INFECTION CONTROL KNOWLEDGE BEHAVIOUR ATTITUDE AND COMPLIANCE PRACTICES IN SELECTED DENTAL LABORATORIES IN CAPE TOWN, SOUTH AFRICA

by

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DECLARATION

I Makua Lilian Madubugwu, hereby declare that the contents of this thesis are entirely my work and that it has not been previously submitted for any academic examination or qualification. Moreover, the opinions expressed in this thesis are solely my own and do not necessarily reflect those of the Cape Peninsula University of Technology.

……………………………… ……28 May 2024………….

Student's signature Date

ABSTRACT

The aim of the study was to assess the dental technicians' and technologists' knowledge, behaviour, attitude, and compliance regarding infection control in dental laboratories in Cape Town. The study utilised mixed-methods and triangulation in a descriptive design guided by three research questions. The study selected a sample of eighty-nine (89) out of one hundred and fifteen (115) dental laboratories in Cape Town. The dental laboratories were selected through probability sampling which considered simple random sampling by lottery. However, the dental technicians and technologists in the dental laboratories were selected through non-probability sampling, using convenience sampling, which selected individuals based on the inclusion criteria of the study. The structured questionnaire and semi-structured interview questions were developed by the researcher based on reviewed literature and were used for data collection. Three professionals in the field validated the research instruments using face and content forms of validation. To assess the reliability of the instruments, a test-retest method was employed. The sets of data were correlated using the Pearson product-moment correlation to measure stability and Cronbach alpha to examine internal consistency in Statistical Package for the Social Sciences software version 28 (IBM SPSS 28, IBM Corp., Armonk, N.Y, USA), results of the test revealed a correlation coefficient (r) of 0.98 and coefficient alpha of 0.9 respectively, indicating a high reliability. Data from the questionnaires (quantitative data) were analysed using descriptive statistics while data from the interviews (qualitative data) were analysed using content analysis, both were carried out descriptively. The Number Cruncher Statistical Software, 2021 (NCSS, 2021, LLC, Kaysville, Utah USA) was used for the analysis. The findings were illustrated using frequencies, percentages, and cumulative percentages. The results revealed that the dental technicians and technologists had moderately good knowledge, behaviour, and attitude to infection control. Furthermore, it revealed that there was an average level of compliance with infection control protocols in the dental laboratories. It is recommended that SADTC organise training or workshops twice or thrice a year, as this would give dental technicians and technologists options to choose a convenient time that suits them. Additionally, SADTC should create a committee whose roles would be to develop infection control guidelines and policies for dental laboratories, dental technicians, and technologists in agreement with dentists or dental clinics and ensure strict compliance with these guidelines and policies.

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DEDICATION

This thesis is dedicated to God, in whom there is no variability nor shadow of turning.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

ADA:	American Dental Association
BTech:	Bachelor of Technology
CDC:	Centers for Disease Control and Prevention
CPD:	Continuing Professional Development
CPUT:	Cape Peninsula University of Technology
DNA:	Deoxyribonucleic acid
dsDNA:	Anti-double-stranded DNA
dsRNA:	Double-stranded RNA
HND:	Higher National Diploma
ND:	National Diploma
OSHA:	Occupational Safety and Health
PPC:	Personal Protective Clothing
RNA:	Ribonucleic acid
SADTC:	South African Dental Technicians Council
ssDNA:	Single-stranded DNA
ssRNA:	Single-stranded RNA
WHO:	World Health Organisation

GLOSSARY

Cross-contamination: The unintentional transfer of micro-organisms from one substance or object to another.

Dental impression: A negative imprint of the teeth and oral structures used to create a dental model or cast.

Dental laboratories: Dental laboratories are facilities that specialise in creating dental prostheses, which are used to improve oral health. These prostheses are vital for patients who have lost teeth or require dental repairs.

Dental prostheses: Intra-oral appliances called prostheses (singular: prosthesis) are used to restore or reconstruct missing parts of the teeth and other structures within the mouth such as the jaw and palate. Dental prostheses include dentures and mouthguards.

Dental technician or technologist: A dental technician or dental technologist is a member of a dental team who creates dental appliances and prostheses based on prescriptions from a dental clinician.

Infection control: Prevention or control of the spread of infections in health-care facilities and communities.

Prosthodontics: A dental speciality that focuses on the design, fabrication and fitting of dental prostheses to restore form and function, and to improve aesthetics.

Pumice: A powder used in a slurry form for cleaning and polishing dental prostheses.

SADTC: South African Dental Technicians Council. A regulatory body for the practice of dental technology in South Africa.

OPERATIONAL DEFINITIONS

Attitude: Attitude in this study refers to the dental technicians' and technologists' views on infection control in the dental laboratories, measured through questionnaires and interviews.

Behaviour: Behaviour in this study refers to the dental technicians' and technologists' acts regarding infection control.

Compliance: Compliance refers to the dental technicians' and technologists' infection control practices in the dental laboratories as obtained from their responses to the questionnaires and interviews.

Knowledge: Knowledge refers to information and facts that the dental technicians and technologists have on infection control in the dental laboratories.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Infection control practices in dental laboratories vary worldwide and often fall short of the required standards. Dentistry is a field that involves exposure to saliva, blood, and other likely infectious mediums. Therefore, it is crucial to maintain a high level of infection control and safety measures to manage cross-contamination and professional exposure to blood and saliva-borne infections (Vázquez-Rodríguez *et al.,* 2018; Gupta *et al*., 2017). Studies by Vázquez-Rodríguez *et al*. (2018) and Gupta *et al*. (2017) highlight the importance of stringent infection control practices in dentistry.

Dental laboratories receive and handle impressions and prostheses from dental clinics and practices, which may contain saliva and sometimes blood from the patient's mouth. This can pose a risk to the well-being of dental technicians and technologists, since they may be exposed to pathogenic micro-organisms from contaminated impressions, and prostheses, or by not adequately handling materials after they arrive at the dental laboratories from dental clinics (Balcos *et al*., 2018; Gupta *et al*., 2017). Infections in dental laboratories are mainly due to exposure to infectious agents such as bacteria, viruses, and fungi through contaminated impressions, and other prosthetic materials from dental clinics and practices which may contain saliva or blood, originating from the patient’s mouth. These infectious agents can cause cross-contamination from patients to dental technicians or technologists and may expose them to infections such as HIV, hepatitis B and hepatitis C (Vázquez-Rodríguez *et al.,* 2018). In addition, Gupta *et al*., (2017) noted that dental professionals stand a greater chance of being infected with hepatitis B than the general population as noted in a study where a case of professional hepatitis B infection in the dental laboratory was reported (Balcos *et al*., 2018).

Another unpopular but deadly infectious agent is the Prions which is a concern in dentistry (Srivastava *et al*., 2022). Prions are misfolded proteins that can change into numerous structures of the same protein. According to research, these infectious organisms are capable of tissue, brain, and nerve disorders, and are referred to as ‘transmissible spongiform encephalopathies’ (TSEs) (Sushma *et al*., 2016). Improper handling of instruments or prosthetic materials used on patients with Creutzfeldt-Jakob disease or other prion diseases can lead to cross-contamination, resulting in serious health implications. Unfortunately, there are no diagnostic tests yet for detecting prion infections, nor are there treatments, or vaccines against prion infections (Srivastava *et al*., 2022; Sushma *et al*., 2016).

A study revealed that despite the sterilisation and disinfection of instruments and equipment by dental clinics and practices, dental prostheses were contaminated with micro-organisms from patients' mouths as prosthetic materials do not receive proper infection control (Balcos *et al*., 2018). Naz *et al*. (2020), reported a national study where 90% of all fractured dentures sent to various dental laboratories were contaminated with micro-organisms.

Furthermore, a study by Sykes *et al*. (2019), highlighted the presence of micro-organisms such as aerobic gram-positive bacilli, including *B. Cereus*, *B. brevis* and *B. licheniformis,* yeasts and moulds in polishing wheels and pumice slurry. These findings corroborate with the findings of Qaisar *et al*. (2015), where the presence of bacilli and levels of contamination in pumice slurry and rag wheel were revealed. In a study, Sykes *et al*. (2019), revealed polishing lathes and pumice slurry were potential sources of contamination for oral and non-oral microbial agents in dental laboratories because of the chances of transferring pathogens from contaminated patients' prostheses to uncontaminated prostheses during polishing in dental laboratories where pumice slurry and polishing lathes are not frequently changed or disinfected. The consequences are that this causes a lot of risks not only to the patients whose prostheses are infected with these micro-organisms but also to the dental technicians and technologists who work with the contaminated equipment and contaminated pumice powder and slurry. They may be at risk of eye infections and conjunctivitis from an aerosol produced within the polishing procedures of dental prostheses.

Research by Sammy & Benjamin (2016), hinted that most dental laboratories in Durban had poor compliance with infection control procedures. Sammy & Benjamin (2016), recommended that there should be mandatory continuing professional development seminars and training programs on infection control, to update dental technicians and technologists on current infection control protocols. Furthermore, Naz *et al*. (2020), recommended that dental technicians and technologists should be made aware of infection control measures and strict policies should be implemented in dental laboratories in a report highlighted that infection control protocols were not appropriately practised by dental technicians in most dental laboratories in Karachi. In addition, Hamida *et al*. (2023), emphasised the need for improved educational programs and infection control awareness for both dentists and dental technicians in a report that highlighted the lack of communication between dental clinics and dental laboratories, as well as the insufficient awareness and practice of infection control among dental technicians in dental laboratories in Tripoli, Libya.

Despite the research and recommendations on infection control in dental laboratories, findings revealed poor compliance with infection control procedures and a general lack of awareness amongst dental technicians and technologists regarding basic infection control procedures and protocols in dental laboratories. However, these findings were identified outside the present area of study, Cape Town, South Africa. It is this gap that aroused the researcher's interest to undertake a study on infection control, knowledge, behaviour, attitude, and compliance practices in Cape Town. The objectives of this study were to assess the level of knowledge, behaviour, and attitude of the dental technicians and technologists on infection control, to identify the possible infection control protocols and practices used by the technicians and technologists in the dental laboratories in Cape Town, and to determine the dental technicians' and technologists' compliance to infection control practices. This will help fill the gap created by other related studies.

1.2 Statement of research problem

Dental prostheses and impressions can serve as sources for the transmission of infections between dental clinics and laboratories (Balcos *et al*., 2018). Cross-contamination can occur from a patient's saliva or blood, especially in the case of high-risk patients. This presents a hazard to the well-being of dental technicians and technologists (Sammy & Benjamin, 2016). Despite varying infection control protocols across dental laboratories worldwide, many of these dental laboratories, still have dissatisfactory hygiene practices indicating the need for more rigid control measures to minimise the risk of disease transmission among dental technicians and technologists. It is of concern that some dental laboratories may lack infection control measures or fail to conform to them. Therefore, it is crucial to evaluate the knowledge, behaviour, attitude, and compliance practices of dental technicians and technologists regarding infection control in the selected dental laboratories in Cape Town, South Africa.

1.3 Research objectives

The study's main objective is to examine the infection control, knowledge, behaviour, attitude, and compliance practices in selected dental laboratories in Cape Town, South Africa. Specifically, the study aimed to achieve the following objectives:

1. Assess, the knowledge, behaviour, and attitude of the dental technicians and technologists on infection control in selected dental laboratories in Cape Town.
2. Identify infection control protocols and practices employed in these dental laboratories.
3. Determine the dental technicians' and technologists' compliance with infection control practices.

1.4 Research questions

The study was guided by the following research questions:

1. What are the dental technicians' and technologists' understanding, knowledge, and insights regarding infection control in the dental laboratories in Cape Town?
2. What are the current measures and infection control protocols in place to prevent the transmission of infectious diseases in dental laboratories?
3. What are the dental technicians' and technologists' compliance with infection control protocols in the dental laboratories?

1.5 Significance of the study

The importance of infection control in the dental laboratory cannot be overemphasized, hence this study would contribute to further research in this area especially with limited information on this topic. The study's findings would help provide insight into the knowledge, behaviour, attitude, and compliance practices of dental technicians and technologists regarding infection control within dental laboratories in the Western Cape. Furthermore, findings from the study would be disseminated to dental laboratories possibly through SADTC which would be of great benefit to the dental profession and the dental professionals and may help provide organisations, scholars, dental professionals, and policymakers with useful information to develop infection control guidelines or plan for the dental laboratories in South Africa and possible ways to ensure strict compliance.

In addition, the study would make an essential contribution to the current knowledge in the dental field globally and at the national level, in the dental profession in Cape Town. Finally, the study would create more awareness of the importance of infection control which will help to minimise the spread of infectious diseases and cross-contamination among professionals in dental practice. This knowledge therefore would help provide a safe environment for all dental personnel.

1.6 Structure of the thesis

The thesis will be structured as follows:

Chapter 1 - Introduction

An overview of the study was presented in this chapter to give readers an insight into what is contained in the study.

Chapter 2 - Literature review

The chapter will review related literature, journals, periodicals, and articles. Literature will be reviewed under the conceptual and theoretical framework.

Chapter 3 – Research design and methodology

The research methodology, design, area of study, population of the study, sample, sampling, data collection, analysis, reliability, validity, and ethical considerations will be discussed in this chapter.

Chapter 4 - Data analysis, interpretations, and discussions of findings

The data from the study were analysed, and interpreted, and will be discussed in chapter 4.

Chapter 5 – Discussions, summary, conclusions, and recommendations

The chapter highlights the discussions, summary, conclusions, and recommendations for further studies.

1.7 Summary of chapter

This chapter presented a background of the study and discussed the problem, research objectives, research questions and the significance of the study. It also presented the structure or layout of the thesis, to provide the reader with a brief overview of the study. This will help the reader understand the study in its entirety.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The review of literature for this study will be organised under two main subheadings- the conceptual framework, and the theoretical framework. These subheadings will help the reader to better understand the background and context of the study. Additionally, a summary of the literature review will be included to provide an overview of the chapter.

2.2 Conceptual framework

The conceptual framework of the literature review for this study will consider the following sub-themes: overview of infectious diseases, infectious agents, types of infectious agents, chain of infection, modes of infection transmission in the dental laboratory, infection control, infection control practices and protocols in the dental laboratory, knowledge, behaviour, attitude, and compliance.

2.2.1 Overview of infectious diseases

Infectious diseases are caused by pathogenic micro-organisms such as fungi, bacteria, and viruses that can be passed directly or indirectly from one person to another (Garg *et al*., 2023; Moore, 2021). According to Van Seventer & Hochberg (2017), infectious diseases are caused by micro-organisms or their poisonous products, and they can be transmitted from infected individuals, infected animals, or contaminated surfaces to susceptible hosts. For an infection to occur, there must be a causative agent (micro-organism) capable of destroying the normal body tissue, reservoirs such as the body fluids (blood or saliva) in which the micro-organisms can flourish and multiply, an exit point through which the micro-organism can leave the host such as the mouth, the nose, the respiratory tract or intestinal tract, a means of transmission like the hands, air currents, vectors, or other routes by which the pathogens can be transferred from one place or person to another; and an entry point through which infectious agents can enter the body of a vulnerable host (Bromberg & Brizuela, 2023; Schmidt, 2020).

Infectious agents are the cause of infectious diseases which are responsible for the immense global burden of diseases and the cause of death in humans and animals (Van den Driessche, 2017; van Seventer & Hochberg, 2017).

Effective infection control in a dental setting requires a comprehensive understanding of infectious agents and the diseases they cause. It is essential to discuss the types of infectious agents and the diseases they cause to minimise the risks of cross-contamination and exposure among dental personnel and patients. By doing so, we can prevent infections and ensure a safe and healthy dental environment for everyone.

2.2.2 Infectious agents

Infectious agents are bacteria, viruses, fungi, parasites, and proteins called prions (Cohen & Ligda, 2015).

According to Mayhall (2012), infectious agents are the reason for various healthcare-associated diseases and these agents are of varying sizes, shapes, and structures. Mayhall (2012), explained that for an infectious agent to successfully be transmitted from the environment to a host, the micro-organism must remain active in the environment until it meets the host to cause infection. Scott (2013), confirmed that micro-organisms can remain active and survive for a long time in an environment or surface depending on the species and conditions such as the presence of water (moisture). Mayhall (2012), pointed out that the important attributes necessary for micro-organisms to survive in an environment are: the ability to attack and overcome the host's immune system; the ability to multiply in cells, tissues or hosts; the ability to withstand ultraviolet radiations, high temperatures or antimicrobials; the ability to produce toxins to cause infections and the ability to contend with other agents and replicate in a host.

2.2.3 Types of infectious agents.

To have good knowledge of infection control practices or protocols, it is important to understand the different types of infectious agents that can cause infections in the dental laboratory or health care setting, as infectious agents are connected to infections. The different types of infectious agents are bacteria, viruses, fungi, parasites, and prions (Cohen & Ligda, 2015; Mayhall, 2012). Knowledge of these infectious agents will therefore contribute immensely to the prevention of infectious diseases caused by these agents.

2.2.3.1 Bacteria

Bacteria (singular bacterium) are tiny, single-celled pathogens called prokaryotes, they are visible only under a light microscope and can grow well in suitable conditions as well as survive in extreme conditions (Pappas & Vidyasagar, 2021). Bacteria can naturally live in the human body, the soil, and other conducive environments (Pappas & Vidyasagar, 2021). According to Pappas & Vidyasagar (2021), bacteria do not have a nucleus however, they contain a double-stranded deoxyribonucleic acid (DNA) that forms a sporadically shaped structure called the nucleoid and a small circular double-stranded extrachromosomal DNA molecule called the plasmid, which is separated from the chromosomal DNA and can freely replicate. The cells of a bacterium are protected by an outer cell wall and an inner cell membrane containing peptidoglycans, making them resistant to white blood cells in the body. Bacteria move around using flagella and possess appendages that help them stick to one another on surfaces and in the human body (Cherney, 2022; Pappas & Vidyasagar, 2021).

Bacteria can be categorised based on their shapes, cellular arrangements, and the appearance of their cell wall in gram stain. There are three main shapes of bacteria: coccus (singular) or cocci (plural) bacteria, which are oval or round shaped; bacillus (singular) or bacilli (plural) bacteria which are rod-like in shape and spiral bacteria which are spiral or curved-shaped (Pappas & Vidyasagar, 2021; Mohamad *et al*., 2014). Based on their cellular arrangement, bacteria can appear singularly, in pairs, groups, chains, clusters, or cubes. For example, cocci exist in two as *diplococci*, in a group of four as *tetrad*, in a chain as *streptococci*, in clusters as *staphylococci* and in cubes of eight as *sarcinae* (Kher, 2012). Furthermore, bacteria can be classified as either gram-positive or gram-negative based on how their cell wall appear in gram stain (Rohde, 2019). The gram stain method was developed by Hans Christian Gram in 1884, who introduced gentian violet dye, iodine and safranin dye used in the staining technique. Gram-positive bacteria appear violet in colour under a microscope when stained with gentian violet and iodine, due to their thick cell wall that retains the crystal violet iodine complex. On the other hand, gram-negative bacteria take up the colour of the dye used for the counterstain (safranin) in the staining technique and appear red in colour (Rohde, 2019).

Bacteria reproduce through a process called binary fusion (Pappas & Vidyasagar, 2021). This process begins with the parent cell or single bacterium cell replicating and continuing to grow until a new cell develops. The new cell then splits into two, forming daughter cells that are genetically identical to the parent cell. Bacterial recombination is another way in which bacteria can reproduce. This process involves the transfer of genetic material and can occur through three different methods: conjugation, transformation, or transduction (Pappas & Vidyasagar, 2021; Vitug, 2021).

Based on the findings of Taheri *et al*. (2021), the dental setting is at risk of infections from several types of bacteria, including *Streptococcus pneumonia*, *Mycobacterium tuberculosis*, *Klebsiella pneumonia*, *Escherichia coli*, *Legionella pneumophila*, and *Pseudomonas aeruginosa*. Meanwhile, a study by Moodley *et al*. (2020), revealed that streptococci are the most common bacterial contaminant that can cause an infection in a dental setting.

Bacteria have the potential to multiply rapidly. Additionally, some strains of bacteria have 'bacterial spores' which make them resistant to heat and chemicals, making it even more challenging to control them (Samaranayake, 2018). To prevent them from multiplying, it is essential to carry out adequate sterilisation and disinfection procedures (Abusalim, 2022; Samaranayake, 2018).

Antibiotics are used to treat bacterial infections. They work by interrupting the processes required for the bacteria to reproduce and grow in the body, thus stopping their growth (Davis, 2020).

2.2.3.2 Viruses

Viruses are smaller than bacteria and have either deoxyribonucleic acid (DNA) or ribonucleic acid (RNA) genome but not both, which is protected by a protein shell known as the “capsid” (Louten, 2016). In most viruses, the capsid is surrounded by a fat membrane known as an envelope (Louten, 2016). Genome, according to Roth (2019), refers to a virus’s genetic material or content which consists of DNA or RNA. Genomes can be single-stranded or double-stranded, linear, or circular, or single or multi-segmented (Li *et al.*, 2016). Viruses are “obligate intracellular parasites” because they rely on the host cell to produce new infectious virions or virus particles. This means that for a virus to infect other cells or individuals, the infectious virus particle must be released from the host cell (Louten, 2016). To successfully release its infectious particle (virion) to other cells or individuals from the host cell, the virus’s genetic properties (DNA or RNA) must be shielded against mutilation by ultraviolet radiation or heat, physical stress, or exposure to enzymes from the extracellular environment, as this could cause damage and prevent new infectious virus particles (virions) (Louten, 2016).

Viruses can be categorised in various ways based on their size, shape, structure, genetic material, and mode of replication. One of the most recognised classification systems is the Baltimore classification system developed by David Baltimore, which is based on the nature of the virus’s genetic material and replication methods (Clark *et al.*, 2018; Louten, 2016). Baltimore’s classification, groups viruses into seven classes: Class I: Anti-double-stranded deoxyribonucleic acid (dsDNA) viruses (for example, herpesvirus), Class II: Single-stranded deoxyribonucleic acid (ssDNA) viruses (for example, parvovirus), Class III: Double-stranded ribonucleic acid (dsRNA) viruses (for example, rotavirus), Class IV: Positive-sense single-stranded ribonucleic acid (ssRNA viruses (for example, picornavirus that causes the common cold), Class V: Negative-sense single-stranded ribonucleic acid (ssRNA) viruses (for example, rhabdovirus that causes rabies), Class VI: Reverse transcriptase ribonucleic acid (RNA) viruses (for example, HIV), Class VII: Reverse transcriptase deoxyribonucleic acid **(**DNA) viruses (for example, hepatitis B Virus) (Clark *et al.*, 2018; Louten, 2016). Additionally, viruses can also be classified based on their envelope, with non-enveloped viruses as negative envelope and enveloped viruses as positive envelope viruses. They can also be classified according to their capsid structure as helical or icosahedral, and their genetic properties as DNA and RNA viruses. Finally, viruses can be classified based on their host cells or organisms such as plant viruses, bacteriophages (viruses that infect bacteria) and animal (viruses that infect humans or animals) viruses (Mateu, 2013).

According to Roth (2019), viruses are unable to reproduce on their own and require a living host cell, such as a plant, bacteria, or human to do so. Roth (2019), further explained that outside of a host cell, viruses protect themselves in a particle called the “virion” and they can survive for an extended period until they encounter a host cell. Once a virion attaches itself to a living cell, it introduces its genetic material (DNA) into the host cell and uses the host's cellular metabolism to replicate a new virus. This new virus then breaks off into other cells to continue the cycle (Ryu, 2017). Viruses can reproduce either through a lytic cycle or a lysogenic cycle (Lodish *et al*., 2000).

Blood-borne viruses of concern in dental settings are human immunodeficiency virus (HIV), hepatitis B virus (HBV), mumps, herpes simplex virus (type 1 and 2), rubella, rotavirus, coronavirus (COVID-19), human papillomavirus, measles, adenovirus, Epstein-Barr virus (EBV), and varicella zoster (Bromberg & Brizuela, 2023; Corstjens *et al*., 2016).

Viral infections cannot be treated with antibiotics. They can be treated using antiviral medications or prevented through immunisation or vaccination (Davis, 2020).

2.2.3.3 Fungi

Fungi are micro-organisms referred to as eukaryotes. They are immotile and include organisms such as moulds, yeasts, and mushrooms. There are organisms which are referred to as fungi because they look like fungi, however, they are not grouped into the kingdom fungi (Raghukumar, 2017). According to Raghukumar (2017), fungi play a significant role in breaking down dead organic materials.

According to Campbell & Johnson (2013), fungi can be divided into three groups namely, the unicellular fungi such as the yeasts, the multicellular filamentous fungi such as the moulds and the dimorphic fungi (able to change to either unicellular or multicellular form). Campbell & Johnson (2013), further explained that the reproduction in fungi is by means of spore which is produced by either an asexual process or a sexual process.

Many pathogenic fungi known to cause diseases in humans and other animals are parasitic in nature and are the cause of many deaths in recent times as fungal diseases or infections are sadly often neglected. Most fungal infections are due to prolonged use of antibiotics, or a weakened immune system (Janbon *et al*., 2019; Seyedmousavi *et al*., 2018).

The most recurrent superficial fungus in a dental setting is the candida with varying species such as *candida albicans*, *candida parapsilosis*, *candida stellatoidea*, and *candida glabrata* which are the cause of candida-associated infections or diseases such as angular chelitis, central papillary atrophy, oral candidiasis, and denture stomatitis (Rajendra Santosh *et al*., 2021; Lombardi & Quanounou, 2020).

Fungal infections are preventable through proper hygiene and may be treated using topical or systemic antifungal medications (Lombardi & Ouanounou, 2020; Gupta *et al*., 2017).

2.2.3.4 Parasites

Parasites are micro-organisms that depend solely on their hosts for survival, without which they cannot grow, live and multiply (Newton & Splete, 2020). Newton & Splete (2020), further explained that parasites disrupt the normal biological activities of the host to cause infections, deformities and sometimes death. Parasites such as the roundworms, that live within the body of the host are called endoparasites whereas the ones that live outside the host's body, such as the tick or lice are called ectoparasites. Parasites can be spread through contaminated food, water, blood, waste or through insects that act as vectors and can cause diseases such as amoebiasis and trypanosomiasis. The three main types of parasites include protozoa, helminths and ectoparasites (Newton & Splete, 2020). However, for this review, only the protozoa and helminths will be discussed, as well as the diseases they cause in the dental setting.

2.2.3.4.1 Protozoa

According to Esteban *et al*. (2015), protozoa are microscopic, single-celled eukaryotic organisms that can live independently or as parasites, and exhibit animal-like motility and feeding features.

Protozoa can be classified based on their movement as amoeboids, flagellated or ciliated (Esteban *et al*., 2015).

Protozoa that are commonly found in dental settings include the *leishmania spp* which can cause leishmaniasis, a disease that is responsible for sores and ulcers in the oral cavity. Another type of protozoa is *trichomonas tenax*, which has been linked to periodontal diseases and *entamoeba gingivalis*, which is known to cause oral inflammations (Puzio *et al*., 2021).

2.2.3.4.2 Helminths

Helminths are a type of worms that can affect humans. They can be elongated, flat, or rounded. Examples of helminths include the flatworm (platyhelminthes), the roundworms (nematodes), tapeworms (cestodes), flukes (trematodes) etc. These worms live and reproduce by laying eggs in the intestinal tracts of their hosts. The eggs are then excreted in faeces into the soil. If the soil is contaminated with the eggs, an individual or animal can become infected by ingesting foods grown from that soil or by touching food or water with hands contaminated with the eggs (Esteban *et al*., 2015; Castro, 2011). Esteban *et al*. (2015), further explained that helminths can also penetrate the skin through larvae that have matured from eggs when an individual walks barefooted, sits or lies on contaminated soil.

In a dental setting oral infections caused by helminths are trichinosis, trichuriasis, and echinococcosis (Hassona *et al*., 2015).

2.2.3.5 Prions

Prions are referred to as “proteinaceous infectious particles” that can be inherited genetically, acquired through infection, or sporadically emerge in human or animal brain tissue and nerves, causing severe damage (Bonda *et al*., 2016). All humans or animals have prion protein (PrP) which exists as PrP^{C} in normal form. However, when the prion protein becomes misfolded, it results in abnormality to the normal function and structure of prion protein (PrP^{Sc}) in humans or animals thereby causing prion protein diseases which are mostly neurodegenerative (Connor *et al*., 2019). Diseases such as Creutzfeldt-Jakob disease, fatal familial insomnia, kuru, etc. are caused by the infectious agent Prion and no successful treatment has been proven for these diseases (Aguzzi *et al*., 2018; Wille & Requena, 2018).

Oral manifestations of prion diseases in a dental setting include dysphagia, dysarthria, and paraesthesia (Sushma *et al*., 2016).

2.2.4 Chain of infection

The chain of infection illustrates how infectious organisms are spread from one person or place to another. Preventing the spread of infection within a locality is critical and can be achieved by breaking the chain of infection or chain of transmission. The chain of infection consists of six interlinked components that facilitate the spread of infectious agents and cause cross-contamination (van Seventer & Hochberg, 2017). According to van Seventer & Hochberg (2017), these components include the presence of a pathogenic micro-organism (infectious agents), an environment that allows the infectious agents to thrive and multiply, a portal of exit for the infectious agents, a means of transmission, a portal of entry, and a susceptible host. Exposure to micro-organisms is inevitable, however, the absence of any of the six links in the chain of infection will prevent the spread of infectious agents. Therefore, the primary objective of infection control is to break one or more of the links of the chain of infection to prevent the spread of these infectious agents (van Seventer & Hochberg, 2017). In the dental laboratory, effective management of prosthetic materials through disinfection, proper hand hygiene, immunisation, and use of personal protective clothing etc., can break the chain of infection and prevent the transmission of infectious agents.

