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Utilization of teledentistry during COVID-19 pandemic

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<p>Objectives The aim of the research is to provide information of utilizing teledentistry during global COVID-19 pandemic. The purpose of the research is to provide an overview how dental services can be offered to patients remotely during global COVID-19 pandemic.</p> <p>Methods The study was made with systematized review. Data search was performed in May 2021 to identify relevant studies focused on teledentistry services during COVID-19 pandemic published between January 2020 and May 2021. Search were done from databases called PubMed, Google Scholar, Science Direct, ResearchGate and CINAHL. The studies included were analyzed by using thematic analysis and the quality of the studies was evaluated using JBI quality appraisal tools.</p> <p>Results 16 references out of 150 were finally selected for this systematized review. Teledentistry has proven to be useful for consulting dental professionals, making diagnosis, monitoring the progress of the treatment, and prioritizing the need for the treatment. The main challenges of utilizing teledentistry are patient and dentist related challenges, ethical and legal issues, technology related challenges or misdiagnosis and medical errors.</p> <p>Conclusion Teledentistry has been used for years but it has not become an integral part of mainstream oral health care system. However, the use and scope of teledentistry have increased during COVID-19 pandemic because of lockdown and social distancing regulations. Current pandemic can be an opportunity to develop teledentistry on a larger scale and continuation of teledentistry after COVID-19 pandemic is possible with help of policy, technological availability, and education.</p>	
Keywords	Teledentistry, COVID-19, Coronavirus, Pandemic

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1 Introduction

According to World Health Organization (2021) coronavirus disease 2019 (COVID-19) is the respiratory illness caused by a coronavirus called SARS-CoV-2. The virus was first reported in 2019 and it has spread globally ever since. In 2020, governments all around the world declared lockdowns to prevent spreading of the virus.

As the virus spreads by droplet dental professionals are most likely to contract the infection and therefore during the lockdown most of the dental clinics were closed for routine dental procedures and clinics were providing emergency treatment only. (Ghai 2020). Because of social distancing regulations teledentistry became more frequently used during the lockdown. (Kalenderian et al 2020; Wallace et al 2021).

Teledentistry means providing dental care remotely with use of information technology and without face-to-face contact with the patient. Teledentistry allows dentists to meet patients virtually to analyze conditions of the patients, make treatment plans, offer dental education, prescribe medications, and arrange a follow-up meeting after operation. (Ghai 2020).

Teledentistry has the potential to improve access to dental care, improve the delivery of dental care, and lower its costs. With teledentistry, a wider range of patients are able to access dental care and therefore a better level of care is achieved through early intervention. Better access to dental care also eliminates the disparities in dental care between rural and urban communities (Bhochhibhoya et al 2020; Jampani et al 2011).

This Master's Thesis is focusing on applications of teledentistry during global COVID-19 pandemic and the challenges of utilizing teledentistry into practice.

2 Theoretical background

2.1 Teledentistry

Teledentistry means remote facilitating of dental care, guidance, or treatment with use of information technology and without face-to-face contact with the patient. Teledentistry allows dentists to meet virtually with patients to analyze their conditions, make treatment plans, offer dental education, prescribe medications, and arrange a follow-up meeting after operation. (Airan 2020; Ghai 2020).

Teledentistry can be implemented through live video call, secure electronic communication system, remote patient monitoring or mobile health. Online conversation allows the exchange of several types of data including written and spoken messages, video messages, high-quality images, clinical examination reports and radiological investigation reports. (Deshpande et al 2021).

Exchange of information can be done also between dental professionals which will improve patient care. Being able to communicate more effectively with colleagues will lead to greater understanding of treatment objectives and therefore improve better treatment outcomes. (Jampani et al 2011). Many general dentists send multimedia patient records to dental specialists enabling the specialist to make a diagnosis and develop a treatment plan without physically seeing the patient. It also enables the patient to have dental specialist consultation without the need to travel to the clinic. Follow-up visit can be also avoided if a proper follow-up can be made to the patient with the help of photographs. (Deshpande et al 2021; Jain et al 2013).

Teledentistry has the potential to improve access to dental care, improve the delivery of dental care, and lower its costs. With teledentistry, a wider range of patients are able to access dental care and therefore a better level of care is achieved through early intervention. Better access to dental care also eliminates the disparities in dental care between rural and urban communities (Bhochhibhoya et al 2020; Jampani et al 2011).

2.1.1 Origin of teledentistry

The concept of teledentistry was developed as a part of the blueprint for dental informatics and it was drafted in a conference in Baltimore in 1989 (Dharsan et al 2020; Rocca et al 1999; Verma et al 2019). In 1994 United States military launched a telemedicine program called Total Dental Access. The goals of the project were to improve access to quality dental care for patients and to create a cost-efficient telemedicine system. Total Dental Access project focused on three areas of dentistry which were patient care, continuing dental education and communication between dentist and dental technician. In the project teledentistry was implemented to offer pre- and post-operative dental visits remotely and thereby hours of travel by the patient was avoided which saves time and money. With the use of teledentistry the project broadcasted dental lectures to clinics where continuous dental education was difficult to achieve. One of the goals of the project was to improve the communication between the dentist and dental technician to be able to send color images of the patient's teeth and thereby prevent mistakes in dental laboratories which saves time and money. (Rocca et al 1999).

Total Dental Access project have had five studies in development of teledentistry which have ended up to the teledentistry method used today. The first study was image file transfer via modem which was conducted in 1994 in Georgia. In the study color images of a patient's mouth taken by intraoral camera was transmitted over a 9600 baud modem to the dental clinic at the distance. The second study was file image transfer via satellite, and it was implemented in 1995 in Haiti. In the study CLI video teleconferencing system was used over International Maritime Satellite (INMARSAT) to allow dental specialists at different locations to talk face-to-face and transfer still images. The third study was implemented in 1996 and it was about ISDN-based teledentistry system. In the study network was created by using desktop video teleconferencing equipment, ISDN lines at 128 Kbps data rates and intraoral and document cameras. The equipment allowed live video consulting and sending of still images. The fourth study was implemented for the dental clinics without internet access in 1997. POTS-based teledentistry system needed desktop computer, a 28.8 Kbps modem, software and hardware and intraoral and document cameras. The last study was about web-based teledentistry system and it was implemented in 1997. The web-based teledentistry system was built of a laptop, a camera, a web browser, and internet access. (Rocca et al 1999).

2.1.2 Current use of teledentistry

Teledentistry is used for consultation, diagnosis, triage, and monitoring (Ghai 2020). Remote consultations can be conducted between dentists or between dentists and patients. In specialist consultations clinical and radiographical photographs of the patients are being shared between dentists to provide an aid for diagnosis and treatment planning. With help of telecommunication patients can receive specialized dental care in remote parts of the world (Deshpande et al 2021). Diagnosis of an oral lesion can be made remotely by exchanging images and data of the patient. Triage is used in teledentistry for remote assessment of patients and prioritizing those requiring dental care. (Ghai 2020). Monitoring is used in teledentistry to make sure the progress of the dental treatment is going to the right direction. Follow-up visit can be also avoided with remote monitoring if the patient condition can be checked remotely. (Ghai 2020; Jain et al 2013).

2.1.3 Teledentistry in dental specialities

Teledentistry allows a new way to provide advice from dental specialist. Telecommunications and information technology have made it possible to provide interactive access to dental specialist opinions that are no longer constrained by distance, space, time, or any other barriers. (Modak et al 2020).

In case of oral and maxillofacial surgery the most common problem is pain in the third molar and by via teledentistry patient can send images to dental specialist for consultation. (Deshpande et al. 2021).

