

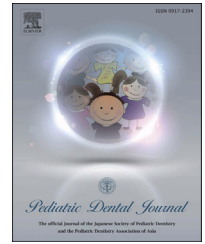


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## Review

# Teledentistry and its applications in paediatric dentistry: A literature review



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### ABSTRACT

**Background:** During the unfortunate event of the COVID-19 pandemic, restrictions were placed on face-to-face interactions in dentistry to promote social distancing and reduce spread of virus. In order to provide dental services teledentistry was employed.

**Objective:** This article aims to review the literature and information available on the provision and utilization of teledentistry as a method to address oral health needs of paediatric patients.

**Results:** Teledentistry has been utilised in paediatric population for the purpose of oral health education and promotion, remote diagnosis and monitoring, and behaviour guidance. Studies involving paediatric population for aforementioned applications have shown that this practice strategy is beneficial to provide dental treatment in remote locations with little access to paediatric dental specialists, monitor patients between appointments, conduct remote diagnosis and screening programmes, promote oral health of children through dental education, and in pre-appointment behaviour guidance. This method was particularly useful during the current COVID-19 pandemic where dentists use their mobile phones, computer webcams for patient appointments while maintaining safe distance and avoid exposing themselves as well as patient to the virus.

**Conclusion:** Teledentistry can be a supplement to face-to-face methods of paediatric dental care, ultimately leading to better patient management. This technology can make a significant contribution in reducing the supply-demand gap of paediatric dental specialists in places where healthcare facilities are limited and ensure safety during the pandemic whilst providing dental care to paediatric patients. Further research is required for safe, effective and evidence-based use of teledentistry in the field of paediatric dentistry.

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## 1. Introduction

“Telemedicine” is delivery of healthcare services over long distances using electronically generated information-based on technology and telecommunication infrastructure [1,2]. It is utilized for diagnosis, consultation, treatment of diseases and patient education [3]. As the use of mobile phones and wireless technologies have increased across globe it has impacted the way dentistry is being practiced. Similar to telemedicine, “Teledentistry” is a branch of dentistry that engages with internet and uses information technology [2,4]. It is the concept of telemedicine as applied to oral health and dentistry [5]. The term, “Teledentistry” was first described by Cook in 1997, and is defined as, “the practice of utilizing video conferencing technologies to provide advice and diagnosis about the treatment over a distance” [1]. The concept drafted in 1994, was used by US Army to communicate via real-time and stored forward method as part of Total Dental Access project [1,6]. Since then, studies were conducted that supported the worldwide expansion of the concept [6,7]. Teledentistry has its origins in dental informatics concept, which involves capturing and management of patient data for better patient care [2,8].

Teleconsultation is established in two ways: a) A real-time consultation involving a video conference in which the dental professional and the patients can see, hear and communicate with each other over distances [9]. b) A store-forward method that involves the exchange of the clinical information and static images that are collected and stored by the dental professional which are subsequently forwarded for consultation and further treatment planning to a specialist [4]. It can be a near-real-time consultation that provides patient information in low resolution [9], or a remote monitoring method to monitor patients from distant locations [10]. This provides a comprehensive platform for interdisciplinary communication amongst dental professionals to share, store and plan treatment for patients. Additionally, mobile health or mHealth apps supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices has been introduced [11]. mHealth utilizes mobile phone's core utility of voice and short messaging service (SMS), general packet radio service (GPRS), third and fourth generation mobile tele-communications (3G and 4G systems), global positioning system (GPS), and Bluetooth technology to interact with patients [11].

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) can spread as a droplet infection through nasal and salivary secretions [12]. This necessitates social distancing, which has been encouraged the use of teledentistry [13]. Due to the long incubation period of the disease (2–14 days) and because children are often asymptomatic or only present with mild symptoms, child patients attending dental treatment can be potential carriers of infection. Thus, use of teledentistry will minimise face-to-face contact and help continue paediatric dental practices in a more effective manner [14]. Therefore, this article aims to review the literature and information available on the provision and utilization of Teledentistry as a method to address oral health needs of paediatric patients.

