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Detection of caries and determination of treatment needs using DentMA teledentistry: A deep learning approach

Munifah Abdat[1], Herwanda[1], Miftahul Jannah[1], Cut Soraya[2]
[1]Department of Dental Public Health, Faculty of Dentistry, Univesitas Syiah Kuala, Banda Aceh, Indonesia
[2]Department of Conservative Dentistry, Faculty of Dentistry, Univesitas Syiah Kuala, Banda Aceh, Indonesia

ABSTRACT

Background: *Teledentistry is considered capable of detecting dental caries remotely without direct contact with patients. Deep learning (DL) algorithms are trained with sufficient datasets to find patterns and models based on learning. By using a DL model, we propose a conceptual framework for the screening of dental caries using smartphones: the DentMA application, a new breakthrough in teledentistry technology. In this study, the DentMA teledentistry application was used for mobile screening for caries.* ***Purpose:*** *This study aimed to analyze the use of DentMA teledentistry to detect dental caries, enamel-dentin caries, and untreated caries, and to determine treatment needs in children.* ***Methods:*** *The participants of this study were 124 children aged 4–6 years. The study was conducted by having the participants' mothers take intraoral clinical photos of the participants using the DentMA teledentistry application on their smartphones. For the photo to be taken, each participant was directed to sit upright, with the head looking straight ahead and the mouth open.* ***Results:*** *The results showed that DentMA teledentistry was capable of detecting dental, enamel-dentin, and untreated caries in children, and its ability to predict dental treatment needs was good ($p < 0.005$). Teledentistry screening using a mobile phone can detect not only caries but also a relationship between the complaints and the medical histories of patients with dental caries.* ***Conclusion:*** *The DentMA teledentistry application can detect dental caries in children according to the individuals' complaints, including enamel-dentin caries and advanced caries, and can help determine treatment needs.*

Keywords: *dental caries; detection; teledentistry; treatment needs; deep learning*
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Correspondence: Munifah Abdat, Department of Dental Public Health, Faculty of Dentistry, Universitas Syiah Kuala, Jl. Prof. A Majid Ibrahim III, Banda Aceh, 23231 Indonesia. Email: munifahabdat_dr@unsyiah.ac.id

INTRODUCTION

Early detection of dental disease is important to avoid complications from advanced caries.[1,2] In 2017, the World Health Organization declared dental caries a pathological condition in the oral cavity, commonly occurring in 60–90% of school-age children, and one that can affect the quality of life of children and their families.[1] The 2018 National Basic Health Research notes that 93% of children aged 5–6 years have cavities,[2] while in the province of Aceh, 53.03% of children aged 5–9 years have damaged teeth, cavities, or dental pain.[3] The caries rate is relatively high in children aged 4–6. This is not sustainable and impacts the emergence of replacement teeth; therefore, early detection of caries is needed.[4,5]

Screening is a visual inspection of the oral cavity that focuses on the early detection of dental caries by identifying problems that occur at an early stage, along with educating children and parents about the conditions and complications that may emerge.[6,7] Dental screening is an efficient and effective way to reach more than one billion children worldwide, alongside families and communities.[8,9]

The first case of COVID-19 in Indonesia was reported on March 2, 2020, and cases were found throughout all 34 provinces. DKI Jakarta, DI Yogyakarta, West Java, Gorontalo, and North Sulawesi are provinces at high risk for COVID-19 infection.[9] In the COVID-19 pandemic era, many patients with various diseases could not obtain the health services they needed. Therefore, to facilitate patient access such that they could continue receiving health services, dentists provided consulting services and disease therapy as first aid through teledentistry.[10] During the COVID-19 pandemic period, patients' medical histories, objective examinations, treatment planning, and

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oral complaints were all addressed through teledentistry. The management of patients through teledentistry considers the sensitivity of the dentist in detecting disease, patient compliance in carrying out the dentist's instructions, and the selection of medications that are both easy to obtain and safe.[11]

