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A Comparative Analysis of Traditional Dental Screening versus Smart Phone Screening

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Abstract

BACKGROUND: Oral diseases are widely recognised for their substantial and adverse effects on the overall quality of life and well-being across the lifespan of individuals affected by them. The management of oral diseases imposes a significant financial burden on both a society and its constituents. The utilisation of technology in a suitable and effective manner can enhance the quality of life, serving as an indicator of good health. Teledentistry is a promising avenue for addressing the disparity in the provision and accessibility of dental healthcare services. This would facilitate the delivery of dental consultations to populations who face challenges in accessing or have limited availability of healthcare services, sometimes referred to as remote screening. Teledentistry presents supplementary opportunities that have significant value for contemporary dentistry. These include the provision of online consultations and the facilitation of secure and lawful transmission of patient data, referral letters, photos, and x-rays via mobile applications.

AIM: This study aims to prove concordance in accuracy and reliability between mobile smartphone photography for remote screening of teeth compared to traditional chairside dental screening.

METHODOLOGY: The study consisted of 152 participants over 18 years of age. The participants underwent dental examinations conducted by two evaluators. The dental examination was carried out in a room without windows, illuminated by fluorescent lighting fixtures. The oral cavity was illuminated using the dental chair's overhead light. Participants were evaluated in a standardised environment with uniform lighting conditions. The dentition was cleared of debris using gauze. Occlusal photographs were captured with the patient reclined on the dental chair, while the remaining three views (left and right lateral and frontal) were taken with the patient in a seated position. The trained chairside examiner utilised the data capture sheet and the diagnosis key to conduct the assessment. The offsite dental examination was performed by a dentist, in a room without windows, and lit by fluorescent lights integrated into the room's structure. The images were analysed using a designated smartphone and repeatedly evaluated under specified conditions. Photographs were standardised using the same type of phone, allowing for image transfer at the original resolution without any loss in quality. The trained off-site examiner used the data capture sheet and the diagnosis key to conduct the assessment.

RESULTS: The Cohen Kappa Statistic scores between clinical and photographic screening methods varied from 84% to 95% for both examiners, all considered high, and fell within the "Almost Perfect Agreement" region, demonstrating a high degree of agreement/concordance between the two dental examiners and methodologies (clinical and photographic examination). The Pearson correlation coefficient exceeded 0.90 across all data sets for the variables "DMFT," "D," and "M," indicating a high level of strength in most cases. This suggested a strong link between the Clinical and Photographic examinations, regardless of whether they were completed by the same or different examiners. There was no statistical significance observed in all data sets for "DMFT," "D," "M," and "F," as indicated by two-tail p-values that were significantly higher than the usually accepted level of 0.05. The high p-value was congruent with the elevated Kappa score, so offered corroborating evidence that both approaches appeared to be reliable for DMFT evaluations.

Based on the comprehensive examination of the five data sets, there were few statistically significant discrepancies among examiners in terms of both intra- and inter-examiner variability. In addition, there was no statistically significant difference detected between the outcomes derived from the clinical examination and the photographic assessment, implying that the captured images offered an accurate and reliable depiction of the clinical situation.

CONCLUSION: Teledentistry has the potential to improve oral health awareness and education in communities by addressing both the symptoms and underlying factors of oral health problems. The utilisation of this technology has the capacity to greatly influence the oral healthcare situation in South Africa, improving its accessibility, equity, and efficacy. Teledentistry examinations are as effective as traditional clinical examinations in detecting dental caries. This study provides empirical evidence supporting the potential use of teledentistry as a viable option for screening dental caries and enabling remote consultation and treatment planning.

Declaration

I, the undersigned, hereby declare that the work contained in this dissertation is my original work and that it has not been previously in its entirety or in part submitted at any university for a degree.

Dr Nuerisha Singh

Dedication

To my dearest Ashen, your unwavering belief in my abilities and your steadfast commitment to being by my side as I ventured forth on this journey holds a special place in my heart. You are the epitome of selflessness and dedication, your sacrifices have paved the way for me to fearlessly pursue my dreams.

Sweet Mila, your boundless optimism and vigour constantly serve as an important reminder of how much of responsibilities I was given when you entered my life as a mother and yet there are times when I find myself leaning on you for support. To you, my dear, I hope to impart my love for research just as you have witnessed me do.

To my dearest family: Mum, Dad, Riona and Shahil, as we embarked on this beautiful journey together, I want to dedicate myself wholeheartedly to cherishing our bond and the profound love that unites us.

I will forever endeavour to make you proud, for you are all my greatest source of inspiration and joy.

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To my esteemed mentor, whose academic attributes shine brighter than the stars.

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To my esteemed mentor, with heartfelt gratitude, I extend my deepest appreciation for the immeasurable impact you have had on my life. Your unwavering dedication to the pursuit of knowledge and your passion for research have ignited a flame within me that will forever burn bright. Through your guidance and mentorship, you have not only imparted invaluable wisdom but have also instilled in me a profound love for the art of research.

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To my esteemed mentor, your unwavering belief in my potential has allowed me to reach for the stars.

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DEFINITION OF KEY TERMS

COVID 19 Pandemic	A respiratory disease that is prevalent throughout the world caused by the SARS-CoV-2 virus through droplet spread (World Health Organization, 2021).
SARS-CoV-2 virus	Severe acute respiratory syndrome coronavirus 2 that causes the respiratory disease COVID 19 (Wang *et al.*, 2020).
Remote Dental Screening	Refers to a consultation that is performed over telephone or video call (Thompson *et al*., 2020). Remote dental screening can also be done with the aid of photographs, radiographs and clinical data that is shared from one clinician to another for a diagnosis.
Smartphone	A mobile telephone device that has a multitude of functions including some functions of a computer. A smartphone generally has a touch screen, internet access and the ability to download applications. A smartphone is capable of taking photographs (Stevenson, 2010).
Teledentistry	Teledentistry is a combination of telecommunications and dentistry involving the exchange of clinical information and images over remote distances for dental consultation and treatment planning (Nutalapati *et al*., 2011).
Mobile application	Mobile applications or apps are add-on software for handheld devices, such as smartphones and personal digital assistants (Adolph, 2009).
Vula Application	Vula is a medical referral app (that is POPIA compliant) that was built to conquer the challenges faced by health care workers in rural settings. The app allows for communication between health care workers. It is a means of seeking advice from specialists. It is also a means to refer patients to specialists (Morkel *et al*., 2019).

Table 1: Definition of Key Terms

CHAPTER 1
INTRODUCTION

The COVID 19 pandemic has changed the world. As a result, the world has to accept this new normal and inspired innovation to embrace it in a safe manner.

The World Health Organization described a pandemic as a worldwide spread of a new disease (Kelly, 2011). The world watched and observed the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which began in Wuhan (China). The Corona Virus belongs to the family of single stranded RNA viruses known as Coronaviridae (Pal *et al.*, 2020).

Importantly to oral health and the clinical practice of dentistry, the routes of transmission of the SARS-CoV-2 virus in the dental practice was identified as airborne spread, contact spread as well as contaminated surface spread. Therefore, dental professionals are at high risk for contracting the SARS-CoV-2 virus, simply because of the nature of clinical dentistry, which involves being in close proximity to the patient, working in an aerosol generating environment, handling sharp instruments and lastly merely by working within the oropharyngeal area (Cumbo *et al*., 2020), which emphasizes the need for tele dentistry.

One of the innovations that the pandemic has expedited is the use of information technology. The use of technology, therefore, not only aids as a resourceful tool during the pandemic but additionally bridges the gap between patients and health care professionals as well as between health care professionals. The use of online platforms has been existence for a while however due to the impact of COVID-19 usage has increased significantly in South Africa (Madonsela, 2021). Online platforms can be used for completion of pre-screening forms online and video consultations with a dental professional. In essence, it has emphasized that information technology and health care can work hand-in-hand (Maret *et al.*, 2020). With the possibility that COVID-19 and its effects may linger, the possibility of future pandemics, and the persistent problem of underserviced outlying communities, it is important that dentistry embraces what technology has to offer for example by the use of smartphone technology. Whether treated in the private or public health sector, all patients stand to benefit when technology and health care merge responsibly.

Health outcomes of a population are largely affected by the ability to have access to health care providers (Tanser *et al.,* 2006). Technology is a resourceful tool not only during pandemics but additionally it bridges the gap in underserved areas for those unable to access health care (Tanser *et al*., 2006). This is known as remote screening.

Teledentistry shows promising potential in its role in the upcoming implementation of the National Health Insurance (NHI), a health financing system, that will be funded by the tax paying citizens (Department of Health, 2020). It is anticipated that the NHI will provide free quality and affordable care to previously disadvantaged South Africans irrespective of their socio-economic status (Malinga, 2019a).

The need for universal coverage of health care in both developed and developing countries is increasing, and the provision of routine dental care cannot be overstressed. Concomitantly the demand for dental care has risen exponentially, especially in remote geographical locations (Tella *et al*., 2019). Barriers to oral health care include low health care provider to population ratio, high costs of dental care, poor infrastructure and inadequate dental facilities (Smit and Osman, 2017). Tella *et. al.,* (2019) reported travel distances to public dental facilities, no /lack of means of transportation as geographic barriers to dental care. The compounding effect of these barriers is the discrepancies on oral health care delivery between rural and urban communities. One of the modalities to alleviate these discrepancies in oral health is teledentistry.

The majority of South African citizens (83%) are dependent on the public health care system for their wellbeing (Ngobeni *et al*., 2020). The health system in South Africa is made up of the private sector and the public sector. The public sector is administered by the government and is separated into the primary, secondary and tertiary tiers (Mahlathi and Dlamini, 2015). Patients who require treatment beyond options available at the primary care health facility are then referred to a health facility in the second tier. Individuals that require more specialised treatment than that which is offered at a secondary level health care facility are referred to a tertiary level health facility. Dental services form part of the public health care system. The first line of intervention for oral disease is the primary care oral health services.

Access to healthcare services is directly affected by the number and spread of health care facilities within their geographical reach and the dentist: patient ratio. Tiwari *et al*., (2021) reported an inadequate ratio of dental practitioners (per 1000 population) within South Africa.

Poor oral health negatively affects a person's ability to function at an optimal level, be it physical or psychological. The outcomes of chronic oral diseases include, pain and sepsis, loss of teeth, poor masticatory function and compromised aesthetics. In addition, there may be reduced enjoyment of life experiences, failure to be part of society, poor self-esteem and malnutrition (Thema *et al.* 2013). Literature widely reports and emphasizes that oral diseases including dental caries, are among the most common and preventable non-communicable diseases (NCDs) worldwide. The 2017 Global Burden of Disease study indicated oral disease affected more than 3.5 billion people worldwide (GDB 2017 Disease and Injury Incidence and Prevalence Collaborators, 2018). The study showed caries as being the most common oral condition contributing an estimate of 2.3 billion to the oral disease pool. Five hundred and thirty million children had caries that affected the primary dentition.

Oral diseases are known to have a significant and negative impact on the quality of life and well-being throughout the entire lifetime of those affected (World Health Organization, 2018). The treatment of oral diseases places considerable economic burden on a society and its individuals (Sheiham, 2005).

As a marker of good health, quality of life can be improved with the appropriate use of technology. Teledentistry is an opportunity to bridge the gap between the availability and access of dental health services. It would enable the provision of dental consultations to populations that are unable to or have limited access health care (known as remote screening) (Alabdullah and Daniel, 2018). Additional, but valuable possibilities that teledentistry offers to modern dentistry, are to have online consultations or simple, safe and legal transfer of patient information, referral letters, photographs as well as x-rays via the use of mobile applications.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Exchange of clinical information or access to clinical care through information technology is referred to as telehealth. Access to the internet, together with the use of a smartphone is on an upward trajectory world-wide, bolstering communication between health care practitioners (Guo *et al*., 2021). Teledentistry can be described as the use telecommunications and dentistry involving the exchange of clinical information and images over remote distances for dental consultation and treatment planning. Mobile health often referred to as mHealth, a field of digital health, makes provision of health care through the use of smartphones, tablets and wearables (Wu *et al*., 2020). The smartphone is used most frequently.

Wu *et al.,* (2020) highlighted that mobile health technologies supported China's fight against COVID-19, and can be replicated globally. Figure 1 illustrates the workflow of mobile health which shows there is communication between the internet, an individual's smartphone, by means of Bluetooth and Wi-Fi.

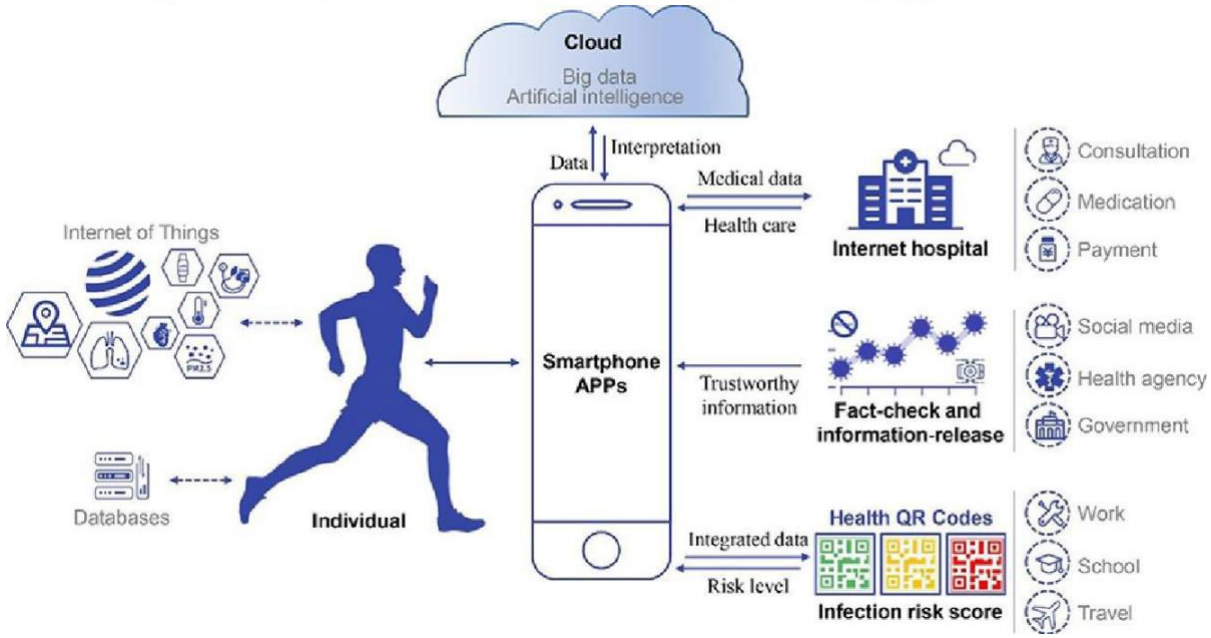

Figure 1: Workflow of Mobile Health (Wu *et al*., 2020)

Teledentistry has the potential to greatly reduce oral health inequalities that exist in a population. Highest disease burdens are often found in low and middle-income countries. For example, while Africa contributed to 10 % of the world's population and 3% of the entire global health workforce, the continent accounted for approximately a quarter of the global disease burden (Fortuin and Naidoo, 2015).

The Department of Health has a recommended a dental practitioner to patient ratio, of 1:60 000 (Smit and Osman, 2017). The latest mid-year population estimates for South Africa is 60 142 978 (Statistics South Africa, 2021). Tiwari *et al*., (2021), further reported an inadequate ratio of dental practitioners (per 1000 population) within South Africa. This challenge in combination with lack of accessibility to oral health services could result in untreated oral pathology, diagnostic delay of oral pathology, that would further comprise oral health status emphasising the need for remote dental screening.

Teledentistry can be advantageous in the remote screening process for the detection of early carious lesions that could ultimately see a reduction in the oral health disease burden and increase in the accessibility of oral health care. Wakhloo *et al.*, (2020) reported that teledentistry is useful for the exchange of clinical information and images over remote distances for dental consultation and treatment planning. The consultation process can be more relaxed and less strenuous. Often people with no or limited access to health care use home remedies rather than consulting with an oral health care worker, an option of remote screening, may discourage this practice.

As a third world country, South Africa is burdened with many challenges that include inadequate access to health care and education, an unstable economy and varying social environments, compounded by the effects of the COVID-19 pandemic. Innovative methods for remote screening are thus required. The literature collectively implies that teledentistry benefits the patient (those who require health care), the citizens (those who want to take responsibility for their health), and health care workers (who want to provide health care to those in remote settings) (National Department of Health, 2019). Research in this area would enable the provision of remote screening to vulnerable populations with access barriers, among other challenges, and eventually determine the impact that this method of screening might have on these populations.

An area for concern amongst colleagues is the use of WhatsApp (now shared by Facebook), to share sensitive clinical data between clinicians, raising many legal, regulatory and ethical issues. The WhatsApp platform is used as it is very user friendly, it saves time and data costs (Mars *et al*., 2019). However, WhatsApp is neither HIPPA nor POPIA compliant making it illegal to transfer sensitive health data about patients (Watson, 2020). The Vula App as a platform to aid teledentistry in South Africa is an important tool and is the official referral app in the Western Cape Province (Department of Health Western Cape, 2019)

2.2 Oral Disease Burden in South Africa

Primary oral health care clinics manage and treat the majority of the uninsured population (Ngobeni *et al*., 2020). Statistics South Africa (2018), reported that an estimated 81.7% of South Africans utilize the public health sector. Primary oral health clinics are also responsible for the diagnosis and referral of more complex oral disease to secondary and tertiary levels facilities for specialised management. The provision of such an essential service on a large scale requires thorough planning and effective implementation.

As an essential part of general health, oral health directly impacts the quality of life of all individuals (Miyazaki *et al*., 2017). The 47 countries of the African continent, as accounted for by the World Health Organization (WHO), have a distinctive burden of oral diseases and risk factor prevalence, which differed from other parts of the world (WHO, 2016). Although recognized as a low level of oral disease burden, it still accounted for much pain and disability. The WHO identified seven oral diseases and conditions that contribute as the major oral disease burden of the continent: these include dental caries, periodontal disease, oral cancer, Noma, oral manifestations of HIV and AIDS, oro-facial trauma as well as cleft lip and palate. They are widespread and mostly preventable or treatable (early stages) and require priority in management and surveillance (WHO, 2016). In addition, Naidoo *et al*., (2015), suggested that violence, motor vehicle accidents and injury, often occurring simultaneously with the effects of drug and alcohol abuse should be considered a concern for the region.