In endodontics teledentistry can be used to identify root canal orifices based on images of endodontically accessed teeth and according to study of Brullmann et al. (2011) remote recognition of root canals by experienced dentists can help younger colleagues in better detection of root canal orifices.

In orthodontics it is possible to share videos and images via teledentistry which is useful for small emergencies to be solved at home, reassuring patient and limiting visits to the dental office to cases of real need which will lead to a positive economic impact on orthodontic offices by decreasing chair time. In orthodontics teledentistry can be utilized

for virtual consultation, treatment progress reviewing, and artificial intelligence assisted treatment monitoring with photos or videos taken by the patients. (Park et al 2021).

In prosthodontics teledentistry can be used for remote diagnosis and treatment planning for patients who requires prosthetic or oral rehabilitation treatment. (Das et al 2021).

In periodontics teledentistry can be used for diagnosis of specific lesions and monitoring the patient for example after periodontal surgery. Consultation between general dentist and periodontist can be done via remote connection where information of a patient with a periodontal abscess are being shared and periodontist suggest the appropriate treatment plan. (Avula 2015).

In pediatric and preventive dentistry teledentistry can be used as an alternative method for screening school children for assessment of dental caries. Teledentistry can be used for remote consultation and treatment planning as well in pediatric and preventive dentistry. (Purohit et al 2017).

2.2 COVID-19 pandemic

Coronavirus disease 2019 (COVID-19) is the respiratory illness caused by a coronavirus called SARS-CoV-2. The virus was first reported in 2019 in Wuhan, People's Republic of China and subsequently spread globally and therefore World Health Organization declared the coronavirus disease as a pandemic in March 2020. (ECDC 2021; WHO 2021).

Most common symptoms of SARS-CoV-2 virus are fever, cough, tiredness and loss of taste or smell. When infected with the virus most people will suffer mild to moderate respiratory illness and recover without any special treatment. Some people infected with the virus will become seriously ill and require medical care. Symptoms that indicate a serious condition include difficulty breathing or shortness of breath, speech or mobility problems, and chest pain. Serious illness is more likely to affect those who are older or have medical conditions such as cardiovascular disease, diabetes, chronic respiratory disease, or cancer. (WHO 2021).

SARS-CoV-2 virus can spread via respiratory droplets including aerosols from an infected person who sneezes, coughs, speaks, sings, or breathes near other people. Droplets including aerosols can be inhaled or deposited in the nose, mouth or on the eyes. The SARS-CoV-2 virus, like all viruses, will constantly change through mutation. Many variants of the SARS-CoV-2 virus have been observed around the world with different sets of mutations. (ECDC 2021; WHO 2021).

To control the pandemic the first mass COVID-19 vaccination program started in early December 2020. According to ECDC (2021) results from observational studies have shown that the vaccines authorized in the EU are currently highly protective against severe COVID-19 illness, hospitalization, and death. It will depend on several factors how COVID-19 vaccines are impacting on the pandemic which includes the effectiveness of the vaccines, development of other variants and how many people get vaccinated. (WHO 2021).

2.2.1 COVID-19 in dental clinic

Commonly used instruments and operations in dentistry generate large amounts of droplets and aerosols which cause the risk for dental care personnel of inhaling of aerosols including SARS-CoV-2 virus. Dental care professionals are prone to occupational exposure due to the complex design of the turbine handpiece, saliva ejector and dental chair drainage pipe as well as the use of sharp instruments during practice. As a result, there may be more cross-infection between dentists, nurses and patients which challenge the prevention and control of the COVID-19 pandemic in dental clinics. (Kalenderian et al 2020; Li et al 2021).

Globally, governments declared lockdowns in 2020, restricting travel and social gatherings to prevent spreading of the virus. Since dental professionals were most likely to contract the infection, most of the dental clinics were closed for routine dental procedures. Patients were able to get emergency treatment only. (Despande 2021). In response to the COVID-19 pandemic, teledentistry has become more frequently used because of social distancing regulations. The risk of virus transmission can be reduced by reducing the number of appointments and the number of people in the dental clinics. (Kalenderian et al 2020; Wallace et al 2021)

3 Research aim, purpose and research questions

The aim of the research is to provide information of utilizing teledentistry during global COVID-19 pandemic. The purpose of the research is to provide an overview how dental services can be offered to patients remotely during global COVID-19 pandemic.

The research questions for the systematized review are:

1. How teledentistry can be utilized during global pandemic?
2. What are the challenges of teledentistry applications?

The PICO (Patient, Intervention, Comparison, Outcome) framework is commonly used to develop focused questions for systematic reviews. A modified version, PICo, was used for construction of research questions as shown in Table 1 below.

Table 1: The PICo framework in research questions 1 and 2

1. How teledentistry can be utilized during global pandemic?
Population: customers using services remotely
Intervention: teledentistry
Context: global pandemic
2. What are the challenges of utilizing teledentistry for dental care services?
Population: professionals providing services remotely
Intervention: teledentistry
Context: challenges

4 Research methods

4.1 Systematized review

The study was made with systematized review. Systematized review is a type of review that does not meet all the methodology requirements for a systematic review but still follows similar methodology. This study was made according to the requirements of systematic review but with only one reviewer while systematic review requires at least two reviewers.

The systematic review is an analysis of the available literature and a judgement of the effectiveness involving particular series of steps. (Aromataris et al 2020). In Figure 1 below the steps of systematic review process is represented by Jessica Kaufman from Cochrane Consumers & Communication review Group. Figure 1 is modified by the author and this review was made according to these steps.

