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A systematic review of the research evidence for the benefits of teledentistry

Mohamed Estai[1], Yogesan Kanagasingam[2], Marc Tennant[1] and Stuart Bunt[1]

Abstract

Objective: This review is designed to inform future decisions about the benefits of integrating teledentistry into routine health services, by presenting an overview of the evidence for the effectiveness and economic impact of teledentistry.

Methods: Two reviewers searched PubMed, EMBASE and CINAHL databases through November 2016 to identify published peer-reviewed studies in English. Teledentistry studies were included if they were; (a) controlled (randomised or non-randomised) assessment studies; and (b) compared outcomes of a teledentistry intervention in terms of clinical or economic evaluation with the outcomes of traditional clinical alternatives. The quality of the studies was evaluated using a quality appraisal tool that considered study performance and design.

Results: This review identified 385 publications, of which 217 full-text articles were retrieved for further inspection. Of these, only 11 articles met the inclusion criteria. Nine of the included articles showed some clinical outcomes; the other two were primarily economic analyses. The balance of these studies assesed the efficacy of teledentistry interventions rather than their effectiveness. Four studies (36%) achieved higher quality scores and have greater potential to influence health-care decision-making. To date, the most convincing published evidence regarding the efficacy of teledentistry was provided by studies on paediatric dentistry, orthodontics and oral medicine. The economic analysis referred only to cost-minimisation, suggesting that the use of teleconsultation in dentistry can be cost-saving when compared to a conventional consultation. However, high-quality economic studies on teledentistry are rare.

Conclusion: There is emerging evidence supporting the efficacy of teledentistry. However, there is not yet enough conclusive evidence, particularly for its effectiveness, cost-effectiveness and long-term use, to make evidence-based policy decisions on teledentistry.

Keywords

Teledentistry, oral health, future decisions, efficacy, effectiveness, cost

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Introduction

Dental manpower shortages, remoteness, funding challenges and the decreasing cost of and advances in technology, have increased the interest in the use of telemedicine applications.[1] 'Telemedicine being a subset of telehealth, uses communications networks for delivery of healthcare services and medical education from one geographical location to another, primarily to address challenges like uneven distribution and shortage of infrastructural and human resources' (page no 576).[2] Teledentistry is a domain of telemedicine that is specifically dedicated to dentistry, and it emerged from the combination of digital and telecommunication technology and dentistry.[3] The implications of teledentistry for oral care services and oral health in rural or remote areas are significant.[1] Teledentistry has the potential to identify high-risk populations, facilitate patients' referrals to a dental consultant and support locally-based treatment, thus reducing waiting lists and unnecessary travel and loss of productivity.[4–7]

A number of areas in dentistry that are particularly appropriate for teledentistry are remote consultations for preparing treatment plans, providing preventive care and supervising practitioners working in rural settings as well as continuing education.[8] The Dental Health Aide Therapists (DHATs) programme is a notable workforce model that makes use of role substitution (using native dental therapists) and telemedicine to address inequity in access to dental care in Alaska. In 2002, the DHATs Programme began in Alaska as an expansion of the Community Health Aide

[1]International Research Collaborative–Oral Health and Equity: School of Anatomy, Physiology and Human Biology, University of Western Australia, Australia
[2]Australian e-Health Research Centre, CSIRO, Australia

Corresponding author:
Mohamed Estai, International Research Collaborative–Oral Health and Equity: School of Anatomy, Physiology and Human Biology, University of Western Australia (M309), 35 Stirling Highway, Crawley WA 6009, Australia.
Email: abdalla177@gmail.com

Programme (CHAP).[9] The CHAP has been the basis of the health care delivery system for rural Alaskan residents, providing 350,000 patient visits annually.[9] Alaskan Natives are trained and employed as DHATs with an expanded scope of practice to perform prophylaxes, restorations and uncomplicated extractions as well as provide preventive care in Alaska Native villages.[10] The DHAT's scope of practice was established by supervising dentists who provided general supervision via telemedicine.[10]

