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## THESIS APPROVAL PAGE FOR MASTER OF SCIENCE IN ORAL BIOLOGY

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## **Evaluating the Diagnostic Interrater Reliability between Virtual and In-person Sick-call Examinations at a Military Dental Treatment Facility**

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Research satisfies AFDS Capabilities-Based Assessments: #8, 10  
and USU Operational Gap: V, D

### **Abstract**

Teledentistry, also known as "virtual" dental examinations, is an innovative approach to increasing access to care. The objective of this study was to evaluate the diagnostic interrater reliability between virtual and in-person examinations for patients seeking emergency dental care (sick call) at a military dental treatment facility. One hundred subjects received both virtual and in-person examinations on the same day, in a random order. The virtual examiner and subject were stationed in separate rooms and used only a laptop equipped with a camera, microphone, and speaker to complete the virtual exam. In contrast, the in-person examiner had access to all standard care modalities in a dental treatment room. After the first encounter, the subject proceeded to the corresponding virtual or in-person exam, and both examiners determined a diagnosis. Interrater agreement was determined between the two encounters for both diagnosis specialty category and diagnostic code using the Kappa coefficient. The results of the interrater analyses showed a Kappa of 0.644 for diagnosis specialty category ( $p < 0.001$ ) and a Kappa of 0.714 for diagnostic codes ( $p < 0.001$ ). Both analyses indicated "substantial" agreement. We conclude that teledentistry can be an effective tool for determining a diagnosis and improving access to care for dental emergencies at military dental treatment facilities.

## **Introduction**

The COVID-19 global pandemic created significant healthcare challenges due to individual isolation and the global response to limit the spread of the virus. In healthcare, access to care and face-to-face patient contact were severely restricted to limit virus exposure. With these obstacles, the pandemic has created opportunities for innovation in healthcare, as new means of access to care were developed to better serve patients. As patients have gained more access to technology and different communication platforms, telemedicine has been investigated as an unconventional method to improve access to care. The response to COVID-19 dramatically increased the utilization of telemedicine and other alternatives to limit the spread of the virus. Recent studies have shown that patients report high levels of satisfaction with telemedicine interventions (Polinski et al., 2015). Telemedicine allows patients to access healthcare via their phones and/or computers, which is an extremely cost-effective option as it allows patients to stay in their homes and avoid traveling. With the success of telemedicine, the use of teledentistry has also been explored as a more viable option to improve access to care, even though dentistry is heavily procedure-based.

Given that we are in an age where our mobile devices do far more than provide a means for communication, we are seeing a shift towards using our personal devices to manage our health. Lower income communities, which frequently face challenges in accessing quality healthcare, may also benefit from telemedicine and teledentistry. In the United States, 71% of lower income people own a smartphone, which shows that there is an opportunity to reduce this barrier to care (Xiao et al., 2021).

Teledentistry is the means of facilitating dental care, guidance, and education via technology as opposed to face-to-face communication. One of the earliest teledentistry projects, Total Dental Access (TDA), was started by the US military in 1994 to serve troops around the world by creating access to dental care that was not available at certain military locations (Rocca et al., 1999). Intraoral images were transferred via a modem, satellite, video teleconferencing equipment, or the internet from the area of operations to a specialist for consultation. Teledentistry can also increase access to dental care in remote communities and increase patient compliance and awareness of their oral health (Estai et al., 2016).

Extensive consideration has gone into implementing virtual appointments as it has become a favorable option to both patients and providers. One study conducted in Italy amidst the COVID-19 pandemic demonstrated that dental patients who were seen remotely immediately following their procedures showed evidence of good recovery and had no need for return visits; and although other patients still had concerns, there was no medical intervention needed during follow-up (Giudice et al., 2020). While the potential benefits of teledentistry have been identified, there are challenges with education and usage, training of employees, and the competency of equipment used to render images that allow for proper diagnosis and treatment. Other constraints include potentially poor internet access, lack of technical support, infrastructure complaints, and simply organizational incompatibility (Ghai, 2020). By introducing virtual dental appointments, diagnostic accuracy becomes pivotal as providers are limited to the amount of information they can obtain from a patient virtually, especially if the patient is a poor historian. Without access to quality images and equipment, it may be difficult for the provider to make an accurate diagnosis. Evaluating the diagnostic interrater reliability among providers in a “tele” or virtual encounter may allow the opportunity to visualize the inadequacies in the field of dentistry and illustrate strengths to enable teledentistry as a more routine dental practice.