Summarily, the chain of infection can be seen in Figure 2.1.

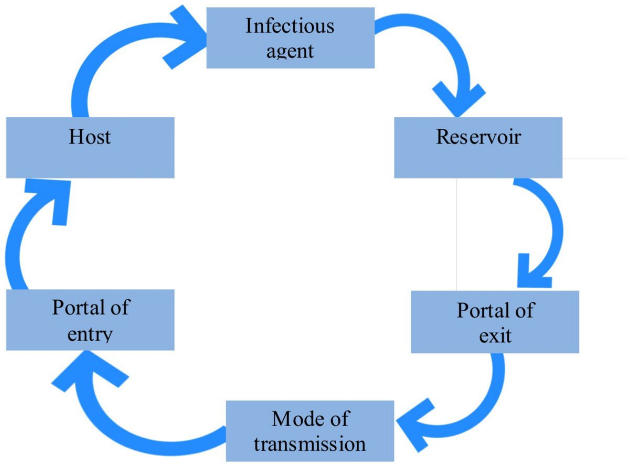

Figure 2.1:
Chain of Infection

(Schmidt, 2020).

Infectious agents refer to bacteria, viruses, fungi, parasites, and prions. These agents live, develop, and replicate in a reservoir which is necessary for their survival (Schmidt, 2020; WHO, 2001).

Reservoirs can be animate reservoirs or inanimate. Humans and animals represent animate reservoirs, while vectors and fomites such as equipment, tools, clothes, etc., represent the inanimate reservoirs (Samaranayake, 2018).

The route through which an infectious agent leaves its reservoir is referred to as the portal of exit. For human reservoirs, the portal of exit includes blood, bodily fluids etc. (van Seventer & Hochberg, 2017).

The modes of transmission are ways through which infectious agents move from their reservoirs to a susceptible host. These modes can be direct or indirect (van Seventer & Hochberg, 2017).

The portal of entry refers to the passage or gateway through which infectious agents penetrate and enter the susceptible host's body tissue. There are various portals of entry for human hosts in health care, however, the portals of entry for infectious agents in dental laboratories or dental health care settings include the respiratory tract, skin (cuts, wounds) and mucous membrane (van Seventer & Hochberg, 2017; Fluent & Molinari, 2013).

According to WHO (2001), susceptible hosts of infectious agents are the immuno-compromised, the newborn, and the elderly. In dental laboratories, the susceptible hosts are the patients and the dental technicians or technologists who may have underlying health conditions or who may not be vaccinated (Volgenant & de Soet, 2018).

2.2.5 Modes of infection transmission in the dental laboratory

Understanding the modes of transmission is critical for infection control and prevention. It is essential to disrupt the transmission of pathogens from their source to prevent the spread of infections. The transmission of micro-organisms in dental laboratories may be through direct contact transmission or Indirect contact transmission.

2.2.5.1 Direct contact transmission

Direct contact transmission involves physical contact from infected persons through infected secretions such as saliva or blood (Peng *et al.*, 2020). According to Higuera (2022), infection or cross-contamination in dental laboratories directly occurs through contact with blood or oral fluid, and via respiratory droplets.

(a) **Contact with blood or oral fluids**

Dental personnel may be exposed to infectious agents through contact with blood or oral fluid from patients through dental impressions and other prosthetic materials (Peng *et al.*, 2020). Transmission of these infectious agents is majorly due to the lack of proper disinfection of prosthetic materials after they are received in the dental laboratories. Receiving prosthetic materials from dental practices without wearing hand gloves or adequate hand hygiene after receiving prosthetic materials, are reasons for cross-infections in dental laboratories.

(b) **Respiratory droplets**

Droplets and aerosols containing micro-organisms generated during coughing, sneezing, or talking without wearing a mask or without covering the mouth with a napkin or coughing into the elbow, may touch broken skin or the mucous membrane of the eyes, or nose to cause infections such as influenza, herpes virus etc. Additionally, aerosols generated while trimming or polishing infected dental prostheses can remain in the air for a long time posing a risk if inhaled (Higuera, 2022; Barabari & Moharamzadeh, 2020; Miller & Palenik, 2018).

2.2.5.2 Indirect contact transmission

Indirect contact refers to the transmission of infectious pathogens from an intermediate object (fomites) to a susceptible host. This type of exposure occurs when a person comes in contact with contaminated materials, instruments, or other laboratory equipment that have been contaminated (Peng *et al.*, 2020).

In dental laboratories, different procedures require the transfer of materials between departments. These materials including Impressions, prostheses, and appliances may be contaminated with saliva and blood which can facilitate the transmission of micro-organisms. For example, micro-organisms found on dental impressions can easily be transferred to dental casts and survive for up to 7 days (Begum *et al*., 2013). This potential for cross-contamination can occur from one case to another within the laboratory as well as from contaminated handpieces, burs, wheels, and pumice pans. Begum *et al*. (2013), also noted that indirect contact transmission of infection can also occur through the transfer of pathogenic micro-organisms to surfaces and instruments from unwashed infected hands or from infected dental instruments or materials to the hands.

2.2.6 Infection control

According to WHO (2021), infection control and prevention is a practical and scientific-based approach to preventing the spread of infection or damage caused by infection to patients, health workers and the public.

It is of utmost importance in a dental laboratory to follow strict infection control measures and practices to prevent or minimise any risk of contamination. Jankare *et al*. (2019), emphasise that the fundamental goals of infection control in a dental laboratory are to protect dental technicians or dental technologists and patients from exposure to work-related infections and to reduce the risk of cross-infection by breaking the chain of infection. This can be achieved by using disinfectants appropriately and adopting healthy practices that reduce the spread of infectious agents.

2.2.7 Infection control practices and protocols in the dental laboratory

To ensure maximum safety, dental laboratories need to follow certain infection control protocols and guidelines. These include immunisation, personal protective clothing, hand hygiene, receiving and disinfecting areas in the laboratory, decontamination, infection control manual or guidelines, changing of pumice slurry, waste management, and education or training of dental personnel.

2.2.7.1 Immunisation

According to Begum *et al*. (2013), the hepatitis B vaccine is highly recommended for health workers. Begum *et al*. (2013), also advised protection against tuberculosis, measles, mumps, etc through vaccination. Dalma *et al*. (2018), agree that not only is immunisation one of the keys to infection control but immunisation for healthcare workers means the protection of the whole society. This means that health workers including dental laboratory workers directly or indirectly see patients or handle materials that belong to the patients who are members of society therefore immunisation for health workers does not save the health workers alone from the effects of cross-contamination but also the entire society from infectious diseases preventable through the vaccine.

2.2.7.2 Personal protective clothing

According to WHO, Personal protective clothing (PPC) refers to clothing worn during work to prevent or minimise exposure to harmful substances or occupational risks that may cause injury, infections, illnesses or even death in the workplace. Dental technicians and technologists are required to wear personal protective clothing while working. Personal protective clothing must be used whenever there is a possibility for splashing, or aerosols such as when operating model trimmers, polishing lathes, or any other rotary equipment. Wearing personal protective clothing involves putting it on (known as donning) before any procedure, which must be performed in a specific order: hand hygiene, laboratory coat, mask, eye or face protection, and gloves. When taking off personal protective clothing (known as doffing), hand hygiene must be performed after taking off each item, starting with gloves, eye or face protection, gown, and mask. Failure to follow the proper procedure could result in the transfer of blood, body substances, and other potentially infectious materials to both dental personnel and patients.

According to the Occupational Safety Health Administration (OSHA) and Centers for Disease Control and Prevention (CDC), employers are responsible for providing personal protective clothing for their employees, providing adequate training on the use of personal protective clothing, cleaning, or replacing PPC, and ensuring that the employees remove PPC before leaving the working area (Schrubbe, 2019). Personal protective clothing for dental technicians and technologists includes but is not limited to hand gloves, face masks, laboratory coats, and goggles or visors (Upendran *et al*., 2022; Goenharto *et al*., 2018).

(a) Hand gloves

Wearing gloves is crucial to protect the hands from injuries and to minimise the spread of pathogenic micro-organisms. In the dental laboratory, various types of gloves, including sterile, non-sterile, and utility gloves, should be worn when handling dental impressions or prosthetic materials, cleaning surfaces, and performing other laboratory procedures that require the use of gloves. Disposable gloves should not be reused while utility gloves can be washed and used again (Schrubbe, 2019; Goenharto *et al*., 2018).

(b) Face masks

Wearing a face mask is essential to protect the face, mouth, and nose. It also helps guard the respiratory system against dust from acrylic or pumice during trimming and polishing procedures or from the strong smell of monomer. According to Bromberg & Brizuela (2023), it is important to never reuse face masks and to replace them for every new procedure.

(c) Laboratory coats

It is important to wear laboratory coats when performing dental laboratory procedures to prevent staining of clothes or cross-contamination. After the day's laboratory work, the laboratory coat must be washed and ironed and should not be worn outside the laboratory (Goenharto *et al*., 2018).

(d) Goggles or visors

Goggles protect the eyes from specks of dust and chemicals that can cause infection or irritation to the eyes while working. On the other hand, the visors or face shield protect the entire face (eyes, nose, and mouth) from splashes, and dust during polishing or trimming procedures and chemicals while working (Goenharto *et al*., 2018).

2.2.7.3 Hand hygiene

Hand hygiene is considered one of the cost-effective ways to prevent healthcare-associated diseases. This can be achieved through hand washing or using an alcohol-based hand gel (Hillier, 2020). According to Loveday *et al*. (2014), hand hygiene should be performed immediately after contact with body fluid, broken skin, or mucous membrane, immediately after contact with contaminated instruments or equipment or engaging in activities that may contaminate the hands. Furthermore, dental technicians and technologists must wash their hands or use hand sanitisers immediately after receiving dental impressions or other prosthetic materials, after disinfecting impressions and other prosthetic materials or after contact with contaminated items in the dental laboratory. They should also wash their hands before and after any procedure, when their hands are visibly dirty, before wearing gloves or immediately after removing them.

The proper hand washing procedures involve turning on the tap at the sink, wetting the hands, dispensing an adequate amount of the liquid soap or antiseptic liquid soap into the palm, and rubbing them to create a lather. The hands should be rubbed for at least 10-20 seconds ensuring that all areas including the palms, the back of the hands, and areas between the fingers and the thumbs are thoroughly washed. The soap should be then rinsed with clean water making sure that there are no remnants of soap. Finally, the hands should be dried thoroughly using a paper towel which should also be used to turn off the tap (Hillier, 2020; Loveday *et al*., 2014).

According to Hillier, (2020), the proper procedure for using hand sanitisers involves applying a generous amount of an alcohol-based sanitiser to the hands, rubbing the hands together until the sanitiser is spread evenly palm to palm, between the fingers, back of the fingers, and the thumbs. The hands should be allowed to dry.

2.2.7.4 Receiving and disinfecting areas in the dental laboratory

Basmaci *et al*. (2021), emphasised the importance of establishing designated areas in dental laboratories for receiving and disinfecting incoming or outgoing cases such as dental impressions and other prosthetic materials. This is to prevent cross-contamination by ensuring that all incoming cases are first received, disinfected without hesitation, and labelled as 'disinfected' before they are transferred to work areas. The same procedure should be followed after the prostheses are completed. They should be disinfected in the same area and labelled as 'sterile' in a sealed box before being sent off to the dental clinics. All containers in this area must be sterilized or disinfected after each use. Sammy & Benjamin (2016), advised that there should be an infection control poster or signage displayed on the wall in this area, that reminds and encourages any dental technician or technologist in that area to maintain proper infection control procedures.

2.2.7.5 Decontamination

According to OSHA, decontamination is the process of removing or neutralising contaminants on materials, surfaces, and equipment to ensure the safety of personnel and patients. The process can be achieved through cleaning or rinsing, disinfection, and sterilization.

To achieve sterility and eliminate all contaminants from a surface, an object, and equipment, a combination of two or all three decontamination processes must be applied. It is important to note that sterility cannot be achieved by applying the processes independently (Rodger *et al*., 2022). Decontamination should be done before the start and after completion of any dental laboratory procedure.

2.2.7.5.1 Cleaning or rinsing

Cleaning in a dental laboratory involves wiping surfaces or equipment to remove contaminants while rinsing involves the removal of unwanted debris like blood, or saliva, which may be present on impressions and other prosthetic materials (Rodger *et al*., 2022). Cleaning is an important step of decontamination. Without proper cleaning or rinsing, disinfection or sterilisation will not be effective or complete as the presence of contaminants will reduce the quality of disinfection or sterilisation. Cleaning or rinsing is usually done using water or detergent, before disinfection or sterilisation (Rodger et al., 2022). Work surfaces, prosthetic materials or impressions and equipment should be cleaned or rinsed prior to disinfection or sterilisation daily (Sammy & Benjamin, 2016).

2.2.7.5.2 Disinfection

According to Jankare *et al*. (2019), disinfection is the thermal or chemical process of eliminating micro-organisms on objects, materials, or surfaces. Mushtaq & Khan (2018), further explained that disinfection kills pathogenic micro-organisms except for the bacterial spore. According to standard precautions, materials containing bodily fluid (saliva) and blood should be treated as potentially infectious, hence dental impressions and other prosthetic material from clinics and practices should be treated with precaution to prevent cross-contamination. It is essential that dental technicians and technologists wear proper PPC while receiving dental impressions and other prosthetic materials from clinics as well as during disinfection procedures (Basmaci *et al*., 2021). Disinfection of impressions and other prosthetic materials is considered compulsory as they are the major sources for contamination in the dental laboratory, therefore disinfecting them will minimise the risk of cross-contamination (AlZain, 2020). The right disinfectant and adequate application time should be considered for the different types of impression materials to prevent dimensional and surface changes, as different impression materials react differently to disinfectants, therefore, it is necessary to adhere to the manufacturer's instructions during disinfection (Mushtaq & Khan, 2018).

For the disinfection of surfaces, dental casts, equipment or tools, work areas etc, an appropriate amount of disinfectant and the right disinfectant should be considered for effective disinfection.

Chemical disinfectants used in the dental laboratory are glutaraldehyde, quaternary ammonium compounds, alcohol, phenol, sodium hypochlorite, and chlorine compounds, (Mushtaq & Khan, 2018; Savabi *et al*., 2018).

According to CDC (2017), three levels of disinfection are: high-level disinfection, intermediate-level disinfection, and low-level disinfection.

(a) High-level disinfection

As the name implies high-level disinfection is a type of disinfection capable of destroying all vegetative bacteria and causing inactivity of bacterial spores but not all bacterial spores, viruses, fungi, and mycobacterium (Lichtenstein & Alfa, 2019). Most of the disinfectants for high-level disinfection usually have tuberculocidal claims. An example of a disinfectant for high-level disinfection is glutaraldehyde, (Lichtenstein & Alfa, 2019).

(b) Intermediate-level disinfection

This level of disinfection destroys all pathogenic micro-organisms, fungal spores, mycobacteria, and viruses but not bacterial spores and usually have tuberculocidal claims (Lichtenstein & Alfa, 2019; Mushtaq & Khan, 2018). The disinfectants for intermediate-level disinfection are phenols, sodium hypochlorite, chlorhexidine, and alcohol. It is important to note that alcohol is not recommended for the disinfection of impressions because they have the tendency to cause surface changes on impressions, (Lichtenstein & Alfa, 2019; Mushtaq & Khan, 2018).

(c) Low-level disinfection

This level of disinfection can kill most micro-organisms but not mycobacteria or bacterial spores (Lichtenstein & Alfa, 2019; Mushtaq & Khan, 2018). They do not have tuberculocidal claims. An example of disinfectant used for low-level disinfection is the quaternary ammonium compounds. Low-level disinfection is not encouraged in a dental laboratory as it cannot destroy all pathogenic microorganisms (Lichtenstein & Alfa, 2019; Mushtaq & Khan, 2018).

2.2.7.5.2.1 Disinfection of impressions and prosthetic materials

Basmaci *et al*. (2021) explained that dental impressions and other prosthetic materials can be disinfected through immersion or spray methods of disinfection.

Disinfection by immersion is considered to be the most effective as it allows all the surface areas to be exposed to the disinfectant solution. On the other hand, the spray method of disinfection tends to act only on the surfaces it is applied to. However, while disinfection by immersion is more thorough, it is also likely to cause dimensional changes as compared to the spray method of disinfection (Chidambaranathan & Balasubramanium, 2019; Mushtaq & Khan, 2018). According to ADA, it is important to note, that for effective disinfection, the impression is rinsed under running water to remove saliva or blood debris and allowed to dry before the application of the disinfectant, as rinsing the impression alone under running water cannot disinfect the impression or thoroughly get rid of micro-organisms (Sedky, 2014).

The most used disinfectants and their various concentrations are chlorhexidine (2%-4%), glutaraldehyde (0.5%, 2%, 2.2% and 2.45%), sodium hypochlorite (NaOCl) (0.5%, 0.525%, 1%, 4% and 5.25%), hydrogen peroxide (0.5%), phenols (7%), iodophors (5% and 10%), and alcohol (60%-90%), (Mushtaq & Khan, 2018). The choice of disinfectant and its concentration depends on the type of impression material used. Disinfectants that do not cause dimensional changes should be used to disinfect polysulphides, addition silicones and condensation silicones. Polyethers are prone to dimensional changes when immersed for more than 10 minutes, whilst prolonged immersion time of hydrophilic impressions makes the material less hydrophilic. The impression compound is best disinfected with phenolic spray or iodophors, (Hardan *et al*., 2022; Azevedo *et al*., 2019).

Different types of impression materials require different disinfectants and techniques to prevent changes in their dimensions and surfaces. Here are some guidelines: For polysulphides, immerse in glutaraldehyde for at least 10 minutes; for zinc oxide eugenol, immerse in glutaraldehyde or phenol for 10 minutes; for irreversible hydrocolloids, immerse in hypochlorite, iodophors or glutaraldehyde for at least 10 minutes; for addition silicon, immerse in glutaraldehyde for 10 minutes; and for impression compound, phenol or alcohol spray method may be applied (Mushtaq & Khan, 2018; Savabi *et al*., 2018; Sammy & Benjamin, 2016).

It is important to disinfect every impression and prosthesis to maintain proper hygiene. Therefore, effective communication between the dental laboratories and dental clinics is necessary to prevent double disinfection which can damage or distort the impression and the dental prosthesis (Sammy & Benjamin, 2016).

2.2.7.5.2.2 Disinfection of surfaces and work area

According to Upendran *et al*. (2022), surfaces should be cleaned and disinfected or covered to prevent contamination. An adequate dilution of the disinfectant should be mixed following the manufacturer's recommendation to clean surfaces. To ensure the complete elimination of micro-organisms, the surfaces are cleaned by spraying enough of the disinfectant and wiping vigorously with clean disposable napkins, the procedure is repeated, using new disposable napkins until the surface is thoroughly cleaned. Surfaces and work areas should be cleaned and disinfected after any procedure and at the end of work activities. It is recommended that the laboratory is fumigated with disinfectants weekly, this targets areas that the hands cannot reach and covers the whole laboratory ensuring the complete elimination of pathogenic organisms (Sedky, 2014; Munagapati & Mallikarjun, 2011).

2.2.7.5.2.3 Disinfection of equipment or tools

According to Munagapati & Mallikarjun (2011), equipment and tools like model trimmers, vibrators, pressure pots and water baths, Lathes, handpieces, articulators, rubber bowls, spatulas, case pans, shade guides etc., should be cleaned and disinfected by spraying disinfectants, following the manufacturer's recommendations while the heat tolerant and moveable instruments like burs, polishing points, rag wheels, laboratory knives, metal impression trays, and face-bow forks that have a higher risk of contamination since they are sometimes directly used for patients cases should be sterilised in an autoclave. It is important not to reuse tools or equipment for a new procedure or prosthesis without properly disinfecting or sterilising them. This means for every new procedure or prosthesis, freshly sterilised or disinfected tools and equipment should be used to avoid cross-contamination as recommended by (Sammy & Benjamin, 2016).

2.2.7.5.3 Sterilisation

Sterilisation refers to the process of eliminating or completely removing all types of micro-organisms including their spores from surfaces, objects, materials, or fluids. This procedure is carried out using a steriliser (Laneve *et al*., 2019). In dental laboratories, various tools, and equipment such as face bows, laboratory knives, burs, polishing points, rag wheels etc., can be sterilised through physical or chemical methods to eliminate micro-organisms.

(a) Physical method

The process of physical sterilisation involves applying heat to eliminate micro-organisms. There are three main methods of physical sterilisation: dry heat, moist heat, and radiation methods.

The dry heat method uses hot air with little or no moisture. A common example of a dry heat steriliser is the hot air oven (Sadeque & Balachandran, 2020; Ozsahin *et al*., 2021).

The moist heat method uses water vapour or steam. A common example of a moist heat steriliser is the autoclave (Qin, 2016).

The radiation method of sterilisation is divided into two types: ionising and non-ionising radiation. The ionising method uses short wavelengths and higher frequencies, such as gamma and X-rays, while the non-ionising method uses electromagnetic energy with long wavelengths and lower frequencies, such as ultraviolet rays (WHO, 2016; Scott, 2014).

(b) Chemical method

Chemical sterilisation involves the use of chemicals and gases, such as aldehydes and ethylene oxide gas, to kill micro-organisms, including their spores (Schoeb *et al*., 2017). It is important to note the difference between disinfection and sterilisation. While disinfection eliminates or removes micro-organisms, it does not kill their spores. Sterilisation, on the other hand, kills micro-organisms and their spores.

In a dental laboratory, disinfection and sterilisation procedures are effective for controlling infections.

2.2.7.6 Infection control manual or guideline

An infection control manual or guideline is a written document that outlines policies and procedures aimed at reducing exposure to micro-organisms and preventing the spread of infectious diseases in health care (Habboush *et al*., 2022). The primary purpose of an infection control manual is to provide adequate information required to increase awareness and prevent infections, as well as promote healthy practices amongst healthcare professionals (Habboush *et al*., 2022). According to Munagapati & Mallikarjun, (2011), an infection control manual or guideline should be easy to understand and should be reviewed annually or whenever the need arises. Dental laboratories should have infection control manuals or guidelines which should include but not be limited to:

- Protection for dental personnel and patients.
- Guidelines for cleaning, disinfection, and sterilisation of laboratory equipment, tools or materials.
- Guidelines for waste management.

- Guidelines for the training of personnel on infection control and prevention as well as provide guidelines for other necessary training.
- State penalties for non-compliance, (Habboush *et al*., 2022).

2.2.7.7 Changing of pumice slurry

Pumice slurry and polishing wheel are one of the major sources of microbial contamination in the laboratory. A study by Sykes *et al*. (2019), revealed that pumice slurry and wheels harbour micro-organisms and were contaminated with micro-organisms such as bacteria, yeast, and moulds. The findings further revealed that these micro-organisms were found more in the pumice slurry than on the pumice wheel. Sykes *et al*. (2019) recommended that pumice slurry should be changed between cases or procedures and disposed of properly after use and that the polishing wheel be cleaned and disinfected or sterilised. The disinfectants used in the dental laboratory as previously discussed are sodium hypochlorite, glutaraldehyde etc., while autoclaves, hot air ovens or aldehydes etc. are used for sterilisation (Bromberg & Brizuela, 2023).

2.2.7.8 Waste management

According to WHO (2015), improper disposal of untreated materials from healthcare activities can pose a threat to human health as it has the potential to harbour and transfer infectious agents. Healthcare waste is any solid, semi-solid or liquid generated during professional activities (Nabizadeh *et al*., 2014). Dental laboratories receive impressions and other prosthetic materials from dental clinics and practices that may contain blood and oral fluids. Therefore, it is crucial to dispose of these materials properly to prevent cross-infection. Materials that contain blood or oral fluids are considered regulated or medical waste and should be disposed of accordingly. Materials that are not contaminated with blood or oral fluid and are generated from the dental laboratory should be disposed of in the same way as household waste (WHO, 2015). The main goal of proper waste management is to prevent cross-infection or injury. Healthcare waste can be classified as hazardous or non-hazardous waste.

(a) **Hazardous waste**

Hazardous waste often referred to as regulated medical waste includes infectious waste, chemical, pharmaceutical, sharps, and radioactive material which make up 20% of waste in health care. Examples of hazardous waste in the dental laboratory include orthodontic wires, certain chemical disinfectants, non-disinfected impressions, occlusal bite blocks etc (Asiri *et al*., 2019; WHO, 2015).

(b) **Non-hazardous waste**

The non-hazardous waste often referred to as non-regulated medical waste is treated as regular solid municipal waste because they are non-infectious waste and therefore are disposed of the same way as household waste. This waste makes up 80-85%% of the waste in healthcare. Examples of non-hazardous waste in dental laboratories include gypsum waste, acrylic resin scraps, sandpapers etc., (Asiri *et al*., 2019; WHO, 2015).

It is essential that waste from dental laboratories is properly disposed of following the local municipal recommendations and protocols to prevent injury. The dental technicians, technologists and other dental personnel are to be well-trained and be well informed of the appropriate methods of waste disposal.

2.2.7.9 Education and training of dental personnel

While the undergraduate curriculum for dental technicians and technologists does not extensively cover infection control prevention, it is essential to provide updated education and training through seminars, in-service training, and refresher courses. This training should focus on infection control and disease prevention and can be conducted annually, quarterly or when needed. Dental technicians and technologists can be educated on the correct use of PPC, methods and techniques for disinfection or sterilisation, and proper waste management (Tsioutis *et al*., 2020).

2.2.8 Knowledge, behaviour, attitude, and compliance

The meaning and overview of knowledge, behaviour, attitude, and compliance as used in the context of the study will be discussed.

2.2.8.1 Knowledge

There are many schools of thought in regard to the definition of knowledge or the meaning of knowledge. However, for this study**,** knowledge can be defined as facts or information gained through reading, education, or experience (Alharbi *et al*., 2019)**.** According to the advanced learner's dictionary knowledge is information and understanding of a subject or skill acquired through education or experience. It is important to note that, the key component of knowledge is information. Taylor (2023), explains that information relies on facts, observations, perceptions etc which are referred to as data. These data are processed and structured in a meaningful way to become information when this information received is applied to something or used it can then be said that the information has produced knowledge. It is therefore important to note that not every piece of information may lead to knowledge, however, only the useful and important information received and applied may lead to knowledge.

2.2.8.2 Behaviour

Behaviour refers to a person's actions that can be observed, described, and recorded either by the person exhibiting the behaviour or by others (Miltenberger, 2023). According to Miltenberger (2023), since behaviour is an action, it can be accessed and measured by calculating the frequency of its occurrence, that is, the number of times it happens.

2.2.8.3 Attitude

Attitudes are ways people view or evaluate things or people. Their views or evaluation towards something has to do with their perception or belief, mindset, feelings, or actions towards the object or subject, (Vargas-Sánchez *et al*., 2015). Arul & Misra (1977), explain that attitude may not be directly measured, however, it can be assessed through direct observation and direct questioning, which agrees with Buhagiar & Sammut (2020), that attitude can be assessed by using a single question or a set of designed questions for the purpose of generating responses that are reliable and generalisable. It is important to note that attitude can greatly influence behaviour and is often a reliable predictor of behaviour.

2.2.8.4 Compliance

Compliance means adhering to policies, rules, or laws (Leisering, 2022). Alharbi *et al*. (2019), stated that the reflection of regulations, policies, laws, and knowledge leads to compliance.

In this study, the knowledge, behaviour, attitude and compliance of dental technicians and technologists on infection control in dental laboratories in Cape Town will be assessed using questionnaires and interviews.

2.3 Theoretical framework

The theoretical framework for the study includes the germ theory of diseases, the modern theory of infection control, and the knowledge, attitude, and behaviour theory (KAB).

2.3.1 Germ theory of diseases

The germ theory of diseases was established in the mid-nineteenth century by renowned researchers such as Louis Pasteur, Robert Koch, and John Lister (Oosthuysen *et al*., 2020). The germ theory of diseases suggests that diseases are caused by the exposure of the body to micro-organisms, which are too small to be seen with the naked eyes but can be seen through a microscope (Mourud, 2010). In other words, this theory supports that viruses, bacteria, fungi, protozoa, and prions are major causes of infections.

2.3.2 The modern theory of infection control

The prevention of diseases using infection control procedures was discovered by Ignaz Semmelweis, who is assumed to be the father of modern infection control because he was able to prove that puerperal sepsis was infectious and that it could be minimised or prevented through proper hand washing (Gould, 2010). Semmelweis during 1846, at the General Hospital of Vienna, observed a high incidence of puerperal fever which resulted in a high mortality rate at the clinics where babies were delivered by the students and physicians compared to the clinics managed by the midwives. Semmelweis urged the students and physicians to clean their hands with chlorine solutions, and this led to a drastic reduction in the number of maternal deaths at the clinics managed by the students and physicians (Oosthuysen *et al*., 2020; Mourud, 2010). Ignaz Semmelweis's findings became the foundation for further research and the discovery of various infection control procedures in modern times. This theory proves that diseases and cross-infections can be minimised or prevented using disinfectants, hand hygiene, vaccination, and other infection control procedures.

