [45], assessment [46] and reinforcement of dental plaque control [47]. Despite the versatility and effectiveness of IOC, an initial investment in IOCs, training and standardization of telepresenters are essential to capture and transmit reliable data to remote professionals. On the basis of early dental diagnosis, oral health education on rural patients represents another possibility on TD programs. Unfortunately, no studies on this issue were found which indicates that it should be the focus on future studies. Also, it must incentive system engineers and dentists to develop strategies such as mobile applications or telepresentations models in order to made oral health education an intuitive and friendly process in rural areas.

The current systematic review had some limitations, including the reduced number of studies that fulfilled selection criteria. This fact may be reinforced by conducting both, further cross-sectional and longitudinal studies as well as more exhaustive systematic reviews on TD in rural areas comparing the outcomes with traditional model. In addition, we did not find studies conducted on Latin American or African countries which should alert researchers from these continents on the need of international evidence on this issue.

## CONCLUSIONS

Based on the limitations of the current systematic review, it could be concluded that TD seems to have a positive impact on dental service in rural areas but more evidence is required to considered it as a practical strategy to improve remote consultation between oral health professionals and patients, diagnosis and treatment planning.

## List of symbols and abbreviations

HD: High definition

IOC: Intraoral cameras

TD: Teledentistry

TM: Telemedicine

WHO: World Health Organization

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