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The Use of Teledentistry in Facilitating Oral Health for Older Adults: A Scoping Review

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Abstract

Background: Teledentistry is used in many countries to provide oral health services. However, using teledentistry to provide oral health services for older adults is not well documented. This knowledge gap needs to be addressed, especially when accessing a dental clinic is not possible and teledentistry might be the only way for many older adults to receive oral health services.

Types of Studies Reviewed: Nine databases were searched, and 5,713 studies were screened using established eligibility criteria. Included studies were original research or review articles where the intervention of interest was delivered to an older adult population (age 60 and older) via teledentistry. Authors followed the “Preferred Reporting Items for Systematic reviews and Meta-Analyses” (PRISMA) extension for scoping review criteria.

Results: Nineteen studies were identified that met the criteria for inclusion. Only one study was from the US. Seven studies had results focusing only on older adult participants, with most of those conducted in elder care facilities. The remainder consisted of studies with mixed-age populations reporting distinct results and/or information for older adults. The included studies used teledentistry, in both synchronous and asynchronous modes, to provide services such as diagnosis, oral hygiene promotion, assessment and referral of oral emergencies, and post-intervention follow-ups.

Practical implications: The current use of teledentistry comprises a variety of promising applications. This review identifies and describes current uses, promising possibilities, and limitations of teledentistry to improve the oral health of older adults.

Keywords

Teledentistry; older adults; oral health status; telemedicine; telehealth

INTRODUCTION

The older adult population is growing rapidly globally. In the United States (US), the number of adults age 65 and older is expected to increase nearly two-fold over the next four decades from 52 million in 2018 to 95 million by 2060.¹ Older adults develop chronic medical and dental conditions as they age and many older Americans have multiple chronic conditions including hypertension, arthritis, dyslipidemias, heart disease, diabetes, and mental health problems like Alzheimer’s disease and other forms of cognitive decline.²

Substantial improvements in preventive and restorative oral health care over the last five decades have helped older adults retain more of their natural dentition. In addition, the proportion and number of older adults has grown significantly. Consequently, the need for oral health services for older adults has grown, requiring comprehensive management of complex oral health conditions, including periodontal diseases, dental caries, root caries, xerostomia, oral mucosal lesions, and oral and pharyngeal cancers. These oral conditions

can also be affected or exacerbated by coexisting systemic diseases.³ Access to oral health services is an important concern for many older adults, especially for those who are institutionalized, living in long-term care facilities, or for those living in rural areas.⁴⁻⁶

Telehealth has been defined by the World Health Organization as “*The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies, for the exchange of valid information for diagnosis, treatment, and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, in all the interests of advancing the health of individuals and their communities.*”⁷ When telehealth is applied in dental settings, the term teledentistry is generally used. Teledentistry is often directed at providing oral health services to vulnerable populations and facilitating access to specialty care. For example, the Eastman teledentistry program in New York state has successfully demonstrated a sustainable, cost-effective approach to providing oral health services to underserved children.^{8,9} Potential benefits of teledentistry include enabling access to oral health services, decreasing cost of care, and reducing oral health disparities.^{10, 11, 12,13, 14}

The importance of telehealth (including teledentistry) has become more evident as a result of the dramatic impact of the COVID-19 pandemic on clinical care.¹⁵ Telehealth holds the promise of reaching many individuals, particularly those with compromised immune systems, underlying medical conditions, or concurrent family responsibilities such as child care, by avoiding unnecessary contact and enabling physical distancing. In recognition of this potential, the Federal Communication Commission (FCC) provided substantial funding for medical providers and health institutions to subsidize telehealth services during the COVID-19 pandemic.¹⁶ Oral health providers, by shifting from in-person visits to teledentistry, can eliminate the risk of infection transmission while providing important oral health services such as triaging orofacial problems, providing after-care follow-up, conducting screenings, and promoting oral health, especially to older adults and those home-bound or living in long-term care facilities—populations at high risk of severe complications when contracting COVID-19.

The topic of teledentistry and its application in older adults have not been studied widely. Therefore, we aim to systematically explore and describe the current literature on the various uses of teledentistry in older adults, including its reported effectiveness and limitations. This scoping review will provide opportunities to inform oral health clinicians and researchers regarding potential uses of teledentistry. A scoping review differs from a systematic review. A systematic review’s purpose is to focus on a specific question regarding existing practice by evaluating the literature systematically, resulting in a synthesis of the abstracted information to inform practice and policy.^{17, 18} A scoping review is an evaluation of the literature using a systematic methodology to determine the “scope” of published information on a topic and to identify and map the available evidence. Therefore, a scoping review serves as a precursor to a systematic review and can be helpful in identifying and analyzing knowledge gaps.^{17, 18}

METHODS

We conducted a scoping review on the topic of teledentistry and geriatric oral health to assess key concepts and knowledge gaps in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). A protocol was developed a-priori and we followed the preferred PRISMA-ScR reporting methodology to guide this scoping review.¹⁹

Review Questions

Two lines of inquiry guided this review:

1. What are the current uses and limitations of telehealth /teledentistry for the prevention, detection, diagnosis, and treatment of oral conditions, and for delivering oral health services to adults 60 years and older?
2. What are the differences (if any) between medical and dental settings in delivering oral health services through a teledentistry approach in terms of use, provider type, population served, and modalities used for service delivery (synchronous vs asynchronous)?