The emergence of telemedicine has led to many research studies that have evaluated teledentistry applications in different settings. Despite the heterogeneity of the studies, there is a growing body of evidence supporting the use of teledentistry, in particular, for early detection of dental diseases.[11–14] A database search for systematic reviews and meta-analyses on teledentistry identified only four systematic reviews[15–18] but, to date, no meta-analyses on teledentistry have been published. The systematic reviews, however, were descriptive, as none considered the quality of evidence or research rigour in the evaluation of studies, and mainly addressed the feasibility or accuracy of various teledentistry applications. This poses a difficulty in determining the impact of teledentistry on clinical outcomes, resultant cost-benefits and the implications for future decisions. This systematic review aims to inform decision-makers who are doubtful about the capability and merit of integrating teledentistry into routine health services by presenting an objective overview of good-quality evidence for the effectiveness and economic impact of teledentistry.

Methods

Data sources

Following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines for systematic reviews,[19] literature searches for teledentistry studies were conducted through November 2016 using the PubMed, EMBASE and CINAHL databases. Research on teledentistry uses the term 'teledentistry' inconsistently in the literature. As a result, various queries were used in the database search to ensure no relevant studies would be missed. Database searches in this review were carried out using a combination of the following keywords: 'dental' and 'real-time'; 'dental' and 'remote consultation'; 'dental' and 'remote screening'; 'dental' and 'store-and-forward'; 'dental' and 'teleconsultation'; 'dental' and 'tele-diagnosis'; 'dental' and 'videoconferencing'; 'tele-dentistry' and 'oral medicine'; 'tele-dentistry' and 'oral surgery'; 'tele-dentistry' and 'orthodontics', 'tele-dentistry' and 'maxillofacial surgery'; 'tele-dentistry' and 'periodontics'; 'tele-dentistry' and 'preventive dentistry'; 'tele-dentistry' and 'prosthodontics' and 'tele-dentistry' and 'endodontics'; 'tele-health/tele-medicine' and 'dentistry'.

Eligibility criteria

The inclusion criteria were studies: (a) published in a peer-reviewed journal; (b) controlled (randomised or non-randomised) assessment studies; and (c) compared outcomes of a teledentistry intervention in terms of clinical or economic assessment with the outcomes of traditional clinical approaches. Studies were excluded if they were; (a) without a comparison between a teledentistry and a conventional alternatives; (b) limited to describing the technical feasibility of a certain application; (c) non-controlled studies (e.g. cross-sectional, case report or case series) due to their high risk of bias; (d) presented in the format of reviews, editorials or letters; (e) dissertations, books, reports or unpublished materials; (f) provided inadequate information such as abstract or conference proceedings; and (g) written in a language other than English.

Study selection and data extraction

Two authors (ME and MT) screened the titles of identified publications independently and in duplicate when titles fulfilled the eligibility criteria or were unclear, the abstracts were read. The same process was used in assessing abstracts, the selection of the relevant studies was based on the data collected from the abstracts, which gave an indication that the eligibility criteria would be met, and was agreed upon discussion among the authors. In the next stage, relevant full-text articles were obtained and independently evaluated for the eligibility criteria by the two authors, who then reached an agreement on whether an article should be included. Full-text articles meeting the eligibility criteria were selected and abstracted into the evidence table (Table 1). The first author (ME) extracted data from the full-texts, and the other reviewer (MT) independently verified the extracted data. Discrepancies between the two reviewers were resolved through discussion. Additional details of each selected paper are presented in the evidence table, in which studies are tabulated by type of speciality, application considered; problem concerned, the technology used; outcome favour and the conclusion reached. In addition, the author's name; country; study sample, study design and type of economic analysis are also listed here.

Evaluation of study quality

The quality of each study, other than those aspects related to economic analysis, was evaluated independently by two authors using the protocol established by Hailey et al. (originally modified from the Jovell and Navarro-Rubio classification), taking into account the study performance and study design (Table 2).[20,21] This protocol is a useful approach, as it can provide a quantitative measure of scientific rigour. For assessing the design of included studies, large randomised controlled trials (RCTs) were assigned a score of five. Small RCTs were assigned a score of three, prospective non-randomised controlled trials a score of two, retrospective non-randomised controlled trials a score of one and non-controlled studies a score of zero.[20,21] For assessing the study performance, five criteria

Table 1. Summary of studies included in the review.