Smit *et al.* (2017), indicated that dental caries was the most prevalent oral disease in South Africa, with an alarming 60 % of children in the 6-year-old age category presenting with dental caries. There has been an increase in the caries rate over the past few years, and the trend appears to be on an upward trajectory.

Having a comprehensive perspective of the oral disease burden in the South African population is essential and illustrates the need for teledentistry. Mobile applications (Apps), as a form of teledentistry, will positively contribute toward improved health systems and serve significantly as a tool or adjunct in dentistry to lessen the burden of disease. Furthermore, teledentistry will enhance the referral system and facilitate a streamlined process of information transfer between clinicians.

2.3 Remote Dental Screening as a tool in the NHI

Remote dental screening can be done with the aid of photographs, radiographs and clinical data that is shared from one clinician to another for diagnosis. Data transmission can be conducted via 'the store and forward method' or real-time telephone or video call.

Intraoral photographs can be a valuable and reliable aid in diagnosis of pathology in the oral cavity (Estai *et al*., 2016). The benefits of remote dental screening are numerous and include:

- A reduction in transmission of communicable diseases between patients and staff;
- Affording patients in areas with no/limited access to dental care the opportunity to have dental care;
- Allowing patients who are isolating due to communicable diseases to have access to dental care and
- Allowing clinicians in remote areas (no access to tertiary level facilities) to carry out dental work on patients with the advice of dental specialists with certain dental procedures and within limits (Thompson *et al*., 2020).

A National Health Insurance (NHI) system endeavours to provide high quality health care to those in need and to improve health services to those that were previously disadvantaged. It is anticipated that every South African citizen will have access to a comprehensive package of healthcare services. The NHI is based on seven principles and has four objectives (Table 2). Treatment modalities that will be affordable and of a high standard. The NHI is expected to strengthen the health care system (Department of Health, 2011). If implemented successfully, the NHI should bring about positive changes in health care, thus reducing disease burdens.

Principles of the NHI	Objectives of the NHI
• The right to access • Social solidarity • Effectiveness • Appropriateness • Equity • Affordability • Efficiency **(Department of Health, 2011)**	• In order to enhance the access to high-quality healthcare services to all South Africans, regardless of their employment status. • The objective is to establish a unified fund that combines risks and resources in order to promote equity and social cohesion. • To effectively obtain services for the entire population and efficiently manage and allocate essential financial resources. • The objective is to enhance the performance of health systems by bolstering the under-resourced and overburdened public sector. **(Matsoso and Fryatt, 2013)**

Table 2: Principles and Objectives of the NHI

Although South African healthcare professionals have become progressively more comfortable with technologies such as artificial intelligence as well as online health applications, telehealth remains a largely untapped instrument in the local healthcare service delivery platform (Malinga, 2019b). In order to ensure streamlined processes prior to the commencement of the National Health Insurance (NHI) within the country, SA requires inclusive, coherent systems. This favours the use and positive growth for e-health services (Mzekandaba, 2015). Remote monitoring tools, mHealth as well as portal technology would play a significant role in the success of the NHI by streamlining processes, increasing efficiency and productivity, as well as expedite waiting times. Additionally, embracing health care technology would enhance capabilities by automating the process of decision-making and importantly ensure that health care workers are able to monitor and engage with patients remotely.

Processes, such as on-boarding technologies, will further facilitate speeding up patient queues as well as tedious administrative processes that are experienced in SA public healthcare facilities. Using telehealth (digital information and communication, i.e., computers and mobile devices) to enable access to healthcare services remotely will facilitate in earlier diagnosis and management of illnesses, avoiding lengthy severe disease, emergency admissions and avoidable deaths. This is of utmost importance as access to quality healthcare is a basic and constitutional right to all people within SA (Malinga, 2019a).

Furthermore, this technology assists the recorded-keeping process by providing the ability to store and share patient information for healthcare purposes. Patient identification can be simplified by using unique patient identity codes, which would enable identification of high priority cases as well as triaging patients more accurately. The current situation in public health facilities of SA dictate urgent innovation for information management systems. Long queues in healthcare facilities can be managed systematically through the electronic screening of patients prior to consultation, this would assist patients and healthcare professionals understand the case as well as the type of medical care that is potentially required (Malinga, 2019a).

In terms of domiciliary healthcare, computers and mobile devices would assist community health workers to conduct services and make decisions for further management or referral of patients, which would typically be made by nurses. This would advocate for more community health care workers in SA, which would facilitate the remote healthcare reach and significantly prolong lives as well as improve the health of vulnerable populations (Malinga, 2019a).

Previous reports suggested that although healthcare professionals in SA have expressed enthusiasm for digital healthcare technology as well as the remote access to digital health records; only 4 out of 10 healthcare professional use digital health records. This could be partly due to the challenges around infrastructure as well as the cost of establishing this type of infrastructure. Although these technologies have been available in some healthcare institutions in SA, the challenge is in the implementation across all health care institutions of the public health system, especially prior to the commencement of the NHI in SA (Malinga, 2019a).

Remote dental screening with the aid of technology (teledentistry) is a tool that illustrates inherent potential in decreasing the disparities that exist in oral health care across South Africa by alleviating some of the barriers to oral health care that is in existence.

The role of teledentistry as a tool in the NHI will play an in important part in the success of the NHI. The power of technology linked with automated decision making will ensure that doctors, nurses and community workers are able to remotely engage with patients (Malinga, 2019b).

2.4 Teledentistry and COVID 19 Pandemic

Evidence has predicted that the COVID 19 pandemic will eventually become endemic (Hunter, 2020). The goal is to avoid close contact with and between individuals. The word 'tele', is of Greek origin, meaning far away or distant; hence satisfying the social distancing rules and in turn preventing the spread of the SARS-CoV-2 virus. Teledentistry offers applications that include the remote triaging and screening of patients. Suspected carriers of the SARS-CoV-2 can be identified with the use of teledentistry and then advised to isolate, reducing the exposure of healthy patients and staff, whilst still providing the patient with emergency palliative care (Ghai, 2020).

2.5 Mobile Applications and its Utilization in Health Care

Masoni and Guelfi (2020), reported that medical and dental practitioners routinely use mobile application platforms to exchange private, confidential and sensitive patient information. The WhatsApp messaging system was developed in 2009, and had become a popular and convenient system that allows for the effective and prompt health care. However, it is non-compliant with the POPI Act, the GDPR and the US HIPA Act (Masoni and Guelfi, 2020). Although it is non-compliant with regulatory acts, it is routinely used to exchange patient data. This is illegal and this type of App needs to be at least POPIA compliant to make it useful to the dental profession for the exchange of patient data. The POPI act came into effect in South Africa on 30 June 2021.

As a type of teledentistry, the Vula App is a free, accessible, secure and compliant Application. It was developed in 2014 by a South African ophthalmologist William Mapham (Vula Mobile, 2021). The App is a medical referral app for primary healthcare workers to get advice from doctors and specialists and to refer patients to other doctors and specialists. The App connects health care professionals on a secure online system that is POPIA and HIPA compliant. This App has been advocated for use by the South African Government and who have advised that the App be implemented in all provinces and is the official referral app in the Western Cape

Province (Department of Health Western Cape, 2019). Mobile application and utilisation of Vula in dentistry offer benefits that include:

- Allows rapid evaluation of patients to determine if referral required.
- Created the opportunity for patient management at remote facilities.
- The app has a chat function which allows for communication between referring health care workers
- Data analysis of usage of app for referrals and referral outcomes is possible. Response time analysis is also possible. This function has the ability to provide information that results in improved quality of care to patients.
- Patient records and data exchanges are done over a secure and POPIA compliant platform (Vula - Secure Medical Chat, 2021).

2.6 Legal and Ethical Concerns Associated with the Sharing of Data in Dentistry

Embarking on the process to digitize health care, including dentistry, has posed many pertinent questions such as

- What should be the limits of information stored by the government of its citizens?
- How can that information be appropriately shared with persons and firms in the private sector in order to unlock its economic value?
- Why does it seem as if the technology changes faster than the law can respond?
- What rights does an individual have in the information about that individual?" (Cachalia and Klaaren, 2021).

The regulatory bodies of digital health care in South Africa are:

2.6.1 HPCSA- The Health Professions Council of South Africa is a statutory body that operates within South Africa to protect the public by governing and guiding health care professionals.

2.6.2 SAHPRA- South African Health Products Regulatory Authority is a subsidiary of the National Department of Health that acts to monitor, evaluate, investigate, inspect and regulate health products.

2.6.3 The South African Pharmacy Council is responsible for registration of pharmacists and pharmacies, manage education disseminated at undergraduate and post graduate level, and monitor levels of pharmacy practice.

2.6.4 The South African Nursing Council act to implement, monitor and evaluation nursing practices. The body is also responsible for providing standardised education and training of nurses.

At present the South African Department of Health has provided no legislative definition of digital health (Global Legal Group, 2021) and use the definition provided the World Health Organization (2019) "the field of knowledge and practice associated with any aspect of adopting digital technologies to improve health, from inception to operation" (National Department of Health, 2019).

In March 2020, the COVID 19 pandemic required the HPCSA to publish pertaining to E-health, in effort to allow patients to stay home and social distance whilst also obtaining a form medical care when required (Global Legal Group, 2021). The guidelines are as follows:

- Healthcare practitioners' conduct should be ethical and professional at all times, even when dealing with patients remotely
- Both the consulting and servicing healthcare practitioners must be registered either with the HPCSA if the practice is in South Africa or an equivalent regulatory body in the country where the servicing healthcare practitioner is based (if outside South Africa)
- Formal (preferably written) consent for among other things, specific services, including diagnosis and prescriptions and Information Communication Technology equipment to be used must always be secured from the patient
- Confidentiality for the patient and all information generated during procedures must always be respected
- The consulting practitioner remains responsible for the treatment, decisions and other recommendations given to the patient
- Routine and standard healthcare procedures, especially face-to-face consultation, physical examination and taking history from patients must be adhered to. Treatment, including issuing a prescription based solely on questionnaires or similar non-personal methods does not constitute an acceptable standard of care and,
- All records generated during the service about the patient and participating healthcare practitioners must be stored, using routine procedures and systems (HPCSA, 2020).

The General Data Protection Regulation (GDPR) was established by the European Union. Although it is the most comprehensive and sweeping regulation in place, it is far from being the only regulatory body protecting patient information. In 2013, South Africa passed the Protection of Personal Information Act (POPIA) that is regarded as the equivalent of the GDPR.

The goal of the POPI Act is to protect data subjects from security breaches, theft, and discrimination. To accomplish this, eight principles have been outlined that South African data processor should adhere to. Each principle encourages responsibility, security, and consent. It also provides special protections for distinct categories of data as well as the data of children.

The Protection of Personal Information Act 4 of 2013 aims:

- to promote the protection of personal information processed by public and private bodies;
- to introduce certain conditions so as to establish minimum requirements for the processing of personal information;
- to provide for the establishment of an Information Regulator to exercise certain powers and to perform certain duties and functions in terms of this Act and the Promotion of Access to Information Act, 2000;
- to provide for the issuing of codes of conduct;
- to provide for the rights of persons regarding unsolicited electronic communications and automated decision making;
- to regulate the flow of personal information across the borders of the Republic; and
- to provide for matters connected therewith

(South African Government, 2013).

The official date of commencement of the POPI act was 1 July 2020, with 30 July 2021 being the deadline for compliance to be met. The main focal area when considering teledentistry is the protection of sensitive data and the security of the data, therefore, any App used for health care reasons is required to be compliant.

2.7 Dental Photography

Dental photography helps patients to visualize their oral condition with the same perspective as the dentist. This in turn helps the patient understand the rationale for recommended treatment and allows diagnosis and comprehensive treatment planning of dental conditions by and oral health care worker. The use of photographs could offer an inexpensive and user-friendly screening alternative to dental examination (Guo *et al.*, 2021).

2.8 Diagnostic Criteria for Remote Dental Screening

Dental caries is regarded as a pathology of the hard tissue. The clinical appearance of oral disease in the form of tooth decay is known as a carious lesion. A diagnosed patient can have numerous lesions or just one lesion. Disease severity is a measure of the magnitude of the carious lesions as well as the number of carious lesions present.

ICDAS is the acronym for International Caries Detection and Assessment System. It is a clinical scoring system which allows detection and assessment of caries activity (Table 3) (Dikmen, 2015). Below (Figure 2) is a visual example of the ICDAS system that will allows for visual diagnosis of caries.

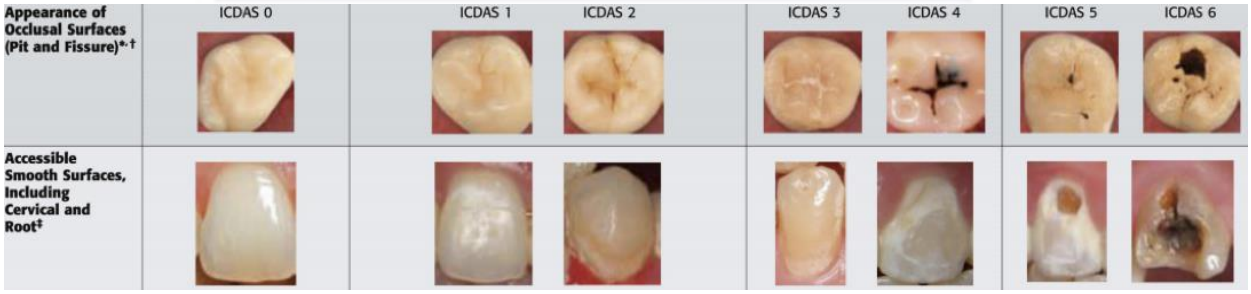

Figure 2: Visual Example of the ICDAS System (Young *et al.*, 2015)

SCORE	ICDAS criteria
0	Sound
1	First visual change in enamel
2	Distinct visual change in enamel
3	Localized enamel breakdown
4	Underlying dark shadow from dentine
5	Distinct cavity with visible dentine
6	Extensive distinct cavity with visible dentine

Table 3: ICDAS Scoring System (Dikmen, 2015)

DMFT (Decayed, missing, filled teeth) is one of the most commonly used indexes in epidemiology for the assessment of caries (table 4) (Moradi *et al*., 2020). DMFT is the sum of the 3 figures (D+M+T). A tooth with both a carious and a restoration is marked as D.

The World Health Organisation (2013) makes use of coding system (Table 4) in their oral health assessment form for children and adults as follows:

STATUS		
Permanent tooth		**Primary tooth**
0	Sound	A
1	Decayed	B
2	Filled & decayed	C
3	Filled, without decay	D
4	Missing due to caries	E
5	Missing any other reason	X
6	Sealant, varnish	F
7	Fixed dental prosthesis abutment, special crown or veneer/implant	G
8	Unerupted tooth	
9	Not recorded	

Table 4: World Health Organisation Coding System (World Health Organisation, 2013)

2.9 Concordance

The general definition of concordance is an "agreement or consistency" and/or a "state of harmony". Diagnostic concordance refers to the agreement of different diagnostic systems about an illness (Langenbucher *et al.*, 1996). There is limited evidence regarding the diagnostic accuracy of telemedicine. The definitions of diagnostic reliability (the agreement of different clinicians applying common diagnostic rules) and diagnostic concordance (the agreement of different diagnostic systems about a disease) have evolved over the past few decades. The simplest measure of reliability and concordance is percent agreement. This measure does not, however, control for chance agreement and, in most research, has been supplanted by Cohen's (1960) kappa (K) and other coefficients. Cohen's kappa is affected by low sensitivity (the proportion of ill patients who satisfy a diagnosis) and specificity (the proportion of well patients who do not satisfy a diagnosis) (Langenbucher *et al*. 1996).

Interventions to improve diagnostic agreement include the introduction of a standard assessment tool/diagnostic protocols that already exists in many other telemedicine applications. Decision support systems or diagnostic aids have been widely implemented to assist health professional's diagnosis using the ICT platform. Standard assessment tools and diagnostic protocols will permit all dentists to utilize teledentistry tools regardless of the level of experience.

A few studies have investigated the diagnostic reliability of teledentistry with concordance studies. Patterson and Botchway (1998) compared DMFT results using visual face-to-face dental screenings and dental screenings using intraoral images and diagnostic concordance ranged from 89% to 100%. Similarly, Kopycka-Kedzierawski *et al*. (2007) compared the two methods on 4–5-year- old children and found a 95% diagnostic concordance implying that there was no statistically significant difference between the screening methods. In the United Kingdom, 130 five-year olds and 140 ten-to-eleven-year-old children were visually examined by 5 calibrated examiners. The same children had intraoral images of their teeth taken which the same five examiners assessed for dental caries. Diagnostic concordance between the two methods ranged from 87.8% to 95.8% in the 5-year-olds and 58.5% to 71.7% in the 10–11-year-olds (Boye *et al.* 2013). A single study from South Africa reported a 93-98% diagnostic concordance between the examiners (Bissessur & Naidoo, 2019).

CHAPTER 3

AIM & OBJECTIVES

3.1 Aim

This study aims to prove concordance in accuracy and reliability between mobile smartphone photography for remote screening of teeth compared to traditional chairside dental screening.

3.2 Objectives

1. To determine the accuracy of diagnosis of DMFT using smartphone photography instead of traditional chair side screening
2. To determine the reliability of diagnosis of DMFT using smartphone photography instead of traditional chair side screening.

CHAPTER 4

METHODOLOGY

4.1 Introduction

This chapter presents the research design and methodology implemented in the present study. A cross-sectional study design, in line with the aims and objectives was used to analyse data at a single point in time to determine the prevalence of a health outcome. A pilot study was conducted on 10 participants prior to the commencement to ensure that conducive methods of dental examination and image acquisition were established. It established potential challenges that may have arisen and provided the researcher the opportunity to make changes for a more streamlined process for both participants and examiners.