Operational Definitions

Telehealth: A broad variety of technologies and applications to deliver virtual health care and education services via information technologies using, but not limited to, the following modalities: live video (synchronous), store-and-forward (asynchronous), remote patient monitoring (RPM), and mobile health (mHealth). For detailed definitions, please refer to (Supplemental Table 4). The term telehealth is an umbrella term that can be further defined when applied to various healthcare disciplines or specialties, including dentistry.²⁰

Teledentistry: Providing oral health care services via telehealth technologies. According to one study, “Teledentistry can be defined as the remote provision of dental care, advice, or treatment through the medium of information technology, rather than through direct personal contact with any patient(s) involved.”²¹

Healthcare providers (in this review): A healthcare practitioner that delivers oral health care (e.g., intervention, education, consultation or any type of service) to improve oral health. They may include dentists, dental hygienists, physicians, physician assistants, nurse practitioners, nurses, or other health professionals meeting this definition.

Study Inclusion Criteria and Search Strategy

We included original research studies and review articles reporting on adults aged 60 and above with no sociodemographic restrictions using targeted oral health interventions and outcomes provided through any type of tele-modalities. Search strategies were developed and conducted in collaboration with a research librarian (AAL) following a comprehensive research methodology to retrieve citations and abstracts from large databases (Supplemental Tables 5-6). Searches were conducted in January 2020 and limited to articles published

in English between 1991–2020. EndNote X9 (Clarivate Analytics) was used to manage citations.

Screening

Covidence²², a web-based application, was used to manage and document the systematic review process. A pilot test on the eligibility criteria was conducted prior to study selection to measure agreement between the reviewers (MOB, DW). Good agreement was demonstrated for title and abstracts and full-text screening (82% and 91%, respectively). The reviewers identified publications independently using the specified and tested eligibility criteria. A third author (SB) reviewed and resolved disagreements. The same screening process was used for the full-text screening. The reference lists of the review articles remaining after the full-text screening stage were compiled independently by two authors (MOB, DW) to identify other articles of potential interest not already retrieved. The articles identified were screened independently (MOB, DW) using the previously defined eligibility criteria. Supplemental Tables 2-3 highlight the eligibility criteria used for screening.

Information Abstraction

Identification and extraction of defined data elements pertaining to oral health status and services was performed by one of the authors (MOB) and reviewed by three authors (DW, SB, BAD). Microsoft Excel was used for collation and storage of collected data. See Supplemental Table 1 for a list of data elements collected.

RESULTS

Search Results and Study Characteristics

5,713 articles were retrieved from the database searches, of which 3,396 were unique articles identified for screening. After title and abstract screening, 359 studies met the inclusion criteria; following full text screening, 19 studies remained and were reviewed for data extraction. Figure 1 shows the PRISMA-ScR inclusion and exclusion flow diagram for this review.

General characteristics of the 19 reviewed studies are described in Table 1. Only one study was from the US. Seven studies focused on a teledentistry approach targeting older adults only. The remaining 13 studies included mixed-age populations, but reported separate results for older adults. Table 2 describes intervention modalities, settings, types of provider, and population description for 19 reviewed studies; Table 3 includes the study limitations, limitations of teledentistry, description of interventions or services provided, and results (success or effectiveness).

Of the seven studies comprising only older adults, all took place at elder care facilities (ECF)²³⁻²⁹. One study attempted to evaluate the feasibility of teledentistry to provide access solutions, including teleconsultation and tediagnosis.²⁴ Another study aimed to provide dental education through a synchronous modality (live audio/video connection). Two studies explored the feasibility and cost of implementing teledentistry in ECFs.^{24, 25} Another study used mixed methods to examine the impact of Teledentistry, through an integrated oral

health program, on older adults' oral health-related quality of life measured by the geriatric oral health assessment index (GOHAI).²⁷ The program employed visiting oral health therapists (an oral health professional dual qualified in dental therapy and dental hygiene in Australia) for screening, education, and referral to a dentist for a remote real-time oral examination if needed.²⁷ A follow-up study measured the impact of teledentistry services on number of avoidable dental visits, staff and residents' feedback on program experience, compliance with oral health care plan implementation, and potential cost saving.²⁸ The last study evaluated the accuracy of the teledentistry service model in diagnosing oral pathologies, evaluating chewing ability, and assisting with the prosthetic rehabilitation for older adults living in ECFs.²⁶

Twelve studies involved mixed-age populations.³⁰⁻⁴¹ We included these studies after careful examination of the reported methods and results to ensure that information about teledentistry uses, interventions, and limitations specific to older adults' oral health were clearly described. One randomized clinical trial (RCT) investigated the effect of using a remote intra-oral camera (IOC) along with text messaging during and after dental hygiene visits to assess bleeding on probing.³⁵ Another RCT examined the feasibility of conducting a teleconsultation through the "WeChat" messaging application to monitor lesion recurrences in patients with head and neck tumors.³⁶ The extent of patient satisfaction, cost, and time associated with the intervention were reported.³⁶ Two non-RCTs tested the potential use and feasibility of teledentistry to provide triage and referral for suspected oral malignant lesions.^{38, 40} Another non-RCT examined perception and acceptance of oral teleconsultation among patients with cognitive and physical problems.³⁹

