Teledentistry for improving access to, and quality of oral health care: An overview of systematic reviews and meta-analyses

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Abstract

Background: Digital interventions including teleledentistry are promising approaches to address some of the inadequacies of healthcare systems. Despite systematic reviews (SRs) on the benefits and implementation challenges of teledentistry, its impact on the quality of care remains unclear.

Objective: The purpose of this overview of SRs is to summarize evidence on the impact of teledentistry in promoting access to and enhancing the quality of oral health care.

Methods: We searched electronic databases in MEDLINE (Ovid), Embase (Embase.com), CINAHL (EBSCO), Web of Science, Cochrane Library, Epistemonikos and grey literature to identify SRs and meta-analysis of quantitative, qualitative, and mixed reviews, with the support of an expert librarian, from inception to March 2024. In addition, we checked the reference lists of included SRs. We included studies without data and language restrictions. Two independent reviewers performed data screening and data extraction and assessed the quality of included SRs using the AMSTAR 2 and ROBIS tools. We assessed the overlap of the included reviews. We reported on the certainty of evidence and on the heterogeneity from the included studies. Data are synthesized narratively and presented with tables and graphs.

Results: The search yielded 1020 articles, of which 30 SRs were included in the overview. The number of participants across these reviews ranged from 130 to 7913 people. All dimensions of the quality of care were addressed to varying extents, with the domains of effectiveness, efficiency, and patient-centered care being the most extensively studied. Conversely, patient safety and equity were the least explored domains. Several SRs exhibited a critically low to low methodological quality and a high risk of bias. The overlap (corrected covered area) of the primary studies in all the SRs was slight (2.3%), while it as moderate (5.7%) for SRs with meta-analysis (SR-MAs).

Conclusions: The findings of this overview suggest that teledentistry is an effective and efficient alternative to in-person oral health care, in line with the Quintuple Aim. However, concerns with the quality of the reviews warrant a call for more rigorous studies to obtain more robust evidence, notably on its potential to achieve equity.

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Abstract:

Background: Digital interventions including teleledentistry are promising approaches to address some of the inadequacies of healthcare systems. Despite systematic reviews (SRs) on the benefits and implementation challenges of teledentistry, its impact on the quality of care remains unclear. The purpose of this overview of SRs is to summarize evidence on the impact of teledentistry in promoting access to and enhancing the quality of oral health care.

Methods: We searched electronic databases in MEDLINE (Ovid), Embase (Embase.com), CINAHL (EBSCO), Web of Science, Cochrane Library, Epistemonikos and grey literature to identify SRs and meta-analysis of quantitative, qualitative, and mixed reviews, with the support of an expert librarian, from inception to March 2024. In addition, we checked the reference lists of included SRs. We included studies without data and language restrictions. Two independent reviewers performed data screening and data extraction and assessed the quality of included SRs using the AMSTAR 2 and ROBIS tools. We assessed the overlap of the included reviews. We reported on the certainty of evidence and on the heterogeneity from the included studies. Data are synthesized narratively and presented with tables and graphs.

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Conclusion: The findings of this overview suggest that teledentistry is an effective and efficient alternative to in-person oral health care, in line with the Quintuple Aim. However, concerns with the quality of the reviews warrant a call for more rigorous studies to obtain more robust evidence, notably on its potential to achieve equity.

Keywords: 3-10

Teledentistry, mobile health, digital health, overview, systematic review, dentistry, quality of care, access to care

Introduction

Oral diseases globally affect more than 3.5 billion people worldwide, highlighting the need for interventions to improve accessibility to and affordability of oral health care.[1] Information and communication technologies (ICTs) offer promising approaches to improve patients' access to and experiences of care, reduce the costs of care delivery, and promote high-value care[2-8] and the quality of health care.[9, 10] Teledentistry involves the interaction between oral health care providers (OHCPs) and their peers, with other health care providers, and with their patients and/or caregivers, to improve patients' outcomes.[11, 12] It facilitates patient–clinician interactions, screening and diagnosis of oral diseases, patients' monitoring, treatment planning, and management of oral health care.[13-16] Emerging evidence suggests that teledentistry has positive impacts for patients, OHCPs, health care providers, and decision-makers.[17-21] In addition, several studies have reported the implementation challenges of teledentistry[8, 17, 22-27] from the perspective of patients, healthcare organizations and OHCPs[12, 11, 28, 29]; these include, for instance, the lack of policy, guidelines, and training, as well as limited digital literacy. Three prior systematic reviews of systematic reviews (SRs) on the topic of teledentistry were limited in their scope, either focusing on certain aspects of teledentistry, or not having a strong and adequate quality assessment of included reviews.[30-32] Further evidence on health, access to care and health-related behaviours from patients' and OHCPs' perspectives could improve the quality of oral healthcare and would be beneficial to inform clinical practice and policy decision-making, as well as future research.[33] There is, therefore, a need to conduct a comprehensive overview of existing SRs on the topic of teledentistry using a rigorous methodology to compile and contrast the evidence, evaluate their quality and the risk of bias,[34] and assess the level of evidence supporting teledentistry, using valid measures.[35] The purpose of this overview is to address this gap and to summarize evidence from SRs examining the impacts of teledentistry on access to and the quality of care. Accurate information resulting from this overview will inform policy and clinical decision-makers on the effectiveness of teledentistry and could assist the development of guidelines to support

OHCPs with its implementation.