Author (year)	Country	Problem	Specialty	Application	Modality/equipment	Study design	Sample/participant	Outcome favour	Outcome reached
Berndt et al. (2008)[22]	USA	Training of postgraduate dental students	Orthodontics	Teleconsultation	Real-time Videoconferencing unit (Polycom VSX 7000, Polycom)	Prospective non-randomized controlled studies (category C)	Children age = 8–11 years $n = 96$ (control) $n = 30$ (case)	Comparable	Peer assessment rating index was 35.6% in the teledentistry group and 44.1% in the direct supervision group (p value < 0.001).
Birur et al. (2015)[23]	India	Screening for oral diseases	Oral medicine	Telediagnosis	Store-and-forward Smartphone camera (HTC Wildfire S)	Prospective non-randomised controlled studies (category C)	Targeted cohort ($n = 2000$) Opportunistic cohort ($n = 1440$)	Comparable	In the targeted cohort, among 51 of 81 (61%) interpretable images, 23 of 51 (45%) of the lesions were confirmed by specialists, while the opportunistic cohort (control) showed 100% concordance with the specialists (106 of 106).
Kopycka-Kedzierawski et al. (2011)[24]	USA	Screening for caries	Paediatric dentistry	Telediagnosis	Store-and-forward Dr Camscope intraoral camera	Large-sample RCT Good (category A)	Age = 12–60 month Power calculated Control = 126 Test = 108	Comparable	The mean dfs score for the children examined by means of teledentistry was 1.75 (SD ± 4.25) and for the children examined by means of teledentistry was 1.40 (SD ± 4.07).
Kopycka-Kedzierawski et al. (2013)[25]	USA	Screening for caries	Paediatric dentistry	Telediagnosis	Store-and-forward Dr Camscope intra-oral camera (Sometech)	Large-sample RCT Good (category A)	Age = 12–60 month Power calculated Control = 162 Test = 129	Comparable	After follow up-examinations at 12 months, the mean dfs score for the children examined by means of teledentistry was 3.02, and for the children examined by means of the clinical method was 1.70.
Mandall et al. (2005)[26]	UK	Patient referrals to consultant	Orthodontics	Telereferral	Store-and-forward Camera type not reported	Large-sample RCT Good (category A)	Patients Power calculated $n = 247$ (control) $n = 80$ (test)	Teledentistry	The sensitivity and specificity of the teledentistry system were 0.80 and 0.73 respectively. The inappropriate referral rate for the teledentistry group was 8.2% and for the controls 26.2% (p value = 0.037).
Mariño et al. (2016)[27]	Australia	Screening for oral diseases	Other dental fields	Telediagnosis Teleconsultation	Store-and-forward Real-time Intra-oral camera (SOPROLIFE)	Cost-minimisation study (category D)	Aged care residents $n = 100$	Store-and-forward Teledentistry	The net cost of store-and-forward teleconsultation was AU$32.35 while, the total cost of real-time consultation was AU$41.28 per resident. The total cost

(continued)