4.2 Study Population, sampling technique and sample size

4.2.1 Study population

The study population consisted of parents/guardians, over the age of 18 years, of children who attended the paediatric dental clinic at the Tygerberg Oral Health Centre. This was to avoid selection bias: patients who present at screening need dental treatment and are not a good representation of the general population).

4.2.2 Sampling technique

A purposive sampling technique was used.

4.2.3 Sample size

The sample size of 145 was determined using the following calculation,

- kapssi 8, se(.085) p(.9)

Estimated sample size for kappa to achieve given standard error, the assumptions were:

- kappa = 0.8000
- m = 2 (number of raters)
- p1 = 0.9000 (rater 1 proportion of positive ratings)
- p2 = 0.9000 (rater 2 proportion of positive ratings)
- se = 0.0850

with a Kappa-statistic positivity rating of 0.8, a positivity rating 0.9, the expected **sample size is 145.**

4.3 Inclusion and Exclusion Criteria

4.3.1 Inclusion criteria

Participants:

- Parents/guardians of paediatric patients attending the paediatric clinic at the Tygerberg Oral Health Centre , over the age 18, who gave verbal consent and written consent to having their personal information and intra oral photographs taken and uploaded on to the Vula App.

Off-site screening dental examiners:

- Qualified dentists who were registered with the HPCSA who gave verbal and written consent to be part of this research study.
- Qualified dentist who was in possession of a smartphone with the capability to download the Vula App from the Android or Apple IOS App Store.

4.3.2 Exclusion Criteria

Participants:

- Parents/guardians of paediatric patients who attended the paediatric clinic at the Tygerberg Oral Health Centre, over the age 18, who do not give verbal and written consent to having their personal information and intra-oral photographs captured and uploaded on to the Vula App.

Off-site screening dental examiners:

- Dentist not registered with the HPCSA.
- Dentist who did not give verbal and written consent to be part of this research study.
- Dentist who were not in possession of a smartphone.

4.4 Data Collection Technique

4.4.1 Overview

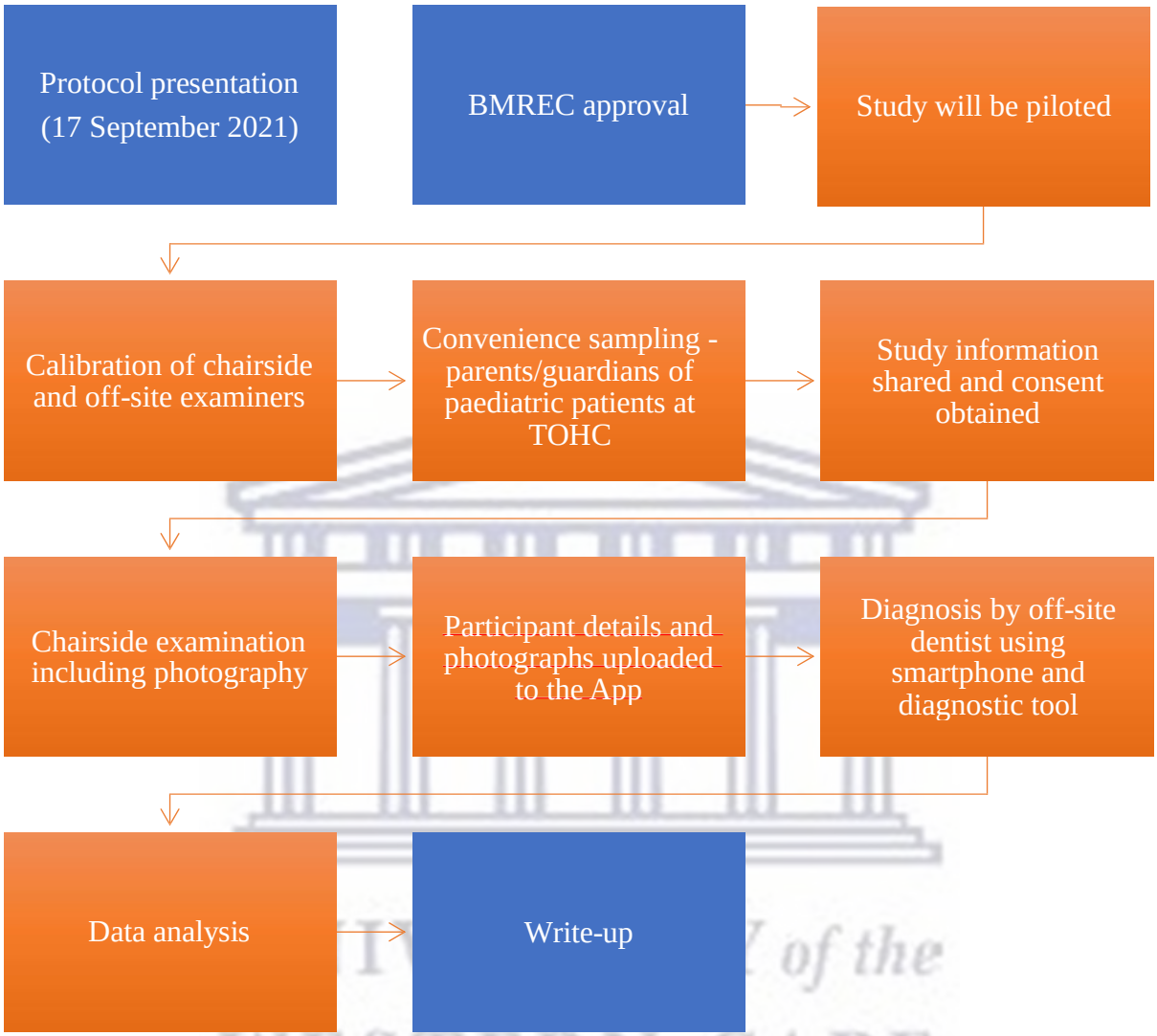

Figure 3: Workflow of the research project

The block shaded in the colour orange represented the methodology section, specifically the data collection technique, as well as the data analysis.

4.4.2 Mobile devices

4.4.2.1 Chairside dental examiner

The chairside dental examiner used an Apple iPhone XS. The phone has a 5.80- inch touchscreen display with a resolution of 1125x2436 pixels at a pixel density of 458 pixels per inch (ppi). The Apple iPhone XS is powered by a hexa-core Apple A12 Bionic processor. The camera of the Apple iPhone XS on the rear packs a 12-megapixel primary camera with an f/1.8 aperture and a pixel size of 1.4-micron, and a 12-megapixel camera with an f/2.4 aperture. The rear camera setup has autofocus. It sports a 7-megapixel camera on the front for selfies with an f/2.2 aperture. Apple iPhone XS is based on iOS 12 and packs 64GB of inbuilt storage" (NDTV Gadgets 360, 2021).

4.4.2.2 Offsite dental examiner

The offsite dental examiner was required to be in possession of a smartphone that had the capability to download and support the Vula App.

4.4.2.3 The Vula app

The Vula Mobile Platform is a cloud-based solution that provides a secure and compliant environment for the collection, processing and storing of all information. Both chairside and off-site examiners were required to download the App from the app store. Download and use of the App is free to users. Once each examiner downloaded and installed the Vula Mobile App, they were required to register via the App and provided personal information to complete their registration. The Personal Information provided was used to create their Vula Mobile Account and Vula verified them as a healthcare worker using their HPCSA number. The Vula mobile Platform is a secure medical chat and referral solution used by healthcare professionals only. The Vula Mobile Platform is cloud based and provides a secure and compliant environment for the collection, processing and storing of all information. Vula acts in accordance with the POPIA and HIPPA act (Vula - Secure medical chat, 2021).

4.2.2.4 Why use the Vula?

The Vula app is POPIA complaint and is advocated for use by the Western Cape Department as the official referral app in the Western Cape Province (Department of Health Western Cape, 2019) and is free to its users. The app has a built-in camera feature linked to the participant

profile, this allows for the photographs to be stored on the cloud (securely), linked to a participant name and clinical information. This prevents any confusion, as opposed to photos in a gallery on the screeners phone that can be lost or confused for another patient.

4.4.3 Chairside dental examination and image acquisition process

Chairside dental screening was done by the primary researcher (chairside dental examiner) at the Tygerberg Oral Health Centre. Consent was acquired from the participants prior to examination for:

- Participation in study
- Image acquisition
- Permission for personal details to be loaded onto the Vula app.

The chairside dental screening involved the use of a basic examination set, featuring a mirror and a WHO explorer probe. The dentition was assessed and charted on the data collection sheet as either sound, decayed, filled with decay, filled with no decay, missing as a result of caries or not recorded (Appendix 5). The dental examination was done with the patient in the supine position, utilising the light from the dental chair to enhance visibility. The study information was shared with the participant. Patients that required further treatment were referred to the appropriate clinical department.

All debris was removed from the participants dentition with use of gauze. An electronic folder was opened for the participant on the Vula App. The participant information and images were be safely stored in the corresponding online in an App-cloud-based system. This ensured that there is a proper tracking system. Security of data was and will be maintained at all times with the use of protective passwords and biometrics of the examiners. Confidentiality and anonymity were maintained at all times.

Gloved fingers of the dental assistant were used to retract the soft tissue to enable a clear field of vision and exposed dentition. The cell phone camera was focused on the dentition only and not on the face of the participant. Images of the oral cavity were obtained using a smartphone camera via the Vula App. The images could be viewed immediately on the cell phone. Unclear images were retaken. The chairside dental examiner determined the clarity of the picture as per the training session to ensure clear, focused photographs were stored for offsite examination at a later stage.

The photographic process was a non-invasive and pain-free, with as little or no discomfort to the participant. The image questioning process took up to 10 minutes per participant. The charting process took up to 10 minutes. The total participant time in the chair was up to a maximum of 30 minutes.

The photograph was captured in a windowless examination room. The room was illuminated with the standard built-in fluorescent lighting in the surgery. The oral cavity was illuminated with the overhead light attached to the dental chair.

With respect to COVID-19 protocols, the smartphone was wrapped in cling film, only exposing the camera. The phone was wiped down with alcohol and the cling film was changed after image acquisition for each patient. Intra-oral photographs were taken without removable dental dentures. Photographs included ONLY the mouth and teeth and not the patient's face, nose, and eyes.

Guidelines for dental photography (Figure 4), required for diagnosis of teeth that were sound, decayed, filled with decay, filled with no decay, missing as a result of caries, and not recorded:

- Front view in occlusion (a)
- Upper occlusal view (b)
- Lower occlusal view (c)
- Left lateral view in occlusion (d)
- Right lateral view in occlusion (e)

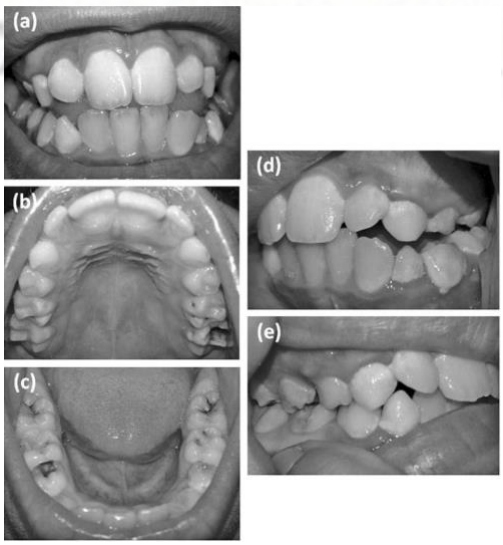

Figure 4: Photography acquired with smartphone (Estai *et al.*, 2017)

Occlusal photographs were taken while the patient was fully reclined on the dental chair; the other 3 views (left and right lateral and frontal) were taken in a sitting position. All photographs were taken with the camera's flash switched on.

Upon completion of the traditional dental screening and the intraoral imaging process, the images, along with patient details, were uploaded onto the Vula App for assessment by an off-site dental examiner. The images, along with patient information, were accessed by the off-site dentist for diagnosis of dentition that were either sound, decayed, filled with decay, filled with no decay, missing as a result of caries, and not recorded (with use of the screening form).

These were compared to the (benchmark) chairside dental screening that had been conducted by the primary researcher.

4.4.4 Summary

4.4.4.1 Viewing and examination conditions of the Chairside dental examination

The dental examination took place in a windowless room illuminated by built-in fluorescent lighting. The oral cavity was illuminated using the overhead light attached to the dental chair. Participants were examined in the same room, always using the exact same lighting. All debris was removed from the dentition using a piece of gauze. Occlusal photographs were taken while the patient was fully reclined on the dental chair; the other 3 views (left and right lateral and frontal) were taken in a sitting position. The calibrated chairside examiner was trained to carry out the assessment with the aid of the data capture sheet (Appendix 4) and the key for diagnosis (Appendix 5)

4.4.4.2 Standardization

The study required standardized presentation of the photographs, which included picture quality, size, and resolution. All photographs were taken in the same room, against the same background, and with the same smartphone camera, the iPhone XS. The iPhone XS had a built-in 12-megapixel primary camera with an f/1.8 aperture and a pixel size of 1.4-micron, as well as a 12-megapixel camera with an f/2.4 aperture. All the photographs were taken with an Apple iPhone XS, with a resolution of 1125x2436 pixels at a pixel density of 458 pixels per inch (ppi). The size of each image was about 6 MB. Photographs were taken in photo mode with no f-stop adjustment at 1X zoom. The flash was always used to take photographs.

Photographs included ONLY the oral cavity and dentition and not the recognizable features of the patient (face, nose, and eyes). Guidelines for dental photography (Figure 4), which were required for the diagnosis of teeth that were sound, decayed, filled with decay, filled with no decay, missing as a result of decay, and not recorded, were as follows:

- Front view in occlusion (a) - 30cm away from the patient, taken in a sitting position on a chair (Figure 5)
- Upper occlusal view (b) – 15cm away from the patient, taken while the patient was fully reclined on the dental chair
- Lower occlusal view (c) – 15cm away from the patient, taken while the patient was fully reclined on the dental chair
- Left lateral view in occlusion (d) - 15cm away from the patient, taken in a sitting position on a chair (Figure 5)
- Right lateral view in occlusion (e) - 15cm away from the patient, taken in a sitting position on a chair (Figure 5)

Figure 5 : Sample of Patient Chair for Photography

4.4.4.3 Viewing and Assessment Process of the Offsite Dental Examination

The offsite dental examination was conducted by a qualified dentist, who during undergraduate training had been equipped with adequate diagnostic experience gained as a core competency. This step took place in a windowless room illuminated by built-in fluorescent lighting. The images were only examined from the allocated smartphone, the iPhone XS screen. The images were assessed under these conditions repeatedly. The offsite examination did not take more than 15 minutes per participant.

The same type of phone was used to standardize the presentation of the photographs, which facilitated image transfer at the same resolution of the original photograph captured, without reducing the image quality. The photograph was viewed in a landscape view on 625 cd/m2 maximum brightness on a 5.8-inch (diagonal) all-screen OLED Multi-Touch display (all the same properties of the phone used to take the image, to have a standardized viewing process).

The examiner was allowed to zoom in to certain areas if the need arose. The calibrated off-site examiner was trained to carry out the assessment with the aid of the data capture sheet (Appendix 4) and the key for diagnosis (Appendix 5).

Resolution & Diagnosis

It was anticipated that by utilizing the same type of smartphone (with the same picture quality settings) at each site, there would be standardization of photographs for this study as well as for similar studies in the future. In addition, by using the same phone type, this also removed the possibility of a smartphone having more or less advantages when compared to a different type of smartphone. It was important for photographs to be standardized so as to ensure direct comparisons and concordance

4.4.4.4 Utility

Two methods of dental screening were employed, namely, a chairside dental screening and a remote off-site dental screening. The benefit of chairside examinations was that the examiner was able to build a rapport with the patient, ask probing questions based on the information that patients revealed, as well as have a visual and tactile sensory advantage. Furthermore, additional investigations that were required could be done much faster to alleviate pain and sepsis.

The limitations to chairside dental screenings include exposure to communicable diseases such as COVID-19 (SARS-CoV-2 virus) and tuberculosis, the availability of a dentist and dental equipment, and geographical barriers, that have been cited as challenges with oral health care provision (Smit and Osman, 2017). On the other hand, remote dental screening is beneficial as it reduced the challenges of lack of a dentist, dental equipment, as well as geographical barriers. Importantly, remote screening protected both the patient and health care provider from unnecessary exposure to communicable diseases.

Although at a tactile sensory disadvantage, examiners were able to improve the accuracy of diagnosis by using various features such as the zoom and brightness functions available with smartphone photography. However, this method was not without its limitations, which largely included the availability of smart mobile devices and availability of internet connectivity.

4.4.4.5 Improvements on both chairside and remote off site dental screening

This was determined following the piloted study on 10 participants

4.4.4.6 Role of the Off-site Dental Examiner

The offsite dental examiner was able to access the photographs via the Vula App. The App user was unable to download the photographs. The off-site dental examiner was calibrated to utilize the data capture (screening) sheet (Appendix 4). An off-site oral screening was performed, recording teeth that were sound, decayed, filled with decay, filled with no decay, missing as a result of caries, or not recorded.

4.5 Standardization and Calibration

The methodology followed in this study was adapted from the WHO Oral Health Survey: Basic Methods (2013). This ensured standardized procedures were followed, which would be reliable and comparable internationally. In an effort to maintain consistency throughout the study, the primary researcher, who is a qualified dentist, conducted the chairside dental screening and took dental photographs. The off-site dentist conducted the remote dental screening. Both dentists were calibrated by an expert in the field of epidemiology, referred to as the "gold standard" for inter- and intra-variability.

Prior to the commencement of the study, inter-observer calibration and intra-observer calibration were carried out for the examiners. Calibration ensured:

(i) Certainty in consistent interpretation, understanding, and application of the criteria for recording the caries detected.

(ii) Each examiner was able to diagnose caries to a consistent standard that was set.