One cross-sectional study examined the screening of oral cancer lesions using a tablet-based mobile microscope;³² while another cross-sectional study applied opportunistic screening of oral health conditions by using a mobile technology, approved by the Food and Drug Administration (FDA), to capture diagnostic oral images.³¹ The remaining three cross-sectional studies used teledentistry to solve a variety of problems among a population of older adults. The first provided an insight into how urgent dental care triage services in the United Kingdom (UK) offered remote and after-hours consultations, and provided referrals if needed.³⁰ A US study examined the pattern of consultations that people of low economic status sought from pharmacists to manage severe tooth pain.³³ Lastly, a Japanese study attempted to use a telemedicine service provided by a physician to monitor and manage dental patients with challenging medical conditions during a dental visit.³⁷

Interventions and Findings

Table 3 shows a summary of various interventions and reported results of the 19 studies reviewed. The main findings are organized into nine domains as follows:

Oral Health Knowledge, Attitudes, Efficacy: The self-efficacy related to oral health, oral health knowledge, and attitudes of the older adults showed improvement after delivery of oral health promotion materials using an Interactive learning telecare application.²³ Additionally, improvements were observed among older adults living in an ECF, where participants' oral hygiene habits including brushing behavior such as brush grasp, increased

power, number of strokes, and brushing frequency improved after intervention delivery. Finally, measured oral health knowledge increased after the tele-demonstration of a color-coded cancer risk assessment tool kit.²³

Access to Oral Care: Accessibility issues were addressed through a variety of methods. An access problem experienced by older adults living at a residential ECF was solved by developing a teleconsultation treatment model. Nurses deployed at the facility delivered oral health prevention intervention under the supervision of a remote dentist. Intra-examiner agreement was high ($\kappa=0.83$) between Teledentistry and face-to-face models.²⁴ In a similar study, the cost of facilitating and implementing teleconsultation was similar to the face-to-face model. Also, cost reductions as a result of reducing avoidable dental visits was similar to the previous “nurse with the guidance of remote dentist” model.²⁵

Another teledentistry model targeted an underserved population in the UK through a dedicated teleconsultation phone number, with advice and referral provided in an average of 60 seconds. Most callers received advice and a small portion required urgent referral to an emergency service provider. However, older adults used the service to a lesser extent compared to the younger population. The study also reported decreased use of resources (avoiding unnecessary travel and reducing time for services) as result of telephone consultation service.³⁰ Another study described a prototype asynchronous video system that screened and triaged a majority of older adults within a participating community in Ireland. It successfully identified urgent cases needing treatment in a hospital setting (20%), and referred other patients to a remote consultant specialist.⁴⁰ In one study, older adults with complex medical conditions were monitored during their dental visits using a synchronous telemedicine approach to prevent adverse events. The majority of patients reported feeling safe and relaxed during the dental visit.³⁷

Oral Self-Care: After a brief demonstration of how to perform an oral self-examination, text messaging was deployed to patients with oral squamous cell carcinoma to maintain proper follow-up and to identify lesion recurrences. About 7% of the recruited patients reported having a recurrence that was subsequently confirmed by a dentist. The remainder of the conditions reported were either mucositis or ulcers.⁴¹ In another study,²³ patients reported increased healthy oral habits after implementation of a tele-video interactive system about oral hygiene and proper oral care measures.

Diagnosis of Oral Health Conditions: One study described screening of electronic images for multiple medical problems (including oral health conditions) by medical providers among participants of mixed ages. Many oral health conditions were identified, with oral pathologies being more prevalent among older adults compared to younger participants.³¹ In another study, oncologists utilized medical visits to perform opportunistic oral health tele-screening using a biopsy device synchronized with an online web-based portal. Specimens from participants were successfully diagnosed by two remote pathologists with high inter-examiner agreement (90%).³² A unique diagnostic method using Artificial Intelligence (AI) was used to predict the recurrence of squamous cell carcinoma of the tongue. High accuracy (92%) in predicting lesion recurrence was attained, using a group of predictive factors for lesion recurrence.³⁴ Lastly, a study relying on synchronous video

capture to diagnose oral lesions among dependent elders living in ECFs demonstrated high sensitivity (93.8%) and specificity (94.2%) compared to a face-to-face approach.²⁶

Oral Function Assessment: A variety of oral functions were assessed using asynchronous and synchronous modalities. For example, in one study synchronous tele-education was used to monitor and improve the technique used by care providers to feed residents in an ECF.²³ Other studies examined the possibility of assessing oral functions through teledentistry. One of these studies used asynchronous video recorded by a nurse and evaluated remotely by a dentist. This method enabled assessment of chewing ability with high sensitivity and specificity (85.0% and 82.8%, respectively).²⁶ In the same study, the prevalence of dental functional units was 70.7% and 94.6% of them were captured by using an integrated oral camera and digital video recorder.²⁶ A third study synchronously evaluated chewing efficiency in older adults through an integrated chewing-gum and optoelectronic evaluation using a smartphone application. This method showed high agreement with a more complex gold standard method for classifying dental status and chewing efficiency of older adult participants.²⁹