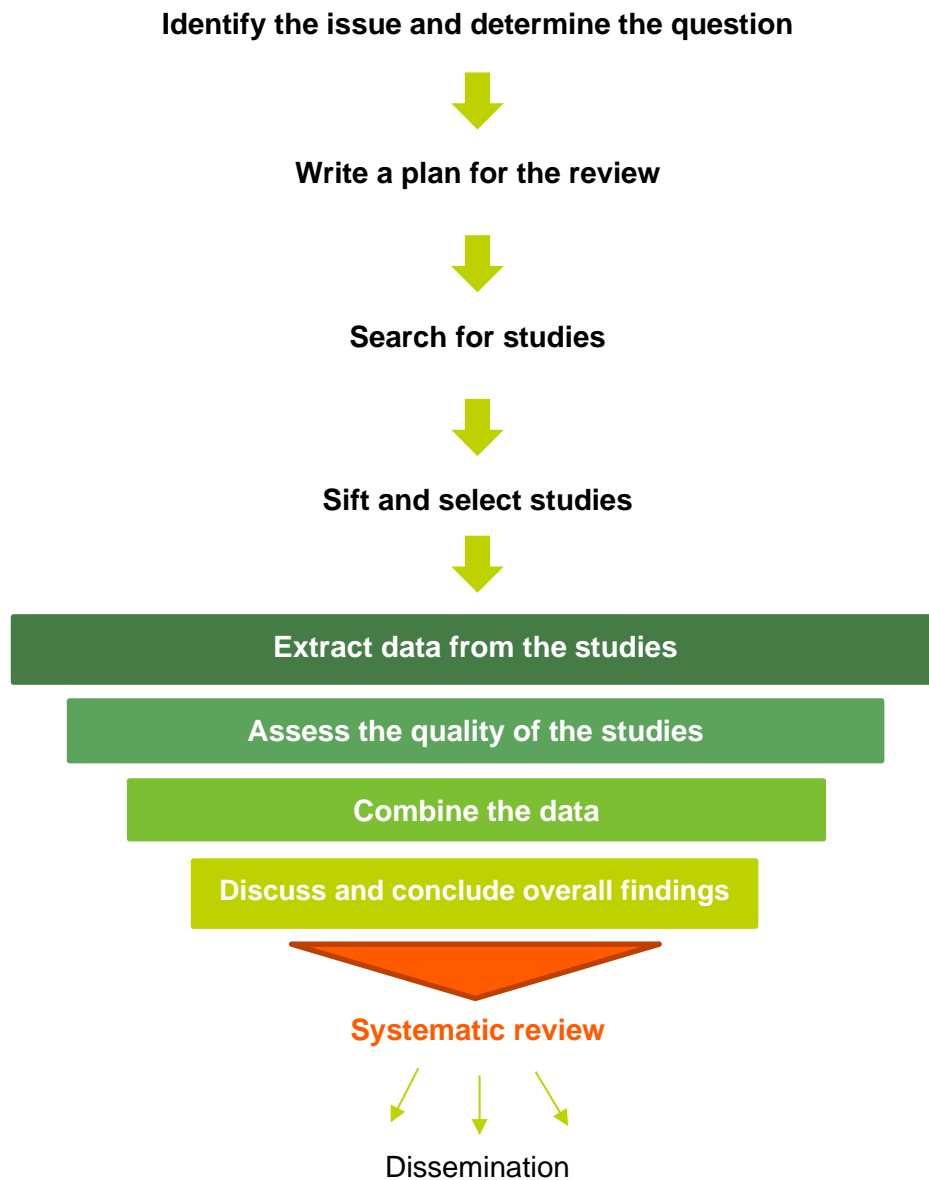


Figure 1: Systematic review process by Jessica Kaufman, Cochrane Consumers & Communication review Group (2011) modified by the author

4.2 Inclusion and exclusion criteria

Inclusion and exclusion criteria were defined before the data search was started. The publication language was limited to English or Finnish and therefore other languages were excluded. The included data type was wide but letters for editors and grey literature were excluded to ensure the quality of the data. The year of the publication was limited as the subject is related to time of COVID-19 pandemic which started in 2020. The inclusion and exclusion criteria are seen on Table 2 below.

Table 2: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Publication language: English, Finnish	Other languages
Data type: electronic databases, reference lists, hand searches	Data type: Letters for editors, grey literature
Papers published in 2020 or later	Papers published before 2020

4.3 Data search and review

The data search for the study was performed in May 2021 and databases chosen for the search were PubMed, Google Scholar, Science Direct, ResearchGate and CINAHL. The keywords used in search were teledentistry, telehealth, COVID-19, coronavirus and pandemic. The keywords were used in similar combinations in the several databases and the keywords were found in the title or abstract of the articles.

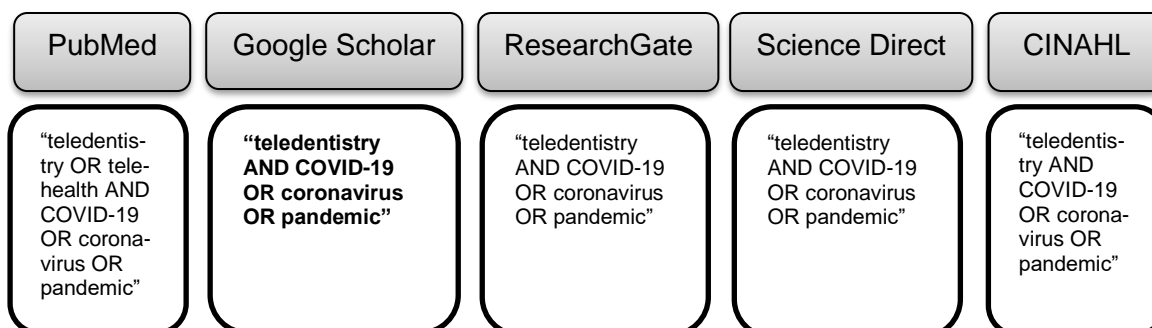


Figure 2: Data search from databases

The data search from chosen databases gave 237 potential references. References collected from the databases were saved to RefWorks software to be reviewed. In the first stage the articles were screened for duplicates and 87 articles were removed. In the second stage title and abstract were screened and 94 articles were removed. In the third stage the full texts were screened, and 30 articles were removed. In the last stage the last 26 articles were assessed for inclusion criteria and quality and 9 articles were removed. After the review process the final 16 references were included in the study in August 2021. The reasons for removing articles from the study were that they were duplicates, the content of the article did not match to the desired material or the article had a low quality. The review process is described in figure 4 below.

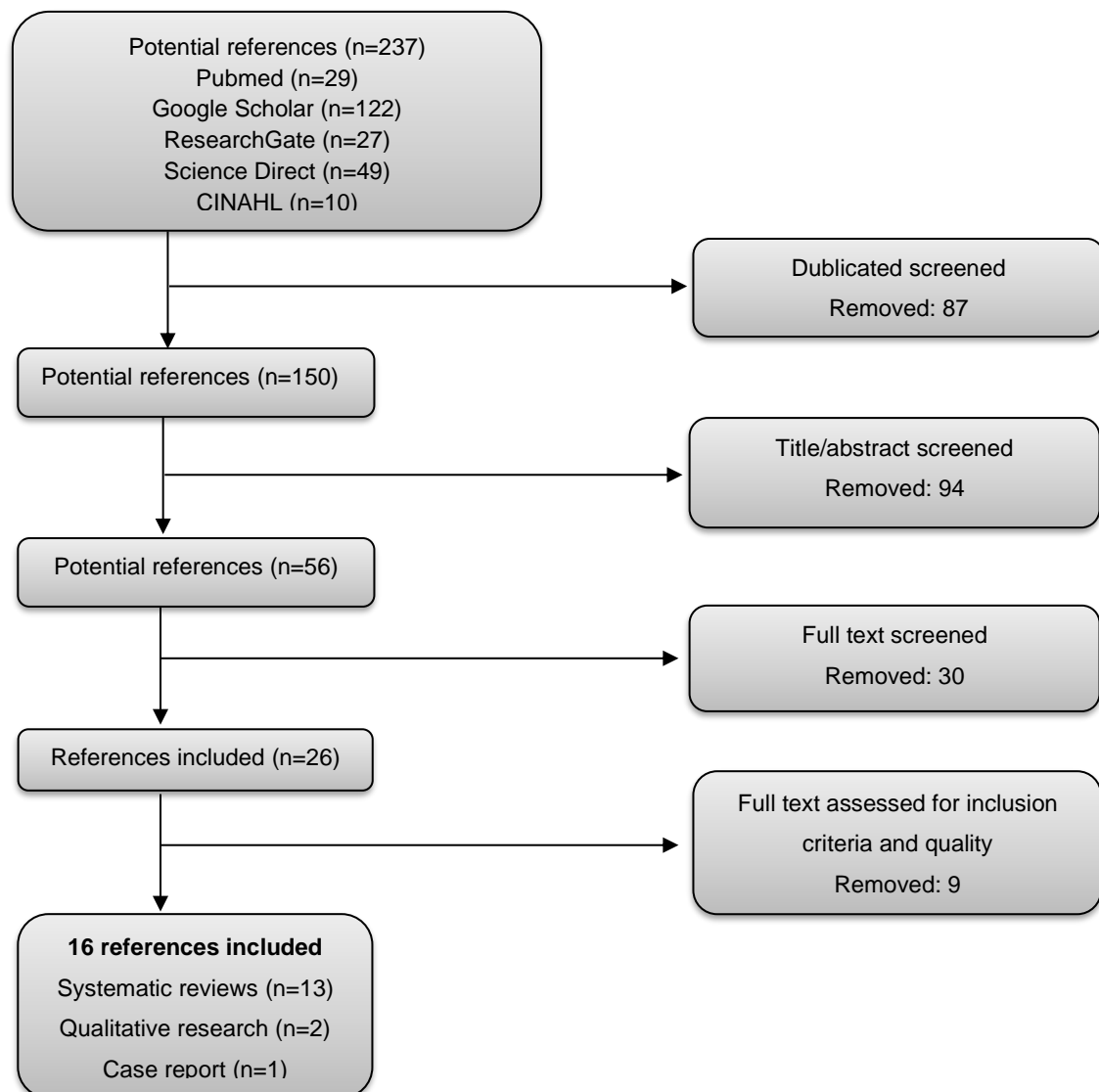


Figure 4: Data review process

4.4 Quality assessment

In all systematic reviews there is a process of critique or appraisal of the research evidence. The purpose of appraisal is to assess the methodological quality of a study and to determine whether and how a study has addressed the possibility of bias within its design, conduct and analysis. (Aromataris et al 2020).