2.3.3 Knowledge, attitude, behaviour theory

Knowledge, attitude, and behaviour theory (KAB) also known as KAP in some literature proposes that an increase in knowledge will influence attitude and behaviour (Hasan *et al*., 2022). According to Pal *et al*. (2020), the KAP theory is divided into three successive stages: the acquisition of the right knowledge, the generation of attitudes and the adoption of behaviour or practice. In other words, the right knowledge of disease prevention and control among dental technicians and technologists in this study, may influence the way they develop certain attitudes and behaviours regarding the prevention of disease in the dental laboratories and consequently, influence their compliance with infection control guidelines or protocols. On the other hand, poor knowledge may lead to poor or lack of compliance.

2.4 Summary of chapter

The conceptual and theoretical framework was discussed by the researcher in this chapter. The conceptual framework was divided under the following major subheadings, overview of infectious diseases, infectious agents, types of infectious agents, the chain of infection, modes of infection transmission in the dental laboratory, meaning and concept of infection control, infection control practices and protocols in the dental laboratory and knowledge, behaviour, attitude, and compliance.

In the theoretical framework, the researcher used the germ theory of diseases, the modern theory of infection control, and the KAB theory.

The next chapter, (Chapter 3) discusses the research design and methodology employed in the study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, the procedures and methods used in the study will be discussed. As noted by Sileyew (2020), research methodology refers to the methods used by the researcher during the research process to achieve the objectives of the study and answer research questions. The processes utilised in the study to ensure valid and effective data collection among the dental technicians and technologists in the dental laboratories in Cape Town, as well as the methods of data analysis, will be discussed under the following sub-headings: research methods, research design, area of the study, population of study, study framework, sample and sampling techniques, the instrument for data collection, response rate, data management, data analysis, bias of the study, ethical considerations, and summary.

3.2 Research methods

Research methods are procedures and holistic processes used by researchers to acquire, analyse, and interpret data, ensuring reliable and valid results that answer research questions or address research aims and objectives (Leedy *et al*., 2019). There are three approaches to research: quantitative, qualitative, and mixed-method paradigms. For this study, the mixed-method pattern was employed by integrating the quantitative and qualitative research methods to assess the knowledge, behaviour, attitude and compliance practices of dental technicians and technologists on infection control in the dental laboratories in Cape Town.

3.2.1 Mixed-method research

According to Molina-Azorin (2016), mixed-method is the combination of quantitative and qualitative methods in the same study. Mixed-method research explores two or more methods within an inquiry to solve research problems (Kumar, 2018; Creswell, 2013). Quantitative research is expressed in numbers and analysed using statistical techniques to confirm theories or test hypotheses and generalise results (Gupta & Gupta, 2022). Data collection in quantitative data requires the use of closed-ended or multiple questions to solicit data from respondents, an example is the questionnaire. Qualitative research, on the other hand, deals with non-numerical data which is aimed at gaining in-depth insights into a problem to understand experiences or concepts. Qualitative data collection involves gathering information from respondents using open-ended questions, such as interviews or focus groups. The responses are then analysed by grouping them into themes or categories (Bhandari, 2022). Molina-Azorin (2016), explained that data can be gathered in mixed-method research at the same time (concurrent design) or in phases (sequential design), however, for this study data was collected concurrently by combining the quantitative method (questionnaire) and qualitative method (semi-structured interview) to describe the knowledge, behaviour, attitude, and the compliance practices of the dental technicians and technologists on infection control, in dental laboratories in Cape town.

The advantages and disadvantages of mixed-method research as revealed by Almeida (2018), are:

3.2.1.1 Advantages of mixed-method research

Mixed-method research enables researchers to extensively understand their study, thereby leading to increased accuracy and validity of research results. By combining both quantitative and qualitative research methods, mixed methods allow researchers to apply different paradigms and obtain answers to research questions that cannot be attained through quantitative or qualitative approaches alone. In mixed-method research, the strength of one research method can compensate for the weakness of the other, providing a complete and more accurate picture of the research topic.

3.2.1.2 Disadvantages of mixed method research

The collection and analysis of data in mixed-method research is time and resource-consuming as it requires a complex data collection process which involves multiple methods of data collection.

3.2.1.3 Justification for choosing mixed-method research

The researcher opted for a mixed method because it provides a broader range of opportunities to better understand, answer or address research problems and overcome the limitations of using a single approach, be it the quantitative or qualitative approach (Molina-Azorin, 2016).

3.3 Research design

Akhtar (2016), defined research design as a plan or blueprint that guides any research process towards addressing a research problem and providing a model for data analysis. Akhtar (2016), pointed out that a well-structured, feasible and efficient research design is necessary for effective research. The research design encompasses the entire research process including data collection, analysis, and reporting (Creswell & Poth, 2016). The types of research designs in quantitative or qualitative research are descriptive, explorative, experimental, case study, or correlational research design etc (Akhtar, 2016). On the other hand, according to Almeida (2018), the four types of mixed-method designs are triangulation, embedded, explanatory, and exploratory design.

For this study, the research design adopted was a descriptive and triangulation approach.

3.3.1 Descriptive design

A descriptive research design is used to provide an accurate depiction of an individual, object, or event's situation (Siedlecki, 2020). This type of research aims to describe the behaviour of a sample population without manipulating the variable (Siedlecki, 2020). Typically, descriptive research questions start with a 'what' or 'how' as seen in the study's research questions: what are the dental technicians' and technologists' understanding, knowledge, and insights regarding infection control in the dental laboratories in Cape Town? what are the current measures and infection control protocols in place to prevent the transmission of infectious diseases in dental laboratories? and what are the dental technicians' and technologists' compliance with infection control protocols in the dental laboratories?

The justification for choosing the descriptive design was that it allowed the researcher to provide an in-depth view of the dental technicians' and technologists' knowledge, behaviour, attitude, and compliance practices with infection control.

3.3.2 Triangulation

Triangulation is a research technique that involves using multiple methods to gather diverse but complementary data on the same topic. It entails attaching equal value to both quantitative and qualitative methods (Almeida, 2018). In this study, the researcher used a questionnaire and semi-structured interview to gather information from participants to address research questions. The use of triangulation enhances the credibility of a study, thereby increasing its validity and reliability.

The researcher applied a triangulation design in the study, which made it possible to use multiple data sets and approaches to enhance the credibility and validity of the research.

3.4 Area of the study

The area of the study was the Western Cape in South Africa. Western Cape has about a total of one hundred and sixty-six (166) dental laboratories (Source: South African Dental Technicians Council, SADTC). The study would be the first of its nature to examine the knowledge, behaviour, attitude, and compliance practices of dental technicians and technologists on infection control in the dental laboratories in Western Cape, South Africa, which was the major reason for the choice of the study area.

3.5 Population of the study

The term 'population' in a study refers to the individuals, animals, or objects under study (Bryman & Bell, 2015). For this study, the population consisted of all dental laboratories in Cape Town, Western Cape in South Africa. According to the South African Dental Technicians Council (SADTC), there are approximately one hundred and fifteen (115) dental laboratories in Cape Town. The reason for selecting Cape Town is the fact that it has the most significant number of dental laboratories in the Western Cape region.

According to Brink *et al*. (2018), the physical location where a researcher collects data for a study is the research setting of that given study. In this study, the research setting was the private and government dental laboratories in Cape Town, where the dental technicians' and technologists' knowledge, behaviour, attitude, and compliance with infection control were assessed through questionnaires and face-to-face interviews.

3.5.1 Private dental laboratories

The private dental laboratories are owned by individuals or by a group of individuals. The researcher observed that they have a smaller number of dental technicians and technologists compared to government dental laboratories. Some of the laboratories had only one (1) dental technician or technologist, while some had two (2) or more dental technicians or technologists working in the dental laboratories. The private dental laboratories receive dental prostheses from dental clinics which are usually not in the same physical location.

3.5.2 Government dental laboratories

The government dental laboratories are owned by the government and have four (4) or more dental technicians or technologists working in the dental laboratories. The government dental laboratories had the dental clinics they receive dental prostheses from, in the same physical location. That is to say, the government dental laboratories and the dental clinics are usually in the same physical location.

3.6 Study framework

According to McMeekin *et al*. (2020), a methodological framework or study guides a researcher through series of processes to complete a task. In other words, the study or framework helps a researcher focus on the scope of the study (Amiri *et al*., 2015). Methodology hints at the methods and framework on the other hand refers to the structure or plan. The study frameworks in Figure 3.1 and Figure 3.2 were developed by the researcher to guide the study, this helped the researcher maintain the right approach and methods within the scope of the research throughout the study.

The methodological framework in Figure 3.1 illustrates the processes, and step-by-step plans developed by the researcher prior to carrying out the research or data collection, to serve as a guide to the researcher while Figure 3.2 illustrates the final framework for the study which was achieved by following the plan in Figure 3.1.

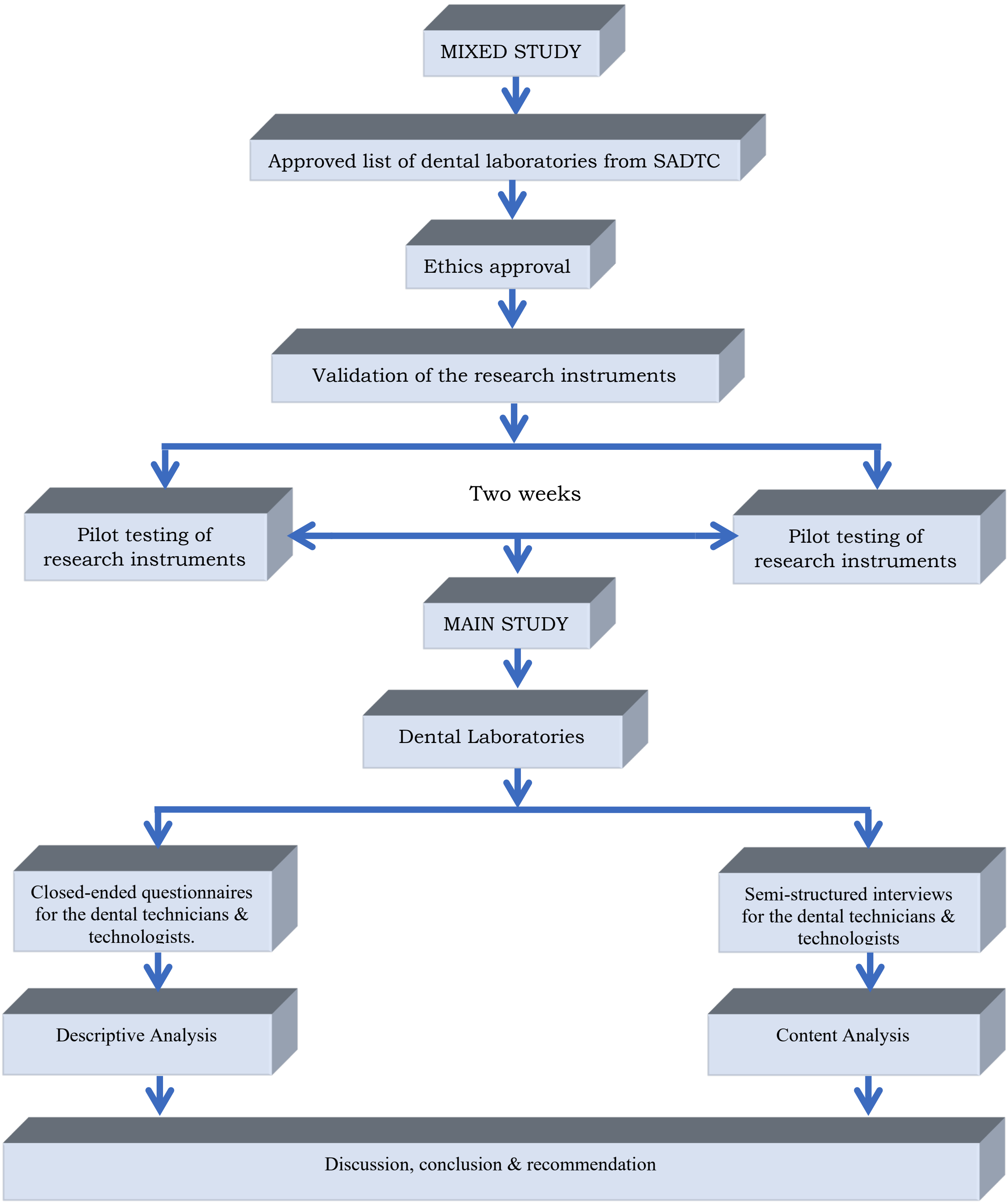

Figure 3.1:

Methodological framework prior to data collection

(Source: developed by the researcher)

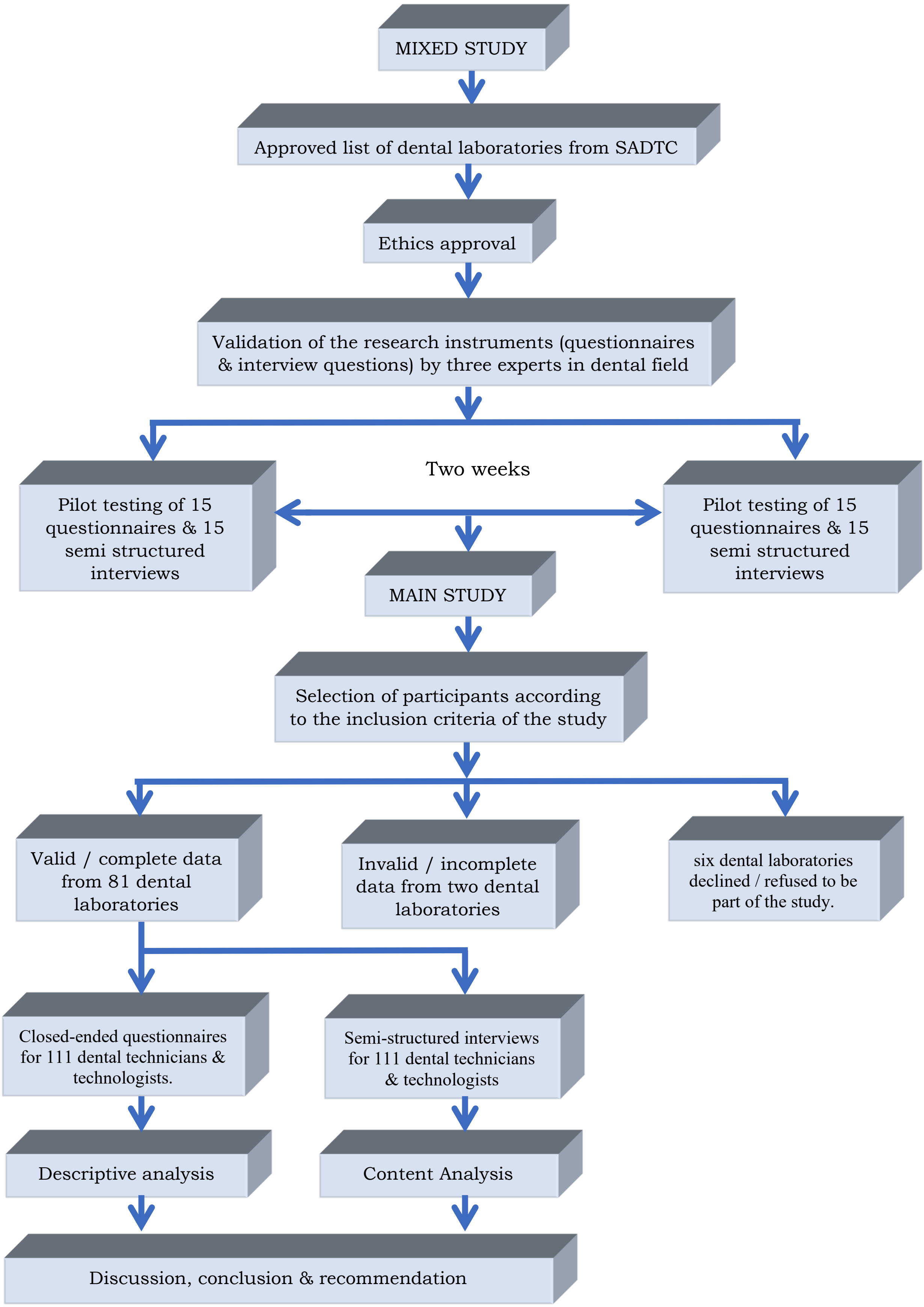

Figure 3.2:

Methodological framework after data collection

(Source: developed by the researcher)

3.7 Sample and sampling

Leedy *et al.*, 2019, defined a sample as a portion or a subset of a larger population, a sample size as the number of participants within a given sample and sampling, as the technique for selecting a sample. The sample, and sampling used for the study are discussed below:

3.7.1 Sample and determination of sample size

A sample is a part, a portion, or a subset of a larger population while a sample size is the number of observations or participants in the sample (Bhardwaj, 2019). Leedy *et al*. (2019), opined that a sample should accurately represent an entire population and be free from bias. For this study, Taro Yamane's formula was employed in determining the sample size, given the formula;

$$n = \frac{N}{1 + N(e)^2}$$

Where n = Sample Size

N= Population size

I = Constant

e = Error of Margin

$$\frac{n = 115}{1 + 115(0.05)^2}$$

$$\frac{n = 115}{1 + 0.2875}$$

$$\frac{n = 115}{1.2875}$$

n=89

Therefore, a sample of eighty-nine (89) dental laboratories was drawn from a population of one hundred and fifteen (115) dental laboratories and was used for this study.

According to Omair (2014), a sample should be representative of the population for findings to be generalised to the target population.

The choice for Taro Yamane's formula was because it provided an adequate sample enough to generalise findings and ensure validity.

The sample used in this study is sufficient to represent the dental laboratories in Cape Town, therefore the findings of this study can be generalised to the dental laboratories in Cape Town.

3.7.2 Sampling

Sharma (2017), defined sampling as the procedure or techniques utilised in choosing a smaller number that accurately represents individuals or items from a predetermined population for experiments or observations. Sharma (2017), opined that for good sampling, factors such as the population size, objectives of the study and techniques must be carefully considered.

A sample of eighty-nine (89) dental laboratories was chosen from the population of one hundred and fifteen (115) dental laboratories in Cape Town using the probability sampling technique. According to Sharma (2017), probability sampling is the type of sampling that gives individuals in the population equal opportunity of being selected for a study. Sharma went further to explain the different types of probability sampling which include simple random sampling, stratified random sampling, systematic random sampling etc., however for the purpose of this study, simple random sampling by lottery was used, where the names of all the one hundred and fifteen (115) dental laboratories in Cape Town were listed and assigned a code. Each of the codes was written out on a piece of paper and folded, the researcher picked out a total of eighty-nine (89) of the folded papers representing the dental laboratories as samples to be included in the study. This was done to ensure that every dental laboratory was given the chance to be picked in the sample to prevent bias and unjustifiable exclusions. Once a dental laboratory was selected, the code was removed from the list without replacement, this process is called simple random sampling without replacement, and this was used by the researcher to avoid selecting any dental laboratory twice.

The non-probability sampling was used in selecting the dental technicians and technologists in the eighty-nine (89) dental laboratories to fill in the questionnaires and for the face-to-face interviews. According to Acharya *et al*. (2013), the different types of non-probability sampling are convenience or purposive sampling, snowballing and quota sampling. For this study, convenience sampling was used in selecting the dental technicians and technologists. (Acharya *et al*., 2013) explained that in convenience sampling, participants are chosen based on the judgement of the researcher and because they met the inclusion criteria of a study. In this study, the dental technicians and technologists were selected based on the inclusion criteria of the study.

3.7.2.1 Inclusion criteria

The following inclusion criteria were applied to this study:

i. Only dental laboratories registered and approved by the South African Dental Technicians Council were considered.
ii. Dental laboratories in operation for at least one year.
iii. Dental laboratories do not necessarily need to provide all four disciplines of dental technology.

For the dental technicians and technologists, the following inclusion criteria were applied:

i. Only qualified dental technicians and technologists (National Diploma (ND), Higher National Diploma (HND), Bachelor of Technology (BTech), Master of Technology (MTech) or Master of Health Science (MHSc) etc.) registered with the South African Dental Technicians Council (SADTC) and comply with the conditions of continuing professional development (CPD) were used.
ii. Only dental technicians and technologists who have practised for at least one year were used in the study.

3.7.2.2 Exclusion criteria

The following exclusion criteria were applied to this study:

i. Dental laboratories that offer only computer-aided design (CAD) and computer-aided manufacturing (CAM) services.

For dental technicians and technologists, the following exclusion criteria were applied:

i. Non-qualified dental technicians and technologists were excluded.
ii. Dental technician and technology students.

3.7.2.3 Recruitment of participants

Approval for the study was granted by the Faculty of Health and Wellness Sciences Research Ethics Committee of the Cape Peninsula University of Technology (Appendix G).

Letters were sent through electronic mail to eighty-nine (89) dental laboratories in Cape Town soliciting their permission to carry out research studies in their dental laboratories using their dental technicians and technologists (Appendix C). The information sheet was attached to the letters (Appendix E) which had exhaustive information about the study and contact details of the research team in case of inquiry and clarifications on the study, to help the dental laboratories make informed decisions as to whether to voluntarily take part or decline to be part of the study.

Follow-up calls were made to the dental laboratories that did not respond to the electronic mail as well as those whose emails declined. This was to ensure that all eighty-nine (89) dental laboratories were contacted.

Eighty-three (83) dental laboratories willingly accepted to take part in the study and informed their dental technicians and technologists, however, six (6) dental laboratories declined and refused to take part in the study. For the dental laboratories that agreed to be part of the study, appointments were scheduled with the researcher (dates and times convenient for the laboratories) for the filling in of the questionnaires and face-to-face interviews.

Before completing the questionnaires and face-to-face interviews, each dental technician or technologist who volunteered for the study was provided with an information sheet. They had the opportunity to ask any question and were informed of their rights to withdraw at any time. The dental technicians and technologists completed and returned the informed consent (Appendix D) which outlined the study requirements and guaranteed to keep them anonymous. The entire procedure for each participant took about 25-30 minutes and was entirely voluntary throughout the study.

3.8 Instrument for data collection

Research instruments are tools for collecting, measuring, and analysing data in a study. Research instruments include questionnaires, interviews, observations etc (Saunders *et al*., 2019). Zohrabi (2013), explained that a good research instrument should be reliable, valid, and able to gather appropriate data to achieve the research objectives, etc. In this study questionnaires (Appendix A) and interviews, using an interview guide (Appendix B) were used for data collection.

3.8.1 Questionnaire

A questionnaire contains questions which are used to elicit information from the study respondents. According to Zohrabi, (2013), a questionnaire is used to collect first-hand information from the respondents (primary data) and therefore should be concise and properly worded, to get quality information during data collection. For this study, the questionnaire which had the title “Infection control, knowledge, behaviour, attitude and compliance practices in selected dental laboratories” was used to elicit information from the dental technicians and technologists. The questionnaire was developed by the researcher according to the information from reviewed literature in line with the objectives of the research.

Zohrabi, (2013) explained that questionnaire questions could be open-ended, closed-ended, or a mixture of the two. However, for this study, the closed-ended questionnaire (Appendix A) was used. In closed-ended questionnaire, the possible answers are included in the questionnaire for the respondents to choose the answers that best answers the questions (Kumar, 2018). In other words, they are provided with a list of answers to choose from.

The advantage of closed-ended questionnaires is that they are easier to code and analyse statistically and the questions are usually easy to answer as it entails just ticking the right options (Kumar, 2018; Zohrabi, 2013).

The disadvantage of a closed-ended questionnaire is that the responses may not reflect a respondent's real opinion as their opinion may not be on the list of options to choose from and the answers are short and therefore do not provide detailed information about the subject (Kumar, 2018; Zohrabi, 2013).

The questionnaire was designed to have a laboratory number and a sequence number at the right top corner, which was generated by the researcher. This was to ensure the anonymity of both the dental laboratories and the dental technicians or technologists. The laboratory number was for the dental laboratories while the sequence number was for the dental technicians and technologists.

The questionnaire was divided into different sections, each of which was designed to help provide answers to the research questions and arrive at the research objectives. The first section (section A) sought the socio-demographic information of the respondents and had nine (9) questions, the second section was divided into two sections, (section Bi) was on personal protective clothing and had eight (8) questions while (section Bii) was on infection control and had twenty-seven (27) questions. In total forty-four (44) questions were generated for the study.

3.8.2 Interviews

Interviews are used to elicit verbal information from the study respondents (Zohrabi, 2013). An interview can be between an interviewer and an individual (one-on-one) or between an interviewer and two or more individuals (group). An interview may be structured, unstructured or semi-structured (Kumar, 2018; Zohrabi, 2013). For this study, semi-structured face-to-face individual interviews were used to elicit verbal information from the dental technicians and technologists using six (6) open-ended interview questions (Appendix B). The justification for using open-ended interview questions was that it allows an interviewee freedom of expression, hence truly reflecting an interviewee's opinion. The researcher had pre-set interview questions to ensure that all the interviewees were asked the same questions throughout the interviews.

According to Burns & Groove (2013), the advantages of individual (one-on-one) interviews are that responses in interviews are more comprehensive and may truly reflect a respondent's opinion and that in-depth information is obtained.

The disadvantages of individual (one-on-one) interviews are that they are time-consuming, and data collected are usually cumbersome and not easy to analyse statistically (Burns & Groove, 2013).

3.9 Validation of research instrument

When a research instrument is consistently able to evaluate or assess what it is designed to evaluate or assess, then it is considered valid. There are various ways to validate research instruments, such as face, construct, and content validity (Middleton, 2019; Taherdoost, 2016). However, for this study, face and content validity were used.

3.9.1 Face validity

Face validity refers to how an instrument can measure the concept it intends to measure or its relevance to the subject matter (Middleton, 2019). According to Taherdoost (2016), a validity test is subject to the researcher's or validator's judgement on whether the questions of the instrument are clear, simple, and relevant.

3.9.2 Content validity

Content validity refers to the instrument being able to fully cover all aspects or areas of a study (construct) it is expected to measure (Middleton, 2019).

The instruments for this study were face and content validated by three (3) experts in the dental profession (Appendix Fi,Fii,Fiii). They were given copies of the instruments, the purpose of the study, and the research questions to critically examine and make useful corrections and suggestions where applicable. They were asked to validate the research instruments in terms of clarity of instruction to the research subject, language of the items, appropriateness, and adequacy of the instruments in addressing the purpose and the problems of the study and to add any other useful information which would help to enhance the validity of the instruments.

After the validation process, comments made by the validators were collated and a few modifications were made to the questions accordingly.

3.10 Pilot testing of instruments

According to Grove & Gray (2018), trial testing entails studying a smaller sample of a planned study. This is to ascertain the feasibility of the study (Kumar, 2018).

After the research instruments for this study were validated, a feasibility study was carried out in the dental laboratories in Cape Town. The researcher pre-tested the instruments on fifteen (15) respondents (dental technicians and technologists). All the respondents filled in the questionnaire and answered the interview questions, hence no questions on the instruments were changed after the pre-test.

3.10.1 Pilot testing procedure

Fifteen (15) respondents were recruited for the pilot study (see 3.7.2.3 on the procedure for recruitment of participants) to fill in the questionnaires and for face-to-face individual interviews. The pilot study took place between November 2021 to January 2022.

Appointments were made at different times and dates. Each of the fifteen (15) respondents was given a questionnaire to fill in, after which a face-to-face interview took place. For each of the respondents, the procedure took about 25-30 minutes to be completed.

The procedure was repeated for the same respondents after two (2) weeks at different times and dates (see Figure 3.2).

The pilot study was done to check if the instruments questions were clear and easy to answer, if there was a need to add or remove questions from the instruments and to check for the feasibility of the study and data analysis.

The respondents agreed that the instruments were clear enough and no ambiguous words were used. In total, thirty (30) questionnaires and thirty (30) interview schedules were used for the feasibility study and were not included as part of the main study.

3.11 Reliability of research instrument

An instrument is said to be reliable if it can consistently produce the same result over time given the same conditions (Heale & Twycross, 2015). According to Middleton (2019), there are about four (4) tests of reliability for an instrument which include the test-retest reliability, inter-rater, parallel forms, and internal consistency test. However, for the purpose of this study, the test-retest reliability test was utilised to ascertain the reliability of the instrument using the pilot survey. The two (2) sets of data generated from the pilot survey were correlated with Pearson product-moment correlation in the Statistical Package for the Social Science software version 28 (IBM SPSS 28, IBM Corp., Armonk, N.Y, USA). The result revealed a correlation coefficient (r) of 0.9 which indicates very strong stability since the value is large and tends to one (1). This was considered high enough for the study.

The Cronbach Alpha was also used to test for the internal consistency of the questionnaire using Statistical Package for the Social Sciences software version 28 (IBM SPSS 28,IBM Corp., Armonk, N.Y, USA). Cronbach coefficient between 0.65-0.70 is the minimum acceptable value, 0.70-0.80 is good, and 0.80-0.90 is the best. The result from this study revealed a Cronbach Alpha (a) of 0.9. This revealed that the Knowledge, behaviour, attitude, and compliance questionnaire had good internal consistency reliability.

See Appendix I for the results of the reliability test.

The researcher chose the test-retest reliability which utilised Pearson product-moment and Cronbach to assess the temporal stability and internal consistency of instrument respectively for optimum reliability.