(iii) A decrease in the amount of variation in caries diagnosis between the two examiners

4.5.1 Calibration

Ten participants were randomly selected to have a chairside dental screening. The participants were each seen twice over two consecutive days. By comparing the results of the two examinations, the examiner was able to obtain an estimate of the extent and nature of the diagnostic errors. Should the level of agreement between the examinations not meet the recommended minimum level, the examiner reviewed the interpretation criteria and additional calibration examinations were conducted until an acceptable consistency was achieved.

Ten participants' online profiles were analysed by the off-site dental screener over two consecutive days. By comparing the results of the two examinations, the examiner was able to obtain an estimate of the extent and nature of the diagnostic errors. Should the level of agreement between the examinations not meet the recommended minimum level, the examiner reviewed the interpretation criteria and additional calibration examinations were conducted until an acceptable consistency was achieved.

4.6 Assistant Training

The dental assistant was trained prior to the study to aid the dentist by retracting the cheeks with their gloved fingers to ensure standardization, obtain quality images, and eliminate bias. The assistant had two training sessions.

Further training regarding the use of the accompanying software (Vula) was also provided to both the chairside dental screener and the off-site dental screener. This training was done by a representative from Vula. On-going technical support to troubleshoot any difficulties during the entire data collection process was provided by Vula.

4.7 Data Analysis

The Cohen Kappa statistic was used for analysis of the data. The Kappa statistic is a metric that was utilized to assess concordance in diagnosis between the chairside dental examiner and the offsite dental examiner, with scores being calculated with the use of a 2 X 2 Table. When applied to recording dental caries at the tooth level:

- a represented the proportion of the dentition that both the chairside dental examiner (examiner 1) and off-site dental examiner (examiner 2) considered sound.

- b represented the proportion of the dentition the chairside dental examiner (examiner 1) considered sound, and the off-site dental examiner (examiner 2) considered carious.
- c represented the proportion of the dentition the chairside dental examiner (examiner 1) considered carious, and the off-site dental examiner (examiner 2) considered sound.
- d represented the proportion of the dentition that both the chairside dental examiner (examiner 1) and off-site dental examiner (examiner 2) considered carious.

The formula for the Kappa statistic is:

$$\varkappa = \frac{P_o - P_e}{1 - P_e}$$

The calculation of the Kappa score is seen below

Examiner 2	**Examiner 1**		
	Sound	*Carious*	**Total**
Sound	a	c	a + c
Carious	b	d	b + d
Total	a + b	c + d	a + b + c + d

where:

P_0 = proportion of observed agreement (a + d);

P_e = proportion of agreement that could be expected by chance (a + c) × (a + b) for sound teeth, and (b + d) × (c + d) for carious teeth. Hence

$$P_e = \frac{(a+c)\times(a+b)+(b+d)\times(c+d)}{(a+b+c+d)^2}$$

The interpretation of the Kappa Statistic is as follows:

- <0.20 - poor agreement
- 0.21–0.40 - fair agreement
- 0.41–0.60 - moderate agreement
- 0.61–0.80 - substantial agreement
- 0.81–1.00 – almost perfect agreement

(World Health Organization, 2013)

4.8 Risks and Benefits of the Study

There were no foreseeable risks associated with the present study. Patients found to have any oral health problems were referred for further treatment to the respective departments. It was anticipated that the present research study will enable the provision of remote screening to vulnerable populations with access barriers and other challenges and may eventually determine the impact that this method of screening might have on these populations.

4.9 Ethical Considerations

Ethical approval was obtained from the Biomedical Research Ethics Committee of the University of the Western Cape (Ethics Ref No. BM21/10/28, Appendix 6). Additional registration of the study on the National Research Database was required in order to have access to the patients of the Department of Health (Western Cape) and the respective research administrative bodies. Participation was voluntary. The participants in the study were informed that their anonymity would be maintained at all times and that they had the right to withdraw from the study at any time during the research project without penalty. The privacy of the information collected from each participant's medical records was and will be respected.

CHAPTER 5

RESULTS

5.1 Introduction

This chapter presents the findings pertaining to the comparison between traditional dental screening and teledentistry screening in detecting dental caries. A comprehensive statistical analysis was performed on a collection of five datasets. The following datasets have been analysed and are presented in this Chapter:

- Clinical Examination (Examiner 1) versus Photographic Examination (Examiner 2)- 145 observations
- Clinical examination (Examiner 1) versus Photographic Examination (Examiner 1)- 145 observations
- Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 2)- 145 observations
- Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 1)- 14 observations
- Photographic Examination (Examiner 2) versus Photographic Examination (Examiner 2)- 14 observations

The statistical measures of p-value, correlation coefficient, kappa coefficients were computed and examined. The analysis includes the components of inter-rater reliability, intra-rater reliability, and accuracy.

Within the field of statistics and research design, the notions of inter-rater reliability, intra-rater reliability, and accuracy play distinct roles and are employed to assess various facets of a measurement system, classification job, or predictive model.

Inter-rater reliability refers to the degree of concordance observed across multiple raters or evaluators who evaluate a shared collection of variables. In essence, this assessment aims to evaluate the degree of agreement in measurements conducted by different individuals, who employ identical methodologies or tools. Cohen's Kappa is often employed statistical techniques for evaluating inter-rater reliability.

Intra-rater reliability refers to the extent of concordance shown in repeated measurements conducted by a single rater in identical circumstances. The aforementioned type of reliability holds significance in situations where raters are tasked with making multiple measurements over a period of time. The primary focus of this inquiry pertains to the extent of consistency exhibited by a certain evaluator in their evaluations across various occurrences.

Accuracy in statistics is commonly defined as the degree of proximity between a measured or calculated value and its real or true value. The performance of a classification model is commonly assessed by a metric known as accuracy, which is determined by dividing the number of correct predictions by the total number of predictions. The probability of a correct classification occurring by chance is considered when calculating accuracy using the Kappa statistic.

The Cohen Kappa test is a statistical measure used to assess the agreement between two raters, specifically examiner 1 and examiner 2 in this study. Table 5 presents an overview of the interpretations assigned to the kappa scores.

Kappa Value	Interpretation of Kappa	
<0.00	Poor	Less than chance agreement
0.01 to 0.20	Slight	Slight agreement
0.21 to 0.40	Fair	Fair agreement
0.41 to 0.60	Moderate	Moderate agreement
0.61 to 0.80	Substantial	Substantial agreement
0.81 to 0.99	Almost perfect	Almost perfect agreement

Table 5: Interpreting kappa scores (World Health Organization, 2013)

5.2 Demographics

In the present study, a cohort comprising 152 individuals, aged above 18 years underwent dental examinations conducted by two evaluators. The purpose of the examinations was to assess the agreement and dependability between two distinct dental screening techniques: the conventional dental screening method and the teledentistry screening method.

A total of seven adult participants were excluded from the study due to their edentulous condition, therefore the final study sample was 145 adult participants (41 male and 104 female) (Table 6) with intact dentition. The sample was parents or guardians of children who are receiving dental care at the Tygerberg Oral Health Centre's paediatric dental clinic. The mean age for the participants was 40.23 years.

Sex	**Frequency**	**Percent**	**Cumulative total**
Male	41	28.28	28.28
Female	104	71.72	100.00
Total	145	100.00	

Table 6: Gender Distribution

5.3 Description of Data Sets

5.3.1 Clinical Examination (Examiner 1) versus Photographic Examination (Examiner 2)

Kappa Coefficient	t-Test: Two-Sample Assuming Equal Variances for "DMFT", "D", "M' and "F" for Clinical Examination (Examiner 1) versus Photographic Examination (Examiner 2)				
				Mean	
		Pearson Correlation	p(T<=t) two-tail	Clinical Examination (Examiner 1)	Photographic Examination (Examiner 2)
0.846 Almost perfect agreement	DMFT	0.98	0.489	12.37	12.99
	D	0.94	0.054	3.85	4.6
	M	1.00	1.000	7.72	7.72
	F	0.93	0.299	0.80	0.59

Table 7: Kappa Coefficient and t-Test: Two-Sample Assuming Equal Variances for "DMFT", "D", "M' and "F" for Clinical Examination (Examiner 1) versus Photographic Examination (Examiner 2)

The Kappa coefficient of 0.846 (Table 7) suggests a high level of agreement between the photographic examination results conducted by Examiner 1 and those by Examiner 2, approaching near-perfect agreement. The obtained high Kappa value indicates a strong level of agreement and consistency in the assessments of dental variables "DMFT", "D", "M", and "F". This finding supports the reliability and concordance of the evaluations.

The Pearson correlation coefficients are utilised to quantify the magnitude and orientation of linear associations between two variables that are continuous in nature. The agreement and coherence observed in the evaluations of dental variables between the two examiners. A Pearson correlation coefficient of 0.98 (Table 7) signifies a complete positive linear association between the "DMFT" scores acquired by both examiners. This implies that alterations in the "DMFT" scores of one examiner are directly aligned with alterations in the scores of the other examiner, thereby emphasising a significant level of agreement and dependability in their assessments (Figure 6). The Pearson Correlation coefficient of 0.94 (Table 8) indicates a highly significant positive linear association between the "D" scores assigned by the two examiners (Figure 6). The strong correlation observed suggests a close alignment between their judgements of the amount of decaying teeth, therefore providing more support for the dependability and consistency in their opinions.

The Pearson Correlation coefficient of 1.00 (Table 7) indicates a robust positive linear association between the “M” scores reported by both examiners (Figure 8). This implies that the evaluations of the number of absent teeth are strongly interconnected, suggesting a notable level of agreement and similarity. The Pearson Correlation coefficient of 0.93 (Table 8) suggests a positive linear association between the F scores provided by the two examiners (Figure 9), albeit marginally lower compared to other variables. This finding indicates a considerable degree of concordance and reliability in their evaluations pertaining to fillings.

The p-value for the two-tailed test conducted on the "DMFT" variable is 0.489, as indicated in Table 8. In Table 8, the two-tailed p-value for variable "D" is found to be 0.054, while for variable "M" it is determined to be 1. Additionally, the two-tailed p-value for variable "F" is calculated to be 0.299. The calculated p-value slightly surpasses the conventional significance level of 0.05, suggesting that the observed difference between the two methods is not statistically significant, although the difference is small. The statistical analysis indicates that the p-values indicate a lack of statistical significance in the observed differences in means between the two techniques, notably in the case of "F".

The Kappa coefficient of 0.84, indicating nearly perfect agreement, provides strong support for the accuracy of measurements, which refers to the degree of alignment with true values. This implies that the assessments made by Examiner 2 exhibit a high level of consistency with their own previous assessments, so minimising the likelihood of systematic errors and improving the overall accuracy of their evaluations.

Inter-rater reliability evaluates the degree of consistency in assessments conducted by the two examiners across multiple instances. In the present case, the Kappa coefficient of 0.84 signifies a high level of agreement between Examiners.

The presence of concordance, which includes both reliability and agreement, is seen in the substantial Kappa coefficient of 0.84 and the robust Pearson correlations. The aforementioned results indicate the presence of consistency, denoting reliability, as well as a notable level of agreement, referred to as concordance, in Examiner 2's judgements over a period of time. The assessments exhibit a high degree of alignment, suggesting a significant concurrence in their recurring evaluations.

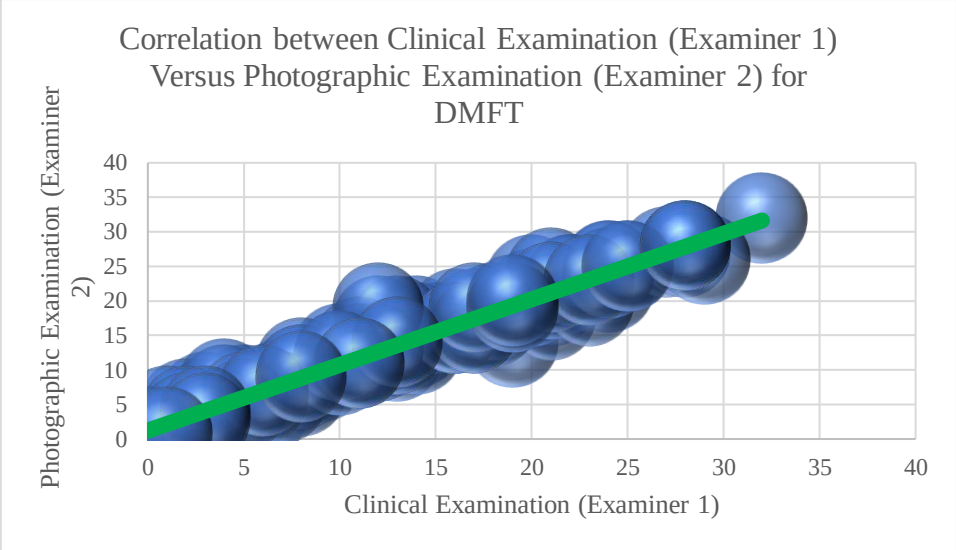

Figure 6: Correlation between Clinical Examination (Examiner 1) Versus Photographic Examination (Examiner 2) for "DMFT".

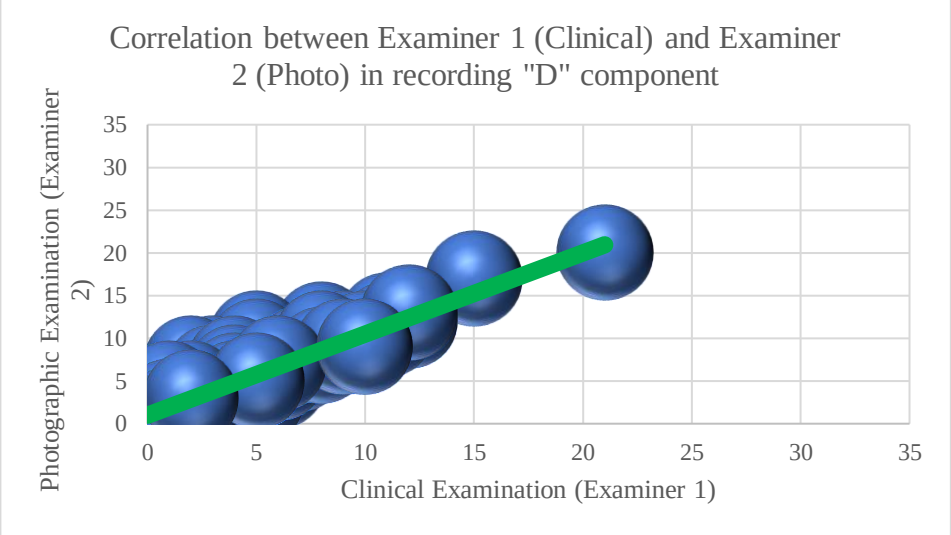

Figure 7: Correlation between Clinical Examination (Examiner 1) Versus Photographic Examination (Examiner 2) for "D".

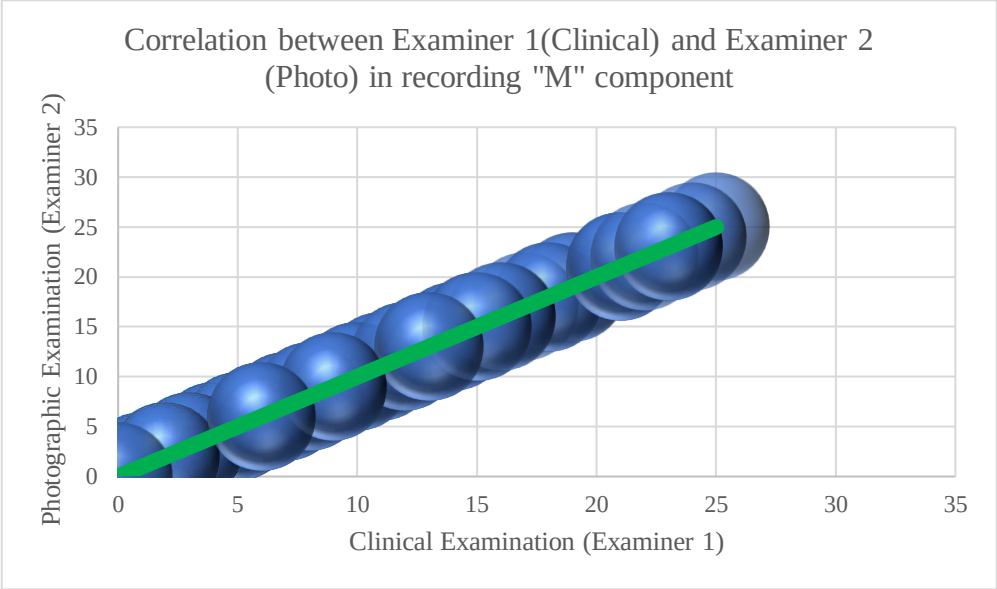

Figure 8: Correlation between Clinical Examination (Examiner 1) Versus Photographic Examination (Examiner 2) for "M".

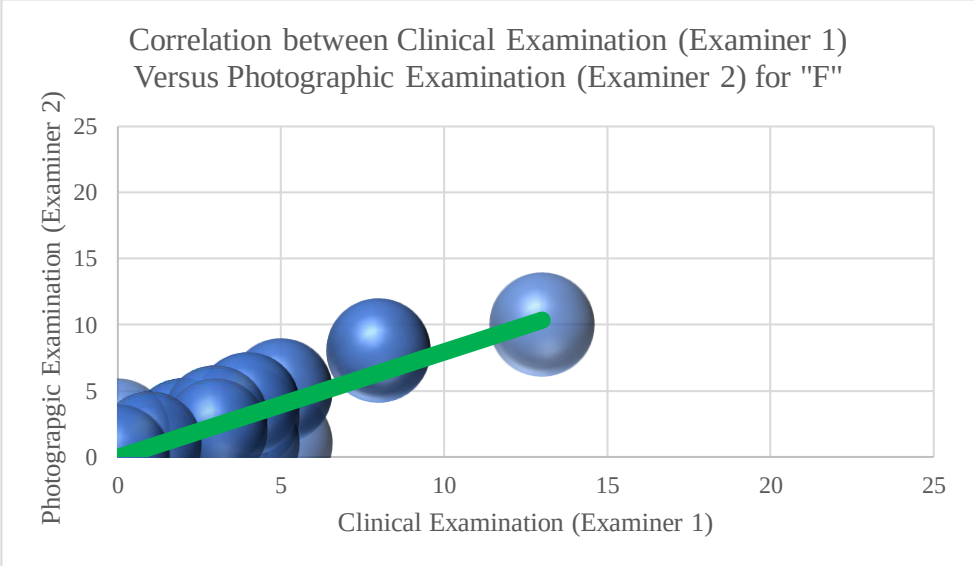

Figure 9: Correlation between Clinical Examination (Examiner 1) Versus Photographic Examination (Examiner 2) for "F".