Table 1. Continued

Author (year)	Country	Problem	Specialty	Application	Modality/equipment	Study design	Sample/participant	Outcome favour	Outcome reached
									of the face-to-face examinations by a dentist was AU$36.59 per resident.
Nickenig et al. (2008)[28]	Germany	Pre-implant dental assessment	Prosthodontics	Teleconsultation	Real-time Videoconference type not reported	Prospective non-randomised controlled studies (category C)	Adult patients $n = 772$ (control) $n = 85$ (test)	Comparable	In three cases (3%), a basic change in the prosthodontic concept was required as compared to the telemedicine plan; in the control group, the concept changed in 7% of cases.
Ojima et al. (2003)[29]	Japan	Oral health promotion	Periodontics	Teleconsultation	Store-and-forward Real-time Digital video camera, camera type not reported	Small-sample RCT Good to fair (category B)	Adult workers $n = 7$ (control) $n = 6$ (test)	Teledentistry	Indices for periodontal destruction, plaque accumulation, gingival inflammation and oral hygiene between the baseline and the 3-month examination were significant in study group ($p = 0.046$, 0.027, 0.028 and 0.028, respectively), whereas in control group, only differences in indices of plaque accumulation and oral hygiene were significant (p value $= 0.026$ and 0.018, respectively).
Salazar-Fernandez et al. (2012)[4]	Spain	Temporomandibular joint disorders	Oral medicine	Telediagnosis Tele-referral Teleconsultation	Store-and-forward Camera type not reported	Prospective non-randomised controlled studies (category C)	Patients average age = 38–41 years $n = 710$ (control) $n = 342$ (test)	Teledentistry	Of the 342 patients with TMJD were assisted by teleconsultation, only 35 (10%) patients presented some other TMJ pathology that required maxillofacial surgery. The remaining 307 (89.7%) received non-surgical treatment in the primary care centre in a mean time of 2.3 days (p value < 0.05), and a mean cost of 16 lost working hours/patient (p value < 0.05).
Scuffham and Steed (2002)[30]	UK	Consultation about dental and oral diseases	Restorative dentistry	Teleconsultation	Real-time videoconference codec cards (Zydacron)	Cost-minimisation study (category D)	Mean age 46 years $n = 25$	Teledentistry	Cost savings are greatest where the cost of travel is greatest. For Orkney (a remote island) patients,

(continued)

Table 1. Continued

Author (year)	Country	Problem	Specialty	Application	Modality/equipment	Study design	Sample/participant	Outcome favour	Outcome reached
									dental teleconsultation resulted in cost-savings of £270 per patient compared with hospital visits. When the value of patient time was included, there were cost-savings of around £900 per Orkney patient compared with hospital visits
Zamzam and Luther (2001)[31]	UK	Lip position in patients with cerebral palsy	Oral medicine	Telediagnosis	Real-time Remote video surveillance camera (Videomech, Newport, UK) and videoplayer (Panasonic)	Prospective non-randomised controlled studies (category C)	Age $<$ 4 years $n = 8$ (control) Age 2 mo-12 years $n = 8$ (case)	Comparable	The agreement between the real-time videoconference and in-person clinical assessment was good (Kappa = 0.68)

dfs: decayed and filled surface; RCT: randomised controlled trial; SD: standard deviation; TMJD: temporomandibular joint disease.

were taken into account: patient selection, description of the interventions, analysis of the study, patient disposal and outcomes reported.[20,21] Each of the five criteria of study performance received a score of zero (if relevant information was not provided or unclear), a score of one (if relevant information was provided but there were some significant shortcomings) or a score of two (if the information provided was satisfactory, with no significant shortcomings).

The maximum overall quality scores (performance plus design) for each selected study was 15. The overall quality scores for each study provide an indication of the degree of confidence that can be placed in its findings and implications for future decisions making on teledentistry. Each study was designated to one of five categories (A to E), according to the totals of the quality scores. A study that had a high degree of confidence in its result was put in category A, whilst studies provided findings of unacceptable uncertainty and had a potential for selection bias were put in category E (Table 2).[20,21]

Quality of economic evaluation

The quality of studies relating to the economics of teledentistry was assessed against Drummond et al.'s[32] criteria which includes a 10-point checklist.

1. Was a well-defined question posed in answerable form?
2. Was a comprehensive description of the competing alternatives given?
3. Was the effectiveness of the programmes or services established?
4. Were all the important and relevant costs and accurately in appropriate physical units?
5. Were costs and consequences measured accurately in appropriate physical units?
6. Were costs and consequences valued credibly?
7. Were costs and consequences adjusted for different timing?
8. Was an incremental analysis of costs and consequences of alternatives performed?
9. Was allowance made for uncertainty in the estimates of costs and consequences?
10. Did the presentation and discussion of the study results include all issues of concern to users?[32]

For each selected paper, a score of one was assigned for each criterion that was fulfilled. Therefore, the score for the economic evaluation of each study, ranged from 1–10.