3.12 Administration of research instrument

Research instruments can be self-administered, or researcher-administered, and this can be done online, through electronic mail, phone or in person Bhandari (2021).

For this study, the instrument was researcher-administered to the dental technicians and technologists in person, in the selected dental laboratories in Cape Town and was collected on the spot. The purpose was to ensure that the respondents fully understand the questions and where need be, ask for clarifications. The researcher-administered instruments also ensured a high response and completion rate.

3.13 Data collection procedure

Data collection took place in the dental laboratories in Cape Town from February 2022 to June 2022 on. The dates and time convenient for the participants were considered. The procedure took about 25-30 minutes for each participant. Only dental technicians and technologists who voluntarily consented to participate were given questionnaires to fill in and were interviewed after reading the information letter (Appendix E). The researcher ensured that the purpose of the study was exhaustively explained to the participants individually and they were given the chance to ask questions before the procedure. The filling in of the questionnaire took place in the dental laboratories and the interviews at the private corners of the dental laboratories for the dental laboratories that had more than one participant.

Interviews were recorded with a Philips voice recorder and the researcher also took notes when necessary. Codes such as LB 1 or LB 2 were used for Laboratory 1 and Laboratory 2 for the dental laboratories while P1 or P2 for Participants 1 and Participants 2, this was done to ensure that the identities of both the dental laboratories and the participants were protected and kept anonymous. The consent letters (Appendix D) were signed by the participants on the day of data collection.

On completion of the procedure in each dental laboratory, the researcher thanked the participants for their contribution towards the study.

3.14 Response rate

The response rate of a survey can be calculated by dividing the total number of respondents who started and completed the survey by the number of participants expected to complete the survey and multiplying by hundred (100) to be expressed in percentage. Cunningham *et al.* (2015), explained that certain factors such as the respondents' interest on a topic may positively or negatively influence the response rate. The response rate for this study was 91% as seen from the calculation below. Response rate is important as it influences the quality of data for analysis. For this study, the response rate was considered high enough for the study, this ensured quality data for analysis and ensured that the data analysed is considered representative of the population.

$$R.R = \frac{\text{no of completed responses to the survey}}{\text{no of participant expected to complete the survey}} \times 100$$

Where:

R.R is response rate.

The number of responses is 83.

The number of completed responses is 81.

The number of Participants expected to complete the survey is 89.

$\mathrm{R.R} = \frac{81}{89} \times 100$ = 91.01%

3.15 Data management

Data management involves handling data ethically, in such a way that the personal information of participants is kept confidential.

All the emails and letters sent to the dental laboratories during data collection were password-protected and the participants were sent the codes to be able to access them. This was to ensure privacy during correspondence.

Furthermore, the soft copies of all the data gathered from the study which includes the list of dental laboratories, raw data, etc were securely stored and password-protected in a memory stick, also known as the universal serial bus (USB).

Additionally, both the softcopies and the hard copies of all the data gathered during the study were securely stored in a locked cabinet at the Dental Science Department of the Cape Peninsula University of Technology, where only the authorised personnel - the researcher and supervisors, had access to. All data gathered will be kept for five (5) years only, and afterwards be destroyed.

3.16 Data analysis

The process of organising the data gathered, testing the data in soft wares and interpreting information to address research questions is referred to as data analysis. The data collected from the study were analysed using Number Cruncher Statistical Software, 2021 (NCSS, LLC

Version 2021, Kaysville, Utah, USA). The data were analysed using descriptive statistics and presented in frequencies, percentages, and cumulative percentages to describe different variables and allow for a clear presentation of data. Results were compared by means of cross-tabulations using Pearson's Chi-square (2-sided) at the significance level of 0.01.

The processes of data analysis in the study were carried out in two phases, namely: the quantitative analysis phase and the qualitative analysis phase.

3.16.1 Quantitative data analysis phase

The quantitative analysis phase utilised data gathered from the structured questionnaire. The following processes were employed to analyse the data:

i. The researcher's supervisors screened the collected data to ensure that it was properly collected and that there was no bias in the data collection process.
ii. The researcher reviewed the data collected to ensure that all the information from each questionnaire was completely and adequately captured to prevent errors that could affect the accuracy of the results.
iii. The questionnaire questions and the responses from one hundred and eleven (111) dental technicians and technologists were entered into a spreadsheet by the researcher ensuring that all information was accurately captured.
iv. The data entered in the spreadsheet were crosschecked to screen for errors.
v. Descriptive statistics.

3.16.2 Qualitative data analysis

For the qualitative analysis phase, the data collected from interviews were analysed using content analysis in a descriptive manner. Content analysis is a technique that involves making replicable deductions from texts, audio, or videos (Krippendorff, 2018). The following steps were taken in the qualitative data analysis process for this study:

i. The researcher transcribed the recorded interview word for word and referred to the notes taken during the interview.
ii. The transcribed data was scanned to look for phrases or words that represented the information from different respondents. This was done to reduce the data, without removing essential information. The assigned phrases or words were then coded, labelled, and entered into a spreadsheet.
iii. The researcher identified themes by categorising related codes under one theme and giving them the same colour across the spreadsheet for different questions. This made the analysis process easier.

3.17 Bias of the study

Bias refers to prejudice towards or against an individual or group, often in an unfair manner (Smith & Noble, 2014). Bias can occur at any stage of research. Therefore, in this study, the researcher made efforts to minimise bias by using an appropriate study design that meets research objectives and addresses research questions, ensuring adequate sampling of participants, and using triangulation to enhance the validity and credibility of the study.

3.18 Ethical considerations

The study received approval from the Research Ethics Committee of Cape Peninsula University of Technology, Faculty of Health, and Wellness Science, CPUT/HW-REC/2021/H18 (Appendix G). A list of the dental laboratories in the Western Cape was obtained from the South African Dental Technicians Council (see Appendix H). Letters of request for permission were emailed to the dental laboratories in Cape Town, and permission was granted by these dental laboratories. The participants (dental technicians and technologists) were duly informed and signed a written consent before the start of the data collection (Appendix D).

According to Varkey (2021), the four main principles of medical and health ethics are beneficence, non-maleficence, autonomy, and justice.

In view of the medical and health ethics, the researcher considered and applied the following ethics throughout the study to ensure the safety, confidentiality, and rights of the participants.

3.18.1 Permission

Permission was obtained from the dental laboratories in Cape Town to use their dental technicians and technologists for the study. The aims and objectives of the study were thoroughly explained to them (Appendix C).

3.18.2 Informed consent

The procedure, duration, aims, objectives, and criteria for participation were explained to the dental technicians and technologists in detail and they were allowed to ask questions. Written consent (Appendix D) was given to them to go through and sign voluntarily before the commencement of the procedures. They were allowed to voluntarily take part in the study and were not coerced, bribed, or paid. They were also informed that the interviews would be recorded and that they had the choice to allow or disallow recording. Finally, dental technicians and technologists, were informed of their rights to withdraw or decline to take part in the study at any point in time without facing any penalty.

3.18.3 Privacy and confidentiality

According to Leedy *et al*. (2019), privacy and confidentiality can be compromised when personal information or data of a person is exposed to another. For this study, the researcher made sure that the personal details or data of the dental technicians and technologists as well as the dental laboratories were anonymous and would not be linked to them. To achieve this, codes and numbers were used to replace their names. The dental technicians and technologists were referred to as P1 or P2, while the dental laboratories were referred to as LB1 or LB2, in the order in which the procedures were carried out.

All information and materials, including the list of dental laboratories, consent forms of participants, and soft copies of data saved in a memory stick was securely stored in a locked cabinet at the Dental Science Department of the Cape Peninsula University of Technology which was only assessable by the authorised personnel (researcher and supervisors). Additionally, this will be kept secured for a period of up to five (5) years and destroyed thereafter.

Findings from the study were reported without any link to the dental technicians, technologists, and dental laboratories.

3.18.4 No harm

The participants in this study were not exposed to any harm or risk, so no referral was necessary.

3.18.5 Justice

The researcher ensured that there were no unjustifiable inclusion or exclusion of participants and therefore selected participants in accordance with the inclusion criteria and requirements of the study only. Participants were respected and treated equally without discrimination.

3.19 Summary of chapter

This Chapter discussed the research methodology used in the study. The study design, framework, sampling procedure and techniques, validation of instruments, test of reliability, instrument for data collection, bias of the study, data analysis and ethics were all discussed. Chapter four (4) will discuss the findings of the questionnaires and interviews.

CHAPTER FOUR

RESULTS AND INTERPRETATION OF DATA ANALYSIS

4.1 Introduction

In this chapter, the results of the study are presented using descriptive statistical techniques. The analysis and interpretation of data were carried out in three sections. The first section which was the quantitative data, was based on the results of the questionnaire. The second section was the qualitative data, which was based on data gathered from the interviews. Finally, the third section was the results of the crosstabulations, which were based on the analysis of variables across data sets to identify relationships.

4.2 Quantitative interpretation of results

Questionnaires were used to gather quantitative data for this study. A total of one hundred and fourteen (114) questionnaires were administered to the dental technicians and technologists in eighty-three (83) dental laboratories in Cape Town, South Africa. One hundred and eleven (111) questionnaires were administered in person to the selected respondents in eighty-one (81) dental laboratories, which were adequately completed and retrieved. Three (3) questionnaires were administered online through electronic mail to two (2) dental laboratories and were retrieved through the same means. The three (3) questionnaires retrieved online were not adequately completed and therefore were completely discarded and not used for analysis. This means that only one hundred and eleven (111) questionnaires were used for analysis.

The analysis, charts and tables below are based on the responses of the participants to the questionnaire items.

4.2.1 Gender

The gender of the dental technicians and technologists is displayed in Figure 4.1.

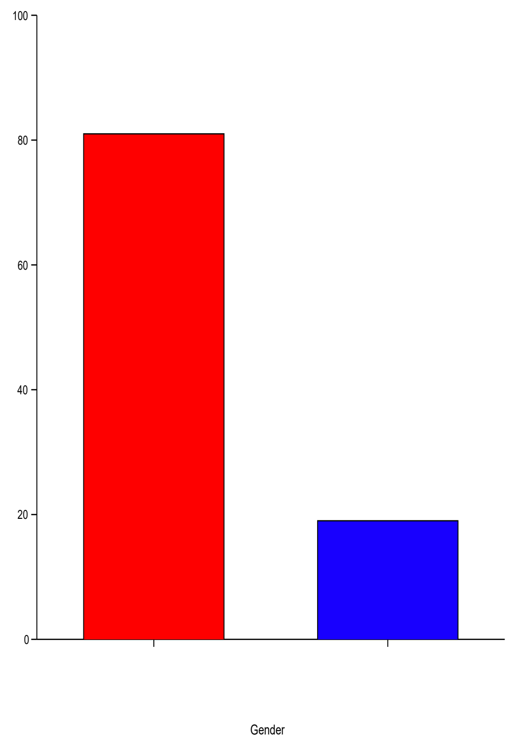

Figure 4.1:

The gender of the respondents

Figure 4.1 shows that 81.08% of the respondents were males while 18.08% of the respondents were females in the dental laboratories in Cape Town.

4.2.2 Age of respondents

The age of the dental technicians and technologists was determined and presented in Table 4.1.

Table 4.1: The age of respondents

Age	Count	Percentage of respondents (%)
18-24	6	5.40
25-64	98	88.29
65+	7	6.31
Total	**111**	**100**

Table 4.1 shows that 5.40% of the respondents were between the ages 18-24, 88.29% of the respondents were between ages 25-64 and 6.31% of the respondents were ages 65 and above.

4.2.3 Years of practice of respondents

Figure 4.2 presents the number of years of practice of dental technicians and technologists.

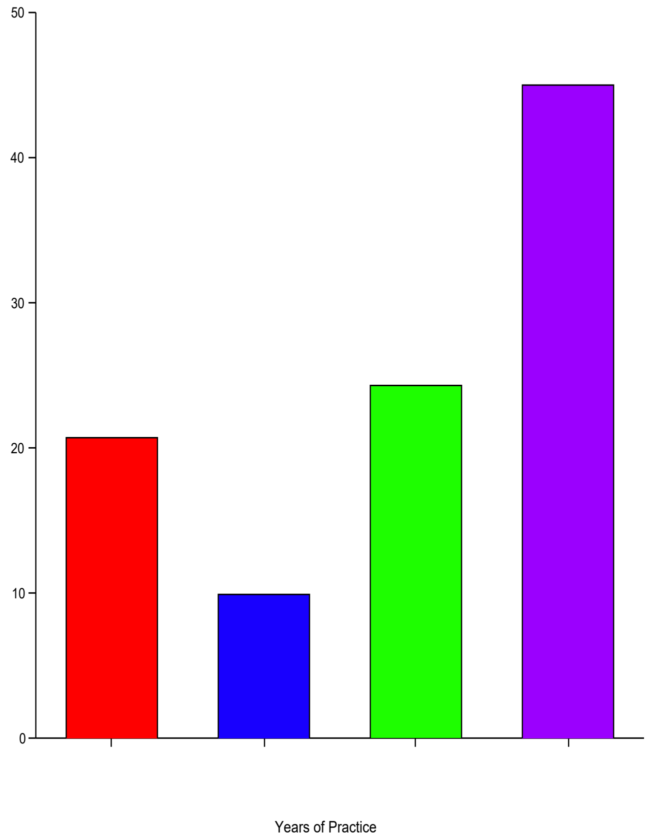

Figure 4.2:

The respondents' years of practice.

From Figure 4.2, the respondents were asked how long they have been in practice as dental technologists or technicians. 20.72% of the respondents have been in practice for 1-5years, 9.91% of the respondents have been in practice for 6-10years, 24.32% of the respondents have been in practice for 11-20 years and 45.05% of the respondents have been in practice for more than 20 years.

4.2.4 Dental laboratories' years of existence

The number of years dental laboratories have been in operation is illustrated in Figure 4.3.

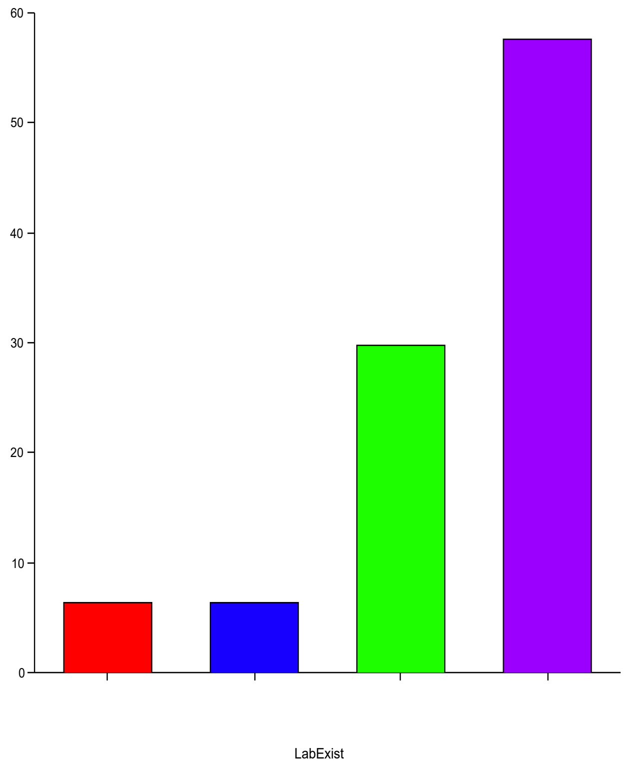

Figure 4.3:

The dental laboratories' years of existence

From Figure 4.3, the dental technicians and technologists were asked to indicate the number of years the dental laboratories they work for, have been in existence. 6.31% of the respondents indicated that their dental laboratories have been in existence for 1-5 years, 6.31% of the respondents indicated that their dental laboratories have been in existence for 6-10 years, 29.73% of the respondents indicated that their laboratories have been in existence for 11-20 years and 57.65% of the respondents indicated that their dental laboratories have been in existence for more than 20 years.

4.2.5 Highest qualification

Figure 4.4 illustrates the qualifications of dental technicians and technologists.

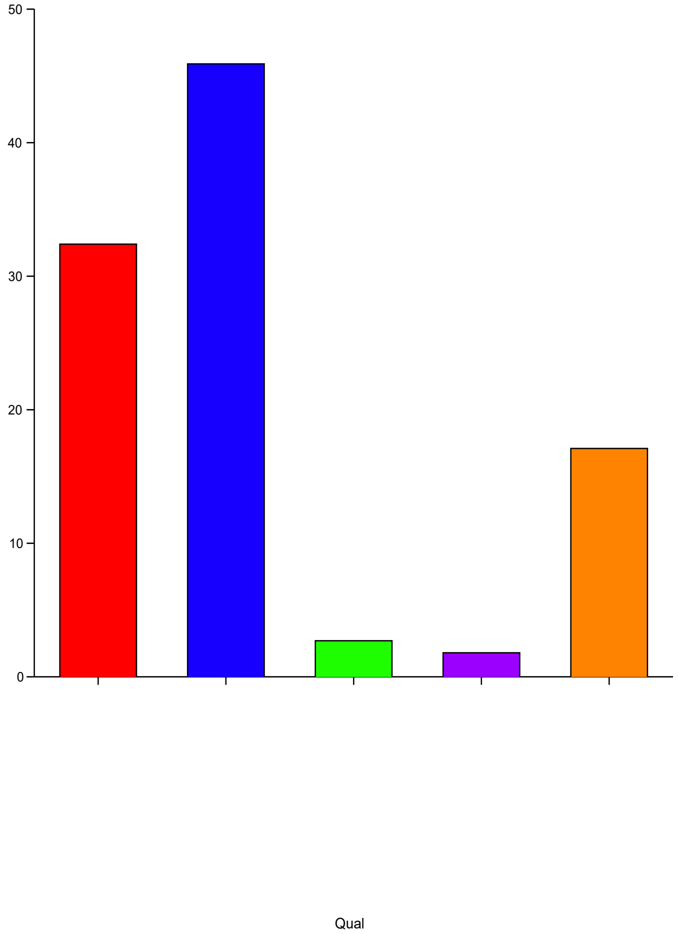

Figure 4.4:

The respondents' qualifications

Figure 4.4 shows that 32.43% of the dental technicians and technologists had a National Diploma (ND) in dental technology, 45.95% had Bachelor of Technology (BTech) in dental technology, 2.70% had Higher Diploma (HD) in dental technology, 1.80% had Higher National Diploma (HND) in dental technology and 17.2% had National Higher Diploma (NHD) in dental technology.

4.2.6 Hepatitis B immunisation

The results of the immunisation status of the dental technicians and technologists are displayed in Figure 4.5.

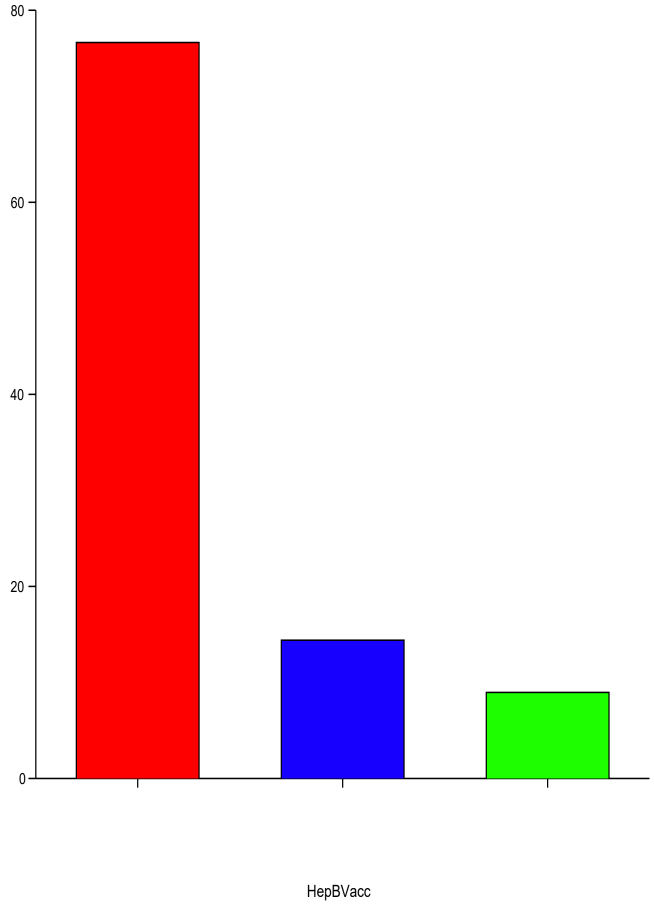

Figure 4.5:

Respondents' hepatitis B immunisation status

In Figure 4.5, the dental technicians and technologists were asked if they had been vaccinated against hepatitis B. 76.58% of them indicated that they had been vaccinated against hepatitis B, 14.41% of them indicated that they had not been vaccinated against hepatitis B and 9.0% of them were not sure if they had been vaccinated against hepatitis B.

4.2.7 Attendance to refresher courses, training, or workshops on infection control

The number of dental technicians and technologists who had attended training, workshops or refresher courses on infection control was obtained and presented in Figure 4.6.

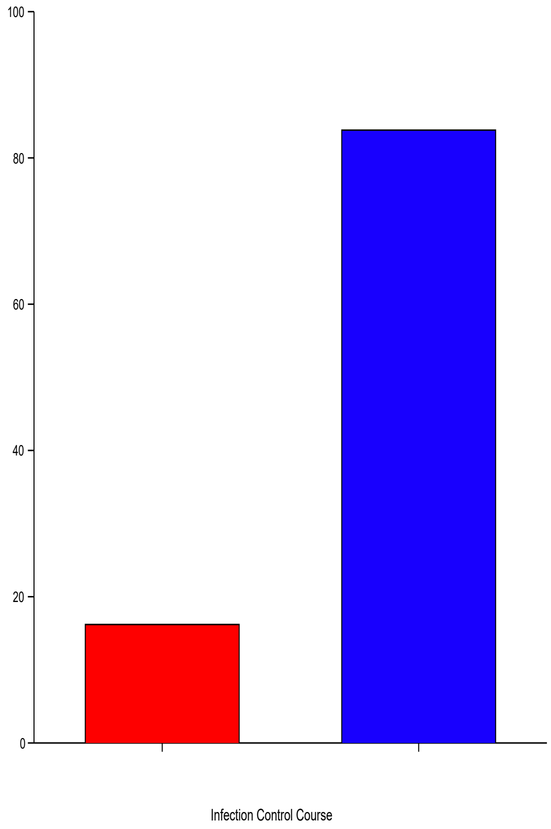

Figure 4.6:

Training on infection control

Figure 4.6 shows that only 16.22% of the respondents had attended a training, workshop or taken refresher courses on infection control in the past two (2) years and 83.78% of the respondents had not attended any training, workshop, nor taken any refresher course on infection control in the past two (2) years.

4.2.8 Interest to attend a training, workshops, or refresher courses on infection control

The percentage of dental technicians and technologists who had interest for infection control training, workshops or refresher courses was determined and presented in Figure 4.7.

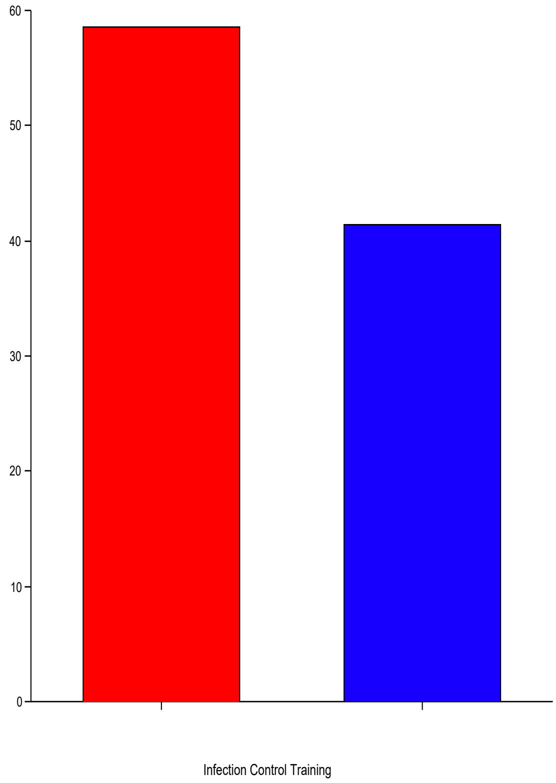

Figure 4.7:

Respondents' interest to attend infection control training or workshop

From Figure 4.7, 58.56% of the respondents indicated an interest in attending a training, workshop, or a refresher course on infection control while 41.44% of the respondents had no interest in attending a training, workshops or refresher course on infection control.

4.2.9 Dental Impressions received by dental laboratories

The number of dental impressions the dental laboratories receive weekly from dental clinics is illustrated in Figure 4.8.

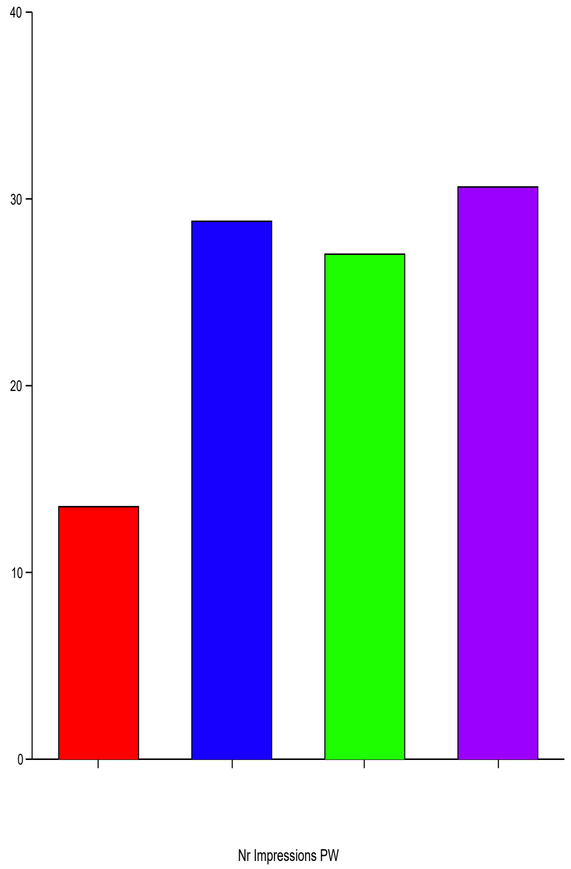

Figure 4.8:

The number of impressions received by the dental laboratories per week

From Figure 4.8, 13.51% of the respondents receive less than twenty (<20) dental impressions per week in their dental laboratories, 28.83% of the respondents receive 20-30 dental impressions per week, 27.03% of the respondents receive 30-50 dental impressions per week and 30.63% of the respondents receive more than fifty (>50) dental impressions per week.

4.2.10 Personal protective clothing

The number of dental technicians and technologists who wore personal protective clothing (laboratory/dust coat and/or masks and/or goggles/visor and/ or gloves) all the time while working was obtained and is shown in Figure 4.9.

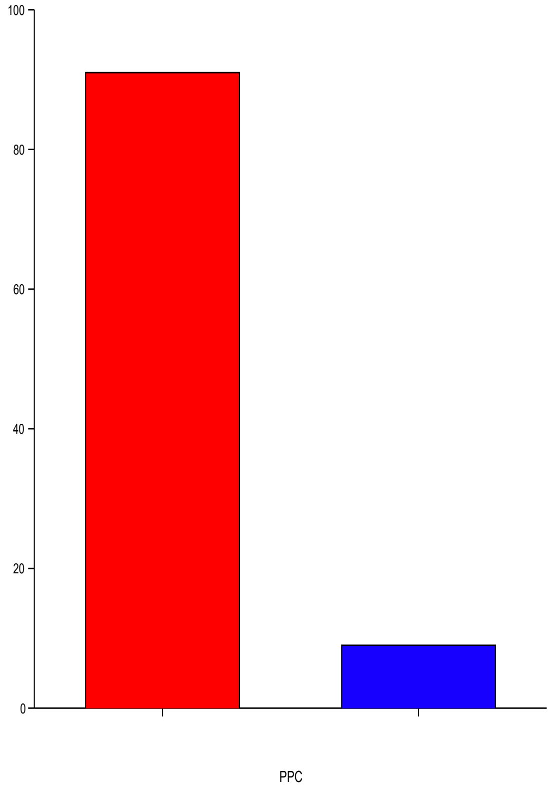

Figure 4.9:

Personal protective clothing.

From Figure 4.9, the dental technicians and technologists were asked if they wore personal protective clothing while working in the dental laboratory. The results of the study indicated that 90.99% of the respondents wear protective clothing such as laboratory coats, face masks, and goggles while working in their various dental laboratories and 9.01% of the respondents do not wear protective clothing while working.

4.2.11 Supply of personal protective clothing

The dental technicians and technologists' supply of protective clothing is shown in Figure 4.10.