In the armed forces, preventable dental issues that have been neglected may be further exacerbated when troops are deployed. The lack of access to care can lead to dental emergencies, which can in turn reduce the ability of our troops to fulfill their mission. Virtual dental examinations could play a crucial role in mitigating such dental issues. By assessing the diagnostic interrater reliability of virtual dental visits, we can determine whether this pragmatic approach can be implemented within our armed forces. Virtual dentistry can provide military members with access to diagnostic care that was previously unavailable. In the aftermath of the COVID-19 pandemic, virtual dental appointments can also help triage patients appropriately. Patients who are identified through a virtual examination as not needing an in-person examination can be scheduled for treatment immediately, reducing the influx of patients. Although research has shown the general benefits of telemedicine/teledentistry in terms of increasing access and improving oral health, there is limited research comparing the diagnostic interrater

reliability of teledentistry to in-person standard of care examinations in a military environment (Gurgel-Juarez et al., 2022).

The objective of this study was to evaluate the diagnostic interrater reliability of virtual and in-person examinations for patients reporting for an emergency dental examination (sick call) at a military dental treatment facility.

## **Methods**

The protocol (C.2022.075d) for this study was approved by the San Antonio Institutional Review Board. The study participants were selected from the 59th Dental Squadron at Joint-Base San Antonio, Lackland, Texas. The study was conducted in accordance with the American Dental Association (ADA) policies for teledentistry, which state that services delivered via teledentistry modalities should be at the same level as those provided for in-person encounters and should not be limited based on technology or location, as long as the healthcare provider is licensed (ADA Policy on Teledentistry, 2020).

Certain individuals, including basic military training (BMT) personnel, pregnant women, children, those who were physically incapable of using personal devices such as laptop computers (e.g., multiple sclerosis, polymyositis), and those who were mentally incapable (e.g., neurocognitive disorders, schizophrenia) or required translators were excluded from the study. Patients who presented with the need for emergent dental treatment were also excluded from the study and referred directly to the in-person sick-call examiner. The study was approved to consent 100 subjects, which provided an 80% power to detect a low effect size (0.28) at the alpha level of 0.05.

Potential study participants were given a brief overview of the study and provided with an informed consent and HIPAA authorization form to review and sign. Participants were then randomized to receive either a virtual or an in-person examination first. Both virtual and in-person examinations were conducted on the same day, with one encounter immediately followed by the other, in random order by licensed general dentists.

To reduce bias, the provider conducting the virtual exam only had access to a completed questionnaire which contained past medical history, current medications, social/family history, and chief complaint. Both the subject and virtual examiner utilized a

laptop (Latitude 5410, Dell, Round Rock, TX) with software (Military Health System Video Connect), camera, microphone, and speaker to complete the virtual visit in adjacent dental treatment rooms. The subject was allowed to point or indicate intraorally to describe their chief complaint. Based upon the individual subject concerns, the virtual provider formulated a diagnosis. Since the virtual provider was not given any access to radiographs or images, the diagnosis was based entirely upon the information that was verbally and visually provided by the subject via the computer monitor.

Upon completion of the virtual encounter, the patient then proceeded to complete the standard-of-care in-person examination with an in-person provider or vice versa, depending on the randomization. In contrast to the virtual examination, the standard-of-care in-person examination was conducted in a standard dental treatment room with dental chair, overhead lighting, and examination instruments. In addition, the in-person provider had access to any pre-existing radiographs or obtained new radiographs, as appropriate, to help formulate a diagnosis and treatment plan for the subject.