Oral Health-Related Quality of Life: A mixed-methods comparative study examined the impact of a Teledentistry model using oral health therapists to deliver oral health screening, education, and referral for older adults living in ECFs. Although the authors didn't find a significant difference between the intervention and control groups in terms of GOHAI scores, the integrated oral health program utilizing this model demonstrated potential to improve the oral health outcomes of ECFs' residents.²⁷

Emergency Management: A US-based research examined a new telehealth method for managing tooth pain among a mixed-age cohort; in this study, low income patients consulted with pharmacists regarding tooth pain management. About 90% of patients followed the pharmacists' advice. It was noted that older adults were among the least likely group to seek consultation using this model compared to younger age groups.³³

Periodontal Care: In one study, providers motivated adults of all ages by sharing their intra-oral images using text messages; this was an effective way to improve oral health behavior and reduce bleeding on marginal probing in an eight-month randomized trial. Authors reported no significant outcome differences between older adults patients receiving traditional care and those receiving text messaging.³⁵

Teledentistry Acceptance: Acceptance of teledentistry was reported in several studies and on-site provider acceptance was favorable. Older adults with no cognitive or physical problems generally accepted teledentistry approaches, such as phone calls and text messaging. Older adults with these conditions showed some refusal either before or during the interventions. In one study, when nurses used an intra-oral camera to capture oral images to be transferred to a remote dentist, about 28% of older adults did not fully cooperate and 7% refused the intervention.³⁹ In another study, the majority of older adults participants with no cognitive impairment (94%) were either moderately or strongly satisfied with the remote teleconsultation. A small portion of the participants (16%) reported slight dissatisfaction with the way dentists handled their oral health needs.²⁴

DISCUSSION

Technologies used for teledentistry range from simple text messaging or phone call follow-up to more sophisticated tele-video conferencing utilizing an intra-oral camera or live monitoring device to capture and transmit live images. These telehealth methods could allow programs with limited resources to deliver targeted interventions to older adults. The availability of AI tools may introduce additional opportunities for enhancing risk identification and diagnostic services, particularly in cases of specialty shortage, distance, and patient mobility problems; or as exemplified during the COVID-19 pandemic when social distancing is necessary and older adults are more cautious about going out in public. ECFs can collaborate with academic and research institutions to build tailored AI tools to help deliver precision oral health services.

Studies that examined older adults within ECFs focused on facilitating access to dental expertise for the purpose of diagnosis, consultation and oral health promotion. Teledentistry is an acceptable option to provide access to the proper diagnosis and management of oral health conditions. This is of unique value during times of restricted access to oral health services due to mobility limitations and/or comorbidities among older adults.

Conversely, studies that included a mixed-age population had a broader scope of interventions, including urgent tooth pain management, oral conditions triage and referral, oral health promotion, oral cancer lesion screening and monitoring, treatment follow-up, and other services. As previously mentioned, older adults can embrace technology targeted at modifying health behaviors, screening for lesions, or simply to comply with treatment plans, but using this technology could be problematic for those living with cognitive or physical problems. Tested technologies, which have been tailored specifically to older adults, could effectively remove or reduce such obstacles.

Teledentistry may be limited in applicability when there are technological challenges, such as slow internet speed or unreliable service. These challenges are likely exacerbated in many developing countries and rural areas, where the necessary infrastructure to adopt teledentistry doesn't exist. Communication infrastructure requires bandwidth and reliability to effectively adopt teledentistry modalities. Another issue reported with adopting teledentistry was the reliance on caregivers among some older adults to communicate and report on their oral health status. However, telehealth can enable HIPAA-covered family members, primary care physicians, language interpreters, or other medical advocates to connect with one another in a virtual visit.

The main limitation of this review is the quality of the studies included, as many were cross-sectional studies with no clear methodology stated, non-RCTs with small sample sizes, or clinical trials that were dependent on self-reports or subjective opinions of participants or their caregivers. An additional limitation was the inclusion of mixed-age study populations, even though we carefully examined studies to include only those with specific results pertaining to older adults. Finally, although the evidence is growing to support the efficacy of Teledentistry in general, there is insufficient evidence to date to support conclusions advocating for cost-effectiveness or demonstrating long-term effectiveness.⁴² Our review

confirms this for similar applications in older adults and suggests a potential limitation for policy decision-making.