5.3.2 Clinical Examination (Examiner 1) versus Photographic Examination (Examiner 1)

Kappa Coefficient	t-Test: Two-Sample Assuming Equal Variances for "DMFT", "D", "M' and "F" for Clinical Examination (Examiner 1) versus Photographic Examination (Examiner 2)				
		Pearson Correlation	p(T<=t) two-tail	Mean	
				Clinical Examination (Examiner 1)	Photographic Examination (Examiner 2)
0.94 Almost perfect agreement	**DMFT**	0.99	0.828	12.39	12.58
	D	0.97	0.575	3.82	4.06
	M	1.00	1.000	7.77	7.77
	F	0.78	0.519	0.91	0.76

Table 8: Kappa Coefficient and t-Test: Two-Sample Assuming Equal Variances for "DMFT", "D", "M' and "F" for Clinical Examination (Examiner 1) versus Photographic Examination (Examiner 1)

The Kappa coefficient of 0.94 (Table 8) indicates a remarkably high degree of concordance between the clinical examination findings performed by Examiner 1 and the photographic examination findings by Examiner 2. The significant level of agreement observed indicates a strong reliability and close association in the assessments of dental variables, hence strengthening the reliability and agreement in their judgements.

A correlation coefficient of 0.99 for "DMFT" (Table 8) signifies a highly robust positive linear association between the "DMFT "scores acquired by both examiners. This phenomenon indicates that there is a strong positive correlation between the DMFT scores of one examiner and the scores of the other examiner, indicating a high degree of agreement and reliability (Figure 10). A correlation coefficient of 0.97 (Table 8) indicates a highly robust positive linear association between the D grades assigned by the two examiners. The strong connection observed suggests that the assessments made by the individuals regarding the number of decayed teeth are highly consistent, hence reinforcing the reliability and concordance of their views (Figure 11). A correlation coefficient of 1.00 (Table 8) signifies a perfect positive linear association between the M ratings assigned by both examiners. This implies that there is a precise linear correspondence between their evaluations regarding the number of absent teeth, showcasing a remarkable degree of consensus and concurrence. (Figure 12). A correlation coefficient of 0.78 (Table 8) indicates a robust positive linear association between the F scores provided by the two examiners (Figure 13), however, there is a noticeable anomaly in Figure

13 where the restorations are visible in the clinical examination (16 restorations found) but can't be seen in the photographic examination (0 restorations seen) in one case. This difference can be explained by cases when dental restorations are so artistically detailed and colour-matched that they are challenging to see in pictures.

The two-tailed p-values for the variables "DMFT", "D", "M", and "F" are 0.828, 0.575, 1.00, and 0.519, respectively. The values observed in this study are more than the threshold of 0.05, suggesting that there is no statistically significant difference between the groups or situations under comparison.

The Kappa coefficient, with a value of 0.940, indicates a level of agreement that can be considered nearly flawless. This suggests that Examiner 1 and Examiner 2 routinely produce assessments that closely resemble each other's evaluations, so reducing systematic errors and enhancing the accuracy of their assessments. The obtained Kappa coefficient of 0.940 indicates a high level of intra-rater reliability, their evaluations exhibit a high degree of agreement, hence reducing the likelihood of subjective bias or variability.

The concept of concordance involves both the notions of reliability and agreement. The Kappa coefficient demonstrates a substantial value of 0.940, while the Pearson correlations exhibit strong values ranging from 0.78 to 1.00. These findings suggest a noteworthy level of consistency and agreement between the two examiners. This suggests that their assessments exhibit both reliability and close alignment, indicating a high degree of agreement in their ratings.

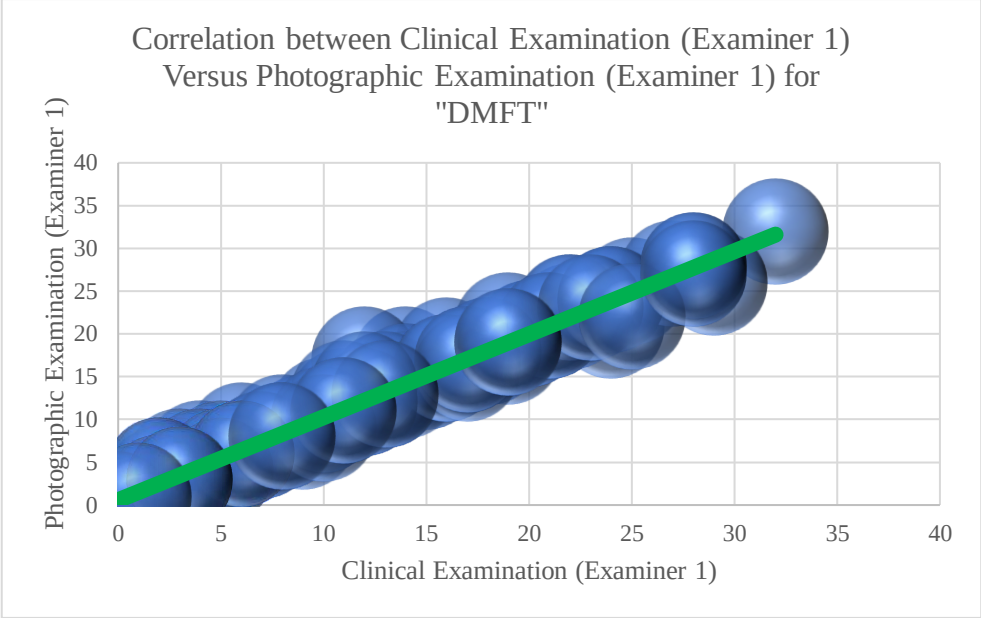

Figure 10: Correlation between Clinical Examination (Examiner 1) Versus Photographic Examination (Examiner 1) for "DMFT".

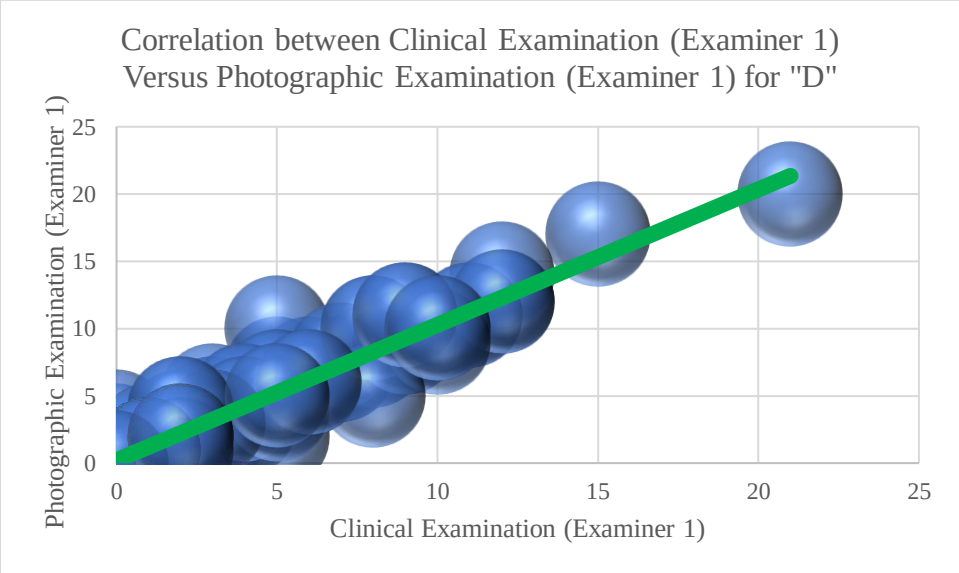

Figure 11: Correlation between Clinical Examination (Examiner 1) Versus Photographic Examination (Examiner 1) for "D".

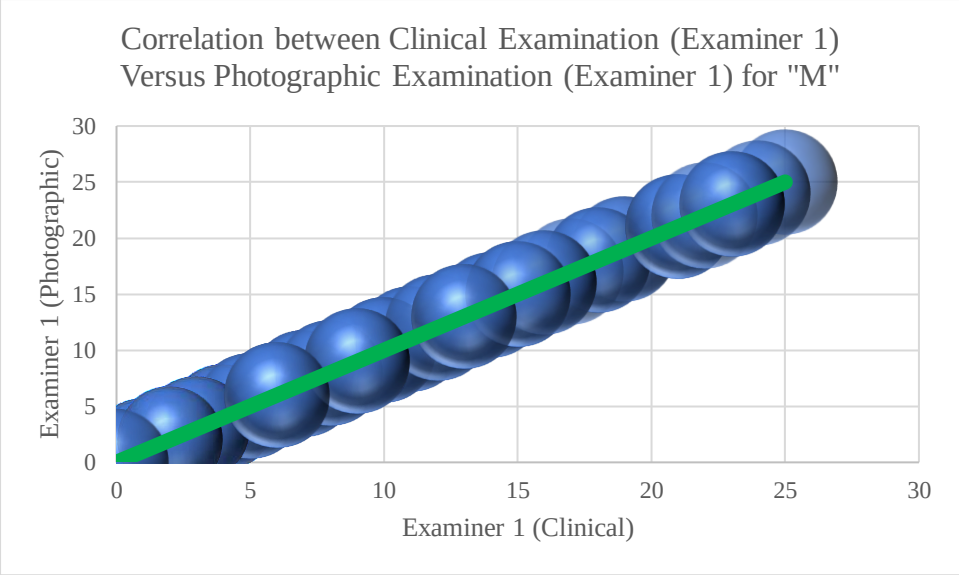

Figure 12: Correlation between Clinical Examination (Examiner 1) Versus Photographic Examination (Examiner 1) for "M".

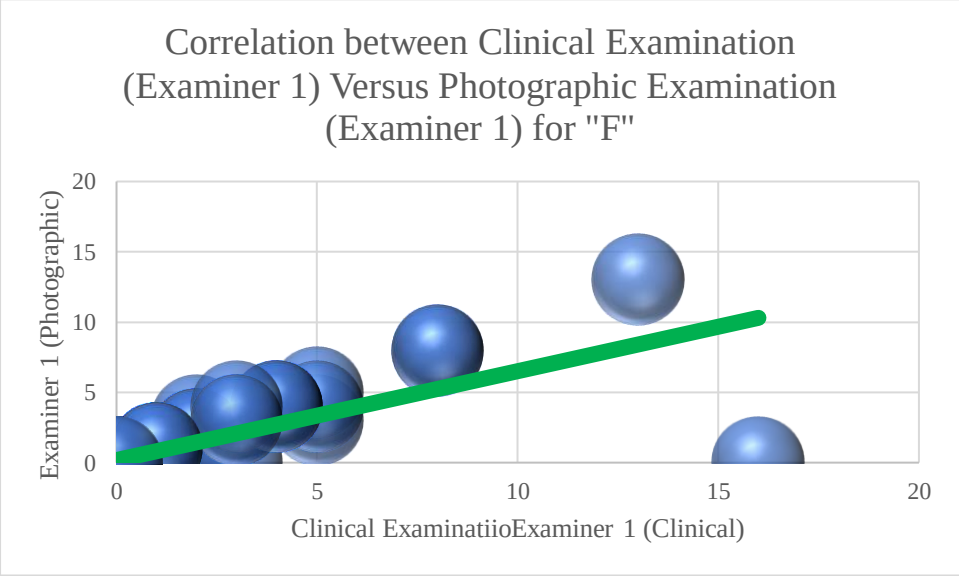

Figure 13: Correlation between Clinical Examination (Examiner 1) Versus Photographic Examination (Examiner 1) for "F"

5.3.3 Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 2)

Kappa Coefficient	t-Test: Two-Sample Assuming Equal Variances for "DMFT", "D", "M' and "F" for Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 2)				
		Pearson Correlation	p(T<=t) two-tail	Mean	
				Clinical Examination (Examiner 1)	Photographic Examination (Examiner 2)
0.88 Almost perfect agreement	DMFT	0.99	0.637	12.59	13.00
	D	0.95	0.191	4.10	4.66
	M	1.00	1.000	7.72	7.72
	F	0.95	0.384	0.77	0.59

Table 9: Kappa Coefficient and t-Test: Two-Sample Assuming Equal Variances for "DMFT", "D", "M' and "F" for Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 2)

The Kappa coefficient of 0.88 (Table 9) indicates a high level of agreement between the results of Photographic Examination conducted by Examiner 1 and Examiner 2, approaching near-perfect agreement. The obtained high Kappa value indicates a strong level of agreement and consistency in the assessments of different dental metrics, such as "DMFT", "D", "M", and "F". This finding underscores the dependability and concordance in the evaluations conducted by the assessors.

A Pearson correlation coefficient of 0.99 (Table 9) signifies a highly robust positive linear association between the "DMFT" scores acquired by both examiners. This suggests that there is a strong linear correlation (Figure 14) between the changes in one examiner's "DMFT" ratings and the changes in the other examiner's scores, indicating a high level of agreement and reliability in their evaluations. The Pearson Correlation coefficient of 0.95 (Table 9) indicates a highly significant positive linear association between the "D" ratings assigned by the two examiners (Figure 15). The strong correlation observed suggests that there is a close similarity between their judgements of the number of decaying teeth, providing more evidence of the dependability and concurrence in their views. A Pearson Correlation coefficient of 1.00 (Table 9) signifies a complete positive linear association between the "M" scores reported by both examiners (Figure 16). This indicates a precise linear correspondence between their evaluations on the number of absent teeth, showcasing a remarkable degree of consensus and concurrence.

The Pearson Correlation coefficient of 0.95 (Table 9) indicates a robust positive linear association between the "F" ratings provided by the two examiners (Figure 17). This finding suggests a high level of consensus and dependability in their evaluations.

The two-tailed p-values for the variables "DMFT", "D", "M", and "F" are 0.637, 0.191, 1.000, and 0.384, respectively (Table 9). P-values greater than 0.05 indicate a lack of statistical significance, suggesting that the observed discrepancies may be attributed to random fluctuation and that the judgements are in accord.

The Kappa coefficient of 0.88 indicates a high level of agreement, suggesting a strong alignment between measurements and true values, thereby enhancing accuracy. This implies that both Examiner 1 and Examiner 2 constantly offer evaluations that closely resemble each other's assessments, so minimising the likelihood of systematic errors and improving the precision of their evaluations.

Inter-rater reliability is a measure used to evaluate the degree of consistency in assessments conducted by many examiners. The Kappa coefficient of 0.88 demonstrates a high level of inter-rater reliability, suggesting that there is a good agreement between Examiner 1 and Examiner 2 in their evaluations of the dental metrics. This indicates that their assessments consistently align with each other. By minimising the presence of subjective bias or variability, the aforementioned approach enhances the credibility and reliability of the evaluations conducted.

The presence of concordance, which includes both reliability and agreement, is indicated by the substantial Kappa coefficient (0.88) and the robust Pearson correlations, which approach 1.00 for the majority of measurements. These scores indicate both the presence of consistency (reliability) and a substantial level of agreement (concordance) between the two examiners. The assessments exhibit a high degree of alignment, suggesting a significant concurrence in their opinions.

The data supplied together highlight a significant level of accuracy, dependability, agreement, and potential statistical significance in the observed discrepancies between the results of Photographic Examination conducted by Examiner 1 and Examiner 2 for the dental variables.

This finding suggests that the evaluations provided by the individuals are not only consistent, but also closely aligned, hence increasing the overall credibility and therapeutic relevance of their assessments. The high Pearson correlation coefficients offer additional support for the dependability and concurrence between the two examiners, so strengthening the soundness of their assessments.

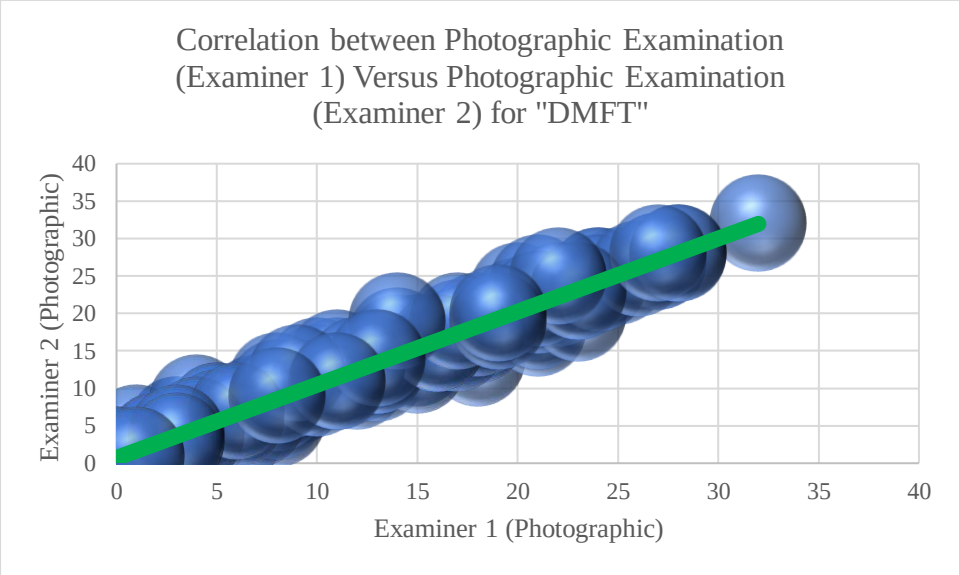

Figure 14: Correlation between Photographic Examination (Examiner 1) Versus Photographic Examination (Examiner 2) for "DMFT".