## 2. Review method

An electronic search of publications was made using electronic databases ScienceDirect®, MEDLINE/PubMed®, Embase, British Medical Journals, Biomed and Cochrane databases for all the articles related to use of mHealth and teledentistry in its widest sense, up to June 30th 2021. The reference lists of all retrieved articles were hand-searched for further cross-references. The inclusion criteria were abstract or full text articles including original research, reviews or systematic reviews and meta-analysis. The following search strings with appropriate alterations for different databases were used: “dental and video conferencing”, “dental store and forward communication,” “tele-dentistry”, “dental and remote consultation and records”, “teledentistry and COVID,”, “tele-dentistry and orthodontics”, “mhealth”, “teledentistry and children”. The articles with only adult population were excluded in this review.

## 3. Results

The literature search identified 197 articles related to teledentistry, after screening the titles, abstract and full text. Amongst them 33 articles included paediatric population. These articles were classified into “Teledentistry in oral health education” (9 articles), “Teledentistry and oral health promotion” (4 articles), “Teledentistry in remote diagnosis” (11 articles), “Teledentistry and teleconsultation” (4 articles), “Teledentistry in behaviour guidance” (5 articles). Search term “teledentistry and COVID” yielded 56 articles with five involving paediatric population.

### 3.1. Applications of teledentistry in paediatric dentistry

Based on the literature search, teledentistry can be beneficial in oral health education and promotion amongst children, diagnosis and monitoring paediatric dental patients over long distances with limited access to dental care and in behaviour guidance of paediatric patients. This method can be particularly useful during the current pandemic situation in order to limit patient-to-patient contact by maintaining a safe distance. At the same time, it prevents exposure of dental staff, dentists through the use of mobile phones, webcams, intra-oral camera and dental applications connected via internet.

#### 3.1.1. Oral health education and promotion

Children's oral health is important for their general health of the body, social, physical and mental well-being [15]. Advancements in the information and technology industry can be utilized by paediatric dentists to provide better access to oral health services and improve oral health behaviours [14,16]. Oral health education and promotion programmes via mobile technology, internet, mhealth application have been able to draw the attention of the public and reach a large population [17,18]. In recent years, the number of mobile and internet users have dramatically increased across the globe, which has changed the way, the patient education can be undertaken [17]. Studies have been conducted using these

methods, particularly targeting paediatric population to assess their effectiveness [Tables 1 and 2].

Children are adept in using digital technology and are more immersed in their use than adults [19]. Social networking applications have been popular amongst dental professionals to interact with their patients [20]. This is also evident during the situation of the COVID-19 pandemic [10]. Therefore, in summary, utilization of internet and mobile-based applications increase patient awareness and knowledge to promote oral hygiene [21], form an effective mode of communication for parents and community in remote areas [22], and cover up for shortage of trained dental public health professionals [23]. They are convenient to use since the apps can be accessed directly via smartphone eliminating requirement of another device, specific reminders and instructions for new behaviours or habits can be personalized with a real-time assessment of the individual and feedback can be delivered [24]. They also help overcome cultural, social and logistic challenges that are often encountered with conventional education methods [22]. The mobile-based health apps, which are used for patient education, should be based on recognized behaviour change techniques. They should provide instructions on how to perform an activity, demonstrate the behaviour, provide prompts and cues, and reward the user upon completion of the desired behaviour [21,25].

However, concerns remain regarding the ease of functionality of the app. If complicated to use the patients may avoid using the app, therefore impeding the expected impact [26]. Further, the application should protect user's privacy, not disturb the user with repeated messages leading to fatigue, have an appealing design to attract interests of the user and be customizable according to patient's requirements [26,27].

### 3.1.2. Remote diagnosis and monitoring

Children and adolescents are the prime target population for early diagnosis and prevention of oral health diseases [28]. Despite the attempts made to improve children's oral health a disparity due to geographic and socioeconomic barriers remains. This lack of access to dental health services requires a cost-efficient and sustainable method to increase access of children, especially in distant locations for dental services [29]. Teledentistry via the medium of electronic dental records, information and communication technology, internet and newer digital devices such as digital camera, intra-oral cameras, webcam, computer monitors have expedited the way dental service is being provided.