Research question

We will answer the following research question: “From the perspective of a range of stakeholders, to what extent is teledentistry effective in improving access to, and quality of oral health care, while reducing related costs?”

Methods

Study registration and protocol

This systematic overview protocol was pre-registered in the International Prospective Register of Systematic Reviews – University of York (PROSPERO: CRD42022373964), and published in the PLOS One Journal.[36]

Search strategy

The search strategy was developed by the research team with the collaboration of an expert librarian. The bibliographic search was carried out without any restrictions (language, age of participants, etc.). Five electronic databases—namely, MEDLINE (Ovid), Embase, CINAHL (EBSCO), Web of Science, The Cochrane Library and Epistemonikos (https://www.epistemonikos.org/)—were searched from inception until March 2024. In addition, we checked the references of the included reviews. Full details of the search strategy, including the list of search terms, can be found in Multimedia Appendix 1. The search strategy was performed following the “PICOSS” format: Participants, Intervention, Comparator, Outcome, Study design and Setting. Participants included patients, informal caregivers, and OHCPs. Interventions were synchronous or asynchronous modalities of teledentistry.[20] Comparators were usual care or no intervention. For outcomes, we considered information reported by authors. Any dental care settings, geographical regions, and countries were included. Regarding study design, we included all SRs with or without meta-analysis

(MA). We excluded duplicate publications, conference abstracts and literature reviews, SRs and SR-MAs) of animal or in vitro studies, and those lacking a formal methodological quality or risk of bias assessment, or that performed a search in a single database only.

Study selection

Two independent reviewers screened and selected the included studies using Covidence software (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia).[37] Disagreements at each stage of study selection were resolved through discussion or consultation with a third reviewer. The decisions and reasons for exclusion were recorded in Covidence software. See Multimedia Appendix 2 for the list of excluded studies with reasons for exclusion.

Deviation from the protocol

We did not have any language restrictions during the review process, as mentioned in the protocol.[36] In addition, we have not performed a new Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) for specific outcomes, due to limited available resources.

Data extraction

Two independent research team members independently extracted the data using a form in Excel (Microsoft Corporation, 2018), following the JBI data extraction form for review of systematic reviews.[38] Any discrepancies were resolved through discussion, or by consultation with a third reviewer. The extracted information included review characteristics, participants, intervention and comparators, outcomes and methods. Particularly for SR-MAs, we extracted details including sensitivity or subgroup analysis, certainty of evidence, and tests of heterogeneity. Other details collected included main conclusions, limitations, next steps, funding, and conflicts of interest.

Quality assessment of reviews

Empirical evidence is lacking on the optimal tool for assessing risk of bias or methodological in overviews of reviews [39], thus we have used two tools. Two independent reviewers performed the quality assessment of included SRs using: i) the AMSTAR-2 checklist (A Measurement Tool to Assess Systematic Reviews-2) to evaluate the methodological quality and the flaws in the conduct of the reviews;[40] and ii) the ROBIS (Risk Of Bias In Systematic reviews) tool to assess comprehensively the risk of bias.[41] Prior to the assessment, a reviewer calibration was conducted through a pilot assessment of 10% of included SRs using both tools. We assessed all 16 items of AMSTAR 2 for SR-MAs. However, for SRs without MA, we excluded items 11, 12 and 15, as these items are related to MAs.[40] Any discrepancies between the reviewers during the process were resolved by discussion or consultation with a third reviewer.

Data synthesis

We conducted a narrative synthesis of the findings. We compiled a list of the primary studies included in all the SRs with or without meta-analysis. We applied the following thresholds for the interpretation of the reported I^2 statistic that assesses heterogeneity[42, 43] in any reported meta-analysis: 0–40% might not be important; 30–60% may represent moderate heterogeneity; 50–90% may represent substantial heterogeneity; and 75–100% represents considerable heterogeneity. When there were no pooled results available, we reported the mean and standard deviation or the odds ratios/ risk ratios and associated CIs, or data regarding sensitivity and specificity whenever available.

We did not conduct any assessment of the certainty of evidence.[44] However, we reported the GRADE assessment, or any evaluation of the strength of the evidence as assessed by the authors of the SRs.

The covered area (CA) (percentage overlap) and the corrected covered area (CCA) were analyzed to

assess the overlap of the included primary studies in the SRs.[45, 46] We used the Graphical Representation of Overlap for OVErviews (GROOVE) tool[47] to explore and present the nature and the extent of the overlap of the primary studies included in multiple relevant SRs. The thresholds for its interpretation were: (0–5%—slight, 6–10%—moderate, 11–15%—high, > 15%—very high)[33, 45].

Results

The search results yielded a total of 1020 articles. After the removal of duplicates, 567 articles were eligible for title and abstract screening. After excluding non-relevant studies, a full-text review of 69 studies was conducted, of which 31 SRs met our inclusion criteria.[5, 6, 8, 17, 23, 26, 27, 48-71] One SR was excluded because the authors mentioned the risk of bias assessment in their methods but had no report of the results and we didn't receive any response after two emails to them.[71] A flow diagram of study screening and selection procedures is illustrated in the PRISMA flow diagram (Multimedia Appendix 3), with reasons for exclusion of 39 SRs (Multimedia Appendix 2).