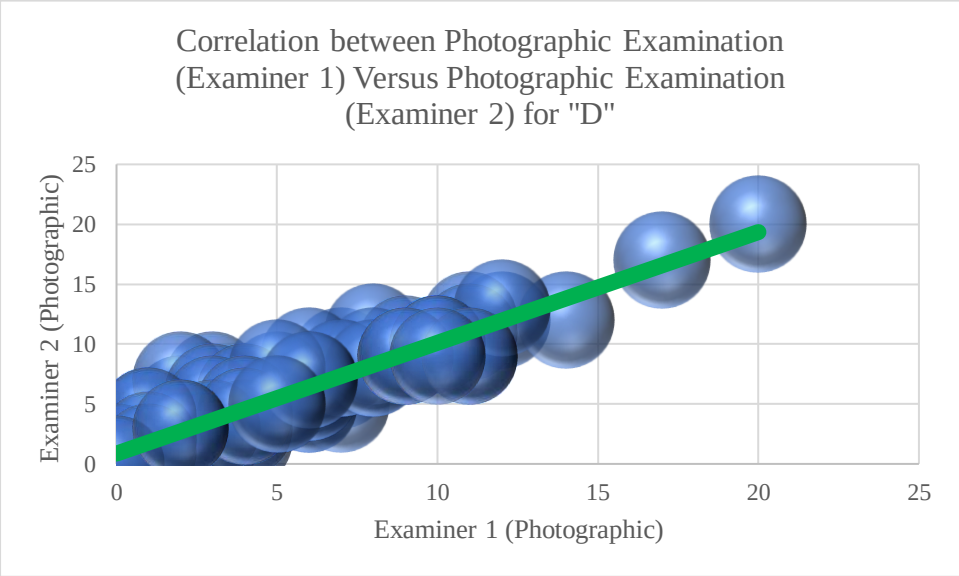

Figure 15: Correlation between Photographic Examination (Examiner 1) Versus Photographic Examination (Examiner 2) for "D".

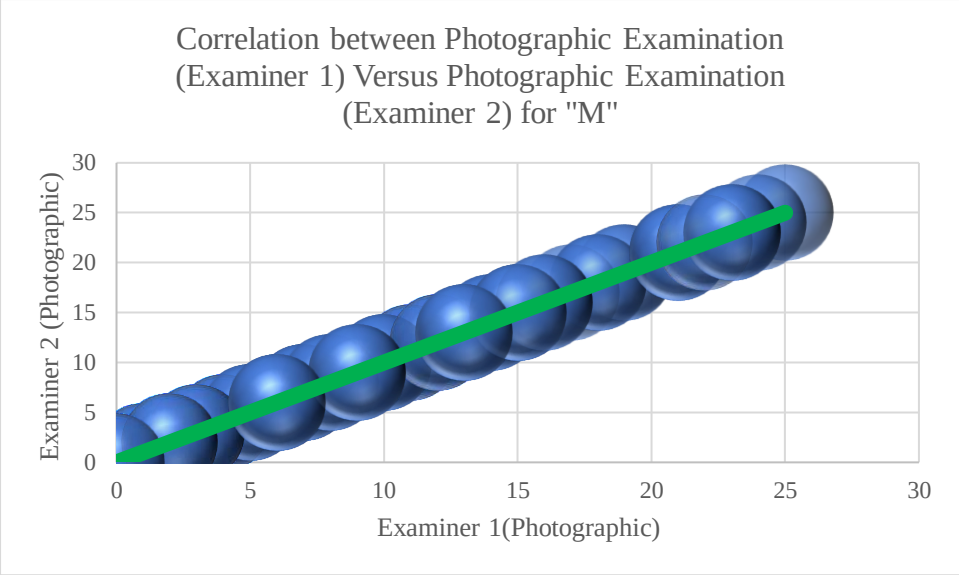

Figure 16: Correlation between Photographic Examination (Examiner 1) Versus Photographic Examination (Examiner 2) for "M".

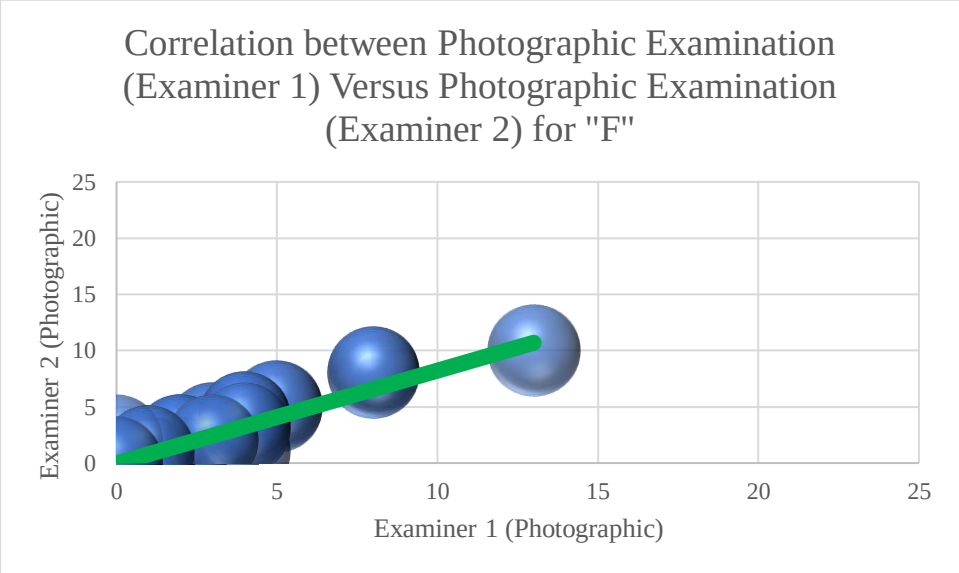

Figure 17: Correlation between Photographic Examination (Examiner 1) Versus Photographic Examination (Examiner 2) for "F".

5.3.4 Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 1)

Kappa Coefficient	t-Test: Two-Sample Assuming Equal Variances for "DMFT", "D", "M' and "F" for Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 2)				
				Mean	
		Pearson Correlation	p(T<=t) two-tail	Clinical Examination (Examiner 1)	Photographic Examination (Examiner 2)
0.95 Almost perfect agreement	**DMFT**	1.00	0.949	12.59	13.00
	D	0.99	0.899	4.10	4.66
	M	1.00	1.000	7.72	7.72
	F	1.00	1.000	0.77	0.59

Table 10: Kappa Coefficient and t-Test: Two-Sample Assuming Equal Variances for "DMFT", "D", "M' and "F" for Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 1)

The Kappa coefficient of 0.95 (Table 10) suggests a high level of agreement between the results of the Photographic Examination conducted by Examiner 1 and those conducted by Examiner 2, approaching near-perfect agreement. The observed Kappa value of considerable magnitude indicates a strong level of agreement and consistency in the evaluations of dental metrics, specifically "DMFT", "D", "M", and "F". This finding underscores the dependability and concordance in the assessments conducted.

A Pearson correlation coefficient of 1.00 (Table 10) signifies a complete positive linear association between the DMFT scores acquired by both examiners (Figure 18). This implies that alterations in the DMFT scores of one examiner are directly proportional to alterations in the scores of the other examiner, therefore emphasising a high level of agreement and dependability in their assessments. A Pearson Correlation coefficient of 0.99 (Table 10) indicates a highly significant positive linear association between the D grades assigned by the two examiners (Figure 19). The strong correlation observed suggests that there is a close correspondence between their judgements of the number of decaying teeth, providing additional support for the reliability and concordance of their opinions. A Pearson correlation coefficient of 1.00 (Table 10) signifies a complete positive linear association between the M ratings assigned by both examiners.

This indicates a precise linear correspondence between the evaluations on the number of absent teeth, indicating a remarkable degree of consensus and concurrence (Figure 20). A Pearson Correlation coefficient of 1.00 (Table 10) indicates a complete positive linear association between the F values recorded by the two examinations (Figure 21). This suggests a high level of consensus and credibility in the intra-observer evaluations.

The two-tailed p-values for the variables "DMFT", "D", "M", and "F" are 0.949, 0.899, 1.000, and 1.000, respectively. *p-values* that exceed the threshold of 0.05 are indicative of a lack of statistical significance. This suggests that the observed differences may be attributed to random variation, and so, the conclusions drawn are in agreement.

The Kappa coefficient of 0.95, indicating nearly perfect agreement, provides strong support for accuracy, which refers to the degree to which measurements align with true values. This implies that the examinations constantly offer evaluations that closely resemble each other, so minimising the likelihood of systematic errors and improving the precision of their evaluations.

The Kappa coefficient of 0.95 demonstrates a high level of intra-examiner reliability, indicating a good intra-observer agreement in the evaluations of dental measures. By minimising the presence of subjective bias or variability, this approach enhances the reliability and credibility of the evaluations.

The presence of concordance, which includes both reliability and agreement, is apparent in the substantial Kappa coefficient (0.95) and the flawless Pearson correlations (1.00) observed for the majority of measures. The aforementioned figures demonstrate not simply the attribute of consistency, but also an unequivocal level of concordance between the two examiners. The ratings of both individuals exhibit a high degree of alignment, suggesting a remarkable congruence in their evaluations.

The data highlights a remarkably high degree of accuracy, reliability, agreement, and potential statistical importance in the disparities identified between the results of Photographic Examination for the different dental measurements. This suggests that the evaluations provided by the individuals are not only consistently reliable but also completely congruent, so augmenting the overall credibility and practical significance of their assessments. The high

Pearson correlation coefficients offer additional support for the dependability and concurrence between the two examinations, emphasising the resilience of their assessments.

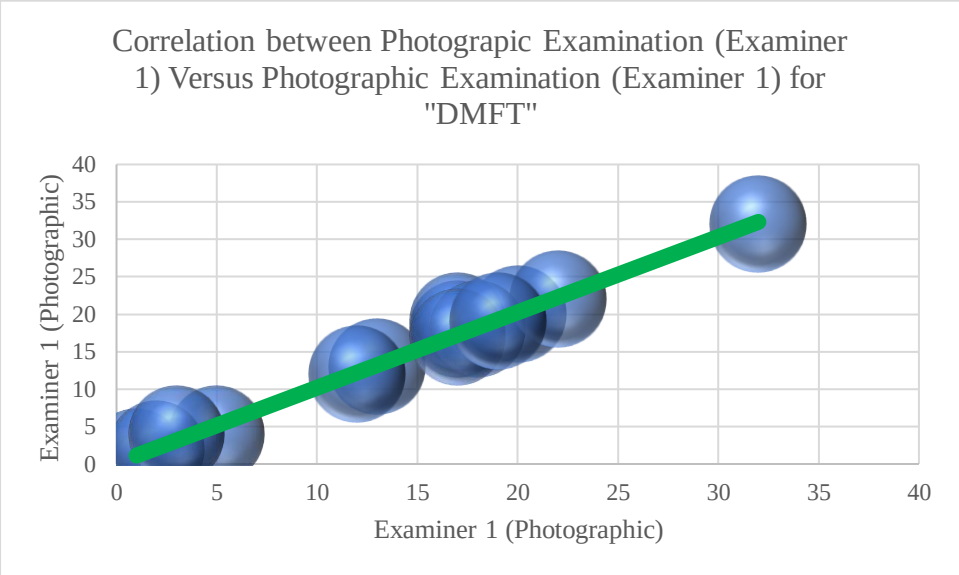

Figure 18: Correlation between Photographic Examination (Examiner 1) Versus Photographic Examination (Examiner 1) for "DMFT".

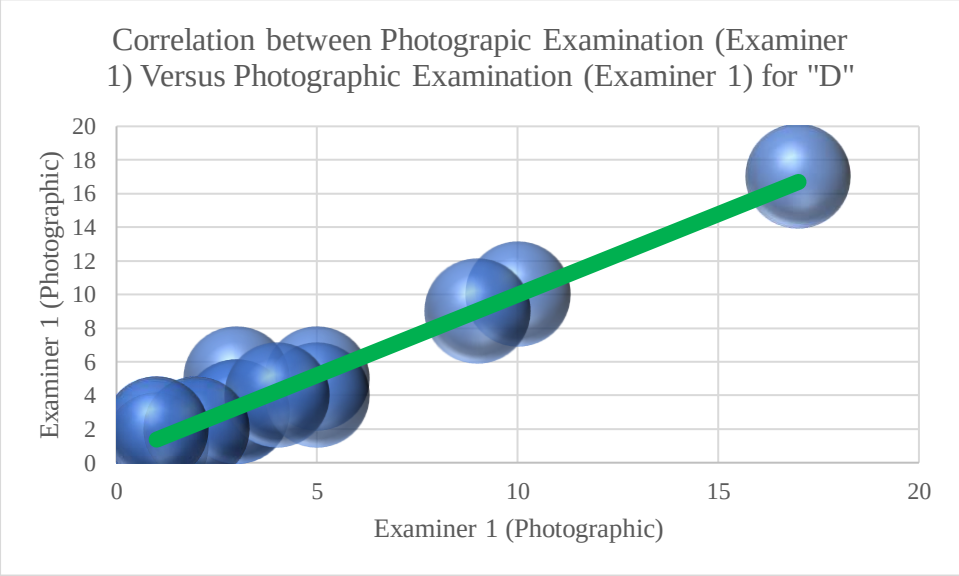

Figure 19: Correlation between Photographic Examination (Examiner 1) Versus Photographic Examination (Examiner 1) for "D".

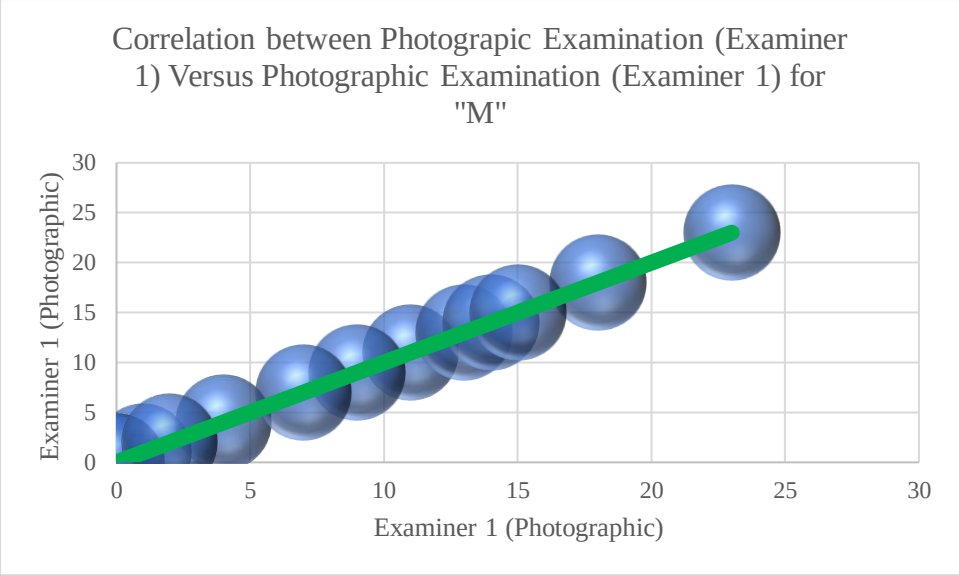

Figure 20: Correlation between Photographic Examination (Examiner 1) Versus Photographic Examination (Examiner 1) for "M".

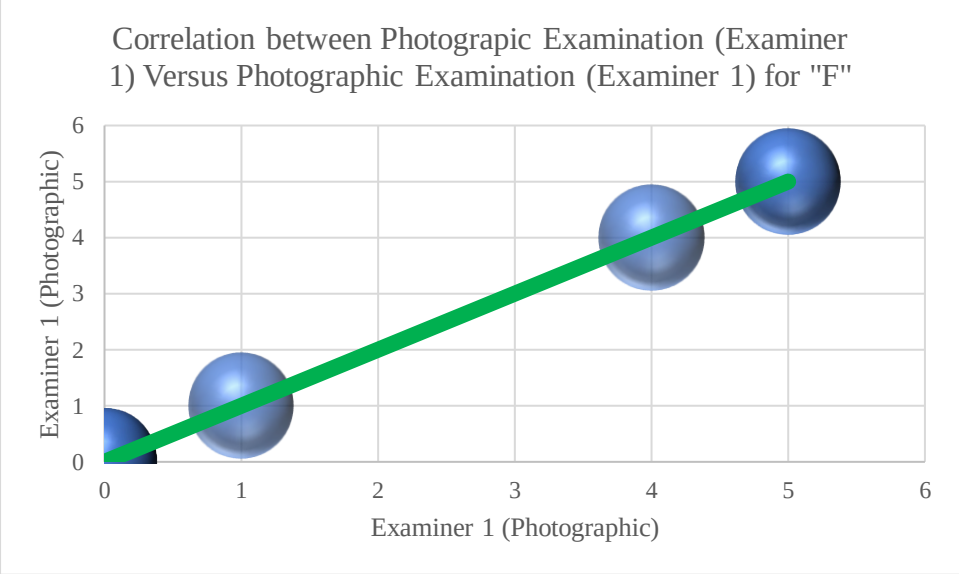

Figure 21: Correlation between Photographic Examination (Examiner 1) Versus Photographic Examination (Examiner 1) for "F".

5.3.5 Photographic Examination (Examiner 2) versus Photographic Examination (Examiner 2)

Kappa Coefficient	t-Test: Two-Sample Assuming Equal Variances for "DMFT", "D", "M' and "F" for Photographic Examination (Examiner 2) versus Photographic Examination (Examiner 2)Photographic Examination (Examiner 2)				
				Mean	
		Pearson Correlation	p(T<=t) two-tail	Clinical Examination (Examiner 1)	Photographic Examination (Examiner 2)
0.95 Almost perfect agreement	DMFT	1.00	1.000	14.57	14.57
	D	1.00	0.966	5.07	5.00
	M	0.99	0.918	8.50	8.79
	F	0.85	0.701	1.00	1.29

Table 11: Kappa Coefficient and t-Test: Two-Sample Assuming Equal Variances for "DMFT", "D", "M' and "F" for Photographic Examination (Examiner 2) versus Photographic Examination (Examiner 2)

The Kappa coefficient of 0.95 (Table 11) suggests a high level of intra-examiner agreement between the Photographic examinations approaching near-perfect agreement. The obtained high Kappa value indicates a strong level of agreement and consistency in the assessments of dental metrics such as "DMFT", "D", "M", and "F". This finding supports the notion that the evaluators' judgements are reliable and closely matched with each other.