Results

Retrieved articles

The database search identified a total of 385 titles, of which 287 abstracts were reviewed to determine if they were relevant to the scope of the study and were retrieved in full-text.

Table 2. Study quality classification by Hailey et al. (2004).[21]

Category	Study design	Strength of evidence	Overall quality score[a]	Potential impact on future decisions
A	Large RCTs	High quality	11.5–15.0	High degree of confidence in study findings
B	Small RCTs	Good quality	9.5–11.0	Some uncertainty regarding the study findings
C	Prospective non-randomised controlled studies	Fair to good quality	7.5–9.0	Some limitations that should be considered in any implementation of study findings
D	Retrospective non-randomised controlled studies	Poor to fair quality	5.5–7.0	Substantial limitations in the study; findings should be used cautiously
E	Non-controlled series	Poor quality	1–5.0	Unacceptable uncertainty for study findings

RCT: randomised controlled trial.
[a]Total score for study design and study performance.

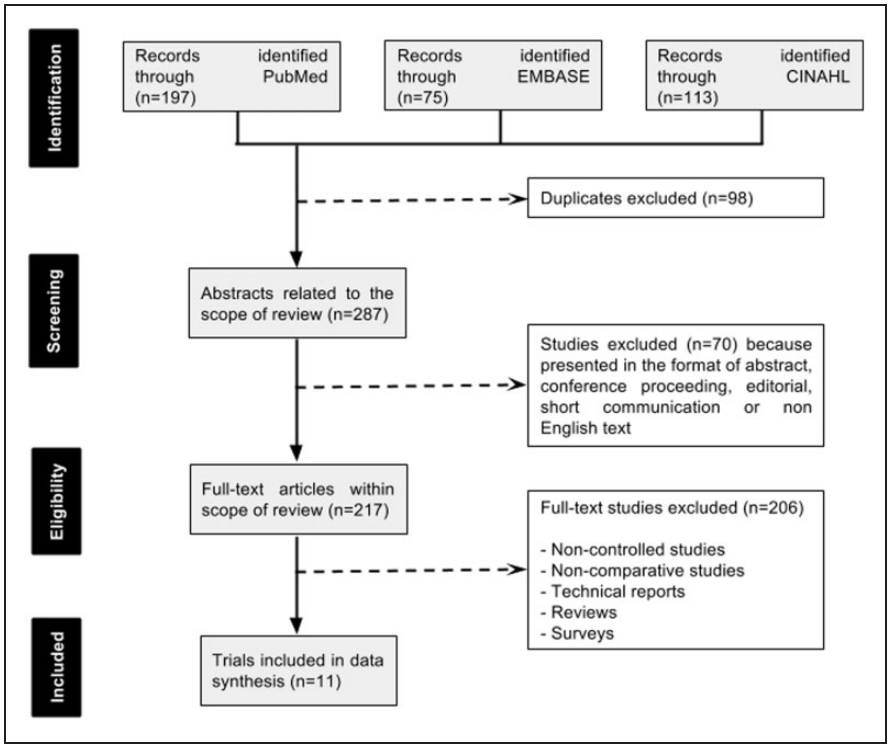

Figure 1. The preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram of included studies.

Based on a review of the abstracts, 217 full-text articles were obtained for closer inspection. Of these, 11 were considered to fulfil the preset inclusion criteria (Figure 1). Nine of the included articles considered some clinical outcomes.[4,22–26,28,29,31] The remaining two were mainly economic analyses.[27,30] Some kind of economic analysis was considered in one study.[4] The Kappa statistic (as a measure of the inter-reviewer reliability for the process of study selection and quality assessment) ranged from 0.62–0.70. This suggests that the concordance between the two reviewers was substantial/good at all stages.

Studies were clustered into two major applications, telediagnosis and teleconsultation. A minority of the reviewed studies were concerned with the referral,[4,26] clinical training[22] or oral health promotion[29]. The majority of the reviewed studies were solely focused on the speciality of oral medicine,[4,23,31] paediatric dentistry[24,25] and orthodontics.[22,26] Two types of consultation technique were used in the studies, store-and-forward ($n = 5$) or real-time ($n = 4$). The studies included in this review were conducted in seven different countries, with the majority of studies from Europe ($n = 5$) and the USA ($n = 3$), with one

Table 3. Proportion of studies as per type of intervention, type of application, type of technology and location of study.