Study characteristics

We included 30 SRs published between 2016 and 2024 in English[5, 6, 8, 17, 23, 26, 27, 48-62, 64-70] and French.[63] The number of studies within these SRs ranged from two to 39, and the number of participants ranged from 130 to 7913, which included patients such as children, adolescents, adults and elderly, and OHCPs (general dentists, dental specialists, dental students, dental hygienists). The countries where the SRs were conducted were Australia,[6, 17, 58] Brazil,[5, 23, 51, 57, 59, 65, 67] Canada,[48] Chile,[62] China,[68] Colombia,[26, 56] France,[63] Hong Kong,[52] Hungary,[53] India,[66] Italy,[8, 55] Malaysia,[50] Saudi Arabia,[70] South Korea,[60] the UK,[49, 54, 69] and the USA.[27, 61, 64] Twenty-two SRs (73 %)[5, 6, 17, 23, 26, 27, 48, 49, 51-53, 56-64, 66, 68] included primary studies conducted in both developing and developed countries, while two SRs[55, 65] did not mention the countries of origin. Most primary studies in the included SRs were set in Brazil (n = 7).[5, 23, 51, 57, 59, 65, 67] The most common study designs of primary studies were randomized

controlled trials,[5, 17, 27, 49, 51, 52, 54, 57, 60-63, 68, 70] cross-sectional studies,[8, 23, 27, 48, 50, 53, 56-59, 62, 63, 69] and non-randomized trials.[17, 48, 52, 56, 61, 62, 68, 70]

Eighteen SRs (60%) had registered their protocols in PROSPERO[8, 48-55, 57, 60-64, 67, 70] or the Center for Open Science.[59] Among the SRs, two did not report information about conflicts of interest.[26, 51] Seventeen SRs (57%) reported that they had received funding to conduct the review,[6, 8, 17, 23, 48-50, 52, 55, 57, 58, 62, 64-66, 68, 69] while seven did not report information on funding.[5, 27, 51, 59, 60, 63, 70] Among included SRs, five exclusively included RCTs,[5, 49, 51, 54, 60] whereas three SRs included studies on cost analysis,[8, 17, 48] and three assessed the impact of teledentistry during the COVID-19 pandemic.[50, 55, 59] Also, among the 30 SRs, 19 (63.3%) conducted qualitative synthesis[6, 8, 17, 23, 26, 27, 48, 54-60, 63, 64, 68-70] and 11 (37%) conducted both qualitative and quantitative synthesis.[5, 49-53, 61, 62, 65-67]

The main domains of dentistry in the included SRs were orthodontics,[5, 6, 24, 27, 49, 51, 54, 55, 60-65] oral medicine,[24, 27, 53, 57, 58, 66, 67, 70] and pediatric dentistry.[6, 24, 26, 27, 58] Oral health-related outcomes included assessments related to dental caries, periodontal diseases, head and neck cancer, orthodontic treatments, and health-related knowledge, awareness and attitudes. In addition, diagnostic accuracy, which included validity and reliability of teledentistry, was assessed in some SRs.[8, 27, 48, 53, 57, 58, 66, 67] Half of SRs included studies on both synchronous and asynchronous modalities of teledentistry.[6, 8, 17, 23, 26, 48, 53, 55-57, 59, 62, 63, 69, 70] The major applications were teleconsultation, telediagnosis, teletriage/telescreeening, and telemonitoring. The type of digital technologies mentioned in the SRs were smartphones, intra-oral cameras, DSLR cameras, tablets and computers.[5, 6, 17, 26, 27, 49, 51-59, 61-70] The most common modes of communication and data transmission were email, text messaging, and applications such as Zoom, Telegram, WhatsApp, WeChat, YouTube and Instagram.[5, 6, 17, 26, 27, 49, 51-56, 58-60, 62-64] The characteristics of the 30 SRs and SR-MAs included in this review are summarized in Multimedia Appendix 4.

Quality of systematic reviews

The AMSTAR-2 scores showed that the methodological quality of one SR (3.3%) was high, four SRs (13.3%) were moderate, 10 SRs (33.3%) were of low quality, and 15 SRs (50%) were of critically low quality. When we considered only the 11 SR-MAs, the quality was critically low in seven SR-MAs (63.63%), low in three SR-MAs (27.27%) and high in one SR-MA (9.09%). According to the ROBIS tool, the overall risk of bias was low in 13 SRs (43.3%), unclear in nine SRs (30%) and high in eight SRs (26.6%). Among SR-MAs, nine (81.8%) had low and two (18.18%) had unclear overall risk of bias. The AMSTAR-2 and ROBIS scores are presented in Multimedia Appendix 5 and 6 respectively. SRs with a published protocol demonstrated a better quality overall (Multimedia appendix 7). However, there is an increased number of studies with low ROBIS rating compared to the number of studies with a high AMSTAR 2 rating. (Multimedia Appendix 6).