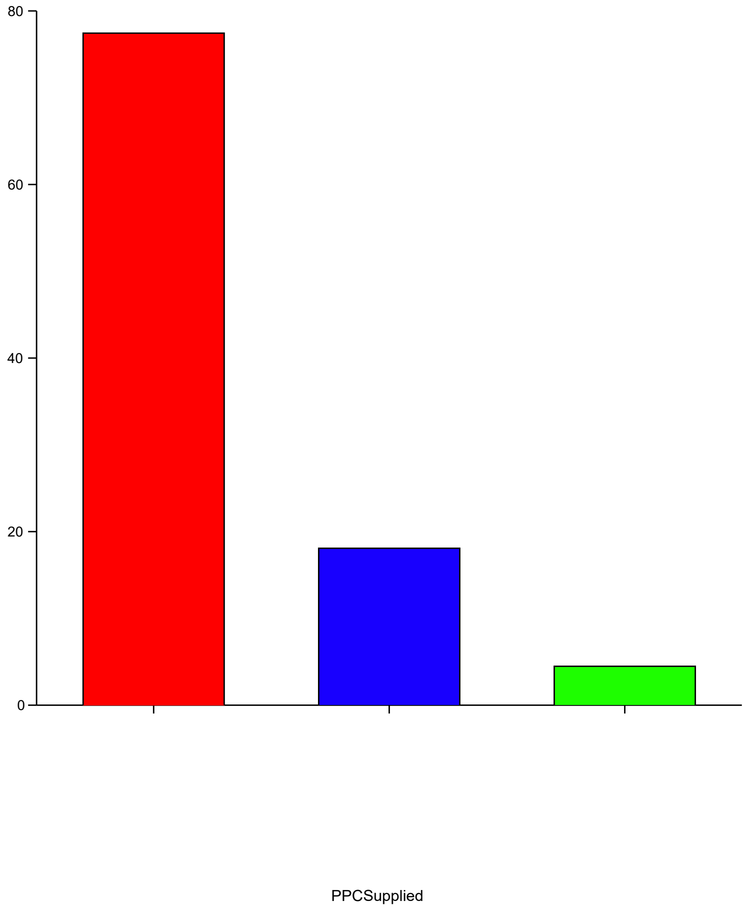

Figure 4.10:

Supplier of personal protective clothing

From Figure 4.10, 77.48% of the respondents indicated that the dental laboratories provided the personal protective clothing they use while working, 18.02% of respondents indicated that their dental laboratories were not responsible for their personal protective clothing and 4.50% of the respondents did not use protective clothing and therefore were not aware whether their dental laboratories provided personal protective clothing or not, for their dental technicians and technologists.

4.2.12 Types of personal protective clothing

The different types of personal protective clothing worn by the dental technicians and technologists are displayed in Table 4.2.

Table 4.2: The personal protective clothing respondents wear daily

Variables	No of responses			
	Yes	**%**	**No**	**%**
Laboratory coat	101	90.99	10	9.01
Mask	84	75.68	27	24.32
Goggles/Visor	81	72.97	30	27.03
Gloves	68	61.26	43	38.74
Do not use PPC	10	9.01	101	90.99
Other(specify)	3	2.70	108	97.29

Table 4.2 revealed that 90.99% of the respondents wore laboratory or dust coats in the dental laboratories and 9.01% of the respondents did not wear laboratory or dust coats.

There are 75.68% of the respondents who wear masks while working daily in the dental laboratories as a means of protection and 24.32% of the respondents do not wear masks while working in the dental laboratories.

From Table 4.2, there are 72.97% of respondents who wear goggles daily while working to prevent eye injuries and disease, and 27.03% of respondents do not wear goggles.

Table 4.2 shows that 61.26% of the respondents in the dental laboratories wear gloves while working daily and 38.74% of the respondents do not wear gloves.

From Table 4.2, only 9.01% of the respondents did not wear personal protective clothing while working in the dental laboratories while 90.99% of the respondents wore personal protective clothing while working in the dental laboratories.

As seen from Table 4.2, the respondents were asked to specify any other protective clothing they make use of which was not listed in the option provided by the researcher. 2.70% of the respondents specified that they make use of other protective clothing such as safety shoes and hair cover while 97.29% of the respondents did not specify because they make use of either laboratory coats, masks, goggles, or gloves which were listed in the options provided by the researcher.

4.2.13 Frequency of change of face masks

The frequency at which dental technicians and technologists change face masks is shown in Figure 4.11.

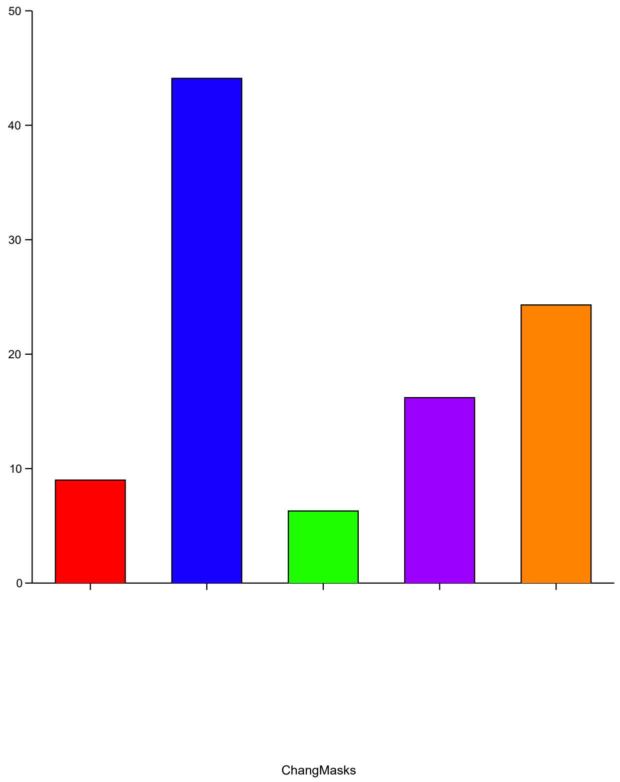

Figure 4.11:

The frequency at which respondents change face masks

Figure 4.11 shows that 9.01% of the respondents change their face masks immediately after use, 44.14% of the respondents change their face masks daily, 6.31% of the respondents change their face masks weekly, 16.22% of the respondents have no specific time they change their face masks and 24.32% of the respondents do not wear face masks.

4.2.14 Change of gloves

The frequency at which dental technicians and technologists changed gloves while working on procedures that require gloves was determined and is displayed in Figure 4.12.

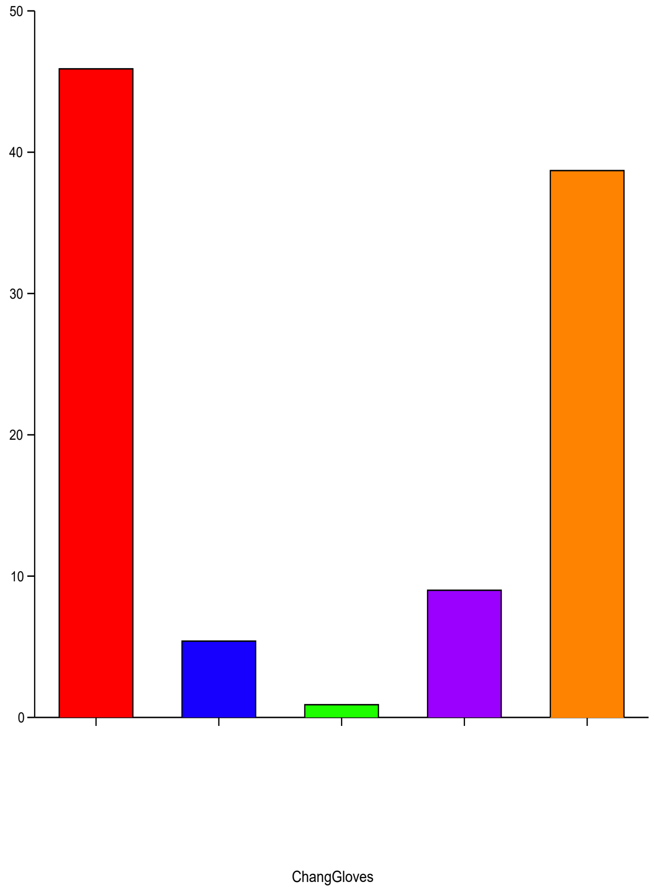

Figure 4.12:

Frequency at which respondents change gloves

Figure 4.12 shows the feedback from the respondents when they were asked how often they change gloves. A total of 45.95% of the respondents dispose of their gloves on completion of a procedure, 5.41% dispose of their gloves daily, 0.90% of the respondents dispose of their gloves weekly, 9.01% of the respondents have no specific time they dispose of their gloves and 38.74% of the respondents do not use gloves while working and therefore provided no answer to the question.

4.2.15 Cleaning of goggles or visors

The number of times respondents clean their goggles or visors is revealed in Figure 4.13.

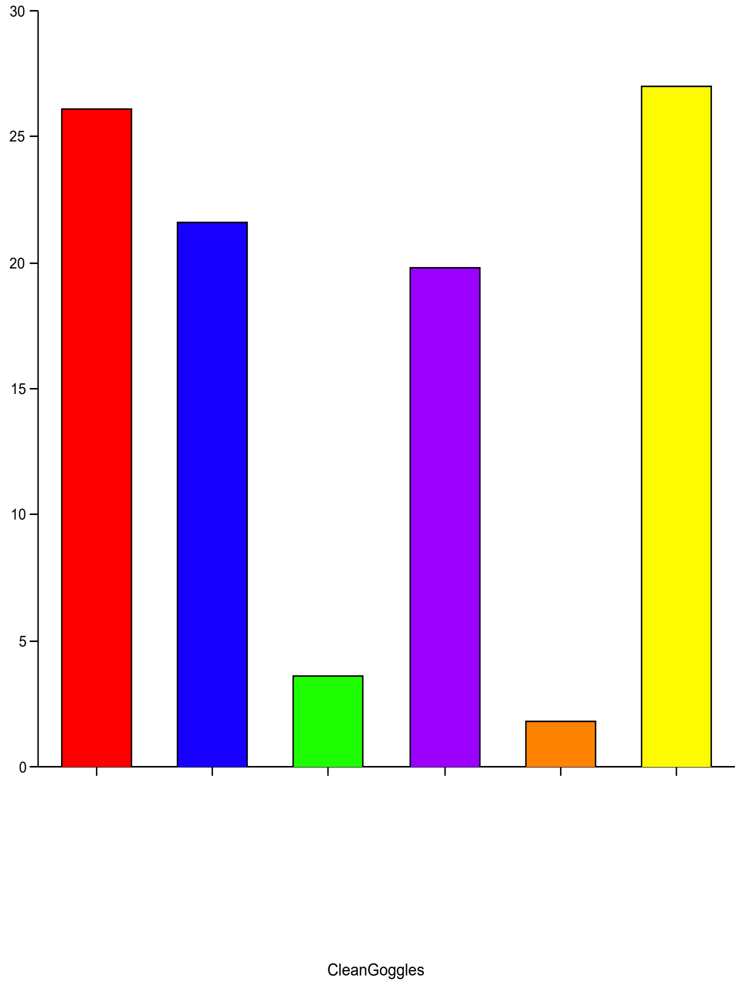

Figure 4.13:

The frequency at which respondents change goggles

The chart displays the respondents' responses when they were asked how often they cleaned their goggles or visors after working. There was 26.13% of the respondents who indicated that they clean their googles or visors immediately after working on a prosthesis, 21.62% of the respondents clean their goggles daily, 3.60% of the respondents clean their goggles weekly, 19.82% of the respondents have no specific time they clean their goggles, 1.80% of the respondents do not clean their goggles and 27.03% of the respondents do not use goggles while working.

4.2.16 Washing of laboratory or dust coat

The number of times respondents washed their laboratory or dust coats was captured in Figure 4.14.

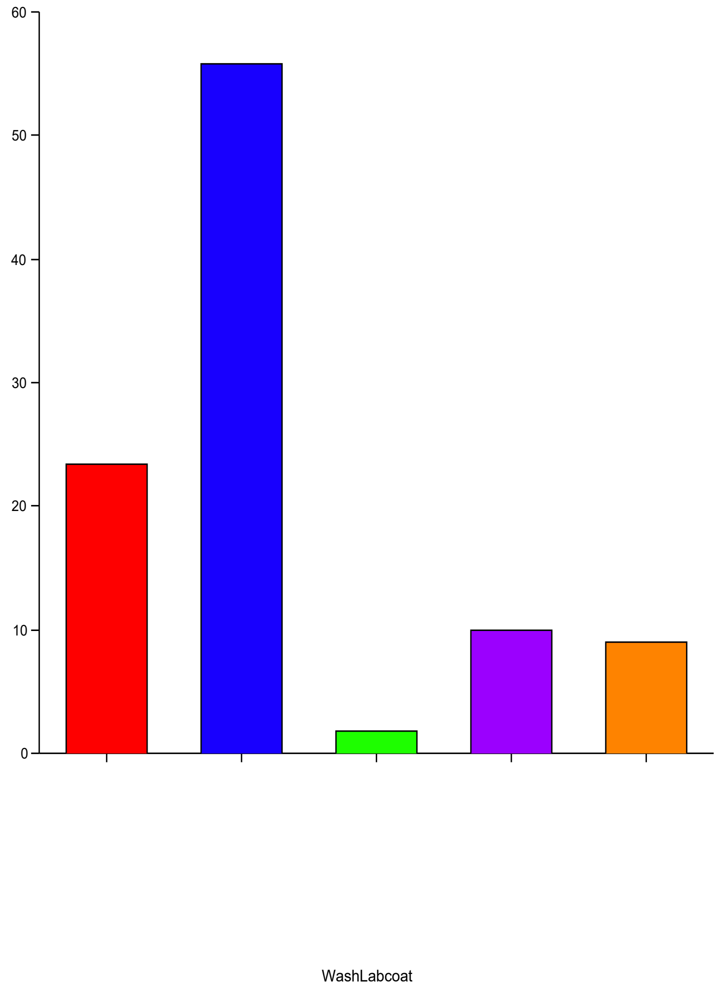

Figure 4.14:

Frequency at which respondents wash their lab coats

Figure 4.14 shows that 23.42% of the respondents wash their laboratory coats daily, 55.86% of the respondents wash their laboratory coats weekly, 1.80% of the respondents wash their laboratory coats monthly, 9.91% of the respondents did not have a specific time they washed their laboratory coats, they only washed their laboratory coats when necessary and 9.01% of the respondents do not wear laboratory coats.

4.2.17 Cleaning Personal Protective Wear

The dental technicians and technologists were asked if they were responsible for cleaning their personal protective clothing or whether their laboratories were responsible for cleaning their personal protective clothing. Their responses were captured and presented in Table 4.3.

Table 4.3: Cleaning of personal protective clothing

Cleaning of PPC	Count	Percentage of respondents %
Yes	30	27.03
No	77	69.37
Do not use PPC	4	3.60
Total	**111**	**100**

Table 4.3 shows that 27.03% of the respondents indicated that their dental laboratories were responsible for cleaning their personal protective clothing, while 69.37% of the respondents indicated that they were responsible for cleaning their personal protective clothing and 3.60% of the respondents did not use personal protective clothing and did not know if their dental laboratories were responsible for cleaning them.

4.2.18 Efficient Infection Control Plan

The percentage of dental laboratories that had efficient infection control plans as revealed by the dental technicians and technologists was obtained and is presented in Figure 4.15.

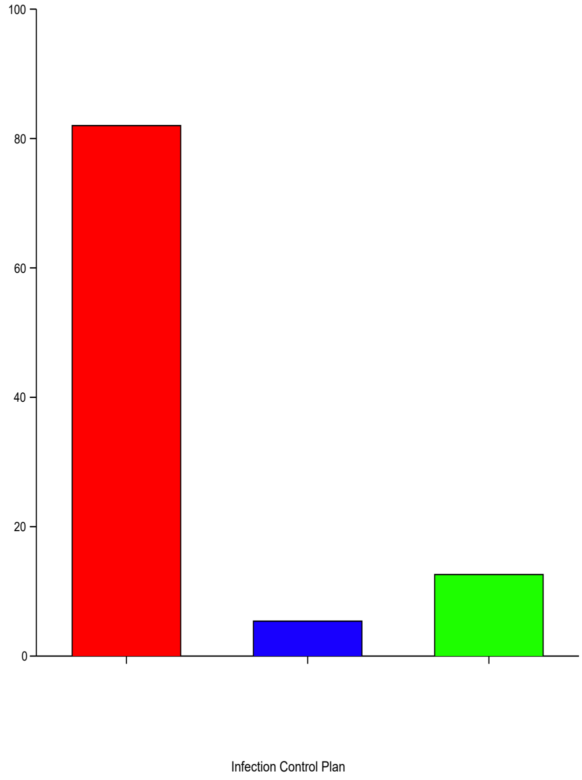

Figure 4.15:

Infection control plan

From Figure 4.15, respondents were asked if their dental laboratories had an efficient infection control plan, the result reveals that 81.98% of the respondents had an efficient infection control plan in their laboratories, 5.41% of the respondents reported that their dental laboratories did not have efficient infection control plan and 12.61% of the respondents were uncertain if they had efficient infection control plan in place in their laboratories.

4.2.19 Infection control manual or guideline document

The percentage of dental laboratories that had infection control manuals or guideline documents was captured and presented in Figure 4.16.

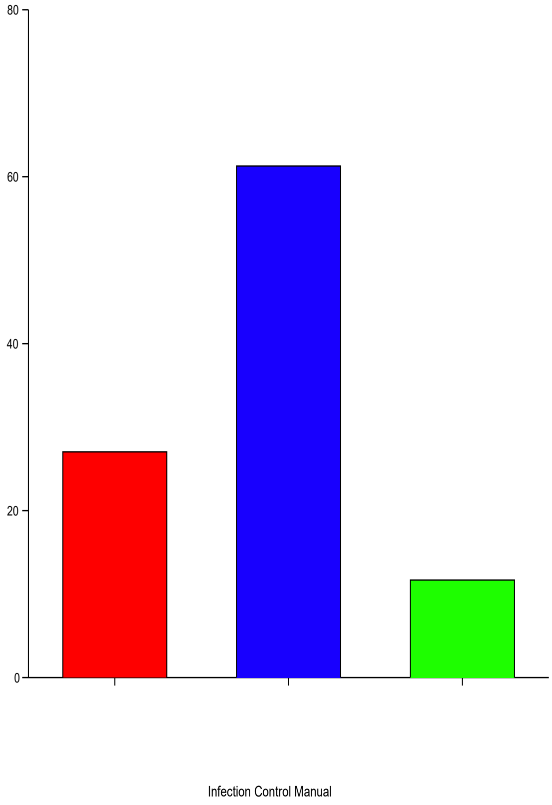

Figure 4.16:

Infection control manual or guideline

From Figure 4.16, respondents were asked if their dental laboratories had an infection control manual or guidelines, the results show that 27.03% of the respondents had an infection control manual or guideline in their laboratories, 61.26% of the respondents had no infection control manual or guideline document and 11.71% of the respondents were uncertain if their laboratories had an infection control manual or guideline document.

4.2.20 Infection control brochures and pamphlets, or posters and signages displayed in the dental laboratories

The availability of infection control brochures and pamphlets or posters and signages in the dental laboratories was determined and illustrated in Figure 4.17.

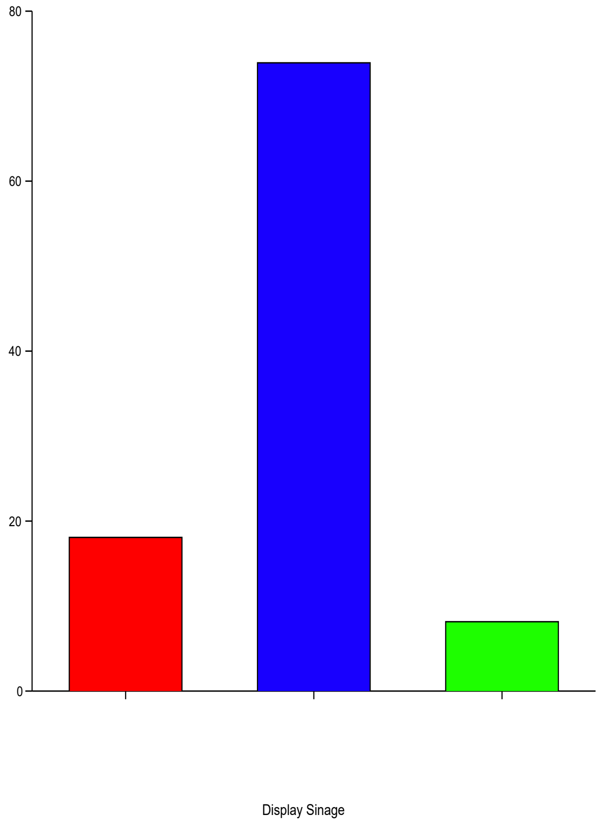

Figure 4.17:

Infection control pamphlets or signage

Figure 4.17 shows that 18.02% of the respondents have infection control brochures, pamphlets, posters, or signage in their dental laboratories, 73.87% of the respondents had no brochure, pamphlets, posters, or signage regarding infection control in their dental laboratories and 8.11% of the respondents were uncertain if there was brochures, pamphlets, posters, or signage regarding infection control in their dental laboratories.

4.2.21 Infection control measures or practices at the dental clinics

Infection control practices at the dental clinics the dental laboratories receive impressions from, was determined and illustrated in Figure 4.18.

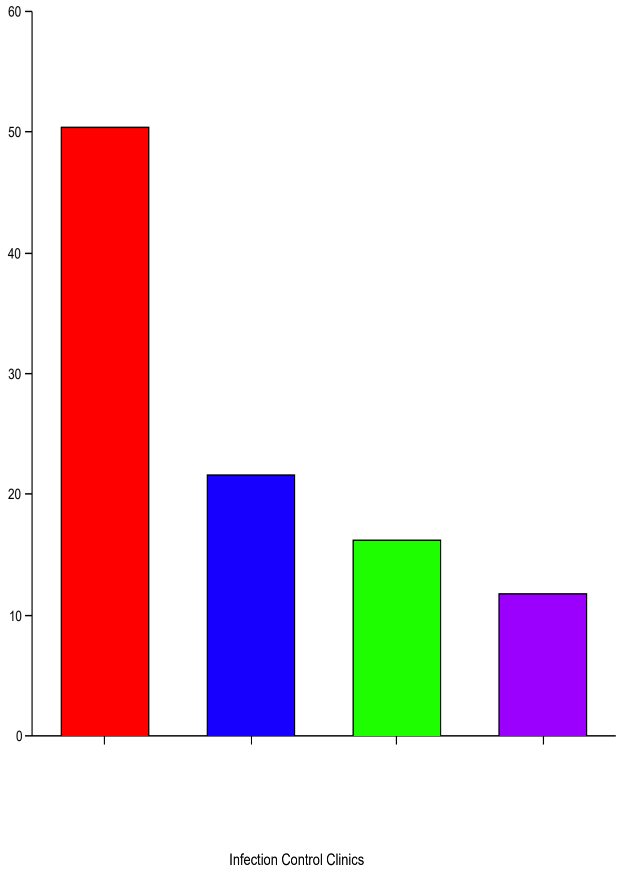

Figure 4.18:

Infection control measures at the clinics

Figure 4.18 shows 50.45% of the respondents indicated that there are infection control measures and practices at all the dental clinics they receive dental impressions from, 21.62% of the respondents indicated that there are infection control measures at some of the clinics they receive dental impressions from, 16.22% of the respondents indicated that there are no infection control measures and practices at the dental clinics they receive dental impressions from and 11.71% of the respondents are not sure if there are infection control measures and practices at the dental clinics they receive dental impressions from.

4.2.22 Information on the disinfection status of incoming impressions

Information on the status of incoming impressions from dental clinics was obtained and presented in Figure 4.19.

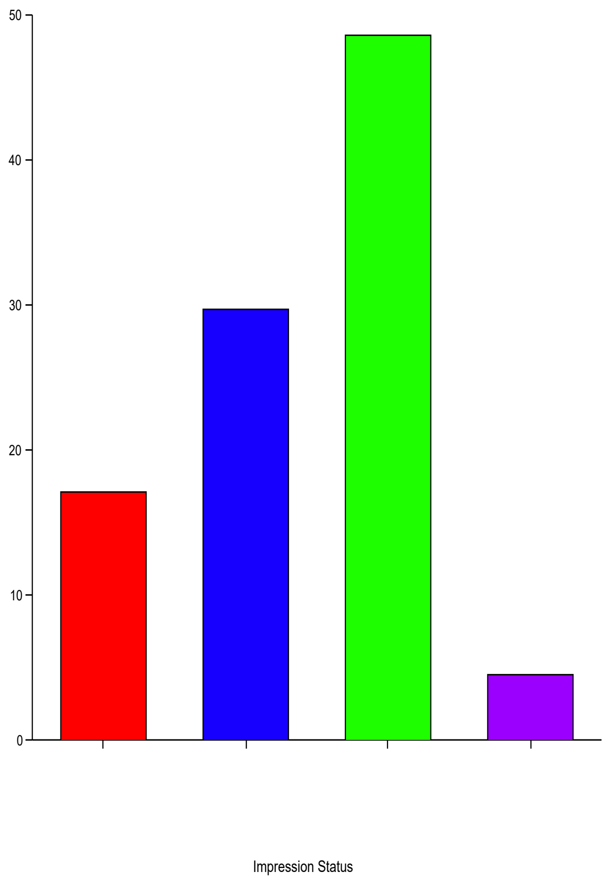

Figure 4.19:

Information on the status of incoming impression

Figure 4.19 shows that 17.12% of the respondents received information on the disinfection status of incoming impressions from all dental clinics, 29.73% of the respondents received information on the disinfection status of incoming impressions from some of the dental clinics, 45.65% of the respondents do not receive information on the disinfection status of incoming impressions from the dental clinics and 4.50% of the respondents are uncertain if their dental laboratories receive information on the disinfection status of incoming impressions from the dental clinics.

4.2.23 Level of confidence for disinfection protocols by dental practices

The level of confidence that the dental laboratories have regarding disinfection by dental practices was assessed and presented in Figure 4.20.

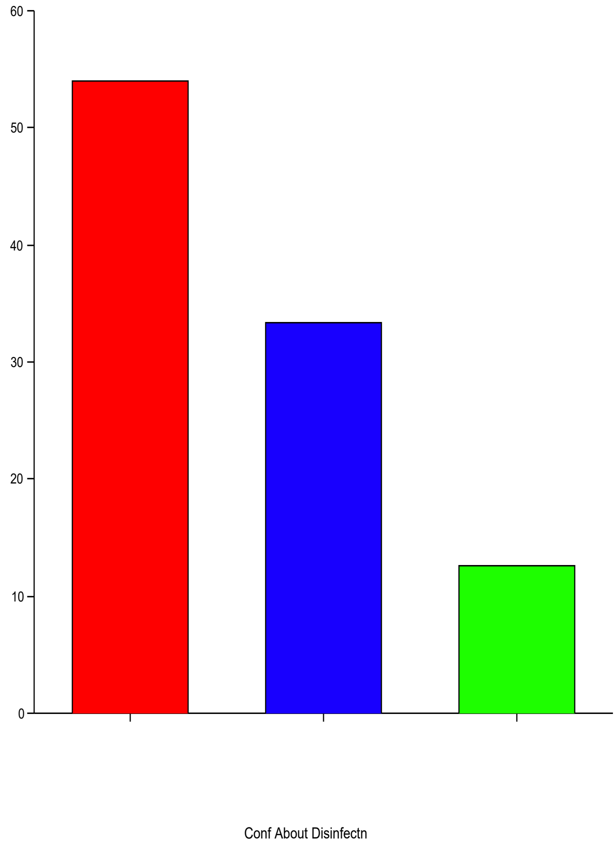

Figure 4.20:

Level of confidence for disinfection protocols by the dental practices

Figure 4.20 revealed that 54.05% of the dental technicians and technologists were confident with the disinfection protocols undertaken by the dental practices and clinics. It further revealed that 33.33% of them were not confident about the disinfection protocols by the dental clinics while 12.61% of them were not sure about their level of confidence regarding the disinfection protocols in the dental clinics, they receive impressions or work from.

4.2.24 Information about impressions from high-risk patients

Information regarding impressions from high-risk patients is shown in Figure 4.21.

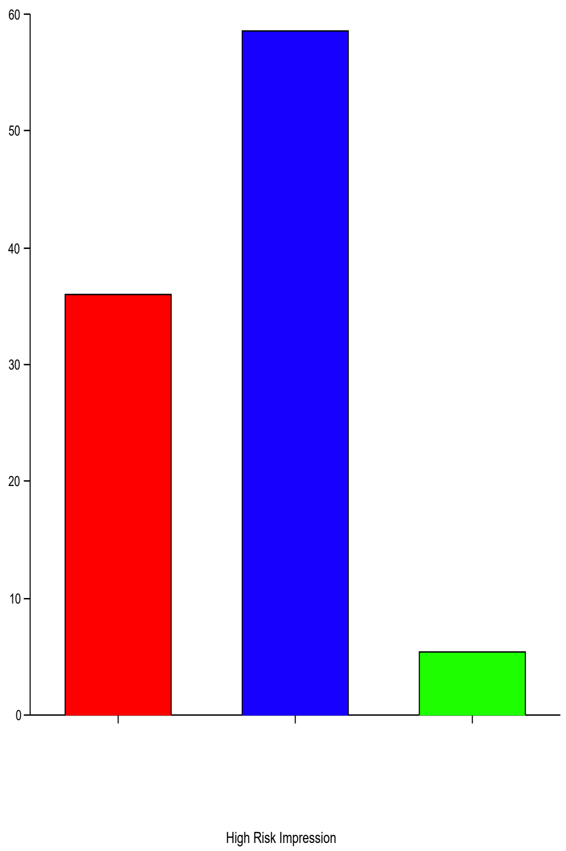

Figure 4.21:

Information about impressions from high-risk patients

In Figure 4.21, 36.04% of the respondents indicated that the dental clinics inform them of impressions from high-risk patients, 58.56% of the respondents are not informed of impressions from high-risk patients, and 5.41% are uncertain if they are informed or not about impressions from high-risk patients.