Characteristics	Number of Studies
Intervention/speciality	
Paediatric dentistry	2
Oral medicine	3
Orthodontics	2
Prosthodontics	1
Periodontics	1
Restorative dentistry	1
Other dental fields	1
Type of application	
Telediagnosis	4
Teleconsultation	4
Tele-referral	1
Telediagnosis and teleconsultation	1
Telediagnosis, teleconsultation and tele-referral	1
Type of technology	
Store-and-forward	5
Real-time	4
Both	2
Country of study	
Europe	5
USA	3
Australia	1
Japan	1
India	1
Total	11

each from Japan, India and Australia. The majority of the reviewed articles did not explicitly report the setting of the study (rural or urban); however, it appears that studies were carried out in either urban or rural settings such as hospitals, clinics, childcare centres or workplaces. More information on characteristics of the reviewed studies is provided in Table 3.

Study scores and classification

Several publications that had a comparison of outcomes between teledentistry and traditional clinical settings were omitted because they were non-controlled, corresponding to category E of Hailey et al.'s protocol.[21] Of the 11 studies included in this review, three were based on large RCTs, one was based on small RCTs, five were non-randomised controlled trials and a further two were non-controlled series. Of the 11 studies, four were considered to be of high or good quality (category A or B),[24–26,29] five studies[4,22,23,28,31] of fair to good quality (category C) and the remaining two studies[27,30] were of poor to fair quality (category D). In many papers, procedures for the selection of patients and randomisation were inadequately described. In large RCT studies,[24–26] little detail was provided on the randomisation procedure and patient disposals. A further report of a small RCT,[29] had a very small sample size and a more limited description of the randomisation procedure. All studies reported sample size, with the majority of the included studies using convenience sampling in the recruitment. However, only three studies reported power calculations.[24–26]

The study design and performance were a good indication of study quality. Studies that had higher overall quality scores had high study design and performance scores. The three large RCTs[24–26] achieved the highest performance scores (7.0–7.50), indicating high quality in their performance and relatively high confidence in their results. Implications for the possible impact of a study on healthcare decision-making regarding teledentistry arise from the reliability of a study as indicated by the overall quality scores and the degree of confidence put in their findings. Studies with higher overall quality scores had a high degree of confidence in their findings, and therefore, greater potential to influence future decisions on teledentistry. Six studies were found to have implications for future decision-making on teledentistry.[4,23–26,29] The remaining studies reported more preliminary results, which may be useful to guide decision-making. The distribution of study design and performance scores with implications for future decisions for individual studies is given in Table 4.

Economic analyses

The economic analyses in the reviewed papers were methodologically more like cost-analysis studies. Cost-minimisation was said to be conducted in two studies,[27,30] since the benefits were calculated as cost-savings (direct and indirect costs) compared with the non-telemedicine alternative. One study included some indirect costs estimation (mainly lost working hours).[4] The effectiveness of a teledentistry intervention was reported to be established in one study[4] and assumed in two studies.[27,30] The perspective of the economic analysis was explicitly reported in two studies, with one being from both the patient's and health-care perspective[30] and one from only the healthcare perspective.[27] Only one study applied sensitivity analyses to evaluate the robustness of the results.[30] Cost-benefit, cost-effectiveness or cost-utility were not considered in the reviewed studies. None of the selected studies considered incremental economic analysis (except Scuffham and Steed).[30] Of three studies that included economic evaluation, two studies satisfied five or six criteria given by Drummond et al.[32] and were judged to be of fair to good quality (Table 4).

Clinical outcomes

Despite the included studies using different objectives, methods and outcome measures, all studies indicated that teledentistry interventions were comparable to, or had advantages, over non-telemedicine approaches. The

Table 4. Quality score and potential of future decisions making on teledentistry.