The quality of the studies was evaluated using JBI quality appraisal tools. JBI means Joanna Briggs Institute which is an international research organisation based in the Faculty of Health and Medical Sciences at the University of Adelaide in Australia. JBI is a global leader delivering evidence-based information, software, education, and training that will improve healthcare practice and health outcomes. Currently JBI provides guidance for conducting reviews of effectiveness research, qualitative research, prevalence/incidence, etiology/risk, economic evaluations, text/opinion, diagnostic test accuracy, mixed-methods, umbrella reviews and scoping reviews. (Aromataris et al 2020).

There are multiple different assessment criteria tools for different study designs. Included studies were systematic review, survey analyses, pilot study and review articles and the quality of the studies was evaluated using JBI critical appraisal checklists. Systematic review and review articles were evaluated in Appendix 2 with JBI checklist for systematic reviews and research syntheses. Two survey analyses were evaluated in Appendix 3 with JBI checklist for qualitative research and pilot study was evaluated in Appendix 4 with JBI checklist for case report.

4.5 Data analysis

Data analysis started by reading all the included studies and finding answers to research questions. The important contents of the studies were underlined. The characteristics of included studies were collected in the table in Appendix 1. Data were organized, coded and categorized by themes and finally the results were written out based on the research questions and themes. The data analysis process is presented in Figure 3.

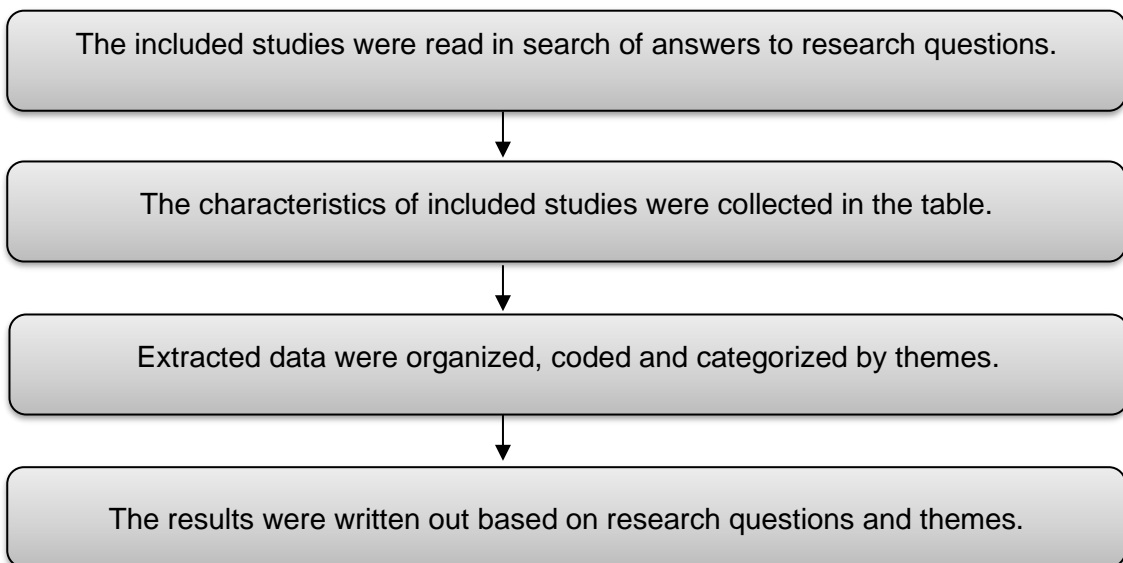


Figure 3: The data analysis process

5 Results

The results of the selected studies were analyzed using thematic analysis. Thematic analysis is a method which is used to identify the necessary information and trends from the collected data. (Braun et al. 2012). The themes recognized from this study were categorized to seven groups. Themes and subthemes of data analysis is presented in Table 3.

Table 3: Themes and subthemes of data analysis

Theme	Subtheme
Methods of teledentistry	Real-time monitoring Store-and-forward method Remote patient monitoring Mobile health
Applications of teledentistry	Teleconsultation Teliagnosis Teliriage TeliMonitoring
Patient related challenges	Acceptability of teledentistry New method to produce dental care services
Dentist related challenges	Acceptability of teledentistry Fear of making inaccurate diagnosis Concern of increased costs
Ethical and legal issues	Confidentiality of dental information Privacy of the patient Medicolegal and copyright issues
Technology related issues	Connectivity Internet connection Hardware materials
Misdiagnosis or medical error	Inaccurate diagnosis Technical errors during data transmission Agreement between remote and clinical diagnosis

5.1 Teledentistry during COVID-19 pandemic

Teledentistry has been used for years and it has proven to be useful for remote dental screening, consulting dental professionals, making diagnosis, and proposing treatment plan. (Ghai 2020). Although teledentistry is not a new invention, the use and scope of teledentistry have increased during COVID-19 pandemic (Singh et al 2020).

There is a significant risk for transmission of the coronavirus in routine dental procedures as it can spread through droplets, fomite and contact and the face-to-face interaction. Dental treatment involves close contact between dental professional and patient which means that dental professionals are the most likely to get infected with coronavirus. (Airan 2020; Bhoohibhoya et al 2020; Ghai 2020). Therefore, dental clinics are decreasing patient visits at the clinics and only emergency dental procedures are performed face-to-face. Routine check-ups, examinations and other non-urgent situations are postponed or treated remotely. (Airan 2020; Ghai 2020; Azam et al 2021).

During COVID-19 pandemic utilizing teledentistry is the solution to avoid person-to-person contact but still deliver dental care to the patients (Ghai 2020; Macapagal 2020).

5.2 Methods of teledentistry

Teledentistry provide health services remotely through telephones, video conference calls and tablets. Useful data of the patient can be collected and shared between dental professionals and the data can be used for delivery of dental care, diagnosis, treatment and consultations. Teledentistry can take place from anywhere and there are several methods that can be used like real-time monitoring, store-and-forward method, remote patient monitoring and mobile health. (Airan 2020).

5.2.1 Real-time monitoring

Real-time monitoring is a live two-way communication between dental professional and patient at different locations. It involves a videoconference in which dental professional and patient can see, hear and communicate with each other by using audiovisual telecommunication technology. (Dharsan 2020; Singh et al 2021; Thakkar et al 2020). Real-time monitoring is also called synchronous method of teledentistry as it requires live or two-way interaction.