4.2.25 Information about impressions from patients with a known blood-borne virus

Information about impressions from patients with a known blood-borne virus was obtained and displayed in Figure 4.22.

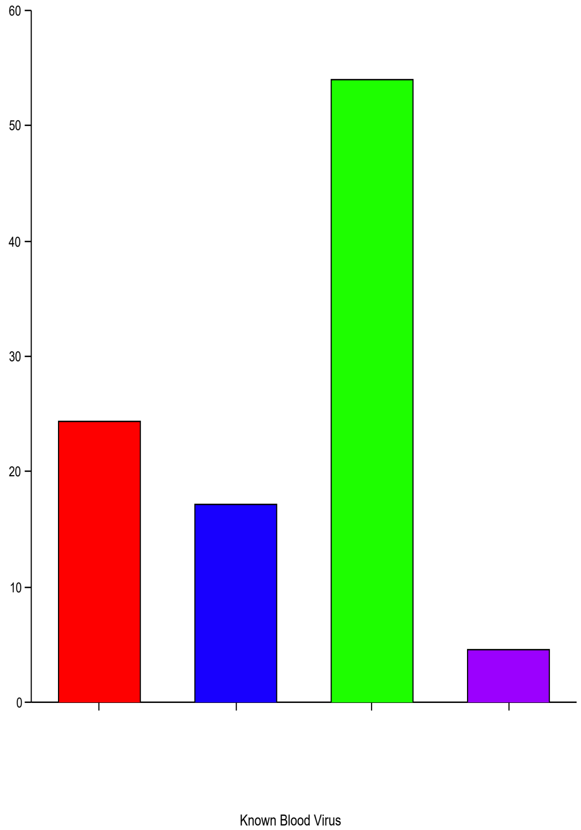

Figure 4.22:

Information about Impressions from patients with a known blood-borne virus

Figure 4.22 shows that 24.32% of the dental technicians and technologists are informed by all the dental clinics they receive impressions from if a patient has a known blood-borne virus, 17.12% of the respondents indicated that they are informed by some of the dental clinics they receive impressions from if a patient has a known blood-borne virus, 54.05% of the respondents are not informed by the dental clinics if a patient has a known blood-borne virus and 4.50 are not sure if they are informed by the dental clinics if a patient has a known blood-borne virus.

4.2.26 Blood-contaminated impressions from dental clinics and practices

Information about blood-contaminated impressions from dental clinics and practices was determined and illustrated in Figure 4.23.

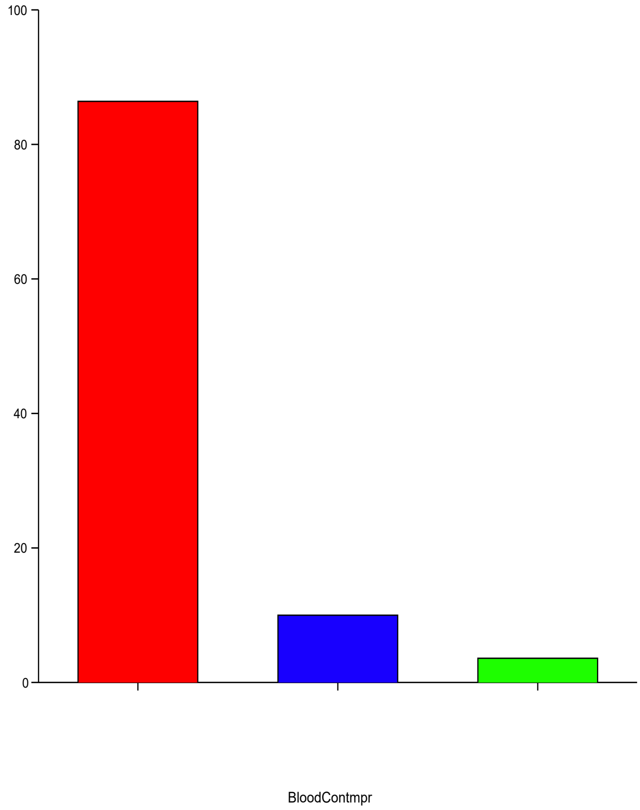

Figure 4.23:
Blood-contaminated impressions

Figure 4.23 shows that 86.49% of the respondents have at some point received blood-contaminated impressions from the dental clinics and practices, 9.91% of the respondents have never received blood-contaminated from the dental clinics and 3.60 of the respondents are not sure if they have ever received a blood-contaminated impression.

4.2.27 Saliva-contaminated impressions from dental clinics and practices

Information about saliva-contaminated impressions from dental clinics and practices was determined and illustrated in Figure 4.24.

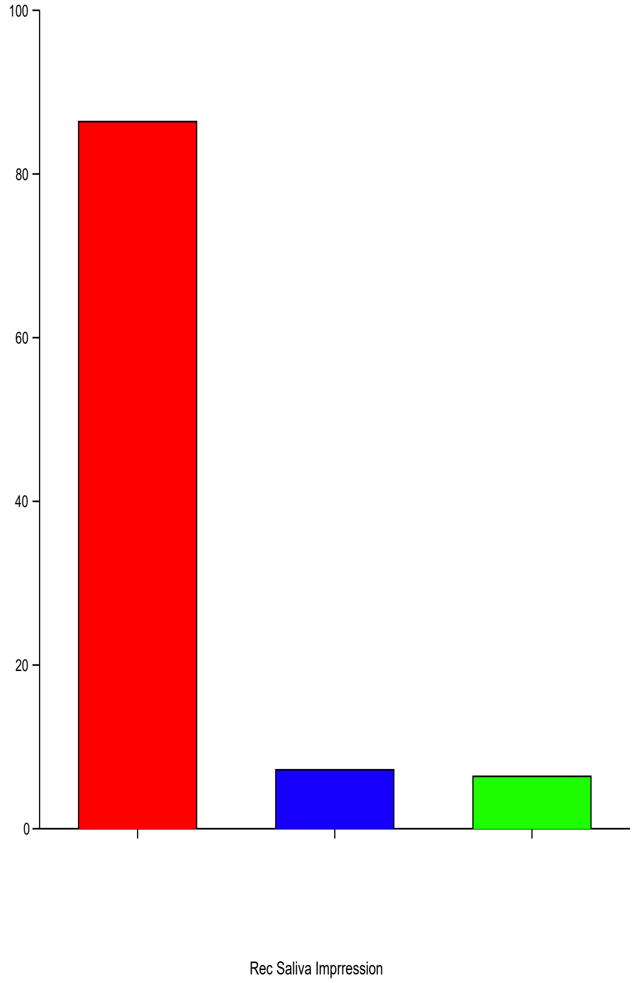

Figure 4.24:

Saliva-contaminated impressions

Figure 4.24 shows that 86.49% of the respondents have received at some point impressions containing saliva debris from dental clinics and practices,7.21% have never received impressions containing saliva debris from dental clinics and practices, while 6.31% of the respondents are uncertain if they have received impressions containing saliva debris from dental clinics and practices.

4.2.28 Infection control policy and practices agreement with dentists

The dental technicians and technologists were asked if the dental laboratories they work for had an infection control policy or agreement with the dentists or dental clinics they receive impressions and prostheses from. Their responses were captured and presented in Figure 4.25.

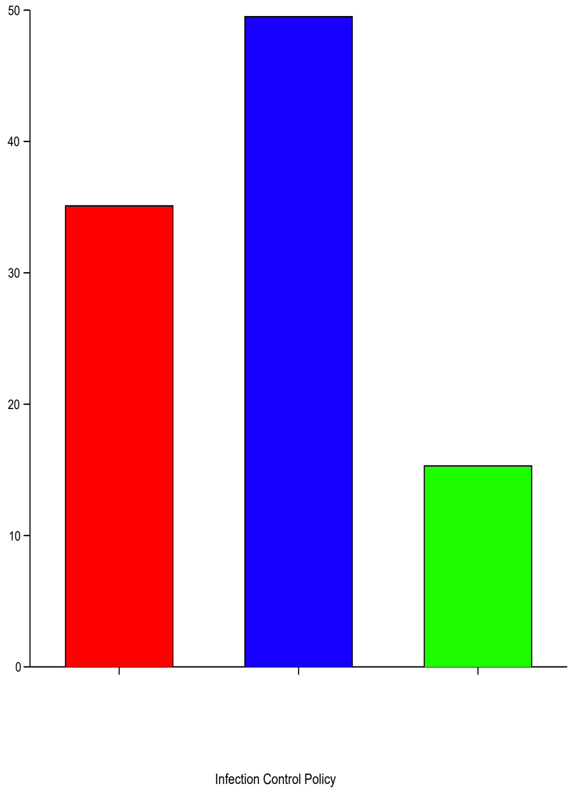

Figure 4.25:

Infection control policy agreement with dentists

Figure 4.25 shows that 35.14% of the respondents have an infection control policy and practices in agreement with dentists, 49.54% of the respondents do not have an infection control policy and practices in agreement with dentists, 15.32% of the respondents are uncertain if they have an infection control policy and practices in agreement with dentists.

4.2.29 Methods of receiving impressions from dental clinics and practices

The different methods the dental laboratories in Cape Town receive impressions from dental clinics and practices were obtained and are shown in Figure 4.26.

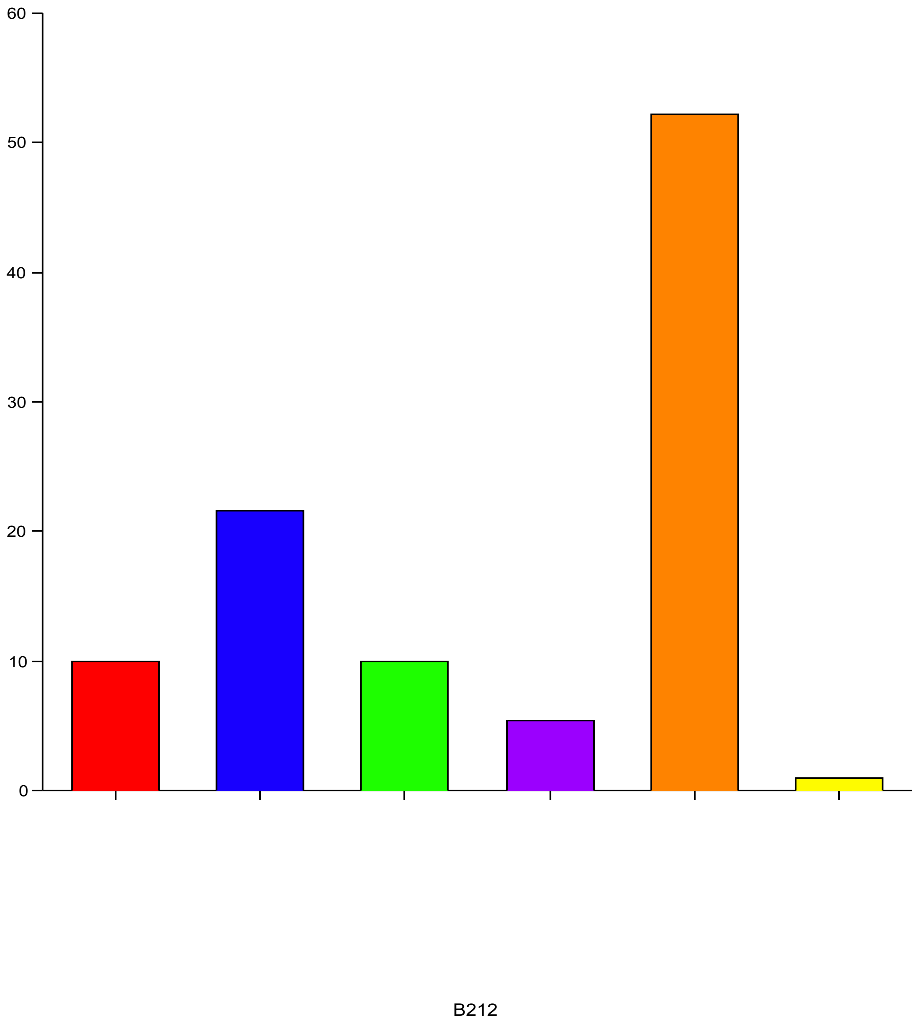

Figure 4.26:

Methods of receiving impressions from dental clinics

Figure 4.26 shows that 9.91% of the respondents receive impressions from the dental clinics in a specific type of bag, 21.62% of the respondents receive impressions in a wrapped bag, 9.91% of the respondents receive impressions in a wet wrapped bag, 5.41% of the respondents receive impressions in a container, 52.25% of the respondents indicated that the way they receive impressions from dental clinics differs from one clinic to another, 0.90% are not sure how impressions are received from the dental clinics.

4.2.30 Methods of receiving impressions or prostheses in the laboratory

The methods of receiving impressions or prostheses in dental laboratories were obtained and interpreted in Figure 4.27.

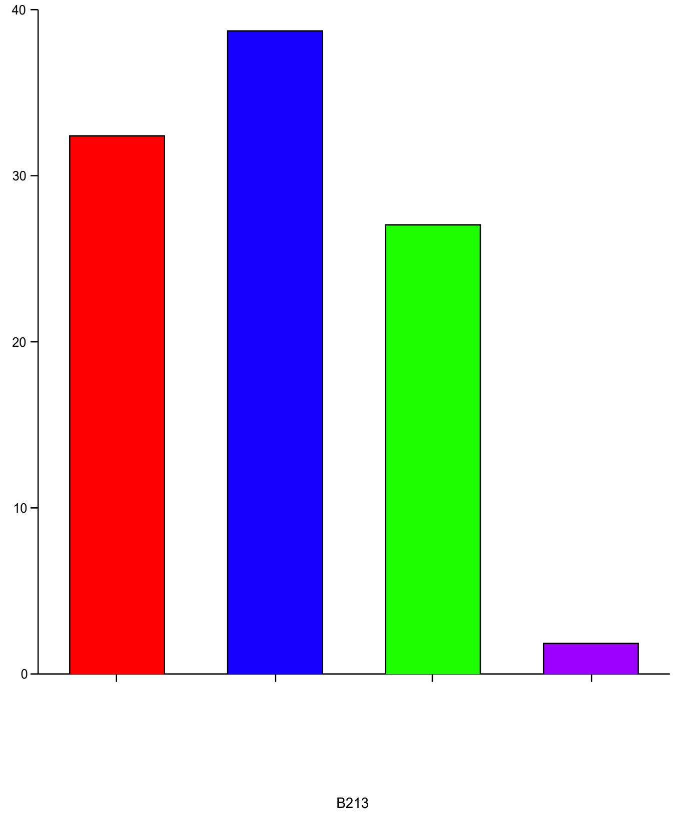

Figure 4.27:

Methods of receiving impressions in dental laboratories

From Figure 4.27, the dental technicians and technologists were asked to explain how they receive dental impressions or prostheses in their dental laboratories, 32.43% of them indicated that they receive impressions with their bare hands, 38.74% of them wore gloves while receiving impressions, 27.03% of them indicated that they wear gloves while receiving impressions in the dental laboratories and on some other occasions they receive impressions without wearing gloves. and 1.80% of them were not sure how impressions are received in their dental laboratories.

4.2.31 Dental impressions received by dental laboratories

The dental laboratories were assessed to determine if dental impressions and prostheses received are disinfected, the result is presented in Figure 4.28.

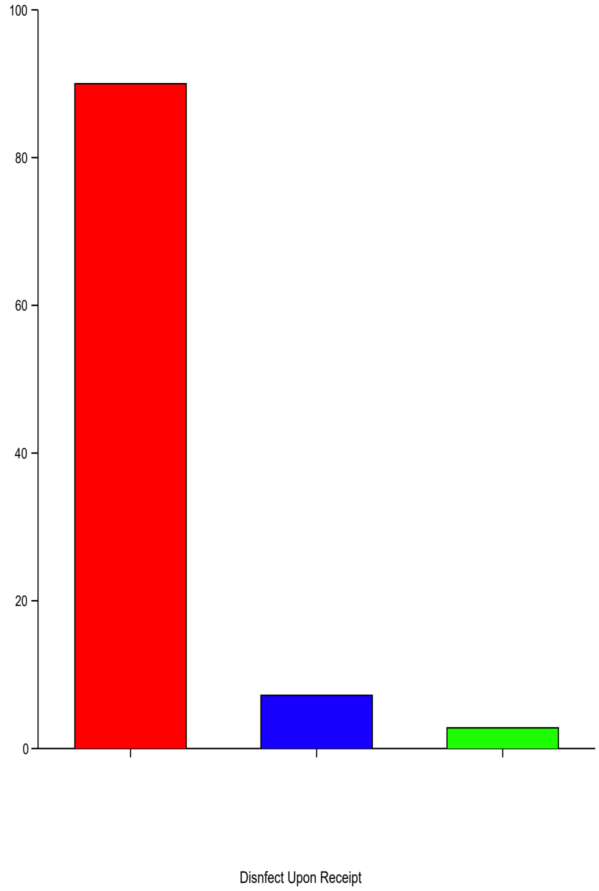

Figure 4.28:
Impressions received by the dental laboratories

Figure 4.28 shows that 90.09% of the respondents disinfect impressions when received in the laboratory, 7.21% of the respondents do not disinfect impressions when received in the laboratory, and 2.70% of the respondents are not sure if impressions are disinfected in their dental laboratories when received.

4.2.32 Impressions for urgent procedures may compromise infection control barrier system

Opinions of the dental technicians and technologists were sampled to find out if urgent dental procedures compromise infection control. Their responses were obtained and illustrated in Figure 4.29.

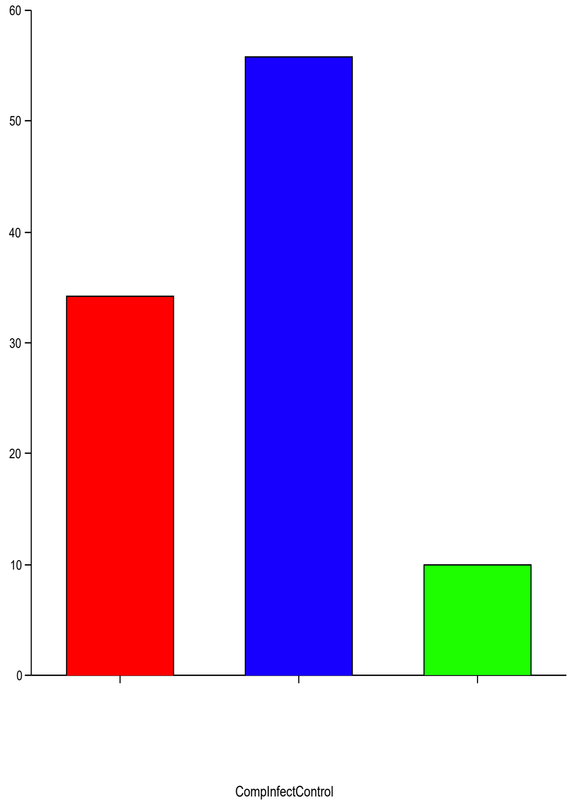

Figure 4.29:

Impressions for urgent procedures may compromise the quality of infection control in the dental laboratory

Figure 4.29 shows that 34.23% of the respondents believe that dental impressions brought into the laboratory to be completed in a shorter than normal time may compromise the quality of infection control for the given dental work, 55.86% of the respondents do not believe that dental impressions brought to the dental laboratory to be completed in a shorter than normal time will compromise the quality of infection control for the given dental work and 9.91% of the respondents are not sure if dental impressions brought to the dental laboratory to be completed in a shorter than normal time will compromise the infection control barrier system.

4.2.33 Disinfection area for infection control in the dental laboratory

The dental technicians and technologists were assessed to determine if they had a special area in their laboratories for disinfection. The result is shown in Figure 4.30.

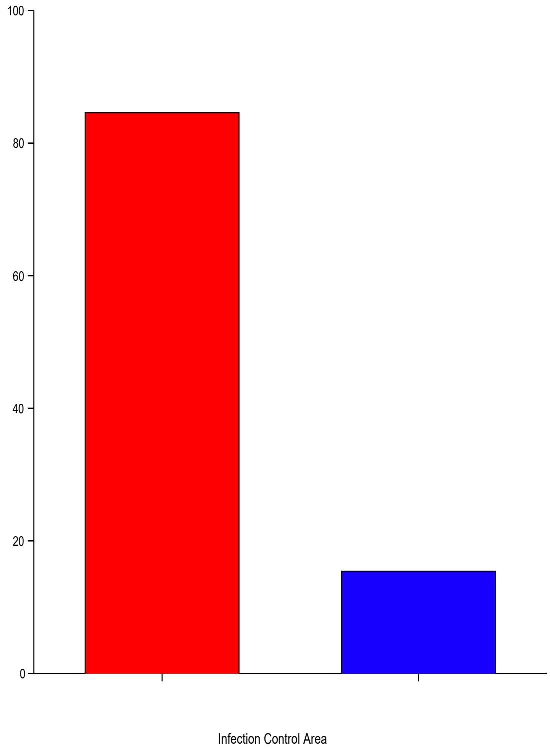

Figure 4.30:

Special area for disinfection in the dental laboratory

Figure 4.30 shows that 84.68% of the respondents have a specific area in their dental laboratory for disinfection and 15.32% of the respondents do not have a specific area for disinfection in their dental laboratories.

4.2.34 Means of disinfection in dental laboratories

The different means of disinfection in the dental laboratories were determined and presented in Table 4.4.

Table 4.4: Means of disinfection

Variables	No of responses			
	Yes	%	No	%
Antibacterial soap	53	47.75	58	52.25
Hand sanitisers	78	70.29	33	29.73
Automatic hand sanitising dispenser	10	9.01	101	90.99
Disinfecting wipes	8	7.21	103	92.79
Disinfecting solutions	65	58.56	46	41.44
Disinfecting sprays	79	71.17	32	28.83
Not sure	3	2.70	108	97.30

Table 4.4 shows that 47.75% of the respondents use antibacterial soap as a means of disinfection in the dental laboratories and 52.25% of the respondents do not use antibacterial soap.

There were 70.27% of the respondents who use hand sanitisers as a means of disinfection in the dental laboratories and 29.73% of the respondents do not use hand sanitisers.

About 9.01% of the respondents use automatic hand sanitisers as a means of disinfection in dental laboratories, and 90.99% of the respondents do not use automatic hand sanitisers.

Table 4.4 shows that 7.21% of the respondents use disinfecting wipes in the dental laboratories as a means of disinfection and 92.79% of the respondents do not use disinfecting wipes.

From Table 4.4, there are 58.56% of respondents who use disinfecting solutions as a means of disinfection in dental laboratories and 41.44% of the respondents do not use disinfecting solutions.

There were 71.17% of the respondents who use disinfecting sprays as a means of disinfection and 28.83% of the respondents do not use disinfecting sprays.

About 2.70% of the respondents were not sure of the means of disinfection employed by their dental laboratories while the rest of 97.30% of the respondents were sure of the means of disinfection employed by their dental laboratories.

4.2.35 Frequency of hand sanitising protocols

The frequency at which the dental technicians and technologists perform hand hygiene in their dental laboratories is presented in Table 4.5.

Table 4.5: Frequency of hand sanitisation in the laboratory

Variables	No of responses			
	Yes	%	No	%
Once per day/at the end of the day	6	5.41	105	94.59
Between each case daily	46	41.44	65	58.56
Before the start of work & at the end of the day	13	11.71	98	88.29
Monthly	1	0.90	110	99.10
Not a specific time, as needed	39	35.14	72	64.86
Other(specify)	6	5.40	105	94.59

From Table 4.5, 94.59% of the respondents did not perform hand hygiene once a day or at the end of the day and 5.41% of the respondents sanitised or washed their hands once a day (at the close of work).

About 41.44% of the respondents performed hand hygiene between cases while working and 58.56% of the respondents did not perform hand hygiene between cases while working.

From Table 4.5, 11.71% of the respondents performed hand hygiene before work started and at the close of work each day at the dental laboratories and 88.29% of the respondents did not perform hand hygiene at the start or close of work.

About 0.90% of the respondents perform hand hygiene monthly (occasionally) while working and 99.10% of the respondents did not perform hand hygiene monthly (occasionally).

Table 4.5 shows that 35.14% of the respondents indicated that they performed hand hygiene only when it was essential and not necessarily at a specific time while working and 64.86% of the respondents indicated that they had a specific time they performed hand hygiene in the laboratory.

Table 4.5 revealed that 5.40% of the respondents who did not choose from the options provided by the researcher specified that they performed hand hygiene a lot of times in a day, some indicated that they sanitise their hands upon entering the lab, others performed hand hygiene as often as possible, some other performed hand hygiene during lunchtime and coffee breaks while some of the respondents performed hand hygiene on personal term and 94.59%

did not specify how often they performed hand hygiene because they already chose from the options provided by the researcher.

4.2.36 Frequency of cleaning and disinfection of dental laboratory or workspace

The frequency at which the dental laboratories were cleaned and disinfected was obtained and is presented in Table 4.6.

Table 4.6: Cleaning and disinfection of workspace

Variables	No of responses			
	Yes	%	No	%
Periodically	10	9.01	101	90.99
Daily	62	55.86	49	44.14
Weekly	27	24.32	84	75.68
Not a specific time as needed	8	7.21	103	92.79

Table 4.6 revealed that 9.01% of the dental laboratories cleaned and disinfected their laboratories at intervals during work and 90.99% of the dental laboratories did not clean and disinfect the laboratories at intervals.

About 55.86% of the respondents revealed that their dental laboratories or workspaces were cleaned and disinfected daily and 44.14% of the respondents revealed that their dental laboratories or workspaces were not cleaned and disinfected daily.

As seen from Table 4.6, 24.32% of the respondents indicated that their dental laboratories were cleaned and disinfected weekly and 75.68% of the respondents indicated that their laboratories were not cleaned and disinfected weekly.

Table 4.6 shows that 7.21% of the respondents do not have a specific time they clean and disinfect their dental laboratories, they clean and disinfect their dental laboratories or workspaces as needed and 92.79% of the respondents indicated that they have a specific time they clean their dental laboratories or workspaces.

4.2.37 Disinfectants used in the dental laboratories

The different disinfectants used for infection control in the dental laboratories were obtained and are presented in Table 4.7.

Table 4.7: Methods of disinfection in the laboratories

Variables	No of responses			
	Yes	**%**	**No**	**%**
Glutaraldehyde	5	4.50	106	95.50
Sodium hypochlorite	21	18.92	90	81.08
Quaternary ammonium compound	5	4.50	106	95.50
Chlorine compound	6	5.41	105	94.59
Iodophors	1	0.90	110	99.10
Phenolic spray	2	1.80	109	98.20
Do not use any	4	3.60	107	96.40
Not sure	42	37.84	69	62.16
Other(specify)	30	27.02	81	72.97

Table 4.7 shows that only 4.50% of the respondents use Glutaraldehyde for disinfection in their laboratories while 95.50% of the respondents do not use glutaraldehyde for disinfection in their laboratories.

About 18.92% of the respondents use sodium hypochlorite for disinfection in the dental laboratories and 81.08% of the respondents do not use sodium hypochlorite for disinfection in the dental laboratories.

Table 4.7 shows that 4.50% of the respondents used quaternary ammonium compounds for disinfection in the dental laboratories and 95.50% of the respondents did not use quaternary ammonium compounds for disinfection.

As seen from Table 4. 7, 5.41% of the respondents revealed that their dental laboratories use chlorine compounds for disinfection and 94.59% of the respondents do not use chlorine compounds for disinfection in the dental laboratories.

About 0.90% of the respondents used Iodophors for disinfection in their dental laboratories and 99.10% of the respondents did not use Iodophors for disinfection in the dental laboratories.

Table 4.7 shows that 1.80% of the respondents use phenol for disinfection in the dental laboratories and 98.20% of the respondents do not use phenol for disinfection in the dental laboratories.

There are 3.60% of respondents who indicated that they did not use any disinfectant or any infection control method in the dental laboratories and 96.40% of respondents who indicated that they use disinfectants and other infection control methods in the dental laboratories.

Table 4.7 shows that 37.84% of the respondents were not sure of the methods of disinfection or disinfectants they use in their dental laboratories and 62.16% of the respondents were sure of the methods of disinfection and infection control they use in their dental laboratories. F

From respondents who did not choose from the options provided by the researcher but specified the disinfectants and methods of infection control, they used in their dental laboratories, 27.02% of the respondents specified that they used disinfectants such as Isopropyl alcohol for disinfection, antifect hand sanitiser for hand hygiene, critic clean, didecyldimethyl ammonium chloride, distal high disinfectant, hydrochloric acid solution, impra dip, trichophyton chlorhexidine, zeta1ultra and 72.97% of the respondents did not specify because they selected from the list of options provided by the researcher.

4.2.38 Infection control practices in the dental laboratories

The different infection control protocols and practices by the dental technicians and technologists were captured and presented in Table 4.8.

Table 4.8: Infection control practices by the respondents while working.