Certainty of evidence

The certainty of evidence for the outcomes was assessed using GRADE in 10 included SRs. However, the diverse findings led to inconclusive certainty of evidence regarding the different outcomes. GRADE was found to be very low,[5, 61] low,[61] moderate,[51, 54, 62] and high[50] for gingival index. It was very low,[61,5,62] low,[62] moderate,[49, 54] and high (long-term)[49, 51] for plaque index. Regarding white spot lesions, GRADE was moderate[62] and high.[49, 51] One SR reported a very low GRADE for four outcomes (knowledge, feeding oral hygiene status, attitude and tooth cleaning) and a low GRADE for caries status.[52] GRADE was low to moderate for accuracy in detecting oral pre-malignant lesions, [53] and very low for the detection of malignant oral lesions.[67] For the outcome of measuring and monitoring maxillary expansion, it was reported to be very low.[65] Two SRs used the Oxford Centre for Evidence-based Medicine level of evidence (OCEBM) with the score mostly at level 4 and 3b,[48] and Level 3.[50] The strength of evidence for the diagnostic accuracy of teledentistry in one SR[58] that used the Jovell and Navarro-Rubio classification was Category VII, corresponding to a fair strength of evidence.

Heterogeneity

The issue of heterogeneity was highlighted in 11 SR-MAs.[5, 49-53, 61, 62, 65-67] Among these SR-MAs, two reviews[49, 51] conducted subgroup analysis at two time periods (short term: 3 months, and long term: 3–6 months) for plaque and gingival scores, and one review on white spot lesions.[51] In the short term, heterogeneity for plaque scores differed between the two SRs as they reported high (92%)[51] and low (24%)[49] values respectively. There was very low heterogeneity (I^2 = 0%) in both the short and long term for white spot lesions.[51] Another SR-MA reported high heterogeneity (I^2 > 95%) for both plaque scores and gingival bleeding, even with a subgroup analysis for age.[5]

The SR and SRs-MA reported high heterogeneity among primary studies for plaque scores (92%) and gingival scores (97%),[62] knowledge, awareness, and practices of teledentistry among OHCPs (> 90%),[50] the detection of oral lesions,[53, 67] and the diagnostic accuracy for the detection of dental caries.[66] There was no heterogeneity (0%) among studies for dental caries,[62] the diagnosis of oral pre-malignant lesions and oral cancer,[53] and white spot lesions.[62] One SR-MA on plaque, gingival and bleeding index did not provide I^2 statistics.[61]. Eleven SRs explicitly indicated they had not conducted a meta-analysis because of high heterogeneity.[6, 8, 17, 48, 54, 55, 57, 58, 60, 63, 64]

Overlap of studies

The CA of the primary studies included in all the SRs was moderate (5.56%). However, the CCA was 2.3%, suggesting a slight overlap. The CA of the primary studies that were pooled for the 11 SR-MAs was high (14.29%). However, the CCA was moderate (5.71%). There was a very high overlap of the primary studies among SR-MAs that assessed clinical outcomes. The CA and CCA of primary studies among five SR-MAs for plaque index[5, 49, 51, 61, 62] were 38.3% and 28.9% respectively, and for gingival index[5, 49, 51, 61, 62] they were 43.8% and 28.8%. Among three SR-MAs that assessed white spot lesions,[49, 51, 62] the CA and CCA were 83.3% and 75% respectively. The graphical representation of

the overlap (GROOVE) for the 30 SRs is provided in the Multimedia Appendix 8. The GROOVE for the SR-MAs is provided in the Multimedia Appendix 9. The GROOVE for each of the clinical outcomes (gingival index, plaque index and white spot lesions) is provided in the Multimedia Appendix 10, 11, 12.

Research findings

The SRs' findings including patients' outcomes and patients' and OHCPs' indicators are grouped under domains of quality of care in relation to teledentistry as follows: i) access to, timely and equity; ii) patient-centered care including barriers and enablers to implementing teledentistry; iii) patient safety; iv) efficiency; and v) effectiveness in improving oral health, including satisfaction, clinical effectiveness and accuracy of teledentistry.

1. *Access to care, timely and equity* toward teledentistry

Teledentistry can be a valuable tool for overcoming public health challenges related to poor access to oral health services, and oral health inequities,[6] as well as in the prevention of oral diseases, and in oral health promotion.[62] As a viable option, teledentistry has offered several advantages such as access to dental practices,[6, 23, 59, 58] including timely surgical treatment, especially during the COVID-19 pandemic. It is particularly important for the underserved communities that lack access to oral care due to geographical barriers, socioeconomic issues, or dental workforce shortages.[17] Such population include children, adolescents, elderly people, prisoners, people living in rural and remote areas with or without dental specialists, people with disabilities, and patients in school-based programs. [6,23, 26,48, 55] Teledentistry applications in the research included long-distance consultations, remote dental examinations and screening of digital images and radiographs, triage, early detection of diseases, telediagnosis, and enabling access to general and specialist dentists.[6] Voice calls and smartphone applications such as WhatsApp® and Messenger were the most common modes of communication (83.8%) between patients and dental staff. [55,55, 63] In addition, teledentistry enhanced the provision of quality of dental care,[6] serving as a major contributory factor toward equity.[23]