All examination data were de-identified and transferred to a password-protected spreadsheet (Excel, Microsoft, Redmond, WA). Diagnosis specialty category (i.e., endodontics, operative, orthodontics, oral surgery, periodontics, prosthodontics, temporomandibular disorder, and no treatment) and diagnostic codes (table 1) were analyzed side by side from both the virtual and the in-patient encounters. The diagnostic codes were provided by Centers for Medicare and Medicaid Services website (CMS.gov) and used as the primary endpoint to verify diagnostic interrater reliability between the virtual and in-person encounters. Interrater reliability refers to the consistency or agreement between two or more raters or observers in their judgments or ratings of a particular phenomenon or behavior. It is a measure of the extent to which different raters or observers arrive at similar conclusions or judgments. Interrater reliability can be quantified using various statistical methods, including Cohen's kappa. Kappa is a statistical measure that assesses the degree of agreement between two raters or observers beyond what would be expected by chance. It takes into account both the proportion of agreement and the proportion of disagreement between the raters or observers. Kappa ranges from -1 to 1, with values closer to 1 indicating higher agreement beyond chance (Cohen, 1960). A Kappa coefficient ( $\kappa$ ) was determined to evaluate the

interrater agreement between the in-person and virtual examinations using statistical software (SPSS, version 25, IBM, Chicago, IL). Cohen suggested that the Kappa results should be interpreted as follows: values  $\leq 0$  as indicating no agreement, 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement (Cohen, 1960).

## **Results**

A total of 100 subjects underwent the virtual and in-person examination in this study. Sixty-three percent of the subjects were male with an age range of 19-63 and mean of 32.2 years old. Thirty-seven percent of the subjects were female with a similar age range of 19-61 and mean of 31.4. The findings of the interrater analysis indicated that the Kappa coefficient for diagnosis specialty category was 0.644, with a statistically significant p-value of less than 0.001. According to the analysis, operative dentistry was the most frequently chosen diagnostic specialty category for 51.1% of the participants. The frequency of diagnosis specialty categories for virtual and in-person encounters is shown in Table 1. The interrater analysis for diagnostic codes yielded a Kappa of 0.714 ( $p < 0.001$ ), with K08.50 (unsatisfactory restoration of tooth) being the most commonly used diagnostic code, accounting for 18.2% of the subjects. The frequency of diagnostic codes for virtual and in-person encounters is shown in Table 2. Based on Cohen's guidelines, both interrater analyses suggest "substantial" agreement among the raters.

## **Discussion**

The start of the COVID-19 pandemic in 2020 forced many providers to examine different methods to provide care for their patients. Many studies have evaluated the effectiveness of providing teledentistry (and telemedicine) services to their patients, however, no studies have ever examined the diagnostic interrater reliability of comparing a virtual to an in-person examination in a military dental treatment facility. The findings of this study showed that there was substantial diagnostic interrater reliability in subjects who completed a virtual compared to an in-person examination.

There has been a surge of interest in the last few years in the field of teledentistry, as it has become an effective (although unconventional) method to increase access to

care. A recent systematic review of systematic reviews demonstrated that teledentistry is an effective means for dental referrals, treatment planning, compliance, and treatment viability (Gurgel-Juarez, et al., 2022). The authors found that the most common uses of teledentistry were virtual screening and diagnosis in pediatrics and oral medicine. Virtual dental assessments were comparable to in-person examinations, especially for diagnostic treatment planning and dental referrals. Greater accuracy was demonstrated when assessors had similar levels of education/experience, as was utilized in this study (Gurgel-Juarez, et al., 2022). A recent teledentistry study was completed using intraoral photographs from a smartphone camera to diagnose dental caries compared with standard clinical dental examination. The study showed that with a smartphone camera, teledentistry was a viable option to appropriately diagnose dental caries in a geriatric population with a mean kappa score of 0.909 (Pandey et al., 2023).

Given that most patients view teledentistry in a positive light, it is equally important that patients are being diagnosed correctly, given the limitations of a virtual exam (Polinski et al., 2015). With a virtual exam, dentists do not have access to diagnostic instruments or radiographic imaging; and may experience technical difficulties which can affect the correct diagnosis. This study provided a unique approach in that the same patients completed both a virtual and in-person examination, allowing the comparison of results from the same patient, even though they were seen by different providers. With access to imaging tools, in-person providers may make different diagnoses depending on the patient's presentation of symptoms versus a virtual examination.