CONCLUSION

Routine oral health services are necessary for older adults to maintain their oral health but accessing these services can be challenging in this population due to general health problems, mobility challenges, limited transportation, and present social distancing requirements. The current body of literature provides a promising, albeit incomplete, guide to the use of teledentistry for older adults. There is evidence that telehealth can be used for a variety of dental service types (e.g. medical and dental specialty consultations, oral health promotions, oral health screening and referrals). But some limitations identified, including the paucity of US-based studies, small sample sizes, and non-randomized designs, which require careful attention and consideration. Future larger, high-quality, and well-conducted studies are needed to optimize the use of teledentistry to improve the oral health of older adults. More US-based studies could help to better inform the delivery of teledentistry in the US, as the healthcare systems of different countries vary in terms of policies, workforce, financing, infrastructure, and attitudes of adults toward technology and novel interventions. These are all significant factors that may influence the adoption and implementation of Teledentistry in this country.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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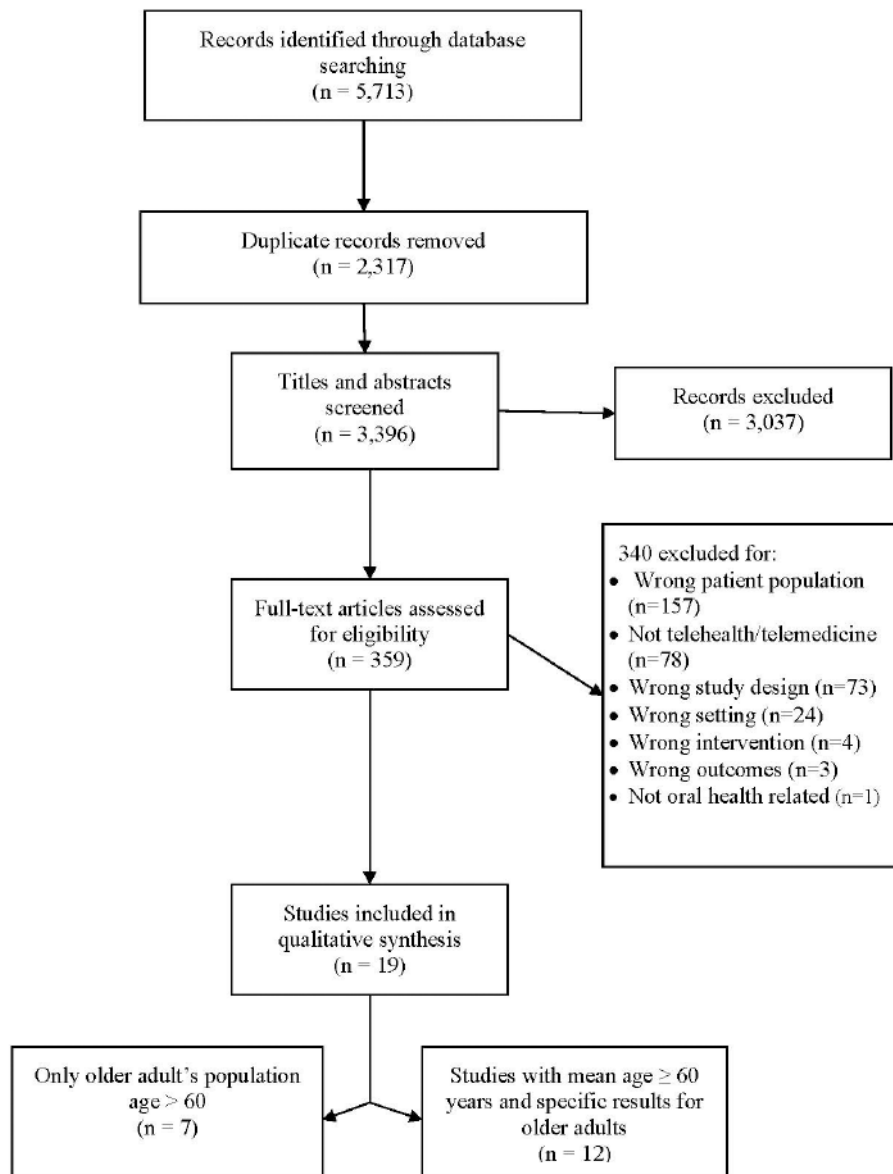


Figure 1:
PRISMA-SCr flow diagram

Table 1:

General Characteristics of 19 Reviewed Studies

Author	Country	Study Population	Study Design	Objective(s)	Oral Health Outcome(s)	Relative Secondary Outcome
Alabi, R. O ³⁴	Finland and Brazil	Older adults and other age groups	Observational with mixed retrospective and prospective designs	Use of Artificial Neural Networks along with a web-based-tool to estimate oral tongue squamous cell carcinoma recurrence	Oral cancer screening	N/A
Araujo, M. R ³⁵	Portugal	Older adults and other age groups	Randomized Clinical Trial	Explore the effect of using an integrated camera while performing oral hygiene procedure followed up by consultation through text messages on the clinical and behavioral measures of patients with periodontal problems	Dental hygiene and bleeding on marginal probing	Social cognitive determinants of behavior change
Buser, R ²⁹	Germany	Older adults only	Non-randomized clinical trial	Use of a purpose-built two-colored chewing gum in conjunction with smartphone application to assess chewing function	Chewing ability	N/A
Bradley, M ⁴⁰	Ireland	Older adults and other age groups	Non-randomized clinical trial	Assess the feasibility of using Teledentistry to process oral medicine referral to a consultant at main hospital (Belfast) using photographs	Triage and management of oral medicine referrals	Acceptability of Teledentistry to both patient and provider (feasibility)
Cohen, L. A ³³	USA	Older adults and other age groups	Cross-sectional	Examine the pharmacist's role in managing dental pain from the patient's perspective.	Tooth pain	N/A
Gomes, M. S ³⁸	Brazil	Older adults and other age groups	Non-randomized clinical trial	Screening for a potential malignant lesion among individuals with high risk	Malignant lesions	N/A
Lyu, K. X ³⁶	China	Older adults and other age groups	Randomized Clinical Trial	Investigate the practicability and advantage of WeChat mobile app in dental follow-up.	Head and neck tumor-related quality of life, and satisfaction with tele approach	Economic saving, satisfaction using both delivery models
Marino, R ²⁴	Australia	Older adults only	Non-randomized clinical trial	Evaluate a Teledentistry model for teleconsultation and diagnosis inside nursing homes	5-level Likert scale to assess acceptability, an economic evaluation based on general cost data	Screening for oral diseases and lesions, opinions of participants about the tele approach
Marino, R ²⁵	Australia	Older adults only	Non-randomized clinical trial	Compare costs /benefits of Teledentistry versus in-person approach following assessments by a dentist at rural nursing homes	Cost saving, effectiveness and feasibility of access through Teledentistry at rural nursing homes	N/A
Peteu, R ³⁹	France	Older adults and other age groups	Non-randomized clinical trial	Measure perception of oral teleconsultation among elder patients with cognitive and physical problems	Acceptance of oral teleconsultation service	N/A
Queyrroux, A ²⁶	France	Older adults only	Cross-sectional study	Assess the precision of Teledentistry for diagnosing dental pathology, assessing rehabilitation status of dental prostheses, and the chewing ability of older adults living in nursing homes	Oral conditions/lesions, chewing ability, dental prostheses rehabilitation	N/A

Author	Country	Study Population	Study Design	Objective(s)	Oral Health Outcome(s)	Relative Secondary Outcome
Shah, P ³¹	India	Older adults and other age groups	Cross-sectional	Assess technology-enabled non-invasive diagnostic screening (TES) utilizing smartphones and other medical devices in conjunction with routine health screenings	Dental conditions	Other medical conditions
Skandarajah, A ³²	India	Older adults and other age groups	Cross-sectional	Assess an automatic tablet-supported portable microscope as an assistant tool for oral cancer screening	Oral cancer screening	N/A
Tomuro, K ²³	Japan	Older adults only	Non-randomized clinical trial	Evaluate a telecare program for home-bound elderly in provision of education on oral and general health care.	Oral care knowledge and attitudes, self-care skills, communication abilities	N/A
Tynan, A ²⁷	Australia	Older adults only	Non-randomized clinical trial	Explore the impact and experience of an integrated oral health program using tele approach and oral health therapists	Oral health- related quality of life	N/A
Tynan, A ²⁸	Australia	Older adults only	Non-randomized clinical trial	Dismantle barriers related to delivering oral health at nursing homes	Experience of older adults with tele approach at nursing homes, reduction of unnecessary appointments, compliance with oral health care plan	N/A
Vaishampayan, S ⁴¹	India	Older adults and other age groups	Non-randomized clinical trial	Assess effectiveness of text messaging (SMS) for postoperative compliance in oral cancer patients, and the efficacy of self-examination for early identification of recurrent lesions	Patient self-examination of oral cancer/oral lesion recurrence	N/A
Worsley, D. J ³⁰	UK	Older adults and other age groups	Cross-sectional	Assess government facility services during both in- and out-of-hours urgent dental service, including telephone triage provider and a sole clinical provider	Telephone consultation delivery, suitability of referral, acceptability of service, cost and relevance	N/A
Yamazaki, S ³⁷	Japan	Older adults and other age groups	Non-randomized clinical trial	Evaluate systemic management of high-risk dental patients during dental procedures by the remote online hemodynamic monitoring system	Remote hemodynamic monitoring of medically high-risk patients in private dental offices	N/A

Note: N/A: not applicable

Table 2: Intervention Modalities, Settings, Types of Provider, and Population Description for 19 Reviewed Studies