2. Patient-centered care with teledentistry

Among the included SRs, teledentistry is considered to be effective in the diagnosis, management

and treatment of oral diseases,[56] and in assisting patients who needed specialized diagnosis and consultations with dental specialists.[57] It had a positive impact on oral health behavior[55, 68] and oral health knowledge, with a higher acceptance of mHealth interventions among older adults.[68] Furthermore, drawing on behavioral change theories, mHealth interventions provided innovative and effective approaches to oral health behaviour management, such as improvement in parents' knowledge and attitudes about their children's oral health.[52] In addition, teledentistry enhanced the continuity of care[55] and was valuable in enhancing patient–clinician communication and improving patients' quality of life.[59,63] It facilitated interactions between general and specialist dentists, thereby increasing the quality of care.[23] Teledentistry also assisted clinicians in managing orthodontic emergencies and the end of orthodontic treatment,[55], in prioritizing patients with highly suspected malignant lesions, in patient follow-up, and in monitoring medication use.[59] In addition, teledentistry contributed to a positive experience in managing temporomandibular symptoms and communicating with healthcare professionals for periodical check-up or monitoring,[70] and for patients experiencing anxiety, fear or a sense of abandonment during therapy.[55] Daily text messaging was found to significantly reduce the intensity of self-reported pain among patients.[60]

Factors related to patients/caregivers and OHCPs, as well as to contextual and structural levels, influence patient-centered teledentistry.[6, 8, 23, 50, 56, 59] The factors related to patients were the familiarity and the ease of using digital technologies and attending technology-based consultations.[59] For OHCPs, several factors (fear of making an inaccurate diagnosis; concerns about increased costs; insufficient financial reimbursement, training and skills; and access to patient information) could influence teledentistry implementation positively or negatively.[56, 59, 48] Moreover, practitioners' education level and years of experiences may influence its implementation and its perception. Postgraduate OHCPs may have had more exposure to information and technology throughout their postgraduate studies.[50] Junior OHCPs with a postgraduate degree had better knowledge of dentistry

than senior practitioners, who may not have received sufficient training related to technology.[59] Clinicians and patients/caregivers' acceptance is incredibly crucial to adopting teledentistry. [6, 8, 59] . One SR[50] reported limited knowledge (57.9 %, CI: 46, 69.9) and poor practice (35.8 %, CI: 14.8, 56.8) among OHCPs during the COVID-19 pandemic. However, the OHCPs had a high level of awareness (70.4%, CI 64.3, 76.5) and positive attitude (72.5%, CI 60.7, 84.3) toward teledentistry. Tele-education, teleassistance and training through workshops, lectures, or seminars could help to improve the teledentistry – oral health outcomes.[50, 23]

At the structural and contextual levels, internet access,[50] the quality of available technologies and their lower costs,[6] the use of smartphones,[6] and support from information technology personnel[8, 50] were considered extremely beneficial to teledentistry's adoption. Among such applications, WhatsApp was the most used tool (83.8%) between the patients and the dental staff during the COVID-19 pandemic.[63] Moreover, significant governmental support with strategic action, the availability of technological resources, and the implementation of a regulatory system for remuneration[23,6] were crucial for the sustainability of teledentistry. On the other hand, the variability of infrastructure between countries, conflicting legislation, inadequate financial remuneration, disparities among rural regions, and the lack of guidelines were cited as factors hindering teledentistry applications.[50,59]

3. Efficiency of teledentistry

Eleven SRs reported on some aspects of the efficiency of teledentistry.[6, 8, 17, 23, 26, 48, 49, 60, 63-65] Teledentistry is cost-effective due to a reduction in waiting lists and unnecessary travel; fewer delays; and more consultations[8,60] for people with special needs,[8] with rural populations,[26] and in school dental screening programs.[48] Other SRs noted that the costs associated with teledentistry's implementation were compensated by savings in travel time and expenses for both clinicians and patients.[6, 8] For instance, teledentistry saves an average of 50 minutes of travel time per visit,[63]

reducing delay in treatment onset and preventing or reducing the loss of productivity among working patients.[17]

Teledentistry reduced the mean waiting interval for patients (3.33 days versus 28 days) and the cancellation rate on the day of surgery (7.8% versus 8.85%), as compared to conventional oral health delivery,[48] allowing time and financial resources to be redirected to patients with higher oral health risk.[23] Teledentistry led to a reduction of waiting time with teleconsultation and telediagnosis for both general and specialized dental care,[17,6] as well as fewer in-office visits.[64] One SR reported a significant reduction in the number of in-person appointments (mean difference = −2.75 [−3.95, -1.55]) and a shorter time to start orthodontic treatment (mean difference = −1.21 [−2.35, -0.08]) with teledental monitoring compared to face-to-face monitoring.[65] Asynchronous teledentistry has shown lower costs than in-person or real-time consultations[17, 48] due to a reduction in the costs of travel for OHCPs,[48] and lower training costs.[8] However, asynchronous approaches could require more time compared to synchronous approaches (20 minutes for store-and-forward vs. 15 minutes for real-time examinations).[8] Some conflicting results were reported on the impacts of teleorthodontics. Despite reducing the number of visits, teleorthodontics was found neither to shorten the duration of treatment,[63,64] nor to reduce the number of emergency appointments.[64] However, other authors reported that teledentistry helped in decreasing the duration of treatment,[60] resulting in a shorter average overall orthodontic treatment duration (MD = 7.3 weeks (95%), CI: 3.7, 11.6).[49]