In Indonesia, teledentistry has been used in some private dental practices, especially during the COVID-19 pandemic. However, the use of teledentistry in Public Health Centers or Pusat Kesehatan Masyarakat (PUSKESMAS), which are governmentally funded health care centers provided for most of the Indonesian population, has not yet started.[11,12] Teledentistry entails an effort to combine telecommunications technology and dental care and to serve remote clinics and education related to patient health, public health, and administrative health.[13] Mobile phone teledentistry incorporates cellular phone technology that can store and transmit data to dental care services and has demonstrated the potential to serve as a valid and reliable tool in dental screening.[14,15] In addition, due to their convenience and ease of use, smartphone cameras have become one of the top options for photography and have also been proven to have better sensitivity and specificity in intraoral photography. Smartphone cameras are lightweight and accessible; they make visual detection of dental diseases easy and they provide satisfactory images.[16,17] In a recent study by AlShaya et al.,[18] a sensitivity of 95% and a specificity of 94.3% for images of primary teeth taken by a dentist, and a sensitivity of 98.3% and specificity of 91.4% for images taken by a non-dentist were reported. Similarly, a sensitivity of 80.8% and 88.5% and a specificity of 94.1% and 96.1% were observed for permanent teeth for images taken by a dentist and non-dentist, respectively.[18,19] Amável et al.[19] studied Portuguese kindergarten children aged 4–6 years and stored and forwarded photographs as a teledentistry model for diagnosing dental caries. The results showed high sensitivity and high specificity values for the photographic method, which ranged from 94% to 100% and 52% to 100%, respectively. The average positive predictive values (PPV) and negative predictive values (NPV) were 80% and 97%, respectively.[19]

The global public health response to managing and coping with pandemics has emphasized teledentistry as a remote treatment that cuts across various medical subspecialties. Due to the exponential growth in internet use, the availability and accessibility of existing teledentistry has been supported. However, there is great variation worldwide in digital preparation, in hospital readiness, availability, and access, and in the implementation of teledentistry.[12] Early detection aims to detect and prevent disease at an early stage before the symptoms of the disease appear.[4,5]

Intraoral self-screening has been performed for a long time, and in the case where people are educated and made aware of the signs and symptoms of dental and oral disease, this is a highly useful technique.[20] Teledentistry is considered capable of detecting dental caries remotely without the dentist having direct contact with the patient. Patients can carry out self-screening by taking close-up photos of the problem or targeted teeth using the scanning feature in the application and focusing such that the resulting images can be read and converted into information in the DentMA teledentistry application, which is based on deep learning (DL). Noninvasive screening with DL, which does not involve radiation, can be a means of motivating people to pay more attention to their health. The DentMA application is an Android-based application that uses segmentation algorithms, DL models, and convolutional neural networks (CNNs) with minimal parameters. No specific conditions in the oral cavity are required as a measuring tool for taking intraoral clinical photos.

The method created can increase the accuracy and reduce computation times. The emergence of the DentMA application has provided advances in teledentistry technology for dental health services using DL models. Deep learning algorithms have the ability to estimate complex functions through a directly defined composition of neuron operations. These algorithms are trained with sufficient datasets to find patterns and models based on learning. Some of the problems that arise in traffic controllers, graphic data, medical image interpretation, agricultural monitoring, and food production can be approached using DL. The DentMA application has provided advances in teledentistry technology in dental health services using DL models. Images obtained from dental photographs of patients can be interpreted using DL models and CNNs as potentially valid and reliable tools for dental screening.

The CNN model has demonstrated an optimum ability to analyze visual images. A CNN is a neural network that uses a mathematical convolution operation to generate a multiplication matrix from input images and filters. Its ability to extract complex patterns by combining its receptive field input with filters enables the reduction of learnable parameters. Hence, CNNs compute more cost-effectively than other DL networks, and this feature can help patients independently screen and detect the condition of their teeth and mouths using a DL approach through the DentMA application. Images obtained from photographs of patients' teeth can be interpreted using DL models and CNNs as potentially valid and reliable tools for dental screening. Before starting the study, the research team compared the results of photos scanned by the application with the gold standard of direct examination of 100 photos taken at the Dental and Oral Hospital/Rumah Sakit Gigi dan Mulut (RSGM) in Aceh; the results achieved in testing the application's accuracy were 90% and worth publishing.

Therefore, the researchers are interested in conducting research on the detection of children's dental caries and the determination of the need to treat them using DentMA teledentistry with a DL approach. Images obtained from photographs of patients' teeth can be interpreted using DL models and CNNs as potentially valid and reliable tools for dental screening.