As a society, we may be moving past the COVID-19 pandemic, however teledentistry may still be considered as a viable option especially in the Department of Defense (DoD). The purpose of many studies was to evaluate teledentistry as an option to increase access to care in communities where in-person examinations may not be feasible (Gurgel-Juarez, et al., 2022). This same logic can be applied to our DoD beneficiaries. Apart from the TDA (Total Dental Access) study completed in 1994 to serve troops who were deployed and increase their access to care, no studies have evaluated the effectiveness of teledentistry in a military environment. Given the positive interrater reliability between virtual and in-person examinations, teledentistry in the military may also allow greater access opportunities to our deployed service members. A dental

concern that could have been preemptively diagnosed or treatment planned virtually with minimal risk, may progress into a more serious invasive procedure, potentially preventing the service member from completing their mission. Teledentistry may also provide an avenue to deliver education on oral health, especially in areas where resources are limited, and oral hygiene may be sacrificed. Even though teledentistry is in its early stages, it is surely showing a positive response from patients and providers (Polinski et al., 2016).

One limitation of this study is its single-site design, which was conducted exclusively at a military dental treatment facility. As a result, the sample may not represent the entire patient population of the Department of Defense (DoD), which may limit the generalizability of the study's results to other military dental treatment facilities. Additionally, the study excluded basic trainees, who could have experienced unique dental emergencies not captured in the study's sample. Another limitation of this study was that the laptop equipment used to conduct the virtual examination was provided for subjects within the dental clinic. This may not reflect the experience of subjects who complete the virtual visit from their own home, where technical difficulties and connectivity issues may arise.

However, this study demonstrated the potential benefits of providing active military troops with access to virtual dental examinations, including expedited dental treatment processes and reduced time away from duty. The study's findings support a proof of concept for the use of virtual dental examinations in the military healthcare system, which may have practical applications for improving patient outcomes and healthcare efficiency in this context.

## **Conclusions**

The results of the study demonstrate that individuals who underwent a virtual examination at a military dental facility exhibited diagnostic interrater reliability very comparable to that of an in-person examination. These findings suggest that virtual examinations in dentistry may be a suitable alternative to traditional in-person examinations, particularly in the military healthcare context.

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Table 1: Frequency of Diagnosis Specialty Categories for virtual and in-person encounters

<b>Diagnosis Specialty Category</b>	<b>Virtual %</b>	<b>In-person %</b>
Endodontics	14	15
Operative	52	44
Oral Surgery	17	18
Periodontics	13	10
Prosthodontics	1	1
TMD	3	4
Orthodontics	0	1
Treatment Complete	0	1
No Treatment	0	6
Total	100	100

Table 2: Frequency of Diagnostic Codes for virtual and in-person encounters

<b>Diagnostic Codes</b>	<b>Virtual %</b>	<b>In-person %</b>	<b>Description</b>
B00.2	0	1	Herpes gingivostomatitis
G47.63	1	2	Bruxism-sleep related
J0190	3	4	Acute sinusitis, unspecified.
K01.1	7	9	Impacted teeth
K02.9	1	3	Unspecified dental caries
K03.1	1	2	Abrasion of teeth (Includes NCCL)
K03.2	1	1	Erosion of teeth
K03.81	2	2	Cracked tooth
K03.89	5	5	Dentin sensitivity
K04.02	11	8	Irreversible pulpitis
K04.1	1	4	Pulp necrosis
K04.4	4	3	Symptomatic apical periodontitis
K04.7	1	0	Periodontal abscess
K05.00	1	1	Gingivitis – dental biofilm-induced (Acute)
K05.01	3	1	Gingival diseases – non-dental biofilm induced (Acute)
K05.21	1	0	Periodontal abscess
K05.3	5	2	Chronic pericoronitis
K06.2	0	1	Gingival lesion associated with trauma
K08.3	1	1	Retained dental root
K08.50	19	18	Unsatisfactory tooth restoration
K08.531	14	14	Fractured dental restorative material with loss of material
K08.81	2	2	Primary occlusal trauma
K12.30	2	2	Oral Mucositis (Ulcerative)
K14.4	1	1	Glossitis
M27.3	2	2	Dry socket/alveolar osteitis
M27.62	1	1	Failure of dental implant due to periodontal infection (peri-implantitis)
M79.1	2	3	Myalgia
S02.5	8	7	Fracture of a Tooth (traumatic)
Total	100	100	