5.2.2 Store-and-forward

Store-and-forward method involves exchanging clinical information of the patient between dental professionals without presence of the patient (Das et al. 2021). Store-and-forward method is also called asynchronous method of teledentistry as interaction is made possible through the transmission of recorded health information (Dusseja et al. 2020). In this method the needed data from the patient is collected and stored and the information is shared through a protected electronic telecommunication to specialist for consultation or treatment planning. The collected information can be digital radiographs, representations of periodontal or hard tissues, lab results, images or other patient information. (Das et al 2021; Deshpande et al 2021; Thakkar et al 2021). With store-and-

forward method the dental treatment can be done cost-effectively and in shorter time (Deshpande et al 2021).

5.2.3 Remote patient monitoring

Remote patient monitoring is used for monitoring patients at a distance and it can be placed in hospital or home. Usually remote monitoring is recommended to elderly care, chronic disease management and rehabilitation supervision but during COVID-19 pandemic it also has been a useful way to decrease unnecessary direct contact with the patients. (Das et al 2021; Dharsan 2020; Singh 2021).

5.2.4 Mobile health

Mobile health means that public healthcare, healthcare organizations and educational institutes are supporting the patient healthcare via communication devices such as mobile phones, computers and tablets (Dusseja et al 2020; Thakkar et al 2021).

5.3 Applications of teledentistry

Teledentistry is supporting the dental practice during COVID-19 pandemic and it is used to avoid unnecessary visits at hospitals and dental clinics. Teledentistry enables patients to safely consult dental professional of their dental problems and concerns or it can be utilized between dental professionals. There are several ways to utilize teledentistry and dental services may include teleconsultation, telediagnosis, teletriage and telemonitoring. (Airan 2020; Mishra et al 2020).

5.3.1 Teleconsultation

The most used method of teledentistry is teleconsultation in which a patient or health care professional seeks advice from a dental specialist over a telecommunication (Ghai 2020; Airan 2020). Dental professional team can collaborate with each other over a telecommunication to discuss different clinical scenarios of the situation of the patient to make sure the diagnosis and treatment plan for the patient is appropriate (Macapagal 2020; Bhargava et al 2021). With collaboration the best outcome of the treatment can

be achieved without the need for dental professionals to be at the same geographical area. Teleconsultation can be used for dental professional to explain common oral problems and ways to prevent or treat them to the audience of patients. (Bhargava et al 2021). Consultation between dental professional and dental patient enable giving feedback cost-effectively to the patient and ensure active participation of the patient to the treatment process ((Macapagal 2020).

5.3.2 Telediagnosis

Telediagnosis is used to make a diagnosis of an oral lesion based on pictures and information transferred to the dentist with the help of technology (Priyadarshi et al 2021; Ghai 2020). When using teledentistry in the diagnosis process, software capabilities allow dental professionals to know the condition of the dental patients. Software platforms used for telediagnosis are designed for transferring patient data like physical examination records, medical reports and previously taken extraoral or intraoral images to the dental professional to be able to make an appropriate diagnosis of the patient situation without physical presence of the patient. (Bhargava et al 2020; Macapagal 2020; Mishra et al 2020). For the diagnosis of oral lesions and dental caries also Whatsapp and smartphones are used. Usually oral lesions are so obvious that diagnosis can be made remotely using the dental photography. (Airan 2020; Ghai 2020; Priyadarshi et al 2021). Especially during COVID-19 pandemic telediagnosis should be encouraged to use to avoid direct contacts with patients (Priyadarshi et al 2021).

5.3.3 Teletriage

Teletriage involves screening of the patient symptoms via smartphone to prioritize the urgency of the desired treatment (Airan 2020; Mishra et al 2020). The aim of teletriage is to deliver the right treatment to the patient at the right time at the appropriate place. Dental professionals can discover whether the case of the dental patient is emergency or elective. During COVID-19 pandemic the emergency cases are prioritized, and the elective cases are postponed to prevent unnecessary direct contact with the patients. (Macapagal 2020; Priyadarshi 2021). The teletriage can be done over phone call where the patient medical history and symptoms are discovered and decided if the problem can be managed remotely or not (Priyadarshi et al 2021). Teletriage can be also made by web-based systems or apps (Mishra 2020).

5.3.4 Telemonitoring

Mostly dental patients visit the dental professional for monitoring the progress of the treatment. The physical visits can be replaced by telemonitoring where disease and treatment progress can be evaluated virtually. (Ghai 2020; Priyadarshi et al 2021). During COVID-19 pandemic telemonitoring is a vital tool to decrease amount of the physical visits and therefore possible chances of getting infection (Mishra 2020). Telemonitoring saves treatment time from the dental professionals and waiting time from the dental patients and therefore it also reduces costs (Ghai 2021; Mishra 2020).

5.4 Challenges of teledentistry

There are challenges that limit the use of teledentistry during pandemic outbreaks and according to Macapagal (2020) many treatment methods require patient to visit the dental clinic as almost all of the dental specialties contain treatment procedures that need to be done at the dental clinic. The other challenges are acceptability of teledentistry among patients and dentists, ethical issues related to confidentiality of patient health information, adequate technical infrastructure to enable the connectivity and possibility for misdiagnosis. (Dusseja et al 2020).

5.4.1 Patient related challenges

One of the challenges for utilizing teledentistry is acceptance of the patients. Teledentistry is a newer platform for patients and it will take some time to be more familiar method to produce dental care services. (Dusseja et al 2020; Mishra 2020).

Many surveys have pointed that acceptability of teledentistry is increasing among patients and dental professionals (Dusseja et al 2020; Ghai 2020). According to survey analysis of Singh et al (2020) 54% of the survey respondents were in the interest of using dental applications for online consultation and the amount increased to 67,2% when asked the interest of using dental applications during pandemic restrictions. Only 9% of the respondents had already used mobile dental applications but still 82,4% of the respondents agreed that teledentistry services should be available in all dental hospitals and clinics. (Singh et al 2020). Also according to survey analysis of Dusseja et al (2020)

70,7% of the respondents were unwilling to visit dental clinics during COVID-19 pandemic and 80,5% of the respondents were in favor of teledentistry to help with their dental problems.

Acceptability of teledentistry will increase when telemedicine in general will become more accepted and it is increasing already (Ghai 2020; Thakkar et al 2020). Also benefits of teledentistry should be explained to the patient more clearly and during COVID-19 pandemic dental professional should clarify the reasons why unnecessary visits at the dental clinic should be avoided (Mishra 2020).

5.4.2 Dentist related challenges

Dentists may find teledentistry complicated and may be resistant to learning new skills, which may explain their reluctance to accept teledentistry. Dentists may have a fear of making inaccurate diagnosis or a concern of increased costs when using teledentistry. Possible problems faced with poor internet access, hardware, training and technical support may also decrease the acceptance of teledentistry by dentists. (Ghai 2020; Mishra 2020).

The acceptance of teledentistry by the dentists can be increased by a proper education of the technology (Ghai 2020). Educating the dentists is assurance for a proper usage of teledentistry and mutually poor knowledge of the capabilities of teledentistry software may restrict the functionality available to dentist (Macapagal 2020). Teledentistry should be included as a part of undergraduate and postgraduate curriculum to ensure that dentists will be familiar with teledentistry in the future. Teledentistry should also be trained as a solution to prevent infection transmission. (Ghai 2020; Mishra 2020).

5.4.3 Ethical and legal issues

Dental records and medical histories are transferred in teledentistry which causes concerns about the confidentiality of dental information. Dental professionals should ensure that privacy of the patient is not compromised during teledentistry. (Das et al 2021; Deshpande et al 2021; Dharsan et al 2020; Singh et al 2020). Patient should be informed of the possible risk of interception of dental information during the electronic exchange of information despite maximum security measures (Deshpande et al 2021).