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MATERIALS AND METHODS

The type of research used was analytical, with a cross-sectional design, in which the research data was measured and collected at once. The study was conducted at the Public Health Center of Darussalam, Great Aceh Regency, in November 2021. The participants of this study were children whose mothers were registered in the Integrated Healthcare Center/Pos Pelayanan Terpadu (POSYANDU) provided by the PUSKESMAS of Darussalam. This study focused on mothers who actively visited POSYANDU and claimed—at least previously via WhatsApp—to have had their children's dental consultations with doctors through the application. The participants were chosen using the purposive sampling technique. To determine the sample size, the Slovin formula was used with a human error of 0.05. A minimum of 124 participants who met the inclusion criteria had to be recruited from a total population of 180.

The inclusion criteria for this study included children aged 4–6 years who visited POSYANDU accompanied by their mothers. Additionally, the mothers needed to have smartphones with functioning cameras, and the children needed to be willing to become research participants with their mothers' approval. The exclusion criteria included uncooperative children and those with special needs. The researchers collected initial data from POSYANDU officers in the Darussalam PUSKESMAS in the form of the names, addresses, and telephone numbers of the mothers registered in the POSYANDU and provided each with a sheet of guidelines on how to take five-way intraoral clinical photos. The photos documented all teeth and the tissues around the teeth involved, based on the photographs taken by each participant of the front teeth, the right and left lateral teeth, the maxillary teeth, and the mandibular teeth.

The researchers recruited the research participants based on the inclusion and exclusion criteria through a Google Form sent to the WhatsApp number of each participant's mother. If, according to the mother, the individual met the inclusion criteria listed, the researchers proceeded to the next Google Forms page, that is, the research explanation page. If the mother agreed that her child could participate in the study, they proceeded to the following Google Form page, that is, the informed consent sheet and medical history page, which was completed according to the condition of the child's teeth.

The DentMA application has contributed to the development of teledentistry technology and dental health services. By using DL models, the method has demonstrated increased accuracy and reduced computation times. Deep learning algorithms have the ability to estimate complex functions through a directly defined composition of neuron operations. These algorithms are trained with sufficient datasets to find patterns and models based on learning. The DL algorithm requires a photo documenting all the teeth and surrounding tissues involved based on the direction in which it was taken, and a close-up photo of the teeth complained of or targeted using the scan feature in the application. The results of the photo display are generally consistent and clear. If the photos provide insufficient and unclear images, the DentMA application automatically instructs the user to retake the photos. The DentMA teledentistry application has been developed by Dr. Munifah since 2021, was tested (simulated) in the Banda Aceh community, and received intellectual property rights (IPR) number EC00202290700.

For the first step in the procedure for taking the intraoral photos, the researchers provided the participants' mothers with video tutorials on how to take intraoral clinical photos using smartphones. As noted, before starting the study, the researchers compared the results of scan application photos with the gold standard of direct examination of 100 photos taken at RSGM and obtained results with an accuracy above 90%. The researchers also provided headlamps and flyers through the healthcare center staff, which were given to the mothers for taking intraoral clinical photos of their children using the DentMA teledentistry application and the smartphone. Shortly before the photos were taken, the mothers cleaned their children's teeth with moistened cotton or gauze, had each child rinse their mouth, and then dried the teeth with gauze before photos could be taken using the DentMA application. Furthermore, all the participants' intraoral clinical photos and medical history results based on the patients' complaints about their teeth were collected and sent via email to expert or competent dentists for early detection through screening by observing the intraoral clinical photos and filling out the available odontogram forms.

Intraoral photo analysis at the screening level, mapping using a combination of the International Caries Detection And Assessment System (ICDAS) II system and the American Dental Association Caries Classification System, was conducted.[15] The expert or competent dentists mapped the intraoral photographs. This clustering method was also used by Giudice et al.[17] In addition, this study also used the dental caries with pulp involvement (P), ulcer due to trauma from the tooth (U), fistula (F) and abscess (A) abbreviated with PUFA index as an epidemiological measure of the clinical consequences of untreated dental caries. Lesions of adjacent tissues unrelated to visible teeth with carious pulpal involvement were not noted. Assessment was conducted visually without the use of instruments, following Marchianti et al.[21] In this study, early detection of the condition of the children's teeth was carried out; this consisted of examination of enamel-dentin caries (healthy tooth surface, no clearly visible cavities, but caries are present) and untreated caries status (PUFA) using the DentMA application.