Intervention	Reference	Overall Quality Score[a]	Impact on Future Decisions	Economic Quality Score
Paediatric dentistry	Kopycka-Kedzierawski et al. (2011)[24]	12.5	A	–
	Kopycka-Kedzierawski et al. (2013)[25]	12.5	A	–
Oral medicine	Birur et al. (2015)[23]	8.5	C	–
	Salazar-Fernandez et al. (2012)[4]	7.5	C	4.5
	Zamzam and Luther (2001)[31]	7.5	C	–
Orthodontics	Mandall et al. (2005)[26]	12	A	–
	Berndt et al. (2008)[22]	7.5	C	–
Prosthodontics	Nickenig et al. (2008)[28]	7	C	–
Periodontics	Ojima et al. (2003)[29]	9.5	B	–
Restorative dentistry	Scuffham and Steed (2002)[30]	6	D	6
Other dental fields	Marino et al. (2016)[27]	5.5	D	5

[a]Total score for study design and study performance.

overall conclusions reached in the selected studies are given in Table 1. Two of the large RCT studies considered store-and-forward telediagnosis for detection of early childhood caries (ECC), and suggested that remote screening for ECC in preschool children using teledentistry was comparable to clinical visual examinations.[24,25] A further report of a large RCT[26] which used a tele-referral system to screen new patient orthodontic referrals, indicated that teledentistry offered a valid tool for identifying appropriate new referrals and avoiding inappropriate referrals. Another report of a small RCT study considered a web-based system for promoting periodontal health in a workplace, suggesting the use of this system allowed the public to access useful health information and enabled effective intervention of oral care professionals.[29]

The non-randomised controlled studies were diverse in their quality, as evaluated by the descriptions of methods, analysis of results and outcomes. For example, Salazar-Fernandez and colleagues[4] evaluated the effectiveness of store-and-forward teledentistry to perform diagnosis and provide treatment for patients with temporomandibular joint disorder (TMJD). The authors indicated that teledentistry can offer valid diagnosis and adequate treatment of TMJD from primary care sites. Nickenig and colleagues[28] evaluated real-time teledentistry for pre-implant dental evaluation. Nickenig et al. suggested that teledentistry has the potential to facilitate preoperative assessment of the implantation operation. Another study by Berndt and colleagues[22] indicated that interceptive orthodontic procedures performed by supervised general dentists via teledentistry can help in reducing the severity of malocclusions among children. Another study by Birur et al. examined the effectiveness of remote oral cancer surveillance programme using the mHealth application.[23] Birur et al. showed that the mHealth-based approach aided remote screening for oral cancer by primary care practitioners.[23] A further report of a non-randomised trial[31] considered teledentistry to assess lip position in children with cerebral palsy. Results indicated that lip position assessed by real-time videoconferencing and direct clinical assessment are comparable, suggesting that videoconferencing offers a more unobtrusive approach than direct clinical assessment.

The effectiveness of teledentistry interventions was reported to be assessed in four studies,[4,23–25] however, none of the studies considered cost-effectiveness. Only a few economic analysis studies,[4,27,30] particularly those concerning with cost-minimisation, were identified and included in this review. Mariño and colleagues[27] compared the cost and benefits of visual examination conducted by a dentist at a residential aged-care facility in rural areas with a teledentistry approach. The authors concluded that store-and-forward teleconsultation was the lowest cost service model compared to the in-person and real-time model of care. Scuffham and Steed[30] undertook a cost-minimisation analysis to compare the costs of teledentistry with two alternatives, outreach visits and hospital visits. Scuffham and Steed[30] reported that cost-savings could be significantly higher when teledentistry was used in remote/very remote regions and even with additional costs, teledentistry can help in reducing oral health inequalities. Another cost-minimisation study by Salazar-Fernandez and colleagues[4] suggests that the use of store-and-forward telemedicine system for management of patients with TMJD can shorten the delay in treatment onset and prevent or reduce the loss of productivity by patients.