Teledentistry has various applications such as tele-triage, teleconsultation, telediagnosis, and telemonitoring [2,13]. While telediagnosis involves the use of images to diagnose oral pathologies remotely, tele-triage helps in prioritizing the patients that require urgent care by remote assessment of the pathology, thus providing safe access to patients for dental care. Telemonitoring, teleconsultation and tele-triage reduce the need for unnecessary travel for patients, especially for those in remote areas, who face socioeconomic and geographical difficulties in utilization of dental care [30]. It also provides the advantage of increased access to paediatric dental specialists who can record, confirm and execute an appropriate treatment plan, based on the images and records provided by dentists who are non-specialists or by dental

assistants [2,31]. Distant dentists can transmit digitally acquired data for triage, detection and referral of the patient [32]. This involves acquiring data related to history of the patient using a questionnaire, performing and recording examination findings, transmission of intra oral and radiographic images using intra oral camera or digital camera. The data related to the patient are transmitted using an online electronic record management system from the remote site to the hub site where the specialist consultant is available [8,33].

Various studies conducted in paediatric population, where telediagnosis and teleconsultation were conducted are summarised in Tables 3 and 4. Use of telediagnosis is as effective as face-to-face examination in making complex treatment plan [34] and the accuracy is superior or comparable to visual examination [35]. It is cost effective, as it involves dental assistants or therapists or general dentists who are paid lower salaries, and saves travel and accommodation costs for patients from remote areas [36]. Telediagnosis is effective in reducing cost and time in school screening programs [36,37]. Increased utilization of dental care services by children, by enhancing communication with paediatric dentists during teleconsultations [31,34,38] has been observed in many studies. Teleconsultation can also involve collaborative care by various specialists. As electronic records of the patient are available, interdisciplinary engagement can occur in shorter time for conditions that require multidisciplinary team management [39].

Despite the advantages and effectiveness of remote diagnosis and monitoring, limitations exist, such as inadequate quality of photographs, learning curve associated with using camera, both for patient and dental health professionals [9]. Dental regulatory bodies, employers or insurance companies should make provisions for adequate remuneration of the dentists for the services rendered through teledentistry, in a structured manner. Avenues for training of dental professionals and availability of appropriate equipment or infrastructure for maintaining quality is essential [30].

### 3.1.3. Behaviour guidance

The pandemic has challenged the way conventional behaviour guidance techniques can be applied to paediatric dental patients due to the use of personal protective equipment (PPE), such as N-95 mask, face shield and disposable gowns [40]. However, use of such protective equipment hides the facial expressions of the paediatric dental professional and limits verbal communications, leading to increased fear and anxiety among children attending dental treatment [41]. Therefore, use of mobile applications, accessible at the ease of home can aid in guiding behaviour of children in the dental clinic. Table 5 illustrates studies done that support the use of advancements in technology for behaviour guidance in children.

Mobile game applications offer children an interactive way to guide their behaviour and are useful in reducing face-to-face contact by reducing the number of dental visits in the pandemic. These applications can incorporate behaviour guidance techniques like tell-show-do, positive pre-visit imagery, distraction, and modelling [42]. Previous studies have shown that video modelling is effective in exerting therapeutic influence in the management of anxiety and at the same time exert an educational influence to improve skills of