The following is a description of the category of treatment needed, as documented in the 2018 National Basic Health Research report, based on the condition of the teeth and oral soft tissues:[2,7] Code 0: No treatment needed—hard and soft tissues appear visually healthy, and there is no obvious reason for the child to be examined before the

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next routine dental check-up; Code 1: Need treatment but not immediately—tooth decay or white spot lesions on one or more teeth or gum infection; Code 2: Need immediate treatment—obvious tooth decay appears in one or more teeth, there is evidence of severe injury or infection, or the child is experiencing pain.

The data used in this study underwent the chi-square test of the IBM Statistical Product and Social Science (SPSS) application, version 25. The research was conducted under a permit from the Ethics Committee of the Faculty of Dentistry, Syiah Kuala University No.316/KE/FKG/2021, and a research permit from the Public Health Office of Aceh Besar and the Public Health Center of Darussalam.

Table 1. Frequency distribution of participants based on age and sex

Gender	Frequency	Percentage (%)
Male	60	48.4
Female	64	51.6
Age		
4 years	50	40.3
5 years	50	40.3
6 years	24	19.4

RESULTS

The study was conducted with 124 participants who met the inclusion criteria. After the informed consent was shared online via Google Forms, the participants' mothers who agreed to participate were asked to take photos of their children's intraoral clinical from five directions: anterior, upper occlusal, lower occlusal, right lateral, and left lateral. The full results of the data collected are presented in Table 1, which shows that most of the children (n = 64, 51.6%) were female, and most participants (n = 50, 40.3%), were 4–5 years old.

As the results in Table 2 show, teledentistry can detect the condition of children's teeth based on the participants' complaints. The chi-square test results ($\alpha = 0.05$; $df = 1$) and the obtained p-value of 0.000 ($p < 0.05$) indicate that there is a significant relationship between participants' complaints and the early detection of dental caries.

As shown in Table 3, the teledentistry examination detected enamel-dentin caries in 74.1% (n = 92) of the children. This indicates that teledentistry can detect early dental caries based on patient symptoms or complaints and can allow for preventive measures before dental caries develop further.

Table 2. Frequency distribution of detectability based on participants' complaints using teledentistry

Participant's complaints	Enamel-dentin caries status (n = 68)		Untreated caries status (n = 81)		p-value
	Detected	Not detected	Detected	Not detected	
Toothache	68 (100%)	0 (0%)	56 (82.3%)	12 (17.6%)	0.000*
Loose tooth	0 (0%)	0 (0%)	3 (100%)	0 (0%)	
Swollen gum	0 (0%)	0 (0%)	8 (80%)	2 (20%)	

*chi-square test, significance ($p < 0.05$)

Table 3. Frequency distribution of dental caries detectability through teledentistry with and without participants' complaints

Criteria	Enamel-dentin caries status	Untreated caries status
Detected	92 (74.1%)	78 (62.9%)
Not detected	0 (0%)	14 (11.2%)

Table 4. Frequency distribution of early detection status of dental-enamel caries and treatment through teledentistry

Caries detection	Care Needs			p-value
	No treatment needed	Need treatment, but not immediately	Need immediate treatment	
Healthy tooth surface	5 (4.03%)	0 (0%)	0 (0%)	0.000*
No visible cavities	12 (9.67%)	15 (12.0%)	0 (0%)	
Visible cavities	14 (11.2%)	78 (62.9%)	0 (0%)	

*Chi-square test, significance ($p < 0.05$)

Table 5. Frequency distribution of the early detection status of untreated caries (PUFA index) and the treatment needs through teledentistry

Detected (n = 78)	Care Needs			p-value
	No treatment needed	Needs treatment but not immediately	Needs immediate treatment	
Pulp involvement	4 (5.12%)	12 (15.3%)	2 (2.5%)	0.000*
Ulceration	0 (0%)	0 (0%)	14 (17.9%)	
Fistula	0 (0%)	3 (3.8%)	34 (43.4%)	
Abscess	0 (0%)	0 (0%)	9 (11.5%)	

*Significance ($p < 0.05$)

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As Table 4 shows, screening using mobile phone teledentistry can detect caries and can determine the need for treatment ($p < 0.05$). The teledentistry revealed that the presence of cavitation or caries that reached the dentin was the most common condition (74.1%).