Author	Source	Modality / Type of Application	Setting (hospital /university/health center/individual provider)	Type of Provider	Population Description
Alabi, R. O ³⁴	Teledentistry	Asynchronous	Hospital service to the public	Dental provider with the help of artificial intelligence	Older adults and young adults with tongue squamous cell carcinoma
Araujo, M. R ³⁵	Teledentistry	Synchronous	Private clinics	Dentist with the aid of dental hygienist	18 years and above who have more than 20 teeth
Buser, R ²⁹	Teledentistry	Asynchronous	Academic setting	Dental provider with the help of artificial intelligence	Older adults
Bradley, M ⁴⁰	Teledentistry	Asynchronous	Community dental clinic	Oral medicine specialist, oral surgeon and general dentists	Mixed ages including older adults, patients with oral mucosal presentation
Cohen, L. A ³³	Telehealth	Synchronous	Pharmacy	Pharmacist	Mixed ages including older adults, general participants have tooth pain
Gomes, M. S ³⁸	Teledentistry	Asynchronous	Academic institution	Dentist	Mixed ages including older adults, high risk smoker patients aged 60-79
Lyu, K. X ³⁶	Telemedicine	Synchronous	Hospital	Physicians	Mixed ages including older adults, patients with tumor treatments
Marino, R ²⁴	Teledentistry	Synchronous and Asynchronous	Nursing home	On-site nurse and remote dentist	Older adults living in nursing homes in rural areas Australia
Marino, R ²⁵	Teledentistry	Synchronous and Asynchronous	Nursing home	On-site nurse and remote dentist	Older adults living in nursing homes in rural areas Australia
Petcu, R ³⁹	Teledentistry	Asynchronous	Long term facilities, two facilities for older adults with severe intellectual - motor -psychotic illnesses	Dentist and nurse aid	Mixed ages including older adults, older adults with cognitive or physical impairment
Queyroux, A ²⁶	Teledentistry	Asynchronous	Nursing home	Dentist and nurse aid	Older adults, nursing home residents with oral health complaints (self-reported or reported by caregiver)
Shah, P ³¹	Telehealth	Asynchronous	Primary care clinic	Group of clinicians including dentist	Mixed ages including older adults
Skandarajah, A ³²	Telemedicine	Asynchronous	University research and primary care clinic	Pathologist	Mixed ages including older adults
Tomuro, K ²³	Teledentistry	Asynchronous	Nursing home	Dentist	Older adult males, 4 older male adults living in the dwelling center
Tynan, A ²⁷	Teledentistry	Synchronous along with integrated service at location	Nursing home	Dentist and oral health therapist	250 older adults living at rural nursing homes

Author	Source	Modality / Type of Application	Setting (hospital /university/health center/individual provider)	Type of Provider	Population Description
Tynan, A ²⁸	Teledentistry	Synchronous along with integrated service at location	Nursing home	Dentist and oral health therapist	250 older adults living at rural nursing homes
Vaishampayan, S ⁴¹	Teledentistry	Asynchronous	Community clinic	Oral oncologist	Mixed ages who had a previous treatment for oral cancer
Worsley, D. J ³⁰	Teledentistry	Synchronous	Governmental agency UK NHS	Nurse or dental nurse	Mixed ages including older adults, patients with unscheduled service (without dentist) need made urgent call to triage service
Yamazaki, S ³⁷	Telehealth	Synchronous	Dentist practice	Physician	Older adults visiting dental office with a need for medical monitoring

Table 3. Study Limitations, Teledentistry Limitations, Interventions/Services Provided, and Results for 19 Reviewed Studies

Author	Study limitations	Limitations of Teledentistry	Description of Interventions or Services Provided	Results (Success/Effectiveness)
Alabi, R. O ³⁴	The tool needed an extra validation from other datasets; based on limited dataset, some predictivity may be absent.	Artificial intelligence learning process required a larger number of cases to predict cases in an accurate way; and required a diverse database to build better results.	A supervised learning method (prognostic estimation) used to estimate recurrence of tongue carcinoma, then a web-based tool created based on neural network to produce prediction model for cancer recurrence.	Online asynchronous prediction tool was able to predict 90% of oral squamous cell carcinoma recurrence, the Azure web-based tool could be used to evaluate cases remotely.
Araujo, M. R ³⁵	Possible selection bias, participants recruited through advertisement	Text messaging may not be a favorable method for older adults even though the results showed no significant difference from younger participants.	Intra-oral camera and text messages used to influence the dental hygiene behavior (through dental hygiene consultation), boost frequency of dental hygiene, and decrease bleeding on marginal probing.	Improvement in the interproximal flossing and tooth brushing habit was attained in both intra-oral camera and text messaging groups, a 70% reduction in bleeding on probing. All gained results were sustained after 8 months. The study did not show significant difference between age groups over time.
Buser, R ²⁹	Not mentioned	Not mentioned	Patients chewed special gum for specific time, and then a Maximum Voluntary Bite Force (MVBFB) measured. Then, gums were evaluated using a smartphone software.	The use of the two-colored chewing gum would provide a fast, simple and inexpensive method for assessment of masticatory performance, which could be used in geriatric wards or in private practices without requiring specialized equipment or trained staff (web-based or smartphone app could aid in diagnosis and assessment process remotely).
Bradley, M ⁴⁰	Small sample size, one assessment with the consultant, asynchronous diagnosis based on photos provided, biopsy was not possible at the point of care	A small percentage of the patients' video clips were problematic. A more rigorous study using advanced method required with more details.	Consultant provided appropriate diagnosis based on the photographs provided by the remote location	Communicating cases with the consultant was feasible and provided access to the participants. Half of the participants were able to manage their conditions remotely with the help of local dental provider. Only 20 participants required urgent care at hospital.
Cohen, L. A ³³	Not mentioned	The type of provider was not dental provider (pharmacists), and presence of language barrier	Telephone consultation with a pharmacist regarding pain	Older adults aged 64 and older were least likely to speak to a pharmacist compared with middle-aged groups; similar results also noticed among the younger population aged 21-34 years.
Gomes, M. S ³⁸	Not mentioned	Knowledge among Brazilians regarding oral cancer was not yet widespread to use such approach; dentists' performance and knowledge of technical issues were not adequate.	Oral lesions screening and diagnosis	High sensitivity, specificity and accuracy obtained during lesions screening and diagnosis as compared with the gold-standard. The positive predictive values were between 71% and 100% and the negative predictive values between 93% and 100%.
Lyu, K. X ³⁶	Not mentioned	Due to inadequate technology usability, older adults may depend on care providers to implement; also, poor literacy regarding this approach	Follow-up consultation through a WeChat app or phone calls (for head and neck tumor patients) for 6 months	Quality of life head and neck tumor