**Table 1 – Summary of studies using mobile apps for oral health education and promotion among children.**

Author name and year	Name of the application used	Purpose of application	Methods	Conclusion/outcome
Soler et al., 2009 [62]	Molarcropolis app	An interactive motivational game aimed at increasing oral health and dental hygiene literacy among adolescents employing persuasion tactics. During the game, players learn about oral diseases and their causes, behaviours and practices that put adolescents at risk, tips on how to improve their oral health.	Survey of individuals aged 13–24 years was done to check the effectiveness of the app in improving awareness and change in habits related to oral hygiene.	Adolescents indicated that the game is both entertaining and informative, helpful to learn new aspects regarding oral health, and has the potential to change oral health habits.
Levine et al., 2012 [63]	MySmileBuddy	1. Diet recall function. 2. Assess risk of early childhood caries due to diet in young children.	Pilot study on mothers (age range not specified) of children with early childhood caries was conducted after training community health care workers (CHW). CHW facilitated use of the app by the mothers. Survey of CHW for ease of navigation and usefulness of the app.	CHW rated the app as very easy and fun for the families to use.
Shao et al., 2014 [64]	DAYA tooth brushing game	A tooth-brushing game to enhance the efficacy and experience of tooth brushing in children, and helping the parents to monitor child's dental health and behaviour towards oral hygiene.	A pilot study involving 6–10 year-olds on usability testing of the mobile application and the game.	The game was better understood by older children (>8 years of age) and found them enjoyable. Parents were able to complete all the tasks related to monitoring. The game was feasible in enhancing the tooth brushing experience for children and monitoring by parents.
Underwood et al., 2015 [21]	Brush DJ app	1. Provide users evidence-based routines to maintain oral hygiene. 2. Motivation by playing music for 2 min while brushing. 3. Set reminders for rinsing mouth, maintain concentration of fluoride, frequency to change toothbrush, dental appointment schedule.	Qualitative survey assessed perception regarding experiences and beliefs regarding oral health app amongst participants aged up to 74 years of age. Majority of the participants (37.1%) were in the 7–12 year age group.	Mobile app is useful for oral hygiene education and promotion. It motivated the participants to brush for longer time. The themes were motivation, education, compliance and perceived benefits.
Alqarani et al., 2018 [15]	Your child's smile	Provide information to parents regarding oral health of their child pre-partum and from the period of infancy to adolescence.	Survey to assess improvement in parent's knowledge before and after the use of the mobile app in children up to 15 years of age.	Significant improvement in knowledge related to dental caries and oral hygiene.
Author Name and Year	Name of the application used	Purpose of Application	Methods	Conclusion/outcome
Zotti et al., 2019 [65]	1. Time2Brush (children >5 years). 2. Little Monsters Toothbrush time (children ≤5 years).	Format of both apps were same. Fictional characters served as motivation to practice oral hygiene along-with a stopwatch to perform routine procedures. Additionally, according to the minutes of use, users could customize the summary accordingly as a bonus.	Randomized trial involving study and control group involving 4–7-year old children. Chair side instructions on oral hygiene for control group.	Decrease in plaque scores, no new caries lesions on permanent molars. Better compliance for oral hygiene by children, increase in knowledge level of parents.

Alkilzy et al., 2019 [66]	Manual toothbrush with sensor that is linked to the smartphone via bluetooth.	Manual tooth brush with a digital motion 3D sensor system (gyroscope), so that the toothbrush follows the tooth brushing movements of the child in real-time. The movements are relayed to smartphone via Bluetooth. Movements are shared with parents for monitoring and as the child reaches optimal movements points are awarded.	A randomised control study evaluating effectiveness of using a manual toothbrush with a gravity sensor and used along with a mobile tooth brushing app in children aged 5–6 years. The control group used a manual tooth brush without the smartphone app.	Decline in plaque index was more pronounced in the test group than in the control group, which gives evidence for the effectiveness of gaming in tooth brushing via a smartphone app.
Farhadifard et al., 2020 [67]	Smartphone app, brush DJ	Provide users evidence-based routines to maintain oral hygiene. 2. Motivation by playing music for 2 min while brushing. 3. Set reminders for rinsing mouth, maintain concentration of fluoride, frequency to change toothbrush, dental appointment schedule.	Randomized controlled trial comparing reminder smartphone application with conventional method of verbal oral hygiene education in maintenance of oral hygiene of 15–25-year-old patients undergoing orthodontic treatment.	Significant differences were noted between the two methods with smartphone application use associated with increased frequency and duration of brushing.

copied in children in stressful situations [43,44]. A peer model coping with similar dental procedures that the child is expected to undergo is better than unrelated model or unrelated video content. It sensitizes the child to the treatment situation, thus decreasing anxiety and enhancing coping. It is important that the behaviour of the model in the video be provided with positive reinforcement for this technique to be effective [44]. It has the convenience of portability, coping strategies for a wide range of treatment can be demonstrated and is cost effective [45]. However, the making of the video representation requires the time of the dentist and the dental staff, though the time required for dentist-patient interaction is reduced [46].