Based on the data presented in Table 5, early detection of dental caries in children through screening using mobile phone teledentistry can not only detect caries but also determine the need for treatment, as indicated by the results of the chi-square test ($\alpha = 0.05$; $df = 1$). As shown in Tables 4 and 5, the p-value = 0.000 ($p < 0.05$), which indicates that there is a significant relationship between enamel-dentin caries and the need for treatment and untreated caries with the need for treatment.

DISCUSSION

Teledentistry is a new field of dentistry based on electronics, telecommunications, the internet, and digital photography technology. It is used to connect patients living in rural areas.[22] Teledentistry during the COVID-19 pandemic was highly useful for many, enabling dentists to avoid direct contact with patients.[23] Teledentistry has been used in many sectors, including telediagnosis, teleconsultation, teletreatment planning, sharing clinical and radiological photographs, teletriage, teleprescriptions, and telemonitoring. Many studies assess the reliability of teledentistry using various devices, such as intraoral cameras, smartphones, WhatsApp images, email, and virtual consultation. However, while the potential use of teledentistry is highly promising, its application still faces many challenges.[11]

As Table 1 shows, the study participants included 60 boys and 64 girls, indicating that there were more females than males. This is in line with research conducted by Riawati et al.,[24] which states that more female respondents visited the Integrated Healthcare Center. Table 1 also shows that most participants were 4–5 years old, with 50 children (40.3%) in each group. This is also in line with Youventri et al.'s research,[25] which assessed the dental health of children at an early age, that is, aged 4–6 years. Participants aged 6 years were the least numerous in the present study (n = 24, 19.4%).

As Table 2 shows, teledentistry can detect the condition of a child's teeth based on perceived complaints. This is in line with the research results from Nutalapati et al.,[15] who state that consultation can be conducted using a teledentistry store-and-forward method, in which information in the form of complaints experienced by the patient is collected along with intraoral clinical photos to assist in establishing a diagnosis and appropriate treatment plan. As Table 2 shows, a p-value of 0.000 ($p < 0.05$) was obtained, which means that there was a significant relationship between the complaints in the medical history of the participants and the early detection of dental caries. This shows that teledentistry can detect the condition of patients' teeth based on perceived complaints. This is in line with research conducted by Fernandez et al.,[26] which reports that the identification of oral diseases, referral, and consultation of remote complaints using teledentistry is valid.

As Table 3 shows, teledentistry can detect dental caries early based on patient symptoms/complaints and can help encourage the use of preventive measures before the caries develop further. Before beginning the study, the researchers compared the results of scan application photos with the gold standard of direct examination of 100 photos taken at RSGM and obtained results with an accuracy above 90%. This is in line with research conducted by Subbalekshmi et al.,[6] which states that teledentistry has the potential to serve as a valid and reliable tool in screening teeth and early detection of dental caries. As shown in Table 4, the teledentistry revealed that the presence of cavitation or caries that have reached the dentin was the most common condition, with a total of 92 children (74.1%), and that there was a need for treatment, albeit not immediately, in the greatest number of children (78; 62.9%). This is in line with research by Alshaya et al.,[8] which reveals that in detecting caries, teledentistry has good sensitivity and specificity when compared with direct dental examinations. Detection of dental caries can be conducted reliably through teledentistry apps, including via the use of smartphones.[8]

As Table 5 shows, the most frequent need for treatment pertained to fistulas due to untreated dental caries, with 37 children (47.4%) needing immediate treatment and 34 children (43.4%) needing treatment, albeit not immediately. This is in line with research conducted in India by Shanbhog et al.,[27] who concluded that 37.7% of school-age children have untreated caries that cause fistula involvement around the affected teeth. Almost the exact same percentage (37.8%) was obtained in a study of children conducted by Costa et al.[23]

The results presented in Tables 4 and 5 indicate that early detection of dental caries in children is effectively carried out through screening by mapping of intraoral clinical photos and that this method can help determine the need for treatment. Furthermore, the research team also compared the scan results of the photo application with the gold standard of the direct examination of the teeth from several photos taken at random by visiting the patients' houses, obtaining the same results (valid and reliable). This is in line with research conducted by Subbalekshmi et al.,[6] who state that the early detection of dental caries through screening of digital images taken by the party who did the screening is highly effective, thus paving the way for the application of teledentistry as an effective means for early detection of dental caries and in determining the need for treatment.