Discussion

There is a consistent trend in the literature supporting the validity and reliability of teledentistry applications in comparison to non-telemedicine alternatives.[11–14,33,34] However, most of the available literature (217 full-text articles screened) is limited to technical reports or feasibility studies, and only a small number of the studies reported a controlled comparison of a teledentistry application with conventional alternatives. In many cases,

the balance of the reviewed studies was towards assessing the efficacy of teledentistry application rather than assessing its effectiveness. Controlled assessments of the clinical outcomes and costs of teledentistry applications are needed to provide scientific evidence of the appropriateness of teledentistry.

Generally, RCTs remain the gold standard for assessing the effectiveness and cost-effectiveness of an intervention within biomedicine, due to their ability to reduce the chances of bias and control for the potential impact of confounding factors.[35] However, many argue that the complexity and methodological limitations of conducting RCTs to evaluate eHealth technologies may impact the generalisability of the findings.[36] Therefore, there is a call for alternative strategies to evaluate the effectiveness of eHealth technological interventions such as using qualitative evaluation methods that allow consideration of sociotechnical contextual issues.[36] Nevertheless, in this review, a robust and scientific approach to evaluating the literature on teledentistry was used that focused on assessing controlled assessment studies reporting a comparison of outcomes of a teledentistry approach with non-telemedicine or conventional alternatives. This approach could provide more conclusive evidence of the performance of teledentistry than those without a comparator.

This review indicates that there are only a few good-quality comparative studies of teledentistry available, especially those evaluating the efficacy of teledentistry.[24–26,29] Apart from few studies that assess the effectiveness of teledentistry,[4,23] none of the reviewed studies considered the effectiveness, cost-effectiveness or long-term outcome of teledentistry applications. A growing body of evidence supporting the efficacy of teledentistry is provided by some of the studies on paediatric dentistry,[24,25] oral medicine,[4,23] orthodontics[26] and periodontics.[29] The majority of the research in these areas reported that teledentistry had similar or better outcomes than the conventional alternative. To date, the most convincing published evidence regarding the economic benefits of teledentistry deals with teleconsultation and telediagnosis. However, cost-minimisation analysis was being considered, rather than cost-effectiveness, cost-utility or cost-benefits. The absence of good-quality economic studies in teledentistry has also been cited in previous reviews.[16,17] Although some useful clinical and economic outcomes have been identified in a few teledentistry applications, conclusive evidence is still rare, and therefore, the generalisability of results is difficult to ascertain.

Teledentistry is an innovative method of oral health-service delivery that can connect dental practitioners and patients with a dental consultant anywhere on the globe. This is important particularly for underserved communities that lack access to oral care due to geographical barriers, socioeconomic issues or dental workforce shortages. Despite its great potential to address the needs of rural or remote populations, our findings indicated that more than half of the reviewed studies were undertaken in urban areas rather than rural settings. This could be attributed to funding difficulties in rural or remote areas or to the fact that the majority of the trials of teledentistry are still in proof-of-concept or pilot stages.[16] The present review also shows that the majority of reviewed studies are clustered in developed countries, in particular, the USA and Europe, and little research work has been done in developing countries. The dearth of teledentistry projects in developing countries could be attributed to the conservatism of decision makers, a lack of resources, ICT infrastructure and equipment. In addition, the provision of dental care services in developing countries is based on emergency rather than preventive care.

There were several limitations in most of the reviewed studies, so that even though the present review was restricted to good quality publications on teledentistry, at present they provide an inadequate indication of the status of this technology. It is possible that a large body of literature on teledentistry assessment was not located. Since the focus of this review was only on identifying controlled assessments of teledentistry and comparative outcomes, there was no attempt to review all the relevant 'grey literature' (e.g. education, technical reports, reviews and dissertations) as it is unlikely that there would be many articles fulfilling the inclusion criteria.

Conclusion

The present review identifies a growing body of evidence supporting the efficacy of teledentistry, particularly, in some areas of dentistry. However, in many cases, the reviewed studies provide only preliminary results and considered only the feasibility and short-term use of teledentistry. Due to limited conclusive evidence and the heterogeneity of the methods used, interventions and outcomes assessed in the reviewed studies, the generalisability of the findings is limited. Well-designed research into the assessment of teledentistry, taking into account its effectiveness, cost-effectiveness and long-term use, will be required before future decisions on whether to establish teledentistry services can be made.

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