Mobile dental apps provided to patients before their first dental visit can help the paediatric patient creating a positive pre-imagery. The term, positive pre-visit imagery refers to the provision of photographs related to dentistry and dental treatment to the paediatric patient before they enter the waiting area that will enable the paediatric patient to be comfortable, relaxed and familiar with the operatory [42]. However, in the current situation of the pandemic, this can be done using social media apps such as YouTube, with videos that can be watched by the paediatric patient before their appointment if needed to the operatory. Mobile dental apps introducing dental operatory and dental treatment procedures using the principles of tell-show-do techniques are effective in reducing dental anxiety during the first dental visit [47,48].

### 3.2. Teledentistry during COVID-19 pandemic

During the unfortunate event of COVID-19 pandemic, teledentistry has enabled dental care of child patients while limiting the spread of the disease and protecting the dental healthcare workers from exposure to potential COVID-19 cases [49]. Interactive live sessions, video chats with specialised dentists, dental education apps for children and parents and photographic triage for dental referral have notably reduced face-to-face interactions. In addition to remote diagnosis, tele-triage, surveillance of oral lesions, assessment of dental development, consultations between junior residents and senior consultants, and maintenance of records for medico-legal purposes is feasible [50,51]. Use of photographic triage has avoided face-to-face consultations in more than 50% of the cases, thus reducing the risk of transmission of the infection [50]. In a study carried out in paediatric patients, teledentistry in the form of telephonic consultation during the first communication with the patient could reduce face-to-face appointments by over a third [52]. In another study involving cleft lip and palate patients, the paediatric dental consultants could reduce face-to-face appointments by 11% after telephonic consultation. It also helped in providing education, reassurance to the patients and prioritising patients for dental treatment procedures [53].

Good patient satisfaction was observed with these services during the pandemic period. Parents of child patients have reported high satisfaction, and considered it to be an effective and convenient method for treatment and follow-up of oral mucosal lesions [51]. Teledentistry has been able to ease the burden on the dental care systems that are already

**Table 2 – Summary of studies using social networking media for oral health education and promotion among children.**

Author name and year	Name of the media used	Purpose of application	Methods	Conclusion/outcome
Zotti et al., 2016 [68]	WhatsApp	Video tutorials regarding oral hygiene. Self-photographs (selfies) and text messages shared by patients and their parents via WhatsApp-based anonymous chat room.	Randomized controlled trial involving adolescent patients (mean age 14.1 years in study group and 13.6 years in control group) undergoing orthodontic treatment requiring maintenance of oral hygiene. Patients and parent were asked to interact via selfies and text messages pre and post oral hygiene practices.	Improved compliance to oral hygiene in patients noted with lesser white spot lesions recorded during orthodontic treatment.
Scheerman et al., 2019 [25]	Telegram	Theory based program consisting of oral health education and behaviour coaching components to promote regular tooth brushing.	Randomized controlled trial evaluated effectiveness of Telegram application in promotion of oral hygiene and oral health related outcomes in adolescents aged 12–17-years along with mothers. The outcomes were based on improvements in tooth brushing behaviour and plaque scores.	Results supported use of health action process-based approach and theory-based program through Telegram with involvement of mothers to improve oral hygiene among adolescents.
Lotto et al., 2020 [27]	WhatsApp	Educational text messages related to early childhood caries.	Randomized controlled trial including child-parent dyad with in children aged 36–60 months and having early childhood caries. The intervention group received educational WhatsApp text messages.	Effective to control the severity of ECC in low socioeconomic pre-schoolers, improving parental eHealth literacy and changing children's dietary patterns.
Simsek et al., 2020 [69]	YouTube	YouTube videos describing oral habits searched.	Evaluated videos on oral habits and assessed quality of information available for patients and parents.	Majority were inappropriate with inadequate information.