Based on Tables 4 and 5, the obtained p-value (P = 0.000; $p < 0.05$) means that there is a significant relationship between enamel-dentin caries and treatment needed, as well as between untreated caries and treatment needed. This suggests that the DentMA teledentistry application based on DL can detect dental caries and determine the need for

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proper treatment. This is in accordance with the conclusion of Alabdullah et al.[28] that teledentistry has proven effective in terms of a method of remote screening, early detection and diagnosis, patient consultation, and treatment plan development. Research conducted by Alsharif et al.[29] states that the level of accuracy in some studies indicates that teledentistry using smartphones for intraoral digital photographic assessments has been proven significant by direct clinical examination, indicating that it has great potential in referring and in speeding up the wait time for consultations with dentists, especially during times such as the COVID-19 pandemic.[29,30]

Based on the results, it can be concluded that there is a significant relationship between the early detection of dental caries in children using the DentMA teledentistry application and the determination of the treatment needed. Teledentistry can detect dental caries and enamel-dentin caries, as well as further detect untreated caries in children based on their complaints, assisting in determining the treatment needed.

REFERENCES

1. Abed R, Bernabe E, Sabbah W. Family impacts of severe dental caries among children in the United Kingdom. Int J Environ Res Public Health. 2019; 17(1): 109.
2. Badan Penelitian dan Pengembangan Kesehatan. Laporan Nasional Riset Kesehatan Dasar 2018. Jakarta: Kementerian Kesehatan Republik Indonesia; 2018. p. 154–65.
3. Badan Penelitian dan Pengembangan Kesehatan. Laporan Provinsi Aceh Riskesdas 2018. Jakarta: Lembaga Penerbit Badan Penelitian dan Pengembangan Kesehatan; 2019. p. 283.
4. Setijanto D, Bramantoro T, Anggraini ND, Maharani AD, Angesti D, Hidayat DS, Ramadhani A. The correlation analysis of dental caries, general health conditions and daily performance in children aged 2-5 years old. Dent J. 2020; 53(3): 122–5.
5. Kunarti S, Saraswati W, Lashari DM, Salma N, Nafatila T. Enamel remineralisation-inducing materials for caries prevention. Dent J. 2021; 54(3): 165–8.
6. Subbalekshmi T, Anandan V, Apathsakayan R. Use of a teledentistry-based program for screening of early childhood caries in a school setting. Cureus. 2017; 9(7): e1416.
7. Regulation of Indonesian Minister of Health on dental and oral health. Peraturan Menteri Kesehatan Republik Indonesia nomor 89 tahun 2015 tentang upaya kesehatan gigi dan mulut. Jakarta: Kementerian Kesehatan Republik Indonesia; 2016. p. 1–250.
8. AlShaya MS, Assery MK, Pani SC. Reliability of mobile phone teledentistry in dental diagnosis and treatment planning in mixed dentition. J Telemed Telecare. 2020; 26(1–2): 45–52.
9. Lestari AA, Adiatman M, Darwita RR. Mapping of health care facilities, dental visits and oral health problems in Indonesia to prevent COVID-19 transmission. Dent J. 2022; 55(3): 154–60.
10. Talahatu LB, Kaban BE, Ayuningtyas NF, Brilyanti IN, Parmadiati AE, Radithia D, Pratiwi AS. Management of patients with aphthous-like ulcers related to aplastic anaemia in the COVID-19 pandemic era through teledentistry: A case report. Dent J. 2022; 55(1): 49–55.
11. Hariyani N, Shanbhag N, Wijayati EW, Prananta AW, Setyowati D, Palupi R. Teledentistry and online referral system in Indonesian primary health care center during the COVID-19 pandemic: A narrative review. J Int Soc Prev Community Dent. 2022; 12(4): 385–92.
12. Setianingtyas D, Nafiah N, Lukisari C, Teguh PB, Haryanto FE, Marlina E. The treatment of Covid tongue in an isolation unit. Dent J. 2021; 54(3): 155–9.