Author	Study limitations	Limitations of Teledentistry	Description of Interventions or Services Provided	Results (Success/Effectiveness)
Marino, R ²⁴	Convenience sample of 50	There were obstacles to implementation largely due to human factors.	Screening patients at nursing homes for oral diseases and pathological conditions	Intra-examiner agreement for screened conditions were excellent (kappa=0.83), and majority of older adults were satisfied with the tele approach.
Marino, R ²⁵	Not mentioned	Older adults needed support to use technology. There was a need to increase internet knowledge, and perceived usefulness.	Access to dental care for older adults living in nursing homes	No difference in terms of cost was observed between the two approaches. Tele approach showed potential to solve access issue for the population living in nursing homes.
Petcu, R ³⁹	Nurses collected data (data validity depended on nurse's subjective judgment)	Observational data collection by nurses may lead to human error. Reliability of the data depended on the level of professionalism and engagement of the medical personnel involved in the study.	Teleconsultations of dental problems and measuring patients' acceptance of tele approach	92% completed the consultation process, older adults with psychotic problems perceived the service as negative experience while non-psychotic elders had an overall positive experience.
Queyroux, A ²⁶	Used same provider to do both assessments which should be blinded.	Not all patients were able to attend the dental clinic.	Patient received 2 examinations. Each patient served as his/her own, individual control. The first assessment consisted of the dentist establishing a diagnosis remotely by reviewing a video recorded in the nursing home. The second examination occurred face-to-face within a maximum of 7 days by the same dentist who made the initial diagnosis.	Sensitivity and specificity of using Teledentistry to diagnose dental pathology was very high.
Shah, P ³¹	Not mentioned	Not mentioned	Tele diagnosis of oral health conditions among other medical problems	A statistically higher prevalence of dental diseases was measured in 65–90-year-old and 40–64-year-old compared with 18–39-year-old.
Skandarajah, A ³²	Not mentioned	Brush biopsy technique is considered sensitive (sensitivity of 70%).	Screening and diagnosis of oral lesions, performing oral biopsy (using brush) and uploading biopsy images to the server where it can be reviewed by a pathologist later	High agreement reached by 2 pathologists screened the cell scope images derived from patients (both cytology and histology).
Tomuro, K ²³	Very small sample (4 participants only)	Older technological approach, where internet connection is limited, can be solved by fast internet connection	Distance tutorials given to older male adults and their families, color-coded oral risk assessment, tooth brushing demonstration, text-based education, eating instructions, psychological motivation, reducing the burden on the caregiver	Qualitative changes were observed in the seven evaluation topics, consisted of knowledge of oral care, self-care skill, attitudes toward oral care, communication ability, impact on the community, oral and general health, and diet.
Tynan, A ²⁷	Mixed methods	Many barriers were observed: not enough time for the staff to focus on management of the program; and some facilities not properly equipped.	Teledentistry along with integrative approach to improve access to oral health services, and ultimately improve oral health	The intervention helped the facilities meet accreditation standards for oral health, and improved access to oral health services for older adults living in ECFs. No significant difference between intervention and control groups in terms of GOHAI scores.
Tynan, A ²⁸	Not mentioned	Associated costs, management issues and need for attendance	Teledentistry along with integrative approach implemented by a visiting oral health therapist to initiate oral health screening and provide oral health promotion. If there was a need for a dentist visit, it conducted through Teledentistry model	Positive feedback received from both residents and staff. Intervention led to increased awareness among residents about their oral health needs.

Author	Study limitations	Limitations of Teledentistry	Description of Interventions or Services Provided	Results (Success/Effectiveness)
Vaishampayan, S ⁴¹	Not mentioned	SMS may not be the favorite method of communication among older adults.	After teaching the MSE method, the participants stimulated through SMS for consistent time to perform MSE	A number of participants reported recurrence of the disease but were normal after confirmatory examination. Education was the only factor associated with both clinical concordance and compliance.
Worsley, D. J ³⁰	Cross-sectional	Patient satisfaction issues	During and after-hours telephone triage service	Majority of calls received needed advice and triage only, the rest of calls referred to dentist for urgent treatment. Service utilized mostly by people living in deprived areas. Fewer people over 54 used the service; it was mostly used by people aged 20-44.
Yamazaki, S ³⁷	Not mentioned	Advanced technical support needed	Medical condition of older adults monitored through tele approach during dental visit to avoid any serious consequences	Common problems were hypertension, heart disease, and diabetes.