**Table 3 – Summary of studies with telediagnosis using smartphone camera/digital camera/web camera in children.**

Author name and year	Device for diagnosis	Methods	Conclusion
Amável et al., 2009 [70]	Digital camera, Web-based system (MedQuest)	Validity of the remote diagnosis of dental problems in 4–6 year-old children was done by dentists using digital camera. Screening and referrals were decided based on images obtained via web-based application.	Use of photographs is a valid method for remote diagnosis of dental problems. Specificity of this method of screening can be enhanced by improving feedback on dentist's evaluation.
Torres-Pereira et al., 2012 [71]	Smartphone camera	Non-Randomized study wherein intra-oral images of first 60 patients (irrespective of age) who visited the dental clinic after ethics committee approval were uploaded on cloud-based servers by dental assistants for mid-level practitioner's and dentists to screen for dental caries.	Photographs taken with 18-megapixel DSLR were able to provide adequate diagnostic information with sensitivity and specificity. Photographic assessment accelerated referrals to specialists that reduced delayed treatment and increased patient inflow.
Kopycka-Kedzierawski et al., 2013 [38]	Intra-oral camera	Randomized comparative evaluation between conventional dental examination and teledentistry aided examination in assessment of early childhood caries prevalence in 12–60-month-olds.	No difference between either type of examination. Provision of coloured pictures of child's cariously exposed teeth helped in motivating parents for getting their children examined.
Purohit et al., 2017 [72]	Smartphone camera	Dentists involved in this cross-sectional survey conducted a clinical versus video-graphic examination to assess DMFT index in 12-year-old children.	Clinical and video-graphic methods of assessment were proven to be comparable for screening of dental caries in school children.
Estai et al., 2017 [73]	Remote mobile teledentistry system for Android phones with 'Remote-i' cloud server that collects, transmits and reviews dental photographs.	Study compared cost-effectiveness of conventional visual-tactile examination with teledentistry approach. Trained tele-assistants carried out dental screening of all age groups, including children, using recorded photographs that were later shared via 'Remote-i' system.	Teledentistry is cost-effective method that can be used for mass dental screening in distant locations.
de Almeida Geraldino et al., 2017 [74]	Mobile phone camera	Cross sectional study involving patients between 3–39 years of age with traumatized teeth. Remote examination by paediatric dentists using electronic records and photographs. Agreement with in-surgery and remote diagnosis was evaluated.	Precision of remote diagnosis was comparable to the diagnosis conducted in person. Mobile phone camera can be a useful tool to capture images for remote diagnosis of traumatic dental injuries.
Kale et al., 2019 [75]	Smartphone camera, social networking application (WhatsApp)	Mothers' ability to diagnose dental caries in 3–5 year-old via smartphone camera post health education was assessed. The captured photographs were shared with dentists via WhatsApp.	The method recorded good sensitivity, specificity and accuracy. Children were more cooperative for examination with smartphone in comparison to conventional visual examination as they are familiar with the former.

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**Table 3 – (continued)**

Author name and year	Device for diagnosis	Methods	Conclusion
AlShaya et al., 2020 [76]	Smartphone camera, Google drive, social media application (WhatsApp Messenger)	Reliability of the intra-oral images taken by paediatric dentist for diagnosis of dental caries in 6–12 year-old children.	Teledentistry using smartphone technology offers acceptable reliability for initial caries diagnosis in children, although it is less reliable due to lack of radiographs.

**Table 4 – Summary of studies with teleconsultation using smartphone camera/digital camera/web camera in children.**

Author name and year	Device for examination	Methods	Conclusion
Lienert et al., 2010 [77]	Telephonic communication	Retrospective study was to assess number of phone calls related to dental trauma made to medical centres by patients of age ranging from 0 to 73 years (mean age 8.7 years) out of which one third of the patients were in the 0–6 years age group.	Tele-dental consultations are helpful when a dentist is not available. Most of the calls were related to injuries in primary dentition.
Mariño et al., 2014 [78]	Intra-oral camera that transmits audio and video, Web camera	Non-randomized field trial where community dental health dentists sent recorded pictures of child patients (mean age $8.6 \pm 4.2$ years) to paediatric dentists for consultation of cleft lip/cleft palate, dental trauma and orthodontics.	Teledentistry conducted at remote locations was successful in provision of accurate diagnosis, reduced screening time thereby promoting appropriate referrals.
McLaren et al., 2016 [34]	Intra-oral camera, Computer camera	Retrospective study assessing accuracy of dental treatment planning by paediatric dentists via live-video consultations was done in children with a mean age of $4.77 \pm 2.36$ years from rural areas.	Live-video consultation facilitates completion of treatment plans by paediatric dentists for paediatric patients with extensive treatment needs. It decreased time and cost and increased access to speciality care.
Sanghvi et al., 2021 [51]	Telephone consultation	Descriptive study assessing the ability of paediatric dentists to assess, and carry out teleconsultation in 2–16 year-olds during the COVID-19 pandemic. Parental satisfaction was assessed after the tele-consultation.	Telephonic consultations reduce face-to-face contacts with good patient satisfaction during pandemic.