Medicolegal and copyright issues need to be taken into consideration in teledentistry practice as well as there are no well-defined standards to ensure quality and safety of information or its exchange. Licensure, jurisdiction, and malpractice are legal issues that have not yet been definitively decided by the legislative or judicial branches of various governments. (Deshpande et al 2021; Dharsan et al 2020; Singh et al 2020).

5.4.4 Technology related challenges

To be able to utilize teledentistry, technology related issues need to be functional which enables the connectivity between the dental care professional and the patient. Besides connectivity means including internet connection and mobile network-based connection hardware materials such as computers, cellphones and tables are needed to be used as a tool in teledentistry. (Macapagal 2020).

To be able to create smooth-running system for teledentistry services there is an initial investment for dental care provider (Singh 2020). For example, according to Thakkar et al (2021) store and forward method of teledentistry requires a computer with internet connection, large hard drive memory, fast processor and sufficient random-access memory and also intraoral camera is needed when photographing the needed area in the mouth.

From patient point of view no additional infrastructure needs to be created (Bhargava 2020). Telephones with audiovisual features and internet connection enables access to dental care services remotely without increasing the cost for patients. However, teledentistry services can only be accessed when people have the ability and opportunity to use the technologies. (Singh et al 2020; Thakkar et al 2021).

5.4.5 Misdiagnosis or medical error

The distant feature is a significant challenge of teledentistry as diagnostic procedures requires clinical presence and almost all the dental specialties requires treatment procedures that must take place at a dental clinic. (Macapagal 2020). Clinical diagnosis is also the most accurate way to diagnose a dental patient (Deshpande et al 2021).

There is a possibility for misdiagnosis or medical error when using teledentistry due to possible technical errors during data transmission. (Priyadarshi et al 2021). The patient

should be made aware of the possible risk of incorrect diagnosis and treatment due to the failure of the involved technology. (Deshpande et al 2021)

Steinmeier et al. (2020) made a pilot study of levels of agreement between remote diagnosis using intraoral scans and diagnosis based on clinical examinations. The study showed that the agreement between remote and clinical diagnosis for dental and periodontal assessments was low. According to the study the remote diagnosis was effective and time-efficient in screening oral soft and hard tissues based on true color intraoral scans, but periodontal conditions could not be evaluated with the same accuracy.

6 Discussion

Teledentistry is not a new innovation but it has received more visibility during COVID-19 pandemic than ever before. As dental professionals are in a high risk of getting infection of coronavirus, new ways of delivering dental care has had to be considered. Before the pandemic teledentistry were more used in the dental clinics which were following the newest technology innovations and new ways to deliver dental care to their patients. When coronavirus started to spread around the world and governments declared lockdowns to prevent spreading of the virus health care section in general had to respond to demand for the health care services but at the same time take social distancing regulations into account. Therefore, teledentistry became more frequently used during the lockdown.

Teledentistry applications were mentioned already in the theoretical part of this study and results of the research were supporting the findings. Few references were used in both research and theoretical part even though theory was written before the research was started. The same applications of teledentistry have been used before and during the pandemic. Teledentistry can be used for consulting dental professionals, making diagnosis, monitoring the progress of the treatment, and prioritizing the need for the treatment.

Teleconsultation have been the most used method of teledentistry and during the pandemic it has enabled patients to safely consult dental professional or dentist to consult other dental professional remotely. Telediagnosis has been encouraged to use during the pandemic to avoid direct contacts with patients even though the agreement between

remote and clinical diagnosis for dental and periodontal assessments has been noted to be low. During the pandemic telemonitoring have enabled to monitor the progress of the treatment as planned and teletriage have been mainly utilized for discovering if the case of the dental patient is urgent or elective and whether the treatment at the dental clinic is needed.

According to studies included in this research there are multiple factors which are acting as a barrier for utilizing teledentistry services in oral health care sector the same way as telemedicine has been utilized in health care sector. Acceptability of teledentistry among patients and dentists might be the biggest reason why teledentistry has been taken into use so slowly. If dental professionals would explain the advantages of teledentistry to their patients and offer more teledentistry services the patients might notice the benefits of teledentistry and other way around if patients would seek for dental care services remotely the dental care providers would have to answer to the demand. Of course, other major challenge is confidentiality of patient information during remote connection which is also affecting to the acceptability of teledentistry among patients and dentists. Dental professionals should ensure that privacy of the patient is not compromised when dental records and medical histories are transferred in teledentistry. Technology related challenges should not be a big problem at least in developed countries as patient needs only telephone with audiovisual features and internet connection which are widely in use already. Dental care provider needs to make an initial investment to be able to create smooth-running system for teledentistry services but after that there are no significant costs of teledentistry. It is important to build technical infrastructure that works as there is a possibility for misdiagnosis or medical error due to possible technical errors during data transmission in teledentistry.

All in all, teledentistry has a huge potential to be an inseparable part of dental care services in the future and pandemic has given a change to develop the services into the correct direction. The development will need a change in attitudes towards teledentistry which can be overcome with proper education and technological development. The future will show if teledentistry will be a tool to be used mostly during pandemic outbreaks or in everyday life in dental care.

6.1 Ethical questions

This study is a theoretical literature review so no ethical approval for empirical studies was needed. The author has no conflicts of interest and no funding sources were used for this study. The data search process, data sources and data review process are presented in a transparent way so the reader can easily follow the stages of the study. The studies included in the literature review are cited correctly and review do not contain plagiarized material.

6.2 Reliability and validity

The studies included in this review were published between January 2020 and May 2021 which is a narrow timeline for a research, but it was used because coronavirus was first reported at the end of 2019 and the data was collected in May 2021. After the data collection was done lot of new studies have been published about teledentistry during COVID-19 pandemic. New research would be needed after the pandemic to really see the effect on teledentistry services and which services will be used after the pandemic as well.

The reliability of the study was ensured by having a clear inclusion and exclusion criteria and research questions were clearly defined before the search. Inclusion criteria defined the publication language to be English or Finnish. Only studies in English were found. According to inclusion criteria approved data type were electronic databases, reference lists and hand searches. Other languages, letters for editors and grey literature were excluded from the search. The reliability of the study was debilitated by the fact that the systematized review was made with only one reviewer.

7 Conclusion

Teledentistry has been used for years but it has not become an integral part of mainstream oral health care system at least the same way as telemedicine has become part of health care system. Many treatment methods require visit at the dental clinic and that has limited the use of teledentistry during pandemic outbreaks and even before that. Other challenges of utilizing teledentistry into use are acceptability of teledentistry among patients and dentists, ethical issues related to confidentiality of patient health information, connectivity challenges and possibility for misdiagnosis. However, the use and scope of teledentistry have increased during COVID-19 pandemic because of lockdown and social distancing regulations. Teledentistry has proven to be useful for consulting dental professionals, making diagnosis, monitoring the progress of the treatment, and prioritizing the need for the treatment. Current pandemic can be an opportunity to develop teledentistry on a larger scale and continuation of teledentistry after COVID-19 pandemic is possible with help of policy, technological availability, and education. After COVID-19 pandemic teledentistry will be a tool which can be utilized during any future pandemic outbreaks.