Additional costs for health organizations and society are reported with teledentistry compared to outreach visits by dental specialists in remote communities,[48] while these societal costs per consultation reduced annual patient costs (transportation, accommodation, and lost productivity) by 69%.[48]

4. Patients' safety related to teledentistry

Three SRs reported the potential of teledentistry on patients' safety.[8, 54, 58] According to Da Silva et

al.,[59] teledentistry could be effective in reducing oral cancer patient's hospital visits and reducing the risk of cross-infection, as evidenced during the COVID-19 pandemic. Saccomanno et al. [55] reported that teledentistry was a valuable aid for resolving orthodontic emergencies for patients with difficulties in attending an in-office visit during the COVID-19 pandemic, and was a means to alleviate anxiety, fear and a sense of abandonment during treatment. Aquilanti et al.[8] found no adverse events with teledentistry.

5. Effectiveness with teledentistry

5.1 Patients and OHCPs' satisfaction with teledentistry

We identified seven SRs that reported patient satisfaction with teledentistry[8, 23, 48, 55, 59, 62, 63] and one noting its impact on self-reported pain among patients receiving fixed orthodontic treatment.[60] Teledentistry was appreciated by both clinicians and patients,[55,63, 47] and most of them have expressed optimism and satisfaction with teledentistry and its integration into current dental practices.[23] Teledentistry can increase patients' and OHCPs' satisfaction and acceptance, particularly empowering the isolated dental workforce working in rural and remote regions.[48] As many as 63–78% of patients living in rural and remote areas were satisfied with e-oral health care interventions.[48] The high satisfaction rate regarding teledentistry mainly was attributed to fewer hospital visits, less travelling time, a better understanding of oral health care needs and self-management, cost savings on transportation, effective communication, and shorter waiting periods,[8, 48, 59, 62] resulting in better motivation and compliance[59] and enhanced oral health,[63] along with a decreased likelihood of missing appointments (RR 0.39; 95% CI: 0.22, 0.70)[49] and improvement in the patients' well-being and quality of life.[59] A high satisfaction rate was reported for elderly residents and their families[8] and patients with oral cancer, as 78% showed a preference for teledentistry and 80% preferred videophones over telephone examinations.[59] Authors suggested that virtual synchronous consultations might achieve behavioral changes, given that some patients found teledentistry easy to

use and were willing to recommend it to other people.[59]

5.2 Clinical outcomes with teledentistry

Nine SRs[5, 49, 51, 52, 54, 60-62, 68] assessed the effectiveness of teledentistry in improving oral health. Among these reviews, six reviews[5, 49, 51, 52, 61, 62] pooled the results of the studies and conducted meta-analyses. The most commonly assessed outcomes were plaque and gingival scores, white spot lesions, and dental caries among orthodontic patients.

The SRs provided valuable insights into patients' compliance and adherence with oral hygiene[49;51;54;62] and adherence to appointments[49] with teledentistry. Significant improvements were found in the plaque index scores and gingival index,[5, 49, 51, 52, 61, 62] along with a reduction in white spot lesions.[5, 49, 51, 52, 61, 62] Beyond oral hygiene, authors reported that reminders have positive effects with fewer bracket failure rates (11.8% versus 16.1 %).[49] However, there was no significant effect with bleeding on probing (SMD = -0.22 (95%); CI: -0.5, 0.05).[61] mHealth was found to improve oral health; and it had a positive impact on oral health behaviour and oral health knowledge, and higher acceptance of interventions among older adults.[68] It enhanced self-performed daily oral hygiene[5] and reduced the frequency of self-reported pain among orthodontic patients.[60] While it improved the parents' knowledge about childrens' oral health, mostly in parental tooth cleaning, it however did not improve the parental attitude, feeding behaviours, oral health behaviours, or their children's oral health.[52]

5.3 Accuracy of teledentistry

Eight SRs[8, 27, 48, 53, 57, 58, 66, 67] found teledentistry to be as reliable as in-person clinical examination, screening and diagnosis of oral diseases, the detection of root canals, caries assessment, referrals and teleconsultations, the management of oral infections, and school-based programs. Authors reported the potential of teledentistry for accurate diagnosis and treatment planning,[48,26] patient triage, and

medical and physical assessment,[48] particularly for populations living in rural regions[26] and older adults living in nursing homes.[8] Teledentistry could effectively substitute visual examination for diagnosing oral lesions, reducing referrals made to special care and resulting in a greater number of patients treated for malignant oral disorders.[53] Overall, teledentistry has the potential to improve the quality of care related to the diagnosis and management of oral lesions.[27]

The sensitivity and specificity of the teledentistry-based assessments showed significant agreement with clinical consultation[57] and with clinicopathological examination.[48] For instance, teledentistry has demonstrated its potential and reliability in the detection of oral lesions (sensitivity: 0.92, CI 0.59, 0.99; specificity: 0.93, CI 0.17, 1.00),[53] pre-malignant oral lesions (sensitivity and specificity values of 0.93 [0.91–0.95] and 0.98 [0.97–0.99], respectively),[67] caries lesions (sensitivity ranged from 43% to 100% and specificity from 52% to 100%),[58] and for differential diagnosis of oral lesions (sensitivity 0.92, CI 0.84, 0.97; specificity 0.99, CI 0.95, 1.00).[53] Photographic methods[58] with smartphones or intra-oral cameras[66] showed comparable results for caries assessment. Teledentistry tools (email, free chat applications, cloud-based storage applications, imaging, etc.) were reliable options for replacing face-to-face dental visits.[53] However, the validity of teledentistry could be influenced by the access to patient information, and the experience of dental professionals.[27]