A Pearson Correlation coefficient of 1.00 (Table 11) signifies a complete positive linear association between the DMFT scores acquired by both examiners (Figure 22). This implies that alterations in the DMFT scores were directly proportional to the alterations in the scores, therefore emphasising a significant level of agreement and dependability in their assessments. The Pearson correlation coefficient of 0.966 (Table 12) indicates a highly significant positive linear association between the D scores assigned by the two examiners (Figure 23). The strong correlation observed suggests a close correspondence between their judgements of the number of decaying teeth, so providing more support for the trustworthiness and concurrence of their views. The Pearson Correlation coefficient of 0.918 (Table 12) indicates a robust positive linear association between the M scores reported by both examiners (Figure 24).

This implies that the evaluations pertaining to the number of absent teeth exhibit a strong correlation, suggesting a substantial level of consensus and concurrence. The Pearson Correlation coefficient of 0.701 (Table 11) suggests a positive linear association between the F scores provided by the two examinations (Figure 25). However, it is marginally lower compared to the correlations observed for other metrics. This implies a moderate degree of concurrence and dependability in their evaluations of restored dental cavities.

The two-tailed p-values for the variables "DMFT", "D", "M", and "F" are 1.000, 0.966, 0.918, and 0.701, respectively. P-values that surpass the predetermined threshold of 0.05 are suggestive of a dearth of statistical significance. This implies that the observed disparities could be ascribed to stochastic fluctuations, hence establishing concurrence between the drawn inferences.

The Kappa coefficient of 0.95, indicating nearly perfect agreement, provides robust support for the accuracy of measurements, which refers to the degree of alignment with genuine values. This implies that the assessments made by Examiner 2 exhibit a high level of consistency with their own previous assessments, so minimising the likelihood of systematic errors and improving the overall accuracy of their evaluations.

The concept of intra-rater reliability pertains to the evaluation of the degree of consistency exhibited by a single examiner in their evaluations conducted over a period of time. The Kappa coefficient of 0.95 in this particular situation signifies a high level of agreement between Examiner 2's re-evaluation of the dental metrics and their initial judgements, indicating consistent and reliable evaluations. This finding substantiates the reliability of their evaluations, even upon repetition.

The presence of concordance, which encompasses both reliability and agreement, is seen in the substantial Kappa coefficient of 0.95 and the robust Pearson correlations. The aforementioned results indicate the presence of consistency, or reliability, as well as a notable level of agreement, or concordance, in Examiner 2's ratings over different time periods. The assessments exhibit a high degree of alignment, suggesting a robust concurrence in their recurring evaluations. The statistics supplied highlight the importance of achieving a high degree of accuracy, dependability, agreement, and potential statistical significance in the

consistency of Examiner 2's evaluations while reassessing dental metrics over a period. This finding suggests that the evaluations not only demonstrate consistency but also exhibit a strong alignment, so augmenting the overall credibility and practical significance of the repeated assessments. The resilience of their assessments over time is reinforced by the excellent Pearson correlation coefficients, which provide additional evidence of reliability and agreement in their repeated evaluations.

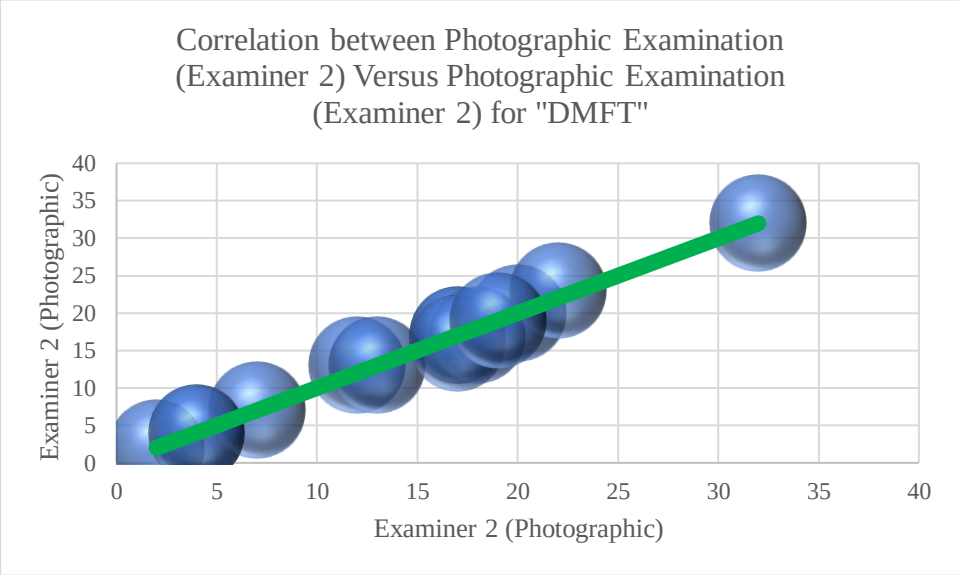

Figure 22: Correlation between Photographic Examination (Examiner 2) Versus Photographic Examination (Examiner 2) for "DMFT".

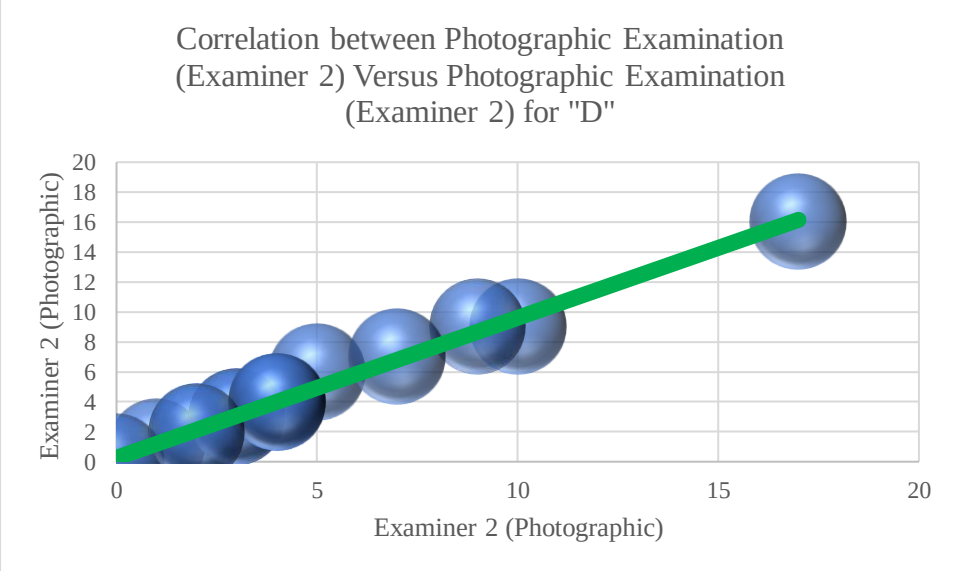

Figure 23: Correlation between Photographic Examination (Examiner 2) Versus Photographic Examination (Examiner 2) for "D"

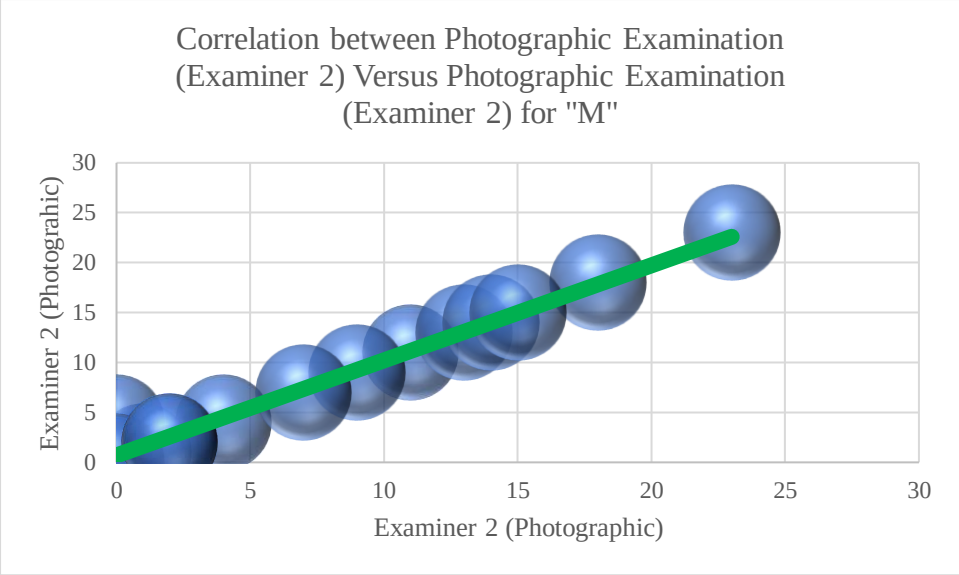

Figure 24: Correlation between Photographic Examination (Examiner 2) Versus Photographic Examination (Examiner 2) for "M".

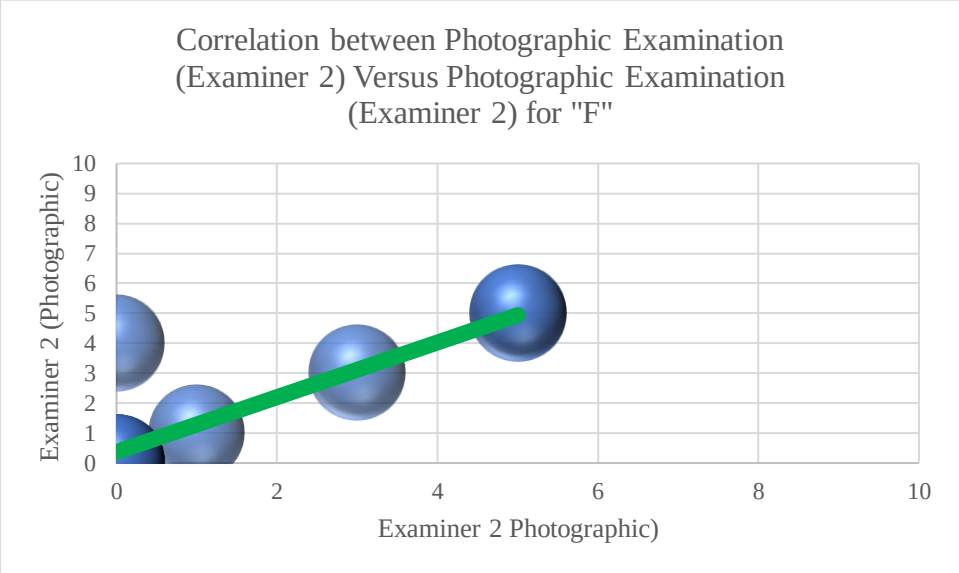

Figure 25: Correlation between Photographic Examination (Examiner 2) Versus Photographic Examination (Examiner 2) for "F".

Based on the analysis of all five data sets, it can be inferred that there is a lack of statistically significant disparities observed across examiners with regards to both intra- and inter-examiner variability. Furthermore, it is important to note that there is no statistically significant disparity observed between the results obtained from the clinical examination and the photographic assessment. Hence, the photographs provide a precise and dependable representation of the clinical scenario.

CHAPTER 6
DISCUSSION

The present study sample was 145 participants, with the majority being female. Participants were a convenience sample of people who were accompanying children to attend the paediatric clinic for care. One potential explanation for the higher proportion of female patients is that it is usually the mother or grandmother who typically assuming the responsibility of accompanying the child for medical and dental care.

The study aimed to examine the diagnostic agreement, accuracy and reliability between the clinical DMFT scores and photographic DMFT scores. The concordance between teledentistry and standard dental screening methods varied from 84% to 95% for both examiners, all considered high, and fall within the "Almost Perfect Agreement" region, demonstrating a high degree of agreement/ concordance between the two dental examiners and methodologies (clinical and photographic examination), when the Cohen Kappa Statistics were calculated.

There was a notable degree of concordance between Examiner 1 and Examiner 2 when they transitioned from clinical to photographic approaches, indicating a certain level of methodological independence in the outcomes obtained. The levels of observed agreement and Kappa Coefficients tended to be only slightly greater when a single examiner evaluated the same teeth using the different methodologies, compared to situations where multiple examiners were involved. The percentages of observed agreement exhibited notable levels of consistency across all circumstances. This observation implied that the techniques employed for evaluating teeth demonstrated both reliability and validity, irrespective of whether they involved clinical or photographic approaches. In all instances, the observed agreement had demonstrated a statistically significant increase compared to the agreement that would have been anticipated by random chance alone. This finding provided additional support for the reliability of the evaluation methodologies utilized.

The datasets comprised a reduced number of observations (14), specifically, Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 1), and Photographic Examination (Examiner 2) versus Photographic Examination (Examiner 2) exhibited slightly

elevated Kappa values, potentially indicating improved concordance within a smaller sample size. However, additional research will be required to validate this observation.

In general, the findings of the present study provided evidence in favour of the assertion that both the clinical and photographic approaches were valid modalities for evaluating the condition of teeth, specifically in terms of determining whether they were healthy or affected by caries. Furthermore, the examiners included in this investigation demonstrated a consistent performance in conducting their evaluations.

The inter-rater reliability between two examiners, namely Clinical Examination (Examiner 1) versus Photographic Examination (Examiner 2), the obtained Kappa coefficient of 0.84 indicated a high level of agreement, approaching near-perfect concordance. This suggested that the examination procedure was not only dependable, but also showed that both examiners possessed comparable levels of knowledge and experience, resulting in outcomes that were notably consistent.

The inter-rater reliability between Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 2) exhibited a Kappa coefficient value of 0.88, indicating a level of agreement that could be classified as almost perfect. Once more, this finding suggested that the approach used to perform the analysis of the dentitions was reliable and that the examiners demonstrated a high level of agreement and consistency in their assessments.

Intra-rater reliability between Clinical examination (Examiner 1) versus Photographic Examination (Examiner 1) yielded a Kappa coefficient of 0.9402, demonstrating a high level of intra-rater dependability, indicating nearly complete agreement. This implied that Examiner 1 demonstrated a high level of consistency when employing either the clinical or photographic method of evaluation.

Comparison of Photographic Examination (Examiner 1) was compared to Photographic Examination (Examiner 1). A Kappa coefficient of 0.9527 signified a high level of concordance between the same examiner's assessments while employing the same methodology in several circumstances.

The comparison between Photographic Examination (Examiner 2) versus Photographic Examination (Examiner 2) revealed a Kappa coefficient of 0.9595, which signified a high level of intra-rater reliability. This finding suggested that Examiner 2 correctly and consistently evaluated the subject matter.

The observed high levels of intra-rater reliability, as indicated by the elevated Kappa scores obtained when the same examiner employed multiple methods or utilised the same method on separate occasions, suggested that the examiners exhibited consistent evaluation practices both over time and across varying methodologies. The observed high levels of concordance suggested that there was no statistically significant distinction between the conventional dental screening method and the teledentistry screening method in terms of intra-rater reliability. Consequently, it could be inferred that the teledentistry screening method was a dependable substitute for the traditional dental screening method. Additionally, this suggested that intraoral imaging served as a dependable diagnostic tool for identifying dental caries, tooth loss, and dental restorations in the adult population.

Regarding reliability, the sample size varied between different tests, with some tests had a larger sample size of 145 observations:

- Clinical Examination (Examiner 1) versus Photographic Examination (Examiner 2)
- Clinical examination (Examiner 1) versus Photographic Examination (Examiner 1)
- Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 2),

while data sets

- Photographic Examination (Examiner 1) versus Photographic Examination (Examiner 1)
- Photographic Examination (Examiner 2) versus Photographic Examination (Examiner 2)

had a smaller sample size of 14 observations (every 10^{th} participant was selected to test for reliability of the photographic examination method. method). In general, it may be stated that bigger sample sizes tend to yield more dependable outcomes.

The Pearson correlation coefficient exceeded 0.90 across all data sets for the variables "DMFT," "D," and "M," indicating a high level of strength in most cases. This suggested a strong link between the Clinical and Photographic examinations, regardless of whether they were completed by the same or different examiners.

Clinical examination (Examiner 1) compared to Photographic Examination (Examiner 1) and Photographic Examination (Examiner 2) compared to Photographic Examination (Examiner 2) exhibited Pearson's correlation coefficients of 0.78 and 0.85, respectively, with respect to the variable "F". The interpretation of the values discussed in this context was found to be similar to a study conducted by Valizadeh-Haghi *et al.,* in 2023 stating that evaluation of composite restorations by smartphone photography demonstrated a modest level of accuracy. While the application of this technology in teledentistry showed promise, further enhancements were required to optimise its effectiveness.

There was no statistical significance observed in all data sets for "DMFT," "D," "M," and "F," as indicated by two-tail p-values that were significantly higher than the usually accepted level of 0.05. The high p-value was congruent with the elevated Kappa score, so offered corroborating evidence that both approaches appeared to be reliable for DMFT evaluations.

In summary, the notions of accuracy and reliability held significant importance within the context of this academic research. A strong positive linear link between two sets of measures, indicating a close association, was suggested by the high Pearson correlation coefficients observed in all data sets for "DMFT," "D," "M," and "F." The strong correlation seen suggested a high level of reliability between the two sets of measurements within each dataset, implying the presence of accuracy. The results of the t-tests suggested that when the p-value exceeded 0.05 in all datasets for the variables "DMFT," "D," "M," and "F," there was no statistically significant evidence to support a difference. This implied that both photographic or clinical examinations should be regarded as reliable. The assessment of intra-examiner and inter-examiner reliability was commonly determined by observing strong Pearson correlations when comparing the same examiner across several techniques, indicating a desirable level of reliability.

The significance of these findings lies in the context of oral disease prevalence in Africa, specifically in South Africa. Teledentistry has promise in alleviating the burden of oral diseases by providing access to oral healthcare for individuals who currently lack such access. There is an increasing burden of oral disease in Africa. The World Health Organization (WHO) African Region showed the highest increase (120%) of caries in permanent teeth between 1990 – 2019 (World Health Organization, 2022). An estimated 480 million individuals in the WHO African Area (or 43.7% of the African population) suffered from some form of oral illness in 2019. Many of Africa's most defenceless and poor residents suffer from oral illnesses. People from lower socioeconomic backgrounds bear a disproportionate share of the burden of oral disorders. This is true across the lifespan, from infancy to old age (World Health Organization, 2021). Inequalities in access to oral health care exist both within and between nations in Africa. There is a mismatch between the accessibility of oral health care and the demands of the people. Services are often unavailable to those who need them the most.