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Appendix 1: Characteristics of included studies

Reference	Country	Aim and purpose	Design	Data and methods	Main results
Azam et al. 2021 Application of Modern Technologies on Fighting COVID-19: A Systematic and Bibliometric Analysis	Switzerland	The aim of the study was to perform the ways of utilizing modern technologies in healthcare during COVID-19 pandemic and to provide a review of the applications used in different healthcare department.	A systematic and Bibliometric Analysis	Study included journal articles published in English only and the relevant literature were collected from Scopus database. Only literature of technological innovation in healthcare system during COVID-19 pandemic was included in the study. In total, 83 articles were selected for the final analysis and these articles fulfilled all the basic criteria.	Researchers found 12 advanced technologies successfully used in the healthcare system and which can contribute to the proper control and management of COVID-19. With the correct application of advancement technologies, it will be possible to offer a number of innovative ideas and solutions that can help combat this virus.
Singh et al. 2020 Effect of COVID-19 Lockdown on Dental Care of Patient: A survey analysis COVID-19 pandemic	India	The aim of the study was to identify dental problems experienced during lockdowns, as well as solutions adopted, and assessed awareness of use of dental apps during lockdowns.	A survey analysis	Questionnaire build in Google form platform were send to 600 patients. In the questionnaire, multiple choice questions were asked about dental care during a lockdown period and awareness and willingness towards teledentistry. Responses were collected and analyzed and correlation established using chi-square test.	All together 516 responses were received of which 267 were from males and 249 from females. The most common dental problem was sensitivity followed by pain and the main relief factors were self-medication and home remedies. The age and gender of patients are no barrier to acceptance of teledentistry and teledentistry facilitates the continuation of dental care. With better awareness of existing mobile applications, the use could have been increased for oral hygiene maintenance.
Dharsan et al. 2020 Teledentistry: A review	India	The aim of the study was to review the literature of teledentistry and the ways of utilizing it during COVID-19 pandemic and in times of emergency.	A review article	Data was collected from different databases with keywords: information technology, teleconsultation, teledentistry, tediagnosis and telemedicine. As the study was review article there was no mention of the databases or whether systematic search methods were used.	Three different methods of utilizing teledentistry in consultation were found in the study. The methods are real-time consultation, store-and-forward method and remote monitoring method.

Bhargava et al. 2020 Teledentistry in Times of Pandemic – A Utility for Health Concerns and Needs	India	The aim of the study was to review the literature of how teledentistry have been utilized for health concerns and needs in times of pandemic.	A review article	Data was collected from different databases with keywords: teledentistry, COVID-19, telecommunication, oral health education and nutrition. As the study was review article there was no mention of the databases or whether systematic search methods were used.	The applications of teledentistry are teleconsultation, telediagnosis, teletraining and teleeducation. Teledentistry can be utilized easily when people have network and tools which teledentistry requires. Teledentistry has been underutilized but COVID-19 pandemic have made it necessary for education, training and preventing oral diseases while social distancing is needed.
Steinmeier et al. 2020 Accuracy of remote diagnoses using intraoral scans captured in approximate true color: a pilot and validation study in teledentistry	Switzerland	The aim of the study was to evaluate the accuracy of remote diagnosis of the mouth based on intraoral scans compared to a proper clinical dental examination.	Case report	10 patients representing different clinical conditions were taking part of the study and full-mouth dental and periodontal examination was done and radiographs were taken from the patients. Ten dentists gave dental and periodontal scorings for each patient. Scores included diagnosis of periodontitis, amount of plaque and calculus, gingival recession on teeth, furcation involvement, erosion, tooth wear, stain and non-carious cervical lesion and presence of decayed, filled, and crowned teeth and implants. Dentists could change their scoring after periapical radiographs were provided. Time of the scoring was taken. Finally the agreement between remote and clinical scorings was analyzed.	The agreement for dichotomized dental and periodontal indices ranged from 78 to 95%. Using radiographs, the remote examiners were able to detect existing filled teeth, crowned teeth, and implants, although the detection of decayed teeth (70%) was not improved.

Thakkar et al. 2021 Telehealth and dental specialties during COVID-19 pandemic	United States	The aim of the study was to review the literature of utilization of teledentistry by different dental specialties and challenges faced by dental professionals and patients during COVID-19 pandemic.	A review article	Data was collected from different databases with keywords: COVID 19, teledentistry and telehealth. As the study was review article there was no mention of the databases or whether systematic search methods were used.	According to the article there are four ways of utilizing teledentistry. Synchronous connection means two way communication between patient and dental professional using audiovisual telecommunications technology. Asynchronous communication means transmission of patient's health information through a protected electronic telecommunications system to a dental professional who assess the situation of the patient. Remote patient monitoring means that patient health information is sent from one location to another (for example from different healthcare provider to another) through electronic communication technology. Mobile health means that public health practices, health care organizations and educational institutes are supported by mobile communication devices.
Singh et al. 2021 Integration of teledentistry in oral health care during COVID-19 pandemic	India	The aim of the study was to review the literature of how teledentistry has been integrated in oral health care and how COVID-19 pandemic is affecting to the integration.	A review article	Data was collected from different databases with keywords: COVID 19, coronavirus, oral health care, pandemic, teledentistry and telemedicine. As the study was review article there was no mention of the databases or whether systematic search methods were used.	The methods of telesonsultation are real-time consultation, store-and-forward method, remote monitoring method and a near-real-time consultation. These methods have been already in use at some level in dental health care but COVID-19 pandemic have pushed dental professionals to accept and use it as an alternative method of dental care.

Airan 2020 The Vital Roles of Tele dentistry during the Current Situation of COVID-19 Pandemic	Arad Emirates	The aim of the study was to provide a brief overview of applications of teledentistry from existing literature.	A review article	Data was collected from different databases with keywords: teledentistry, telehealth, telemedicine, COVID-19, coronavirus. The used databases were PubMed, Google Scholar and Cochrane.	In times of COVID-19 pandemic the person-to-person contact should be avoided and therefore teledentistry helps to contain the spread of the virus but at the same time patient will get help in dental emergency situations. Teledentistry services may include tele-consultation, tele-triage, telemonitoring and tele-diagnosis. Through teledentistry applications patient's complain can be assessed by dental professional and time and money can be saved and trip to the dental clinic may be avoided at the pandemic situation.
Macapagal 2020 Applications of Teledentistry during the COVID-19 Pandemic Outbreak	Philippines	The aim of the study was to show a summary of the potential application of teledentistry during COVID-19 and future pandemics.	A review article	Data was collected from different databases with keywords: telemedicine, oral medicine, triage, dental health services. There was no mention of the databases or whether systematic search methods were used.	Telemedicine was widely used in 2020 during COVID-19 pandemic. Application methods of teledentistry are screening for triage, diagnostic, treatment planning, screening tool for possible COVID-19 patients, specialist consultation and disease consultation. Teledentistry is useful during pandemic and it should be applied soonest to be used more in future pandemic outbreaks.
Dusseja et al. 2020 Patients' Views Regarding Dental Concerns and Tele dentistry during COVID-19 Pandemic	India	The aim of the study was to assess satisfaction and perceptions toward teledentistry and dental concerns during COVID-19 pandemic.	Qualitative research	Data was collected from an online survey made in Google forms. The survey was sent to 1000 people through various social media platforms.	642 responses were received to the survey. The most of the people who responded were in between the age of 18 to 40 years. 70.7% of respondents did not want to visit dental clinics during COVID-19 pandemic. 80.5% of the participants were in favour of using teledentistry. Even though 76.1% of participants were aware that dentists are at high risk of infection only 45.3% of participants agreed to a significant increase in fees for protective equipment used for personal reasons.