Discussion

The purpose of this overview was to summarize evidence from SRs with or without meta-analysis that examined the effects of teledentistry, to gain a comprehensive insight for improved evidence-informed decision-making in relevant practices and policies. The findings of this overview of SRs highlight a comprehensive portrayal of teledentistry's impact in improving access to, and quality of oral healthcare. Synchronous methods such as videoconferencing were used in some

studies and were particularly liked by patients. However, store-and-forward seems to be the most popular approach. Among the asynchronous modalities, the most frequent intervention was delivering mHealth through text messages. In line with the Quintuple Aim, the findings of this overview suggest that teledentistry is valid and comparable to face-to-face consultations aligning with five key objectives of any oral health care system including patients' experience, OHCPs' experiences, population health, reducing costs of treatment, and fostering health equity.[72] All the domains of quality were covered to various degrees, with the domains of effectiveness, patient-centered care, efficiency, and access to being the most studied (71%). This result is consistent with those of a recent mapping review on digital health and quality of health care where authors have not considered the area of dentistry,[9] and an umbrella review on telemedicine[73] where authors highlighted the greater number of studies on its clinical effectiveness. According to these authors, the equity domain was addressed by only a few studies. Recent SRs on the quality of oral care highlighted a limited number of studies addressing various dimensions of quality such as patient safety, equity and efficiency in dentistry, resulting in a lack of quality improvement in dentistry.[74, 75] Our results highlighted the promising cost-effectiveness of teledentistry, mostly for asynchronous modalities. Teledentistry saves the number of in-office visits and unnecessary travel, resulting in environmental benefits and a more sustainable delivery of oral health care, [76, 77] due to reduced energy consumption, greenhouse gas emissions and waste production.[78]

Patients and OHCPs reported a positive experience with teledentistry including satisfaction, better communication, and reduction of isolation.[8, 48, 59] Teleconsultation, triage, telediagnosis and telemonitoring were the most common activities within the current field of teledentistry. Therefore, teledentistry shows clear benefits for preventive oral health care, treatment planning, improved access to care, screening and diagnostic performance, and reduced inappropriate referrals. Teledentistry can increase the achievement of equity because it could be used with different

population groups, living in various contexts and suffering a range of diseases, resulting in a better experience of care, a reduction of oral health inequalities, and ultimately improved quality of life.[6, 23, 48]

The included SR-MAs showed that teledentistry interventions had greater benefits in improving clinical outcomes (plaque scores, gingival scores, white spot lesions, dental caries). However, there was a very high overlap of primary studies that assessed some of these outcomes. Several SRs in our overview had a critically low (50 %) to low methodological quality (33.3%) and a high risk of bias (26.6%), which could influence the robustness of the results. In general, there were many studies with a low risk of bias in comparison to the number of studies with a high methodological quality. According to other studies in the literature on differences between the AMSTAR 2 and ROBIS ratings,[79-81] this discrepancy between ROBIS and AMSTAR2 highlights the nuance between these two tools, emphasizing their relevance in evaluating the conduct of reviews, the way authors report their data, and the importance of publishing the protocol of systematic reviews (SRs).[82]

Assessing the degree of overlap in overviews of SRs is important, given that they can generate valuable and reliable information to guide policies and practices. [33,83] A low degree of overlap is usually something to be expected for a broad-scope overview of systematic reviews.[83] That is the case with our overview, where the CCA was 2.3%, meaning a slight overlap. However, there was a high overlap between SR-MAs reporting the same outcomes. Despite this difference, the GRADE level of evidence among SR-MAs varied for the same outcomes. This discordance could be due to the difference in inclusion criteria, the time range of measures (3 vs 6 vs 12 vs 18 months). This variability in the certainty of evidence and heterogeneity reported in several of the included SRs are concerns for the robustness of results on teledentistry.

Strengths and limitations of our overview

Although there are previous overviews of teledentistry in some specific conditions,[30-32] to our knowledge this is first comprehensive overview that compiles results on the effectiveness of teledentistry regarding access to and quality of care, including both methodological quality and assessments of the risk of bias. This overview has several strengths. First, it used a comprehensive search strategy in many databases, without any publication, date and language restrictions, to identify and summarize the evidence on teledentistry. We identified many gaps and priority areas for future research. Second, we used two robust tools to assess the quality of studies. Two reviewers were involved in the screening, the data extraction, and the quality assessments. In addition, the protocol was registered and published. Third, this overview is comprehensive, included multiple domains, and assessed multiple outcomes regarding teledentistry.

Despite the use of rigorous methods, some limitations still exist. First, we did not search for grey literature, potentially limiting the representativeness of our findings compared to all relevant work in the field. Second, we did not retrieve data from the primary studies included in our review notably for the certainty of evidence; however, re-analysis of primary data and conducting a new meta-analysis is not often required in an overview.[84] Third, some errors in assessment could be possible given the challenges in using both ROBIS and AMSTAR-2 from new users of these tools; however, a calibration exercise was performed. Despite these limitations, this comprehensive overview gives us an in-depth understanding of teledentistry.