Kimmie-Dhansay *et al.* (2022) found an increasing prevalence of dental caries in South Africa (SA). SA has one of the highest HIV burdens in the world, and noncommunicable diseases (NCD) were not evaluated by the government until they strated developing them for HIV patients (Kimmie-Dhansay *et al*., 2022). Similarly, the oral health sector does not receive the attention it deserves even though dental caries is a globally prevalent NCD (Chikte *et al*., 2020).

South Africa is a populous developing nation. With a total population of 59.62 million, it is classified as a upper middle income country (The World Bank, 2023). About ten per cent (5.7 million) are children under the age of five. It has a long history of political and racial discord. During the apartheid era, race and socioeconomic status were significant determinants of the utilisation and access to healthcare services. While it has been a democracy for 29 years, inequality remains high in many sectors, including the health care sector. Access to quality services is primarily determined by a person's socioeconomic status, not their care requirements. The majority rely on public healthcare facilities to access healthcare services (Mhlanga and Garidzirai, 2020). In 2014, the Gini index for income inequality was calculated to be 63.0, making it the country with the greatest income gap among its citizens (Statista, 2022). Dental caries frequency is linked to underserved populations due to income disparities in the country (Kimmie-Dhansay *et al*., 2022).

The global average density for dentists is 3.28 dentists per 10 000 population, for "dental assistants and therapists" it is 1.88 per 10 000 population and for "prosthetists/technicians" it is 0.57 per 10 000 population (World Health Organisation, 2022). These estimates need to be context and country specific. According to Bhayat and Chikte (2017), the SA population and the number of dentists increased steadily between 2000 and 2015. The number of dentists increased by 34% during the study period, from 4,560 to 6,125. The proportion of clinical practitioners to the population in 2015, based on a population of 54,002,000, is one dentist for every 8817 persons in the population (Bhayat and Chikte, 2017). According to Ndlovu *et al.*, (2021) the number of dentists practising in the public sector in SA was 1009 in 2021.

Population health outcomes are significantly influenced by access to health care providers (Tanser *et al.,* 2006). The use of technology as a useful tool bridges the health care gap in underserved areas and plays a role for the portion of the population that lacks access to health care (Tanser *et al.,* 2006). Only about 17% of the population in SA is enrolled in medical aid programmes; while the majority of rely on the public health care system for their health (Ngobeni *et al*., 2020). There are public dental health services and the initial care for oral diseases is provided by primary oral health care facilities.

Access to healthcare services is directly influenced by the number and distribution of health care facilities within a given area. Teledentistry can be useful in the screening process for the detection of oral diseases, which could ultimately lead to a decrease in the prevalence of oral diseases and an increase in the accessibility of oral health care. Wakhloo *et al.* (2020) reported that teledentistry is beneficial for the remote interchange of clinical data and images for dental consultation and treatment planning. The consulting procedure might be less stressful and more pleasant. Those with limited or no access to health care frequently employ home remedies instead of consulting an oral health care professional.

Teledentistry shows promise in primary health care and UHC oral health care. One of the primary objectives frequently mentioned in relation to teledentistry is the achievement of cost reduction and improved resource utilisation (Daniel & Kumar, 2014). The role of teledentistry in the upcoming implementation of the National Health Insurance (NHI), a health financing system that will be funded by tax-paying citizens (Department of Health, 2020), to provide free quality and affordable care to disadvantaged SA citizens regardless of their socio-economic

status, is viewed as promising (Malinga, 2019a). However, to ensure efficient processes prior to the launch of the NHI in the country, SA needs mechanisms that are inclusive and cohesive and to facilitate the usage and expansion of e-health services.

By streamlining operations, enhancing efficiency and productivity, and decreasing waiting times, remote monitoring tools, mHealth, and portal technologies would play a vital part in the development of the NHI. In addition, adopting health care technology would boost capacities by automating the decision-making process and ensure that health care professionals can remotely monitor and interact with patients.

The presence of extended delays in diagnosing specific oral lesions leads to elevated levels of morbidity and mortality, hence incurring additional costs. The utilisation of teledentistry for the purpose of documenting illness prevalence and treatment requirements, as well as seeking consultations from specialists, shows promise in the development of an oral disease screening tool. It also has the potential to alleviate extended waiting periods for specialised oral lesion evaluations, mitigate patient discomfort and distress, and lower financial burdens on individuals seeking such evaluations. Teledentistry can be employed by dental hygienists or nurses to conduct screenings, deliver care, and mitigate the advancement of oral diseases to an irreparable or unrecoverable state in underserved regions (Daniel & Kumar, 2014).

CHAPTER 7
RECOMMENDATIONS

The implementation of teledentistry in South Africa offers a promising prospect for enhancing the accessibility of oral healthcare, particularly in geographically isolated or underserved regions. The key components for the implementation of a comprehensive strategy in this context include regulatory measures, technical infrastructure, skill development, socio-economic factors, partnerships, funding, oral disease surveillance and in cooperation of teledentistry into the NHI.

Regulatory measures refer to the policies and actions implemented by governmental or non-governmental entities to establish and enforce rules and standards for teledentistry:

- The establishment of a legal and regulatory framework for teledentistry should be pursued in collaboration with the Health Professions Council of South Africa (HPCSA). This may encompass the implementation of licensure requirements for teledental providers as well as the establishment of a clear delineation of the area of practise.
- The imperative of data privacy necessitates adherence to data protection legislation in order to safeguard the security and confidentiality of patient data. It is advisable to choose encrypted and secure platforms for the purpose of communication.
- The establishment of quality assurance measures is crucial in the development of standards for teledentistry services. These standards should encompass several aspects such as the specification of criteria for equipment, guidelines for data preservation, and the provision of comprehensive skills training.

Technical Infrastructure

- In the early phase of deployment, it is recommended to prioritise regions that possess sufficient internet access. In order to enhance infrastructure in remote places, it may be necessary to establish partnerships with telecommunication providers.
- When selecting teledentistry platforms, it is advisable to opt for hardware and software that are both dependable and user-friendly. It is recommended that dental units be furnished with intraoral cameras of high resolution, while the accompanying software

should possess the capability to provide both store-and-forward and real-time consultations.

- The incorporation of the teledentistry system into pre-existing electronic health record systems should be ensured.

Skills enhancement

- Delivery of thorough training to dental professionals, including dentists and auxiliary staff, with the aim of enhancing their proficiency in utilising the teledentistry system in an efficient manner.
- Provide patients with comprehensive information regarding the concept of teledentistry, the range of services available through this platform, and the methods through which they can access and utilise these services.

Socioeconomic factors refer to the various social and economic conditions that influence individuals, communities, and societies

- Development of service models that are economically accessible to individuals with limited financial resources. One potential approach to address the issue of affordability is to explore the implementation of government subsidies or private sponsorships.
- It is imperative for the service model to demonstrate cultural sensitivity in order to effectively cater to the various population residing in South Africa.
- In order to accommodate the diverse linguistic terrain of South Africa, it is imperative to guarantee the availability of teledentistry services in multiple languages.

Collaborations and funding

- The utilisation of public-private partnerships facilitates collaboration between public and private healthcare providers, hence enhancing the scope and impact of healthcare services.
- Endeavour to secure funding from both domestic and foreign entities as a means to initiate teledentistry. In addition, the utilisation of crowd-funding platforms and the provision of assistance by non-profit organisations may also be seen as viable options.
- It is recommended to initiate pilot programmes as an initial step in order to assess the feasibility and consequences of implementing teledentistry in specific locations prior to its widespread implementation across the entire nation.

Teledentistry has the potential to serve as a valuable instrument in the surveillance of oral diseases, providing a distinct method for gathering data, identifying cases at an early stage, and facilitating continuous monitoring. Engage in a collaborative effort with relevant stakeholders to establish a comprehensive regulatory framework that incorporates teledentistry as an officially recognised healthcare service under the NHI system. It is imperative to guarantee that each health facility is equipped with essential tools such as smartphones, intraoral mirrors, and cheek retractors to facilitate the advancement of teledentistry.

CHAPTER 8
CONCLUDING REMARKS

The present study has demonstrated that the teledentistry screening method is a dependable substitute for traditional dental screening. Additionally, the present study showed that intraoral imaging is a dependable screening tool for identifying dental caries, tooth loss and dental restorations in adult populations.

Inequalities in access to oral health care exist both within and between nations in Africa. There is a mismatch between the accessibility of oral health care and the demands of the people. Services are often unavailable to those who need them the most. Teledentistry has the potential to play a crucial role in South Africa, as it will address many of the challenges in the country's healthcare system (Bissessur & Naidoo, 2019). The equitable delivery of dental care in South Africa is impeded by various systemic obstacles, hence creating a strong rationale for exploring alternate approaches such as teledentistry.

A significant segment of the population resides in rural or physically remote regions, where specialised healthcare services, such as dental treatment, is limited (Coovadia *et al*., 2009). This geographic disparity is further exacerbating economic obstacles, as socioeconomically disadvantaged populations frequently face financial constraints that impede their ability to obtain dental care (Ataguba *et al*., 2015) so contributing to the expansion of health disparities. Furthermore, the nation is confronted with a significant incidence of oral disease, most of which remain untreated (van Wyk & van Wyk, 2004). In addition, there is a low dentist:patient ratio, particularly in rural regions (Bhayat & Chikte, 2017).

In light of the aforementioned challenges, teledentistry presents itself as a viable and promising solution for mitigating these deficiencies. It has the potential to revolutionise the provision of dental treatment and address oral health disparities between rural and urban areas (Estai *et al.*, 2018). The integration of dental care into a broader healthcare framework is a prospective avenue that holds promise for the holistic management of illnesses that manifest oral symptoms (Petersen, 2003).

Teledentistry has the potential to function as a potent mechanism for enhancing oral health awareness and education among communities, effectively targeting both the symptoms and underlying factors contributing to oral health problems. Its use has the potential to significantly impact the oral healthcare landscape in South Africa, enhancing its accessibility, equity, and efficacy. The efficacy of teledentistry examinations in detecting dental caries is comparable to that of traditional clinical examinations. This research study presents empirical evidence supporting the potential use of teledentistry as a feasible alternative for screening dental caries and facilitating remote consultation and treatment planning.

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APPENDICES

APPENDIX 1: Information Sheet

INFORMATION SHEET

Research title: **A Comparative Analysis of Traditional Dental Screening versus Smart Phone Screening**

What is this study about?

This research study is being conducted by Dr Nuerisha Singh (a MChD student at the Faculty of Dentistry, University of Western Cape). This study aims to prove concordance in accuracy and reliability between mobile teledentistry using the smartphone camera, via the Vula app, for remote screening of teeth that are either sound, decayed, filled with decay, filled with no decay, missing as a result of caries or not recorded compared to traditional chairside dental screening.

What will I be asked to do if I agree to participate?

As patient, you will be invited to participate in our study if you are 18 years or older, your will be required to allow the dentist to take pictures of your mouth that will be uploaded on to the Vula App.

What is the Vula App?

Vula is a medical referral app (that is PoPi complainant) that was built to conquer the challenges faced by health care workers in rural settings. The app allows for communication between health care workers. It is a means of seeking advice from specialists. It is also a means to refer patients to specialists

Would my participation in this study be kept confidential?

Data collected will be confidential and kept securely at all times. Your participation and personal information will remain strictly confidential. Data reported on will be anonymous. The Vula App is cloud based and is POPI and HIPPA compliant.

What are the risks of this research?

This research bears no risk to you.

Do I have to be in this research and may I stop participating at any time?

Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time without being disadvantaged.

For any questions about the research study itself, please see full list of contact details below:

Name	Telephone No.	Email Address
Dr Nuerisha Singh	021 937 3147	3000940@myuwc.ac.za

University of the Western Cape. Private Bag X1. Tygerberg 7505. South Africa.

APPENDIX 2: Informed Consent

UNIVERSITY of the WESTERN CAPE

FACULTY of DENTISTRY
UNIVERSITY of the WESTERN CAPE

CONSENT FORM

Research title: **A Comparative Analysis of Traditional Dental Screening versus Smart Phone Screening**

I have read the information presented in the information letter. It has been described to me in a language that I understand and I freely and voluntary agree to participate. My questions about the study have been answered. I understand that my identity will not be disclosed and was informed that I may withdraw my consent at any time by advising the researcher. I agree to have my personal details uploaded on the Vula App and to have intra oral photographs taken via the Vula App. With full knowledge of all foregoing, I agree to participate in this study.

I, _____, agree to participate in the study.

Signature: _____ Date: _____

Place: _____

Student Researcher: **Nuerisha Singh**

Student Researcher Signature: _____

Student Number: **3000940**

Mobile Number: **0844445502** Email: 3000940@myuwc.ac.za

APPENDIX 3: Consent for Photography

UNIVERSITY of the WESTERN CAPE

FACULTY of DENTISTRY
UNIVERSITY of the WESTERN CAPE

Photography Consent Form

Project title: A Comparative Analysis of Traditional Dental Screening versus Smart Phone Screening

Principal Investigator: Dr Nuerisha Singh (MChD Student; University of the Western Cape)

Supervisor: Prof. S. Naidoo (UWC)

Department: Community Oral Health

Phone: 021 927 3147

Email: 3000940@myuwc.ac.za

I, ... hereby consent to photographs being taken of me as requested, I understand that these photographs will be stored appropriately, treated with the utmost confidentiality and be part of my dental record. I hereby give consent for the images or recordings to be used ONLY for the boxes I have indicated with a tick (√):

☐ **Record purposes and for my/my child's future management**

The photographic images and recordings will form part of the information collected for your care and treatment. This information is handled in accordance with the HPCSA Booklet 9: Guidelines on the keeping of patient records.

☐ **Education and training purposes**

The photographic images and recordings may be used for teaching purposes and viewed by health professionals outside of the UWC Faculty of Dentistry. The images may be used for example, in talks, conference presentations, posters or on the internet to help train other health professionals in the management of dental and oral diseases

☐ **Approved research purposes & publication**

This may involve the photographic images and recordings being used for example in medical or dental publications, journals, textbooks, conference material, e-publications and on the Internet. Images will be seen by health professionals and researchers who use the publications in their professional education. The

images may be seen by the general public. Images will not be used with identifying information such as name, however, full confidentiality is not guaranteed.

☐ **Other purposes** (please specify): …….

Declaration by the Participant

I (full name) …….

- Have read, understood and received a copy of the foregoing photography consent form, written in a language with which I am fluent;
- Have had the opportunity to ask questions regarding this and any questions I have asked have been answered to my satisfaction;
- I understand that all efforts will be made to conceal my identity but that full confidentiality cannot be guaranteed.
- I understand that my consent or refusal will in no way affect my dental care.

Signature of participant: _____ **Date:** _____

Witness Name & Signature: _____ **Date:** _____

We thank you for your contribution to our research

APPENDIX 4: Data Collection Sheet

Modified WHO Oral Health Assessment Form (2013)

Data collector	
Patient name	
Patient identification number	
Gender	
Date	

Status	**Treatment needed**
A= Sound	**0** = None
B = Decayed	**1** = Filling
C = Filled with decay	**2** = Extraction
D = Filled no decay	**3** = Pulp care
E = Missing as a result of caries	**4** = Fissure Sealant
F = Not recorded	**5** = Need for other care

	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
Status																
Treatment needed																
	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
Status																
Treatment needed																

Which clinical department should the patient be referred to? _____.

APPENDIX 5: Key for Data Collection Sheet

Key for data capture sheet

Status	Explanation
A= Sound	A crown is coded as sound if it shows no evidence of treated or untreated clinical caries. The stages of caries that precede cavitation, as well as other conditions similar to the early stages of caries, are excluded because they cannot be reliably identified in most field conditions in which epidemiological surveys are conducted.
B = Decayed	Caries is recorded as present when a lesion in a pit or fissure, or on a smooth tooth surface, has an unmistakable cavity, undermined enamel, or a detectably softened floor or wall. A tooth with a temporary filling, or one which is sealed but also decayed, should also be included in this category. In cases where the crown has been destroyed by caries and only the root is left.
C = Filled with decay	A tooth is considered filled, with decay, when it has one or more permanent restorations and one or more areas that are decayed. No distinction is made between primary and secondary caries and the same code applies regardless of whether the carious lesions are in contact with the restoration(s)

D = Filled no decay	A tooth is considered filled, without caries, when one or more permanent restorations are present and there is no caries anywhere on the crown. A tooth that has been crowned because of previous decay is recorded in this category.
E = Missing as a result of caries	This code is used for permanent or primary teeth that have been extracted because of caries. For missing primary teeth, this score should be used only if the subject is at an age when normal exfoliation would not be a sufficient explanation for absence.
F = Not recorded	This code is used for an erupted permanent tooth that cannot be examined for any reason such as orthodontic bands, severe hypoplasia, etc.

APPENDIX 6: BMREC Approval

UNIVERSITY of the WESTERN CAPE

RESPICE PROSPICE

60 YEARS of hope, action & knowledge

01 December 2021

Dr N Singh
Community Oral Health
Faculty of Dentistry

Ethics Reference Number:	BM21/10/28
Project Title:	A Comparative Analysis of Traditional Dental Screening versus Smart Phone Screening.
Approval Period:	**01 December 2021 – 01 December 2024**

I hereby certify that the Biomedical Science Research Ethics Committee of the University of the Western Cape approved the scientific methodology and ethics of the above mentioned research project and the requested amendment to the project.

Any further amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report annually by 30 November for the duration of the project.

For permission to conduct research using student and/or staff data or to distribute research surveys/questionnaires please apply via:
https://sites.google.com/uwc.ac.za/permissionresearch/home

The permission letter must then be submitted to BMREC for record keeping purposes.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

NHREC Registration Number: BMREC-130416-050

FROM HOPE TO ACTION THROUGH KNOWLEDGE.