Variables	No of responses			
	Yes	**%**	**No**	**%**
Rinse all impressions in running water when received	69	62.16	42	37.84
Disinfect all impressions upon receipt	100	90.09	11	9.91
Disinfect working areas	69	62.16	42	37.84
Change pumice slurry at intervals or by using different pumice slurry for different prostheses during polishing	32	28.83	79	71.17
Disinfect casts	36	32.43	75	67.57
Disinfect dental prostheses when they are completed by immersing them in disinfectants or by spraying disinfectants on them	65	58.56	46	41.44
Not sure	2	1.80	109	98.20
Other(specify)	7	6.30	104	93.69

Table 4.8 shows that 62.16% of the respondents rinse all impressions in running water when received in the dental laboratories and 37.84% do not rinse all dental impressions in running water when received in the dental laboratories.

Table 4.8 shows that 90.09% of the respondents in the dental laboratories disinfect impressions when received and 9.91% of the respondents do not disinfect all impressions when received in the dental laboratories.

About 62.16% of the respondents disinfect working areas and 37.84% of the respondents do not disinfect work areas in the dental laboratories.

Table 4.8 shows that 28.83% of the respondents changed pumice slurry at intervals or by using different pumice slurry for different prostheses while working at the dental laboratories and 71.17% of the respondents did not change pumice slurry while working at the dental laboratories.

As seen From Table 4.8, 34.43% of the respondents disinfect casts while working in the dental laboratories and 67.57% of the respondents do not disinfect casts.

Table 4.8 shows that 58.56% of the respondents in the dental laboratories disinfect dental prostheses when they are completed by immersing them in disinfectant or by spraying disinfectant on them and 41.44% of the respondents do not immerse or spray disinfectant on prostheses after completion.

Table 4.8 shows that 1.80% of the respondents are not sure of the infection control practices employed in their dental laboratories while working on prostheses and 98.20% are sure of the infection control practices employed in their dental laboratories while working on prostheses.

From Table 4.8 the respondents were asked to specify the infection control practices not listed in the options provided by the research that they follow in their dental laboratories while working on prostheses. 6.30% of the respondents indicated that they follow infection control practices such as adding disinfectants to pumice slurry during polishing, using steam on prostheses after working, and changing pumice slurry daily after working. The other 93.69% of the respondents did not specify because they had already chosen from the list of options provided by the researchers.

4.2.39 Infection control practices regarding working tools and equipment

The infection control practices of the dental technicians and technologists regarding their work tools and equipment were obtained and are presented in Table 4.9.

Table 4.9: Infection control practices regarding tools and equipment in the laboratory.

Variables	No of responses			
	Yes	%	No	%
Lathes, grinders, and laboratory handpieces are connected or used near a dust chip evacuation system	69	62.16	42	37.84
Regular washing and sterilisation of lathe brushes and burs	46	41.44	65	58.56
Autoclave instruments	2	1.80	109	98.20
Disinfect all mixing bowls	35	31.53	76	68.47
Not sure	7	6.31	104	93.69
Other(specify)	6	5.41	105	94.59

Table 4.9 shows that 62.16% of the respondents used extractors during trimming procedures to keep the dental laboratory free from dust and prevent dental professionals from inhaling the dust particles while working and 37.84% of the respondents did not use extractors during trimming procedures.

About 41.44% of the respondents washed or sterilised lathes, brushes, and burs regularly and 58.56% of the respondents did not wash or sterilise lathes, brushes and burs regularly.

Table 4.9 shows that only 1.80% of the respondents used autoclaves to sterilise instruments in the dental laboratories and 98.20% of the respondents indicated that they did not use autoclaves to sterilise instruments in the dental laboratories.

There are 31.53% of the respondents who disinfect mixing bowls in the dental laboratories and 68.47% of the respondents did not disinfect mixing bowls.

Table 4.9 shows that 93.69% of the respondents are sure of the infection control practices employed in their dental laboratories regarding tools and equipment while 6.31% of the respondents are not sure of the infection control practices employed in their dental laboratories regarding tools and equipment.

From Table 4.9, the respondents were asked to specify the infection control practices employed in their dental laboratories regarding tools and equipment if they did not select from the ones listed in the options provided by the researcher. 94.59% of the respondents did not specify the infection control practices regarding tools and equipment as they had already selected from the list of options provided by the researcher, while 5.41% of the respondents indicated that they used fogging sanitiser or ultraviolet light to disinfect tools and equipment, while some washed all tools and equipment.

4.2.40 Disinfection of all dental laboratory work

The dental technicians and technologists were asked if they disinfected all dental laboratory work, their responses are shown in Figure 4.31.

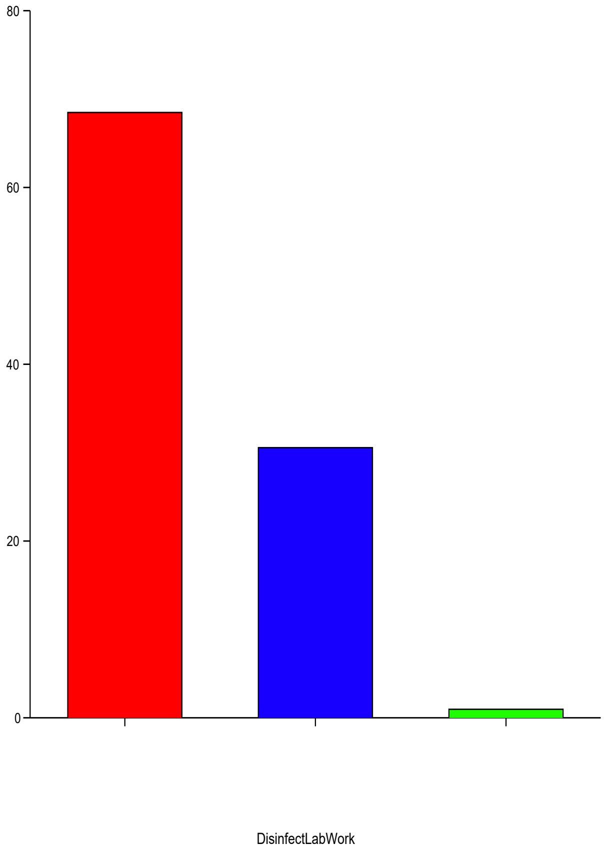

Figure 4.31:

Disinfection of dental laboratory work (prostheses)

From Figure 4.31, 68.47% of the respondents disinfect laboratory work before sending it to the dental clinics, 30.63% of the respondents do not disinfect laboratory work before sending it to the dental clinics and 0.90% of the respondents are uncertain if they disinfect laboratory work before sending it to the dental clinics.

4.2.41 Waste disposal by the dental laboratories

The percentage of dental laboratories that properly dispose of their wastes is shown in Figure 4.32.

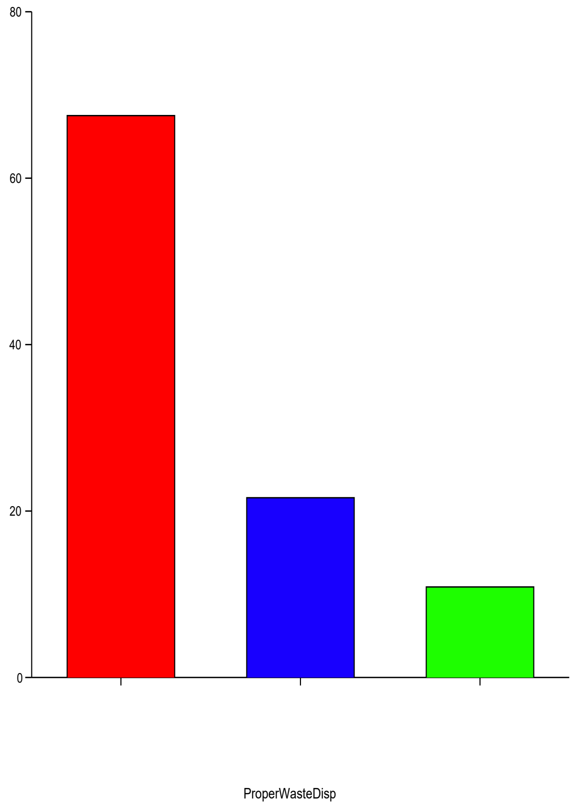

Figure 4.32:

Waste disposal in dental laboratories

Figure 4.32 shows that 67.57% of the respondents use proper disposal methods for wastes in the dental laboratories, 21.62% of the respondents do not use proper disposal methods for wastes in the dental laboratories and 10.81% of the respondents are uncertain if their dental laboratories use proper disposal methods for wastes.

4.2.42 Treatment of dental-related infections

The responses of the dental technicians and technologists regarding treatment of dental related infections in their dental laboratories were captured and is illustrated in Figure 4.33.

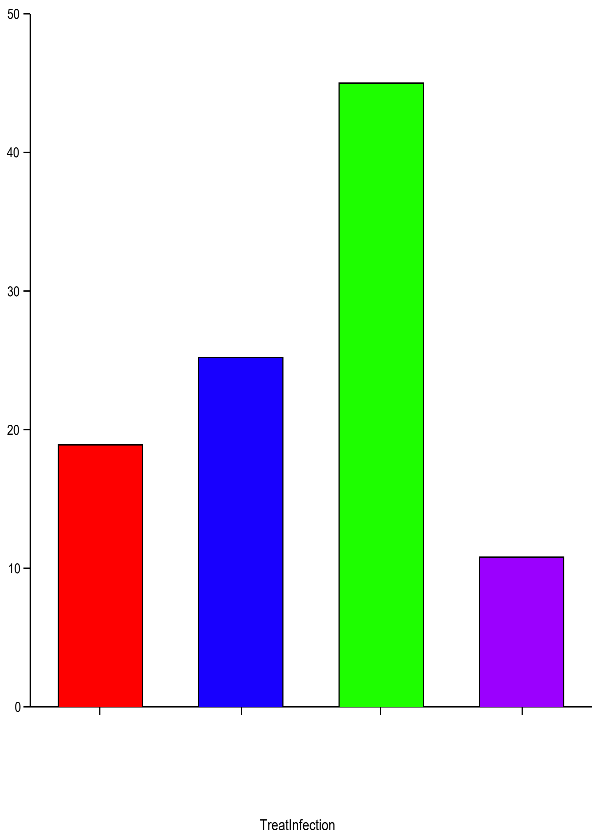

Figure 4.33:

Treatment of dental-related infections in dental laboratories

Figure 4.33 shows that 18.92% of the respondents indicated that their dental laboratories are responsible for the treatment of dental-related infections, 25.23% of the respondents indicated that their dental laboratories are not responsible for the treatment of dental-related infections, 45.05% of the respondents indicated that they have not cases and therefore cannot tell if their laboratories would treat dental related infection, and 10.81% of the respondents are uncertain if their dental laboratories are responsible for the treatment of dental related infections.

4.2.43 Financial burden of using the cross-infection preventions and protocols

The response of the dental technicians and technologists regarding the additional cost of using infection control preventions and protocols in the laboratories were captured and presented in Figure 4.34.

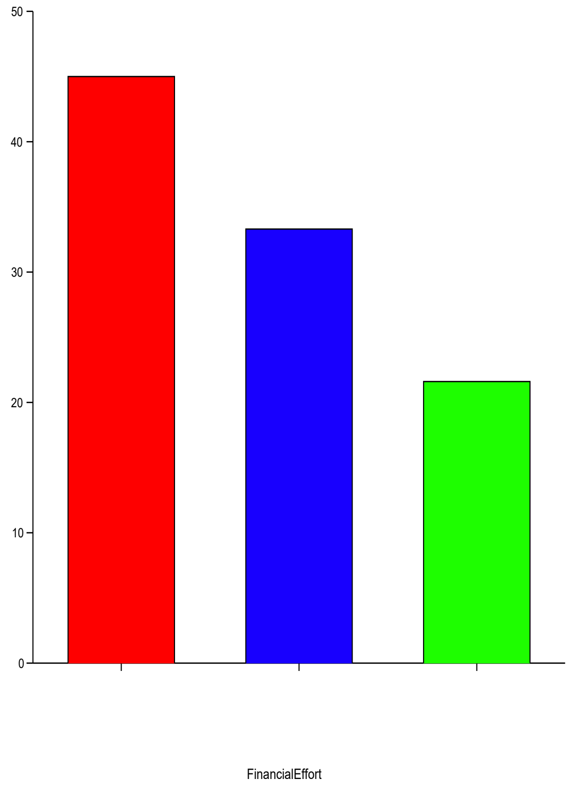

Figure 4.34:

Financial burden of infection control in dental laboratories

Figure 4.34 shows that 45.05% of the respondents consider the additional financial stress or cost of using cross-infection prevention methods, 33.33% of the respondents do not consider the additional financial stress or cost of using cross-infection prevention methods and 21.62% of the respondents are uncertain if they consider the additional financial stress or cost of using cross-infection prevention methods.

4.2.44 Eating and drinking in the dental laboratories

The responses of the dental technicians and technologists regarding eating and drinking in the dental laboratories were determined and illustrated in Figure 4.35.

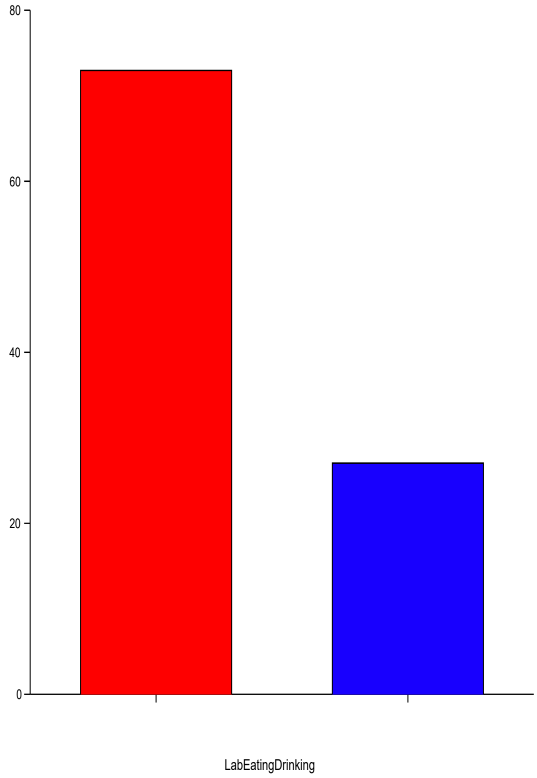

Figure 4.35:

Eating and drinking in the laboratories

In Figure 4.35, the result reveal that 72.97% of the respondents allow eating and drinking in their dental laboratories and 27.03% of the respondents do not allow eating and drinking in their dental laboratories.

4.2.45 Additional information and comments

Additional comments indicated by dental technicians and technologists are summarised in Table 4.10.

Table 4.10: Comments by dental technicians and technologists

Other comments	Count	Percentage of respondents (%)
There should be communication before sending out Impressions/Patients should Clean dentures before repairs	1	0.90
Dental techs should go for a refreshers course on infection control	1	0.90
Disinfect lab slips with UV light	1	0.90
Fogs the lab using hypochlorous mist	2	1.80
Infection control is often overlooked in the dental laboratory	2	1.80
Infection Control is good but not practical in a dental lab	1	0.90
Infection control is neglected in the dental lab & should be enforced	1	0.90
It is important that proper infection control is adhered to in dental labs	1	0.90
N/A	100	90.09
Use different sprays for incoming and outgoing dental work	1	0.90
Total	**111**	**100**

Table 4.10 shows additional information/comments from some of the respondents. 0.90% of the respondents commented that there should be communication before impressions are sent to the clinics and suggested that patients should be informed to clean their dentures prior to sending dentures for repairs to prevent food particles on the denture. 0.90% of the respondents commented that dental laboratory professionals should go on a refresher course on infection control, 1.80% of the respondents commented that infection control is overlooked in dental laboratory practices,0.90% of respondents also commented that infection control is taken for granted in dental laboratories and therefore infection control should be enforced. 0.90% of the respondents commented that it is important to adhere to infection control protocols in the dental lab and 0.90% commented that infection control is good but not practical in dental laboratories. 0.90% of the respondents gave a piece of information about disinfecting lab slips as a means of infection control, while 1.80% of the respondents gave information about using hypochlorous mist for disinfecting the labs and 0.90% of the respondents gave information on using different sprays for incoming and outgoing dental work. About 90.09% of the respondents did not give additional information or comment.

4.3 Qualitative interpretation of results

The qualitative data collection for this study was carried out through semi-structured interviews, to gain a better understanding of the participants' knowledge, behaviour, attitude, and compliance practices on infection control in the dental laboratories in Cape Town. A total of one hundred and fourteen (114) dental technicians and technologists were contacted in eighty-three dental laboratories in Cape Town, South Africa but only one hundred and eleven (111) dental technicians and technologists in eighty-one (81) dental laboratories complied and were interviewed face to face. The interviews took place between January to June 2022 at the dental laboratories in Cape Town. The researcher used content analysis to determine and categorise similar words and themes within the qualitative data, and codes and labels were assigned to the grouped data. Data analysis was done using descriptive statistical analysis.

The analysis and charts below are based on the responses of the respondents to the semi-structured interview questions.

4.3.1 Definition of 'infection' by the dental technicians and technologists

The different definitions of 'infection' by the dental technicians and technologists were categorised under suitable themes and are presented in Figure 4.36.

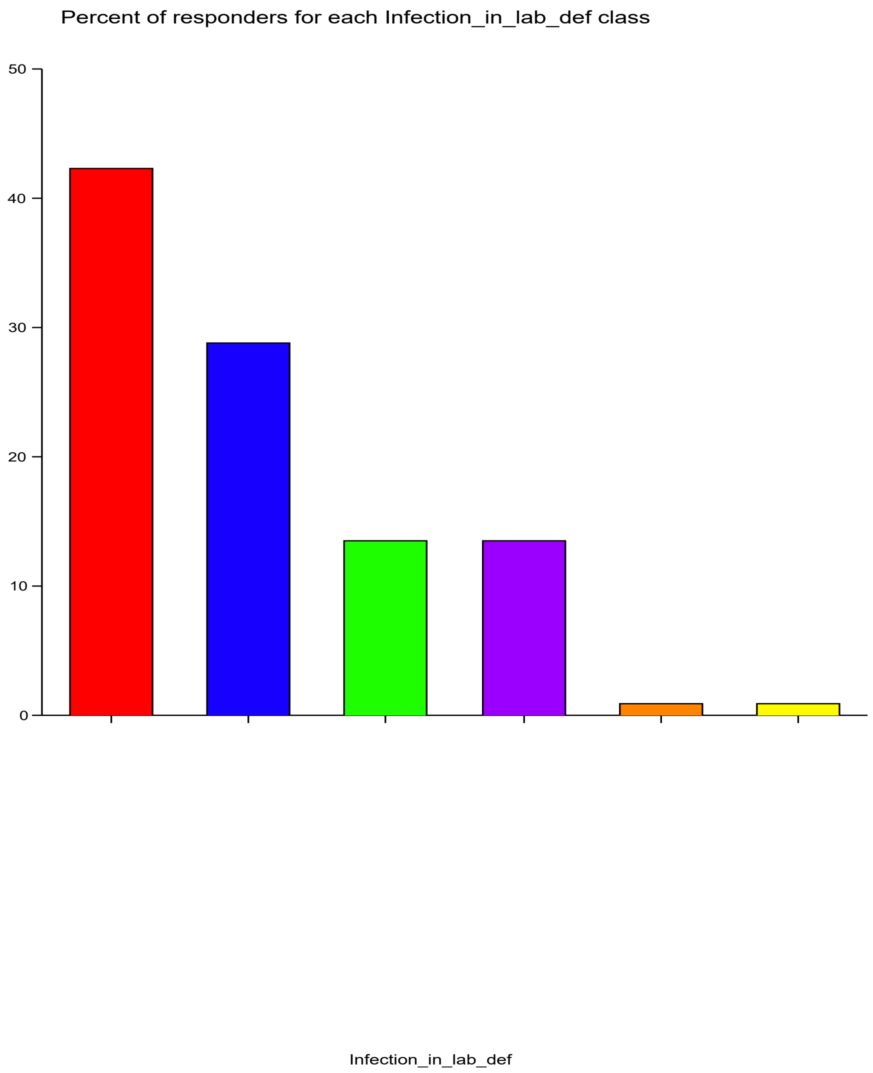

Figure 4.36:

Understanding of the definition of infection control

Figure 4.36 shows that 42.34% of the respondents defined infection as a disease,28.83% of the respondents defined infection as exposure to micro-organisms,13.51% of the respondents defined infection as the growth of infectious agents in the body, 13.51% defined infection as illness, 0.90% of the respondents defined infection as infection and 0.90% of the respondents were uncertain about the definition of infection.

4.3.2 Knowledge about infection in the dental laboratory

The different places the dental technicians and technologists got their knowledge and information about infection in the dental laboratory are presented in Figure 4.37.

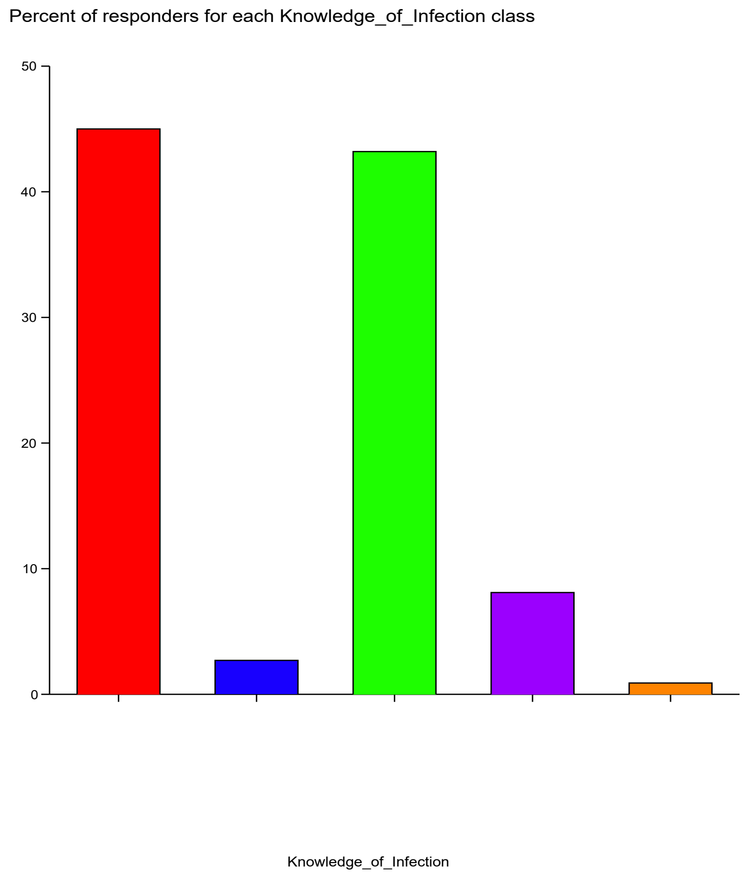

Figure 4.37:

Knowledge about infection

From the findings of the study (Figure 4.37), 45.05% of the respondents indicated that they got to knowledge about infection while working in the dental laboratory, 2.70% of the respondents got to know about infection from personal studies through reading, the internet etc), 43.24% of the respondents got to know about infection from school, 8.11% of the respondents indicated that they got to know about infection from school and it became clearer while working in the dental laboratories and 0.90% of the respondents were uncertain about how they got to know about infection in the dental laboratory.

4.3.3 Risks of getting infected in the laboratory

The opinions of the dental technicians and technologists regarding the risks of getting infected from dental laboratory work are summarised and presented in Figure 4.38.

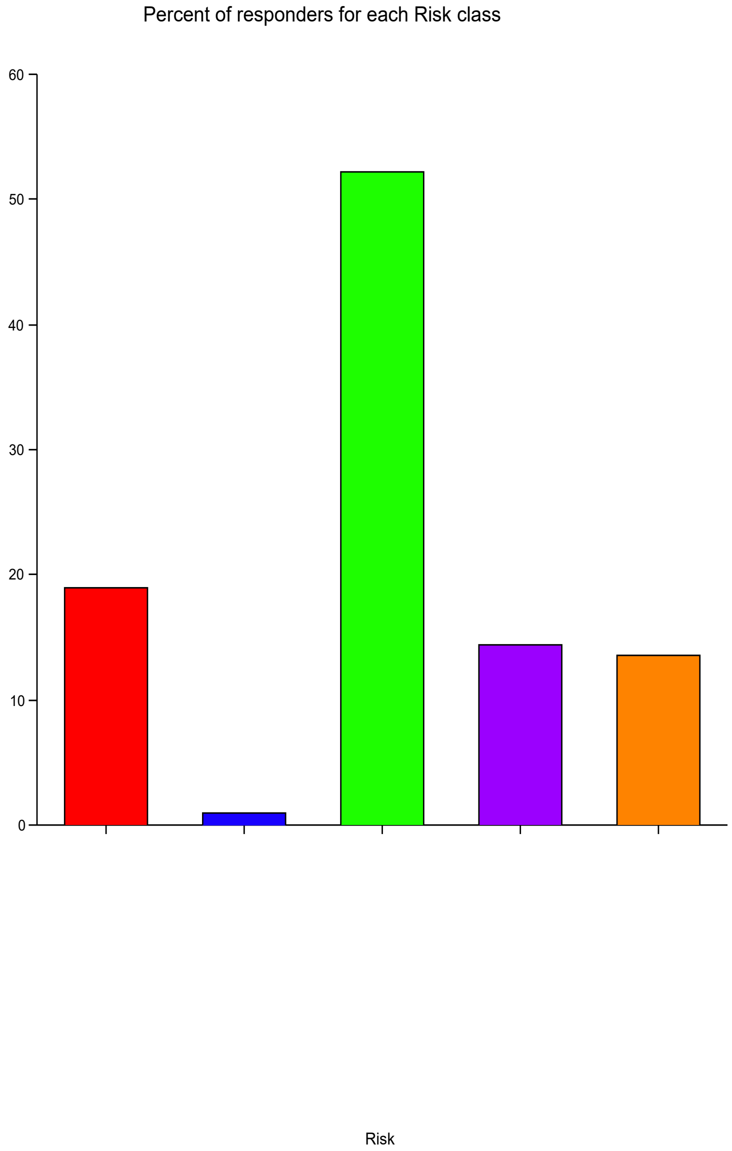

Figure 4.38:

Risks of infection in the dental laboratory

Figure 4.38 shows that 18.92% of the respondents indicated that they are not at risk of getting infected in their dental laboratories because dental laboratories do not handle patients directly,0.90% of the respondents are uncertain about the risks of getting infected in the dental laboratory, 52.25% of the respondents agreed that they are at risk of getting infected in their dental laboratories because of dental impressions from dental clinics and practices, 14.41% of the respondents agreed that they are at risk of infection in the dental laboratories because of dental impressions and other prosthetic materials from the dental clinics or practices, and 13.51% of the respondents indicated that they are at risk because working in a health facility (dental laboratory) is a predisposing factor to getting exposed to infections.

4.3.4 Precautions to prevent infection in the dental laboratory

The precautions taken by the dental technicians and technologists to prevent infection in laboratories are summarised in Figure 4.39.

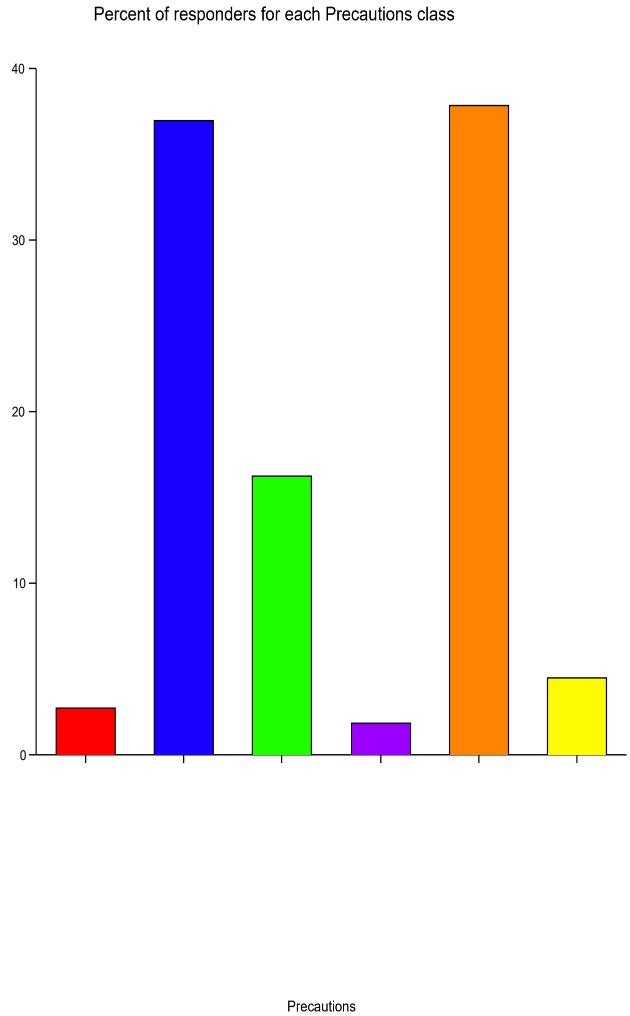

Figure 4.39:

Precautionary measures to prevent exposure to infection in the laboratory

Figure 4.39 shows that 2.70% of the respondents change pumice slurry as precautions to prevent cross-contamination in the dental laboratories, 36.94% of the respondents disinfect and rinse impressions from dental clinics and practices, 16.22% of the respondents dispose of wastes and clean the dental laboratories, 1.80% of the respondents indicated that they take no precautions, 37.84% of the respondents wear protective clothing and observes hand hygiene as precautionary measures and 4.50% of the respondents returns blood stained impressions to dental clinics and practices.