**Table 5 – Summary of studies utilizing teledentistry for behaviour guidance in children.**

Author name and year	Mobile application used	Methods	Conclusion
Patil et al., 2017 [48]	Mobile dental application “My little dentist”	Pilot study assessing effectiveness of mobile dental application in managing behaviour in children aged 8–12 years. Participants were made to perform dental procedures on virtual characters in the app to familiarize with dental clinic.	Mobile application successfully decreased anxiety, increasing positive behaviour among the participants in subsequent dental visits.
Meshki et al., 2018 [79]	Mobile dental application “Crazy dentist”	Preliminary double-blinded parallel randomized clinical trial in 4–7 year-old children to assess modeling as pre-exposure method to reduce anxiety in children, using a smartphone dental simulation game.	Due to the engaging reward-dependent experience, dental simulation games can act as pre-treatment modeling and decrease anxiety during anaesthetic injections and drilling.
Elicherla et al., 2019 [47]	Mobile dental application “Little Lovely Dentist”	Parallel arm design study comparatively evaluating conventional tell-show-do (TSD) and a dental simulation mobile app in reducing anxiety and fear in 7–11 year-old children on their first dental appointment.	Psychological and subjective aspects of anxiety associated with first dental appointment had reduced significantly with use of mobile app. The app was more successful than TSD due to its interactive nature.
Radhakrishna et al., 2019 [80]	Smartphone dentist game	Randomized interventional clinical study comparatively assessed effectiveness of mobile dental game, tell-show-play-doh and conventional tell-show-do in 4–8 year-old children.	Mobile dental game application and tell-show-play-doh were significantly more effective in reduction of anxiety than conventional methods due to their interactive nature.
Asokan et al., 2020 [81]	Mobile dental application “Little Lovely Dentist”	A double-blinded randomized trial comparatively assessing use of a magic trick with mobile dental application for reduction of dental anxiety in 4–5 year-old children with conventional tell-show-do as control.	Active distraction with dental game was accepted readily by child patient however, all techniques of distraction were successful in reducing anxiety.

constrained due to workforce reduction and limitation of resources [30]. In a survey [49] conducted patient's experience of teledentistry was determined during the pandemic. They reported 97% and 94% satisfaction with virtual-clinics and telephonic consultations, respectively. A similar study [54] assessing both patients' and clinicians' satisfaction regarding online consultations with 'Anytime Anywhere' software for orthodontic treatment monitoring during the pandemic revealed overall satisfaction was good among 76% patients and 90% clinicians.

The pandemic has also affected the attitude and knowledge of dentists towards teledentistry, which was evaluated in a cross-sectional survey [55]. This questionnaire survey revealed the knowledge and practice of teledentistry among dentists had significantly increased post the onset of pandemic with around 93% of the dental practitioners finding teledentistry to be useful for their clinical practice, and with around 60% considering continuing post pandemic as well.

Teledentistry, derived from the concept of telemedicine, is a developing innovative strategy to ensure continued dental care under specific considerations during the pandemic [55]. However, its effectiveness in paediatric dental practice is still an evolving concept. It is important to understand the scope and limitations of teledentistry in the paediatric dental practice. Teledentistry can be a useful tool in diagnosis, preventive and post treatment monitoring of the patient, prescription of drugs during emergencies, multidisciplinary consultation and pre-appointment behaviour guidance to child patients during the pandemic [5,54] but cannot replace traditional dentistry. Given the better acceptance of teledentistry by both patients and dentists during the pandemic [30,55] these applications of teledentistry can supplement the traditional face-to-face dentistry, even without the COVID-19 pandemic.