13. Estai M, Kanagasingam Y, Huang B, Checker H, Steele L, Kruger E, Tennant M. The efficacy of remote screening for dental caries by mid-level dental providers using a mobile teledentistry model. Community Dent Oral Epidemiol. 2016; 44(5): 435–41.
14. Bhaskar S, Bradley S, Chattu VK, Adisesh A, Nurtazina A, Kyrykbayeva S, Sakhamuri S, Yaya S, Sunil T, Thomas P, Mucci V, Moguilner S, Israel-Korn S, Alacapa J, Mishra A, Pandya S, Schroeder S, Atreja A, Banach M, Ray D. Telemedicine across the globe-position paper from the COVID-19 pandemic health system resilience program (REPROGRAM) international consortium (Part 1). Front public Heal. 2020; 8: 556720.
15. Jampani N, Nutalapati R, Dontula BSK, Boyapati R. Applications of teledentistry: A literature review and update. J Int Soc Prev Community Dent. 2011; 1(2): 37.
16. Javaid M, Haleem A, Singh RP, Suman R. Dentistry 4.0 technologies applications for dentistry during COVID-19 pandemic. Sustain Oper Comput. 2021; 2: 87–96.
17. Giudice A, Barone S, Muraca D, Averta F, Diodati F, Antonelli A, Fortunato L. Can teledentistry improve the monitoring of patients during the Covid-19 dissemination? A descriptive pilot study. Int J Environ Res Public Health. 2020; 17(10): 3399.
18. AlShaya M, Farsi D, Farsi N, Farsi N. The accuracy of teledentistry in caries detection in children – A diagnostic study. Digit Heal. 2022; 8: 205520762211090.
19. Amável R, Cruz-Correia R, Frias-Bulhosa J. Remote diagnosis of children dental problems based on non-invasive photographs - a valid proceeding? Stud Health Technol Inform. 2009; 150: 458–62.
20. Kale S, Kakodkar P, Shetiya S. Assessment of mother's ability in caries diagnosis, utilizing the smartphone photographic method. J Indian Soc Pedod Prev Dent. 2019; 37(4): 360–4.
21. Marchianti ACN, Sakinah EN, Diniyah N. The effectiveness of nutrition counseling on the first thousand days of life group in improving knowledge and attitude on nutrition awareness. J Agromedicine Med Sci. 2017; 3(3): 12–8.
22. Agarahari P, Jain A, Tangade P, Kumari T, Subhangi S. Teledentistry: Transforming dental care delivery and education in the digital age. Int J Dent Med Sci Res. 2023; 5(3): 581–6.
23. Böhm da Costa C, da Silva Peralta F, Aurelio Maeyama M, Goulart Castro R, Lúcia Schaefer Ferreira de Mello A. Teledentistry system in dental health public services: A mixed-methods intervention study. Int J Med Inform. 2021; 153: 104533.
24. Riawati D, Sari AN. Analisis faktor keteraturan kunjungan posyandu balita dan status gizi balita berdasarkan berat badan/umur. J Kebidanan Indones. 2019; 10(1): 137–46.
25. Youventri C, Adhani R, Sari GD. Hubungan perilaku ibu dalam pemberian edukasi kesehatan gigi dan mulut dengan rampan karies pada anak (Tinjauan pada ibu dan anak usia 4-6 tahun di TK Nusa Indah Berangas Kecamatan Alalak Kabupaten Barito Kuala). Dentin J Kedokt Gigi. 2020; 4(1): 11–5.
26. Fernandez C, Declerck D, Dedecker M, Marks L. Treatment needs and impact of oral health screening of athletes with intellectual disability in Belgium. BMC Oral Health. 2015; 15(1): 170.
27. Shanbhog R, Godhi BS, Nandlal B, Kumar SS, Raju V, Rashmi S. Clinical consequences of untreated dental caries evaluated using PUFA index in orphanage children from India. J Int oral Heal JIOH. 2013; 5(5): 1–9.
28. Alabdullah JH, Daniel SJ. A systematic review on the validity of teledentistry. Telemed e-Health. 2018; 24(8): 639–48.
29. Alsharif AT, Al-harbi SS. Dentists' self-perception on teledentistry: The changing landscape driven by technological booming in the 21stCentury. Open Dent J. 2020; 14(1): 291–7.
30. Pandey P, Jasrasaria N, Bains R, Singh A, Manar M, Kumar A. The efficacy of dental caries telediagnosis using smartphone: A diagnostic study in geriatric patients. Cureus. 2023; 15(1): e33256.

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