Mishra et al. 2020 Role of Teledentistry during Covid-19 pandemic: A review	India	The aim of the study was to review the literature of the role of teledentistry during COVID-19 pandemic and delivering dental health care for patients.	A review article	Data was collected from the databases called Cochrane, PubMed and Google Scholar. The keyword used for searching data were COVID-19, teledentistry and pandemic.	Teledentistry has proven to be the safest method of treating patients during the current pandemic. Teledentistry includes teleconsultation, telescreening, telediagnosis, teletriage, and telemonitoring.
Priyadarshi et al. 2021 Teledentistry & COVID 19 in Tele- Era	United Arab Emirates	The aim of study was to show a summary of applications of teledentistry and possible disadvantages of implementing teledentistry in to use.	A review article	Data was collected from different databases with keywords: teledentistry, telemedicine, COVID-19, pandemic, teletriage and teleconsultation. As the study was review article there was no mention of the databases or whether systematic search methods were used.	By using teledentistry human-to-human transmissions and nosocomial spread can be reduced. Teledentistry will also eliminate communication gaps between patients and their consultants and improve patient safety on all levels. There are also disadvantages of using teledentistry because it can lead to a misdiagnosis or medical error as a result of technical problems during data transmission. Also privacy and security of patient details must be maintained in cyberspace.

<p>Das et al. 2021 Is a teledentistry an opportunity in a COVID-19 pandemic?</p>	<p>India</p>	<p>The purpose of the study was to determine methods, limitations and legal aspects of teledentistry during COVID-19 pandemic.</p>	<p>A review article</p>	<p>Data was collected from different databases with keywords: coronavirus disease, COVID-19, dentistry, pandemic and teledentistry. As the study was review article there was no mention of the databases or whether systematic search methods were used.</p>	<p>Methods of utilizing teledentistry to consultation purpose are tele-screening, triaging, patient evaluation and cohorts. The major limitations of teledentistry are connected to technical difficulties such as technical infrastructure, cost of equipment and lack of high-speed connection. Another challenge is training of the dental professionals and the ability to perform root canals and extractions via virtual connection. Patients' privacy should always be protected by dental professional and a patient should be made aware of the inherent risk of improper diagnosis or treatment due to the failure of the technology used in teledentistry. Copyright and medical-legal issues should also be addressed.</p>
<p>Deshpande et al. 2021 Teledentistry: A Boon Amidst COVID-19 Lockdown: A review Narrative Review</p>	<p>India</p>	<p>The aim of the study was to provide a brief overview of teledentistry, its applications and specialty dental practice during COVID-19 pandemic from existing literature.</p>	<p>A review article</p>	<p>Data was collected from different databases but no keywords are mentioned in the article. As the study was review article there was no mention of the databases or whether systematic search methods were used.</p>	<p>Teledentistry may happen in real time or with store and forward method where the dental professional collects all the needed data of the patient and forward it to the specialist for consultation or planning for treatment. The role of teledentistry in specialty dental practice are listed for oral medicine and diagnosis, oral and maxillofacial surgery, endodontics, orthodontics, prosthodontics, periodontics and pediatric and preventive dentistry.</p>

<p>Bhochhibhoya et al. 2020 Teledentistry: A Novel Tool in our Arsenal to Combat COVID-19</p>	<p>Nepali</p>	<p>The aim of the study was to review the literature of teledentistry during COVID-19 pandemic and challenges and opportunities of it.</p>	<p>A review article</p>	<p>Data was collected from different databases with keywords: pandemics, infection control, viruses and dental care. As the study was review article there was no mention of the databases or whether systematic search methods were used.</p>	<p>Teledentistry enhance access to dental care services, provide early intervention and health education to improve quality, efficiencies and effectiveness of dental care services. Challenges of utilizing teledentistry more widely into use are that teledentistry requires sources, funding, and detailed guidelines and the exchange of patient personal information in teledentistry requires confidentiality and security.</p>
<p>Ghai 2020 Teledentistry during COVID-19 pandemic</p>	<p>India</p>	<p>The study provides a brief overview of teledentistry applications.</p>	<p>A review article</p>	<p>Data was collected from different databases with keywords: teledentistry, telehealth, telemedicine, COVID-19, coronavirus. The used databases were PubMed, Google Scholar and Cochrane.</p>	<p>Teledentistry utilizes technology to facilitate dental treatments, guidance, and education via the internet instead of face-to-face interaction. Applications of teledentistry are teleconsultation, telediagnosis, teletriage and telemonitoring. The challenge of utilizing teledentistry is that it is not widely accepted by the dental professionals or patients.</p>

Appendix 2: Quality assessment of systematic reviews and review articles applied from JBI Critical Appraisal Checklist

REFERENCE	1	2	3	4	5	6	7	8	9	10	11	
Azam et al. 2021	•	x	•	•	•	•	x	x	•	•	o	9/11
Dharsan et al. 2020	•	x	•	•	x	•	x	•	•	•	x	7/11
Bhargava et al. 2020	•	x	•	•	x	•	x	x	•	•	x	7/11
Thakkar et al. 2020	•	x	x	•	•	•	x	x	•	•	o	6/11
Singh et al. 2021	•	x	•	•	•	o	x	x	•	•	o	5/11
Airan 2020	•	•	•	•	x	•	x	x	x	•	•	6/11
Macapagal 2020	•	•	•	•	x	•	x	x	x	•	•	7/11
Mishra et al. 2020	•	•	x	•	x	•	x	x	x	•	•	7/11
Priyadarshi et al. 2021	•	•	x	•	x	•	x	x	o	•	•	6/11
Das et al. 2021	•	•	x	•	x	•	x	x	x	•	•	6/11
Deshpande et al. 2021	•	•	x	•	x	•	x	x	x	•	•	6/11
Bhochhibhoya et al. 2020	•	•	•	•	x	•	x	•	•	•	•	6/11
Ghai 2020	•	•	•	•	•	•	•	x	•	•	o	9/11

• Yes

o No

x Unclear

- Assessment criteria do not apply

1. Is the review question clearly and explicitly stated?
2. Were the inclusion criteria appropriate for the review question?
3. Was the search strategy appropriate?
4. Were the sources and resources used to search for studies adequate?
5. Were the criteria for appraising studies appropriate?
6. Was critical appraisal conducted by two or more reviewers independently?
7. Were there methods to minimize errors in data extraction?
8. Were the methods used to combine studies appropriate?
9. Was the likelihood of publication bias assessed?
10. Were recommendations for policy and/or practice supported by the reported data?
11. Were the specific directives for new research appropriate?

Appendix 3: Quality assessment of qualitative research applied from JBI Critical Appraisal Checklist

REFERENCE	1	2	3	4	5	6	7	8	9	10	
Singh et al. 2020	•	•	•	•	•	•	•	•	o	•	9/10
Dusseja et al. 2020	o	•	•	•	•	•	o	•	o	•	7/10

• Yes

o No

x Unclear

- Assessment criteria do not apply

1. Is there congruity between the stated philosophical perspective and the research methodology?
2. Is there congruity between the research methodology and the research question or objectives?
3. Is there congruity between the research methodology and the methods used to collect data?
4. Is there congruity between the research methodology and the representation and analysis of data?
5. Is there congruity between the research methodology and the interpretation of results?
6. Is there a statement locating the researcher culturally or theoretically?
7. Is the influence of the researcher on the research, and vice-versa, addressed?
8. Are participants, and their voices, adequately represented?
9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?
10. Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?

Appendix 4: Quality assessment of case report applied from JBI Critical Appraisal Checklist

REFERENCE	1	2	3	4	5	6	7	8	
Steinmeier et al. 2020	•	•	•	•	•	•	o	•	7/8

• Yes

o No

x Unclear

- Assessment criteria do not apply

1. Were patient's demographic characteristics clearly described?
2. Was the patient's history clearly described and presented as a timeline?
3. Was the current clinical condition of the patient on presentation clearly described?
4. Were diagnostic tests or assessment methods and the results clearly described?
5. Was the intervention(s) or treatment procedure(s) clearly described?
6. Was the post-intervention clinical condition clearly described?
7. Were adverse events (harms) or unanticipated events identified and described?
8. Does the case report provide takeaway lessons?