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#### 4. Benefits, challenges and future scope

Teledentistry can widen the scope of child oral healthcare at reasonable costs, easing issues of the paucity of paediatric dental specialists especially in remote areas [2]. Virtual appointments eliminate the time taken for travelling, thus making it convenient for children and parents, as they do not have to take time away from school or work [53]. It can help dentists to triage patients requiring urgent dental care and provide advice during follow-up care, thus reducing the patient burden in busy dental practices [30]. During video consultations, the treatment plan can be explained to the parents better, using intra oral photographs [54]. The initial virtual appointment can reduce the anxiety related to dental visits, gives parents more time to contemplate about treatment options before the actual visit to the dental clinic [52]. It also gives a possibility of better interdisciplinary interactions, thus improving the treatment outcomes [2].

However, currently the applicability of teledentistry in routine dental practice has several limitations, which are similar to telemedicine. Problems such as lack of consumer awareness, which is often associated with age and education level of the patient, cost and efficiency of equipment used for teledentistry, lack of clarity on reimbursement, confidentiality and security of data that affect telemedicine, are common to

teledentistry also [56]. Constraints regarding infrastructure such as poor access to the internet, a shortage of hardware, organisational incompatibility of teledentistry with health-care system, insufficient financial support, difficulties in obtaining cooperation with remote centres, inadequate directives and the costs involved in the installation are the challenges faced by the dentists [57]. Resistance to new technologies, poor information technology literacy and inadequate training among the dentists are further barriers faced by the dentists [58]. To subdue the challenges mentioned, training dentists regarding the use of technology, the provision of informed consent to patients before commencement of any treatment [59] can aid in increasing the acceptance of teledentistry further. Further, more research on the efficacy of the teledentistry for paediatric patients, considering cost effectiveness is required. Clear directives and laws regarding reimbursement structure of the service, guidelines on copyright, licensure and taxation, malpractice and medico-legal issues from the government are also required in order to encourage global utilization of teledentistry [36].

The practice of teledentistry requires the services of software companies for technical support [3], but these services which support telemedicine with reimbursement, do not have clear policies on compensation for dental services [60]. The sustainability of teledentistry as a business model even in the times of pandemic is compromised due to lack of clear policies on reimbursements by the insurance companies. While there is no sufficient evidence regarding the cost effectiveness, most of the research projects related to teledentistry are not sustained for everyday dental practice due lack of financial support [2,36]. Most of the research related to teledentistry have been conducted in developed countries, while the effectiveness in developing countries, in rural and remote areas is yet to be established [36,61]. Further research needs to be conducted to overcome these gaps. Unless these limitations and barriers are overcome, the establishment of teledentistry as a tool in dental practice will remain slow and inconsistent [60].

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#### 5. Conclusion

Teledentistry, the foundation of which lies in the internet and advances in information technology can be a supplement to face-to-face methods of paediatric dental care, ultimately leading to better patient management. Paediatric dentists can leverage this technology for patient/parent education, monitoring preventive care and post treatment follow-up, assessment of dental development, diagnosis of dental diseases, treatment planning and pre-appointment behaviour guidance to decrease anxiety among child patients. This technological advancement in dentistry can make a significant contribution in reducing the gap between the supply and demand of paediatric dental specialists in places where oral healthcare facilities are limited. The use of teledentistry during the pandemic expands the potential of this technology to reduce the spread of virus. Further research is required for safe, effective and evidence-based use of teledentistry in the field of paediatric dentistry. Despite the drawbacks, teledentistry can be a tool to provide long-term oral healthcare for the paediatric population, overcoming the inequalities in access to

specialist care. This requires mutual efforts by the health authorities and paediatric dentists.

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- (2) Drafting the article or revising it critically for important intellectual content: Suprabha BS, Rao A.
- (3) Final approval of the version to be submitted: Suprabha BS.

### Declaration of competing interest

The authors of this manuscript declare that they have no conflicts of interest.

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