Future research

This overview addressed some points reported by authors in the literature regarding the imperative need for a broad understanding of the quality and effectiveness of teledentistry. Authors of included SRs reported limitations related to the small number of studies, language restrictions, heterogeneity, low certainty of evidence, different follow-up periods, low-quality studies, non-transparent reporting

of interventions, and limited generalizability restricting the robustness of their findings, with suggestions to exercise caution when interpreting results. However, there are still some areas for future research. Some aspects of quality of care have been addressed through the included studies, such as effectiveness, access, patient-centered care, and efficiency; however, there remain a limited number of studies on safety and equity associated with teledentistry. Despite many SRs being conducted during the previous years, they are not diverse regarding different population groups and cultures, resulting in the need for robust and high-quality research to show how to maximize teledentistry to improve the quality of oral health care and of key stakeholders' outcomes and experiences.

Most of the studies on the effectiveness of teledentistry have involved people undergoing orthodontic treatments, including adolescents and young adults, highlighting the need for evidence on other age groups to inform teledentistry's impacts across the entire life span. In addition, studies in other specialties of dentistry are required for more comprehensive evidence. The quality of images captured through devices such as intra-oral cameras, DSLR cameras and smartphone cameras could impact the accuracy of diagnosis using teledentistry, resulting in the need to standardize the tools used in teledentistry to compare data. A limited number of interventions are based on behaviour change theories. Therefore, studies involving theories, models and frameworks in implementation science are necessary to improve the implementation efforts among OHCPs and patients as well as teledentistry's adoption, spread and sustainability. Also essential is the inclusion of the ecology domain in the quality of care framework to ensure the sustainability of teledentistry implementation.[85] Further studies on teledentistry with strong methodological quality are required to foster its implementation.

Conclusion

The findings of our overview have highlighted the growing body of SRs on teledentistry during the

last few years. They suggest that teledentistry is an effective and efficient alternative to in-person oral health care. Teledentistry is a patient-centered approach aiming to improve access to care while focusing on patients' needs. Considering the advances of digital technologies and their worldwide use, it is imperative that the dental regulatory bodies step up and develop teledentistry guidelines to improve its implementation in different settings, including rural, urban, private and public dental settings. However, the issues with the quality of the SRs call for more rigorous studies to obtain more robust evidence, notably on its potential to achieve equity.

List of abbreviations

SRs: Systematic Reviews

SR-MAs: Systematic Reviews – Meta-Analysis

OHCP: Oral Health Care Providers

ICT: Information and communication technologies

PRISMA: Preferred Reporting Items for Systematic Review and Meta-Analyses

QUADAS: Quality Assessment of Studies of Diagnostic Accuracy

AMSTAR-2: A MeaSurement Tool to Assess systematic Reviews-2

ROBIS: Risk Of Bias In Systematic reviews

GRADE: Grading of Recommendations, Assessment, Development and Evaluation

RCT: Randomized Controlled Trials

CA: Covered Area

CCA: Corrected Covered Area

CI: Confidence interval

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The data of this study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

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Authors' contributions

PKT has conceptualized, developed and written the first draft of the manuscript. PA, AB, AR, EE have critically and substantially edited and written the manuscript. FB and NG have contributed to editing and writing of the paper. All authors have read and approved the submitted final version.

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Supplementary information

Multimedia appendix 1: Search strategy

Multimedia appendix 2: List of excluded studies with reasons

Multimedia appendix 3: PRISMA flow diagram

Multimedia appendix 4: Characteristics of included studies

Multimedia appendix 5: AMSTAR-2

Multimedia appendix 6: ROBIS

Multimedia appendix 7: AMSTAR2, ROBIS and protocol publication

Multimedia appendix 8: GROOVE systematic reviews

Multimedia appendix 9: GROOVE SR_MA

Multimedia appendix 10: GROOVE gingival index

Multimedia appendix 11: GROOVE plaque index

Multimedia appendix 12: GROOVE white spot lesions

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Supplementary Files

Multimedia Appendixes

Search strategy.
URL: http://asset.jmir.pub/assets/874dac34225e21cc5035f55c0e72c553.docx

Table of excluded studies.
URL: http://asset.jmir.pub/assets/33dc8bcb07a996f9fbe94ce23a87abe1.docx

PRISMA flow diagram.
URL: http://asset.jmir.pub/assets/ed3d2f94af7ce881d3d2d4b8d25758ef.docx

Characteristics of included studies.
URL: http://asset.jmir.pub/assets/a19025a2a8beb5c43f5a82f3887a71ad.docx

AMSTAR 2 rating.
URL: http://asset.jmir.pub/assets/eaef78d810420aaff61de15debd48097.docx

ROBIS rating.
URL: http://asset.jmir.pub/assets/0cca12cebe5bb1e92333f88fea553eb5.docx

Comparison of AMSTAR2, ROBIS and protocol publication.
URL: http://asset.jmir.pub/assets/00db99a2c3e611514ac73c61463b5d56.docx

GROOVE for SR.
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