4.3.5 Benefits of infection control

The benefits of infection control in dental laboratories are summarised and presented in Figure 4.40.

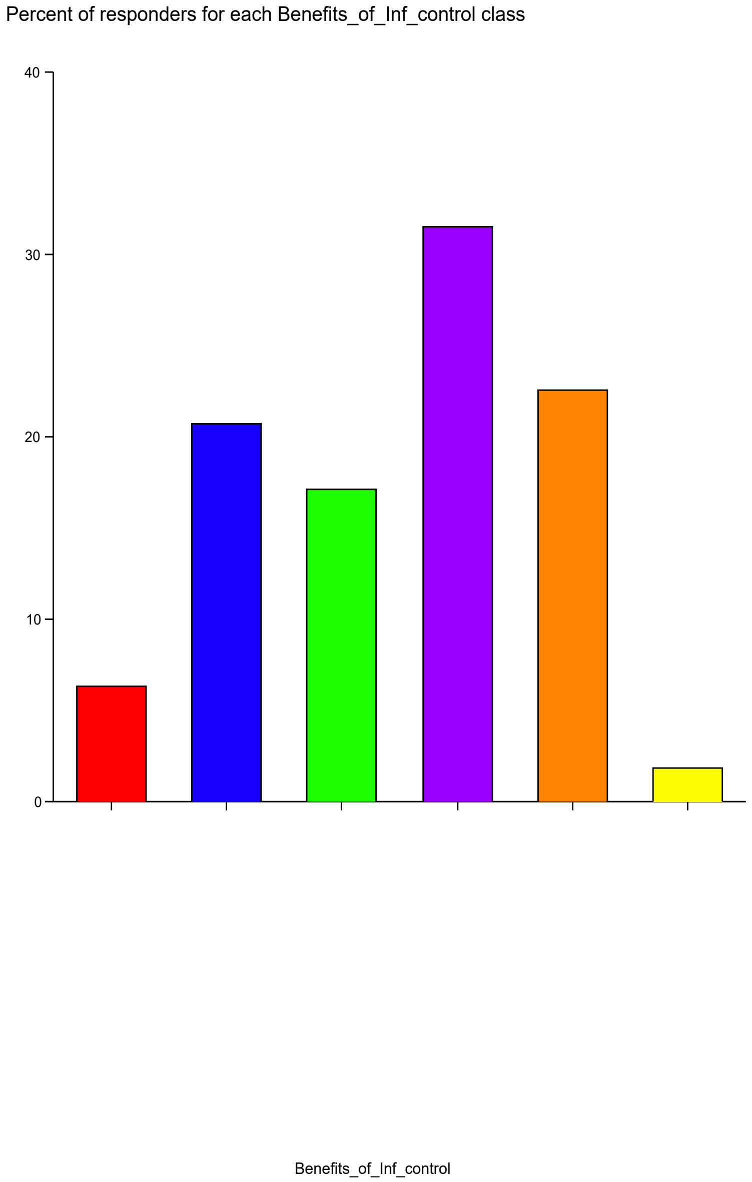

Figure 4.40:

Benefits of infection control

Figure 4.40 shows that 6.31% of the respondents indicated that infection control boosts confidence and productivity, 20.72% of the respondents explained that infection control ensures the safety of workers and saves costs, 17.12% of the respondents indicated that good health and longevity are benefits of infection control, 31.53% of the respondents indicated that infection control prevents cross-contamination, 22.52% of the respondents indicated that infection control prevents exposure to micro-organisms, and 1.80% of the respondents indicated that one of the benefits of infection control is staying true to self.

4.3.6 Degree of compliance with infection control protocols and policies

The level of compliance of dental technicians and technologists with infection control protocols and policies is shown in Figure 4.41.

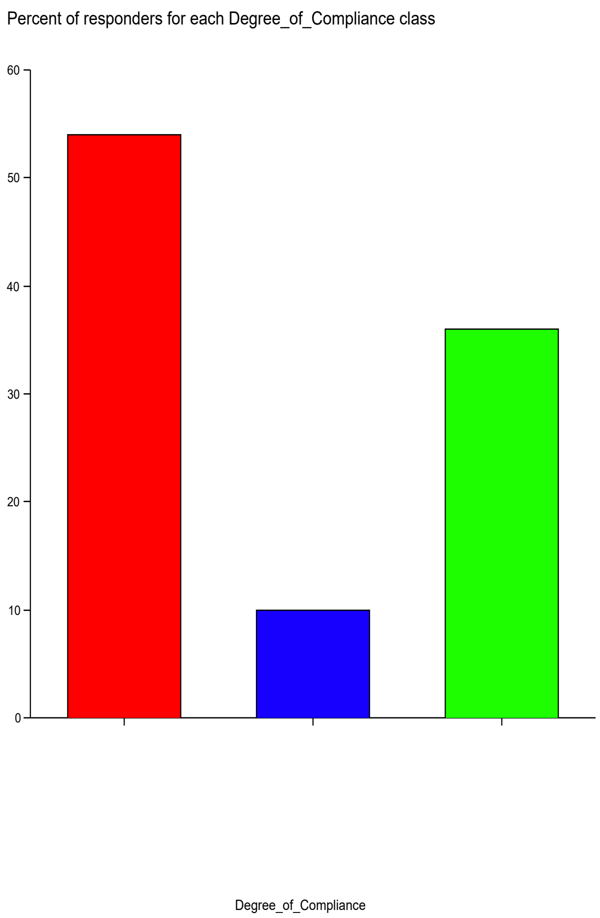

Figure 4.41:

Degree of compliance with infection control protocols and policies

Figure 4:41 shows that 54.05% of the respondents in the dental laboratories fully comply with infection control protocols or policies, 36.04% of the respondents partly comply with infection control protocols or policies, while 9.91% of the respondents do not comply with infection control protocols or policies.

4.3.7 Reasons for compliance or non-compliance with infection control policies

The dental technicians' and technologists' reasons for compliance or non-compliance with infection control protocols and policies are summarised and is shown in Figure 4.42.

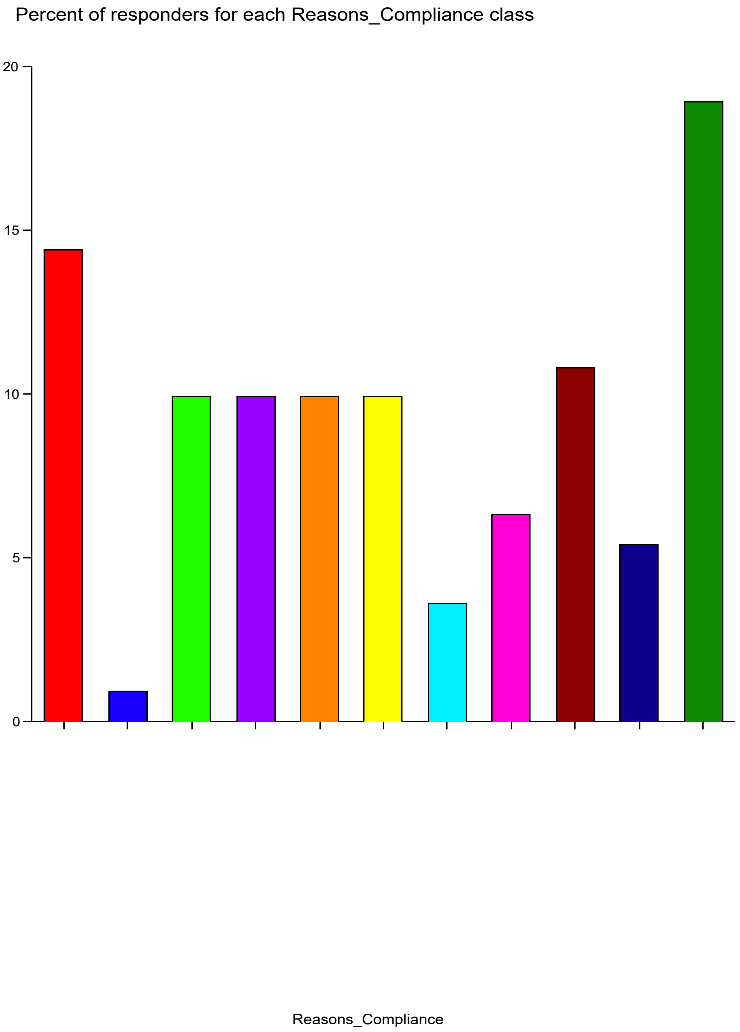

Figure 4.42:

Reasons for compliance or non-compliance with infection control policies

Figure 4.4 shows that 14.41% of the dental technicians and technologists fully comply with infection control protocols as a means of care for self, family and patient, 0.90% of the respondents indicated that they fully comply with infection control because prevention is cheaper, 9.91% of the respondents indicated that they do not comply with infection control protocols or policies as they do not believe that infection control is essential in dental laboratories, 9.91% of the respondents fully comply with infection control protocols or policies as a matter of ethics, 9.91% of the respondents comply to infection control protocols or policies because it is a necessity, 9.91% of the respondents partly comply with infection control protocols or policies because of care for self, family and patient, 3.60% of the respondents partly comply with infection control protocols or policies because they try to meet up with deadlines in the dental laboratories, 6.31% of the respondents partly comply with infection control protocols or policies because it is ethically right to do so, 10.81% partly comply with infection control protocols/policies because it is necessary, 5.41% partly comply because of safety, and 18.92% of the respondents indicated they fully comply with infection control protocols or policies because of their safety.

4.4 Cross-tabulations results

Cross-tabulations were used to compare results within the variables across the data set. Below are the results of the crosstabulations.

4.4.1 Cross-tabulation showing years of practice and infection control refresher course

The cross-tabulations of dental technicians' or technologists' years of practice and infection control refresher courses were captured and presented in Table 4.11.

Table 4.11: Row percentage and cross-tabulation of years of practice and infection control refresher course

Years of practice	Infection control refresher course (%)		Total
	Yes	No	
1-5	4	96	100
6-10	9	91	100
11-20	19	81	100
>20	22	78	100
Total	16	84	100

Cross-tabulation result

Test	Type	Chi-square value	DF	Probability level	Reject H0 at α = 0.01?
Pearson's Chi-Square†	2 sided	4.132	3	0.2476	No

H0: Years of practice and infection control refresher courses are independent.

H1: Years of practice and infection control refresher course are associated (not independent).

Table 4.11 represents the statistical relationship between the dental technicians' and technologists' years of practice and their attendance to infection control refresher courses or training. To test for significance using Pearson's chi-square, the probability value (P) was set at a value of 0.01. If the value of P is greater than 0.01 (P > 0.01) then there is no statistically significant difference (H0). However, if the value of P is less than or equal to 0.01 (P ≤ 0.01) then there is a statistically significant difference (H1). Based on Table 4.11, the value of P is 0.24 which indicates that there is no statistically significant difference between the dental technicians' and technologists' years of practice and their attendance to infection control refresher courses or training in the dental laboratories in Cape Town.

4.4.2 Crosstabulation illustrating hepatitis B vaccine and face masks

The cross-tabulation of hepatitis B variables and face masks is presented in Table 4.12.

Table 4.12: Row percentage and cross-tabulation of hepatitis B and face masks

Hepatitis B vaccine	Face mask (%)		Total
	No	Yes	
Yes	16	84	100
No	56	44	100
Unsure	40	60	100
Total	24	76	100

Cross-tabulation result

Test	Type	Chi-square value	DF	Probability level	Reject H0 at α = 0.01?
Pearson's Chi-Square†	2 sided	13.043	2	0.0015	Yes

H0: Hepatitis B vaccine and face mask are independent.

H1: Hepatitis B vaccine and face mask usage are associated (not independent).

Table 4.12 displays the statistical relationship between dental technicians and technologists who received the hepatitis B vaccine and those who used face masks as a means of infection control. Pearson's chi-square was used to test for relationships given the value of P as 0.01. If the value of P is greater than 0.01 ($P > 0.01$) then there is no significant relationship (H0). However, if the value of P is less than or equal to 0.01 ($P \leq 0.01$) then there is a significant relationship (H1). According to Table 4.12, the value of P is 0.001, indicating a statistically significant relationship between dental technicians and technologists who have received the hepatitis B vaccine and those who used face masks.

4.4.3 Cross-tabulation showing hepatitis B vaccine and goggles

The cross-tabulation of dental technicians and technologists who received the hepatitis B vaccine and those who used goggles are presented in Table 4.13.

Table 4.13: Row percentage and cross-tabulation of hepatitis B vaccine by goggles

Hepatitis B vaccine	Goggles (%)		Total
	No	Yes	
Yes	20	80	100
No	63	38	100
Unsure	30	70	100
Total	27	73	100

Cross-tabulation result

Test	Type	Chi-square value	DF	Probability level	Reject H0 at α = 0.01?
Pearson's Chi-Square†	2 sided	12.381	2	0.0020	Yes

H0: Hepatitis B vaccine and goggles are independent.

H1: Hepatitis B vaccine and goggles are associated (not independent).

In Table 4.13, the statistical link between dental technicians and technologists who received the hepatitis B vaccine and those who used goggles as a means of infection control is shown. Pearson's chi-square was used to test for significance given that P is 0.01. If P is greater than 0.01 (P > 0.01) then there is no statistically significant difference (H0). However, if the value of P is less than or equal to 0.01 (P ≤ 0.01) then there is a statistically significant difference (H1). According to Table 4.13, the value of P is 0.002, indicating a statistically significant difference between dental technicians and technologists who have received the hepatitis B vaccine and those who used goggles.

4.4.4 Cross-tabulation showing hepatitis B vaccine and gloves

The relationship between the hepatitis B vaccination and gloves was captured and is shown in Table 4.14.

Table 4.14: Row percentage and cross-tabulation of hepatitis B vaccine and gloves

Hepatitis B vaccine	Gloves (%)		Total
	No	Yes	
Yes	27	73	100
No	94	6	100
Unsure	50	50	100
Total	39	61	100

Cross-tabulation result					
Test	**Type**	**Chi-square value**	DF	**Probability level**	**Reject H0 at α = 0.01?**
Pearson's Chi-Square†	2 sided	25.823	2	0.0000	Yes

H0: Hepatitis B vaccination and gloves are independent.

H1: Hepatitis B vaccine and gloves are associated (not independent).

Table 4.14 represents the statistical relationship between the dental technicians and technologists who had the hepatitis B vaccine and those who wore gloves as a means of infection control. To determine significance, Pearson's chi-square (P) was set at a value of 0.01. If the value of P is greater than 0.01 ($P > 0.01$) then there is no statistically significant difference (H0). However, if the value of P is less than or equal to 0.01 ($P \leq 0.01$) there is a statistically significant difference (H1). Based on Table 4.14, P is 0.00 which indicates that there is a statistically significant difference between the dental technicians and technologists who had hepatitis vaccine and those who wore gloves.

4.4.5 Cross-tabulation showing years of practice and washing of laboratory coat

The cross-tabulation of the dental technicians' and technologists' years of practice and washing of laboratory coats are illustrated in Table 4.15.

Table 4.15: Row Percentage and cross-tabulation of years of practice and washing of laboratory coats

Years of practice	Washing of laboratory coats (%)					Total
	Daily	Weekly	Monthly	As needed	Do not wear	
1-5	13	61	4	17	4	100
6-10	27	64	0	0	9	100
11-20	26	52	4	15	4	100
>20	26	54	0	6	14	100
Total	23	56	2	10	9	100

Cross-tabulation result

Test	Type	Chi-square value	DF	Probability level	Reject H0 at α = 0.01?
Pearson's Chi-Square†	2 sided	10.738	12	0.5515	No

H0: Years of practice and washing of laboratory coats are independent.

H1: Years of practice and washing of laboratory coats are associated (not independent).

In Table 4.15, the statistical correlation between the years of practice of dental technicians and technologists and the washing of their laboratory coats is shown. To determine if the correlation is significant using Pearson's chi-square, a probability value (P) of 0.01 was set. If the value of P is greater than 0.01 ($P > 0.01$) then there is no statistically significant correlation (H0). On the other hand, if the value of P is less than or equal to 0.01 ($P \leq 0.01$) there is a significant correlation (H1). According to Table 4.15, the value of P is 0.55, which indicates that there is no statistically significant correlation between the years of practice of dental technicians and technologists and the washing of their laboratory coats.

4.4.6 Cross-tabulation showing laboratories years existence and efficient infection control plan

The row percentage and cross-tabulation results showing laboratories' years of existence and an efficient infection control plan are presented in Table 4.16.

Table 4.16: Row percentage and cross-tabulation of laboratories' years of existence and efficient infection control plan

Lab existence	Efficient infection control plan (%)			Total
	Yes	No	Uncertain	
1-5	86	14	0	100
6-10	86	0	14	100
11-20	70	6	24	100
>20	88	5	8	100
Total	82	5	13	100

Cross-tabulation result

Test	Type	Chi-square value	DF	Probability level	Reject H0 at α = 0.01?
Pearson's Chi-Square†	2 sided	25.823	2	0.0000	Yes

H0: Laboratories' years of existence and efficient infection control plan are independent.

H1: Laboratories' years of existence and efficient infection control plan are associated (not independent).

Table 4.16 examines the relationship between the years of existence of dental laboratories and the efficacy of their infection control plan. To determine if the relationship is significant, Pearson's chi-square test was used with a probability value (P) set at 0.01. If the value of P is greater than 0.01 ($P > 0.01$) then there is no significant relationship (H0). However, if the value of P is less than or equal to 0.01 ($P \leq 0.01$) then there is a significant relationship (H1). The results from Table 4.16, indicate that P is 0.00, which means there is a statistically significant relationship between the years of existence of dental laboratories and the effectiveness of their infection control plan.

4.4.7 Cross-tabulation showing infection control plan and infection control manual

The relationship between an efficient infection control plan and an infection control manual is shown in Table 4.17.

Table 4.17: Row percentage and cross-tabulation of efficient infection control plan and infection control manual

Infection control plan	Infection control manual (%)			Total
	Yes	No	Uncertain	
Yes	33	55	12	100
No	0	100	0	100
Uncertain	0	86	14	100
Total	27	61	12	100

Cross-tabulation result

Test	Type	Chi-square value	DF	Probability level	Reject H0 at α = 0.01?
Pearson's Chi-Square†	2 sided	10.815	4	0.0287	No

H0: Efficient infection control plan and infection control manual are independent.

H1: Efficient infection control plan and infection control manual are associated (not independent).

Table 4.17 presents the statistical relationship between having an efficient infection control plan in the dental laboratories and having an infection control manual. To test for significance, Pearson's chi-square test was used with a probability value (P) set at 0.01. If the value of P is greater than 0.01 ($P > 0.01$) then there is no statistically significant relationship (H0), whereas if the value of P is less than or equal to 0.01 ($P \leq 0.01$) there is a statistically significant relationship (H1). The results from Table 4.17, shows that the value of P is 0.02, which means that there is no statistically significant relationship between having an efficient infection control plan in the dental laboratories and having an infection control manual.

4.4.8 Cross-tabulation showing infection control plan and infection control clinics

The statistical correlation showing efficient infection control plan and infection control at the dental clinics is illustrated in Table 4.18.

Table 4.18: Row percentage and cross-tabulation of the infection control plan and infection control at the dental clinics

Infection control plan	Infection control clinics (%)				Total
	Yes all	Yes some	No	Uncertain	
Yes	56	21	12	11	100
No	33	0	17	50	100
Uncertain	21	36	43	0	100
Total	50	22	14	12	100
Cross-tabulation result					
Test	**Type**	**Chi-square value**	**DF**	**Probability level**	**Reject H0 at α = 0.01?**
Pearson's Chi-Square†	2 sided	22.132	6	0.0011	Yes

H0: Efficient infection control plan and Infection control at the clinics are independent.

H1: Efficient infection control plan and infection control at the clinics are associated (not independent).

From Table 4.18, the relationship between an efficient infection control plan and infection control at the dental clinics is shown. The significance of the data was determined using Pearson's chi-square with a probability value (P) set at 0.01. If the value of P is greater than 0.01 ($P > 0.01$) then there is no noteworthy difference (H0). However, if the value of P is less than or equal to 0.01 ($P \leq 0.01$) there is a noteworthy difference (H1). From Table 4.18, the value of P is 0.001 showing a statistically significant difference between having an efficient infection control plan in the dental laboratories and having infection control measures or practices at the dental clinics.

4.5 Summary of chapter

This Chapter presented a thorough analysis of the data obtained through structured questionnaires, semi-structured interviews, and crosstabulations. Moving forward, the next chapter presents the discussion interpreting the results of the study within the context of the reviewed literature. Finally, a summary of the findings, conclusions, and recommendations will be included.

CHAPTER FIVE

DISCUSSIONS, SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter discusses the researcher's findings supported by the literature. It will also include a summary of the findings, conclusions, and recommendations.

5.2 Discussion of findings

To prevent dental technicians, technologists, and other health workers from getting exposed to infectious organisms or diseases, immunisation is highly recommended (Dalma *et al*., 2018; Begum *et al*., 2013). The study conducted in Cape Town showed that most of the dental technicians and technologists in the dental laboratories had been vaccinated against hepatitis B vaccine (Figure 4.5), which is higher compared to similar studies by Al-Aali *et al*. (2021) and Naz *et al*. (2020) where about 40.4% and 72.6% had received a valid hepatitis B vaccine respectively. One possible reason for this result may be the awareness of the importance of vaccines in disease prevention among dental technicians and technologists. Another reason could be that the hepatitis B vaccine is a requirement for employment. According to the crosstabulation results in Tables 4.12, 4.13, and 4.14, there is a significant correlation between individuals who have received the hepatitis vaccine and those who use face masks, goggles, and gloves. This suggests that dental technicians and technologists who have been vaccinated against hepatitis B are more likely to follow safety precautions and wear personal protective clothing.

It is highly recommended that dental technicians and technologists participate in courses, training, or workshops at least biannually to stay updated on the latest infection control protocols and interventions in the profession (Tsioutis *et al*., 2020). However, the results of the study showed that only a small percentage of the dental technicians and technologists (as shown in Figure 4.6) had attended such training or workshop on infection control within the past two years. This corroborates with the findings of Sammy & Benjamin (2016), in Durban, where only 6.7% had undergone refresher courses or training on infection control within one year. One explanation for this low number could be a lack of interest among dental technicians and technologists in attending such training or workshops, as 41.44% of those surveyed in this study indicated that they had no interest in doing so (as shown in Figure 4.7). Another reason for the low participation could be a lack of continuous professional development courses specifically focused on infection control for dental technicians and technologists. Additionally, it is possible that some dental technicians and technologists did not attend due to a lack of time to register for a course or workshop. The crosstabulation results (as shown in Table 4.11) showed that there was no statistically significant relationship between the dental technicians' and technologists' years of practice and their attendance to infection control refresher courses or training.

The World Health Organisation, (WHO) recommends the use of personal protective clothing (PPC) to reduce the risk of exposure to infectious organisms and occupational hazards during work. The study conducted in Cape Town showed that an impressive 90.99% of dental technicians and technologists wore PPC while working in the dental laboratories (as shown in Figure 4.9). This indicates a positive attitude towards the use of PPC and a high level of compliance with its use. The reason for this may be the technicians' and technologists' awareness of the importance of wearing personal protective clothing for infection control and prevention. Nevertheless, the researcher noted that some practices involving the use of PPC among dental technicians and technologists in Cape Town could lead to cross-infection. For example, Figure 4.11, shows that a third of those who use face masks either change them weekly or do not have a set time for changing them. Additionally, in Figure 4.14, over half of those who wear laboratory coats wash them once a week. These practices may put them at risk of cross-infection. Bromberg & Brizuela (2023) and Goenharto *et al*. (2018), emphasised that face masks must not be re-used and should be disposed of immediately after use while laboratory coats should be washed and ironed daily to prevent cross-infection or cross-contamination. The correlation between the number of years dental technicians or technologists practised and their attitudes towards washing their laboratory coats did not show any significant difference (Table 4.15).

When asked if they had an efficient infection control plan, over half of the dental technicians and technologists stated that they had an efficient plan in place (as seen in Figure 4.15). However, the results revealed that very few have infection control manuals or guidelines (as seen in Figure 4.16) and even fewer have infection control pamphlets or signs in their dental laboratories (as seen in Figure 4.17). This aligns with the findings of Al-Aali *et al*. (2021), who reported that only 42.9% of dental laboratories had infection control manuals or guidelines and pamphlets or signs. Habboush *et al*. (2022), explained that infection control manuals serve the purpose of increasing awareness and providing guidance on disease prevention for health workers. This highlights the importance of having a guideline or manual and pamphlets or signs in dental laboratories to ensure efficient infection control and to help dental technicians and technologists understand and implement proper infection control measures. In this study, a noteworthy correlation was observed between the number of years that dental laboratories had been operating and their implementation of an effective infection control plan (see Table 4.16). However, the presence of infection control guidelines in the form of manuals, pamphlets or signs did not have a significant impact on the efficiency of infection control plans in dental laboratories (see Table 4.17). Overall, the study revealed a statistically significant relationship between having an efficient infection control plan in dental laboratories and the knowledge of whether infection control measures were being implemented in dental clinics (Table 4.18)

In a workplace, work policies are a set of guidelines, rules or laws that ensure proper conduct (Habboush *et al.*, 2022). According to the South African Dental Technician's Council ethical guidelines, duties and code of conduct document, dental technicians and technologists should treat personal and private information as confidential in professional relationships with colleagues, clients, and clients' patients unless overriding reason confers moral or legal rights to disclosure.

In this study, only a few dental technicians and technologists reported that their dental laboratories have policies in agreement with dentists or dental clinics (Figure 4.25). This low number may explain why over half of the laboratories were not informed of impressions from high-risk patients (Figure 4.21), or impressions from patients with known blood-borne viruses (Figure 4.22) as most of the dental technicians and technologists had at some point received blood-contaminated (Figure 4.23), and impressions containing saliva (Figure 4.24) from dental clinics and practices. The researcher believes that if there were policies in place, the dental clinics or dentists would have been obligated to abide by those rules or laws.

Nearly half of dental technicians and technologists, around 45.65% reported that their dental laboratories were not provided with information on the status of the impression they received from the dental clinics. This includes whether the impressions or prosthetic materials have been disinfected or if they came from high-risk patients (refer to Figure 4.19). Although this percentage is lower than the findings of Al Mortadi *et al*. (2022) where 71% did not receive a disinfection note. It is still a concerning issue. As stated by Sammy & Benjamin (2016), it is crucial for dental clinics and practices to attach a note or tag indicating if impressions or prosthetic material have been disinfected and with which disinfectant. This helps in avoiding duplication of services, which could lead to distorted impressions or a waste of resources. It is also important for dental laboratories to do the same when they are sending back jobs to the clinics.

During the study, it was observed that the way the dental laboratories receive impressions or prostheses from the dental clinics varies (as shown in Figure 4.26). Some laboratories receive them in a wrapped bag, while others use a specific type of bag, container, or wet-wrapped bag. This differs from the findings of Al Mortadi *et al*. (2022), where most of the impressions were received in a bag and wet-wrapped. When it comes to handling these materials, about a quarter of the respondents received them with bare hands while less than a quarter used gloves or sometimes handled them without gloves (as depicted in Figure 4.27). Not using gloves while receiving impressions or prosthetic materials in the laboratory is hazardous and puts dental technicians and technologists at risk of cross-contamination.

It was found that almost all the dental laboratories had a designated disinfecting area (as shown in Figure 4.30), with more than half of them using disinfecting spray and the other half using disinfecting solutions through immersion (as indicated in Table 4.4). This contrasts with the study conducted by Hamida *et al*., (2023) where only 12% of the laboratories used the spray, and another 12% used the immersion method for disinfection.

The study found that more than half of the dental laboratories disinfect the impressions they receive from dental clinics (Figure 4.28) and before sending them back to the dental clinics (Figure 4.31). However, the study also revealed that more than a quarter of dental technicians and technologists are unaware of the disinfectants used in their facilities (refer to Table 4.7). This is a concern because using the wrong disinfectants can cause dimensional changes and it is crucial to choose appropriate disinfectants for optimal disinfection and to prevent cross-infection, as highlighted by *Al Mortadi et al*. (2022).

Based on the findings of the study (refer to Table 4.6), it can be concluded that more than 50% of dental laboratories in the study followed a daily routine of cleaning and disinfecting their dental laboratories. Moreover, Figure 4.29 indicates that over 50% of dental technicians and technologists did not believe that infection control could be compromised because of urgent jobs. It is important to note that regardless of the urgency of a job, proper disinfection procedures should be followed.

Pumice slurry is commonly used for polishing in dental laboratories; however, it has been identified as the primary cause of microbial contamination (Sykes *et al*., 2019). The study reveals that only 28.83% of dental technicians and technologists change pumice slurry while polishing (as shown in Figure 4.32), which is consistent with the findings of a similar study conducted by (Naz *et al*., 2020) where only 30.6% changed pumice slurry regularly. This practice of not changing pumice slurry regularly has been identified as a major cause of cross-contamination, and therefore dental technicians and technologists are advised to change pumice slurry between procedures. Additionally, the polishing wheels and rags should be disinfected with an approved disinfectant to prevent microbial contamination.

From the study, more than half of dental laboratories were found to be adhering to infection control regulations. About a quarter were partially compliant, and only a small fraction were non-compliant as seen in Figure 4.41. This contrasts with the findings of Sammy & Benjamin (2016) where majority of the dental laboratories did not adhere to infection control protocols. From this study when the dental technicians and technologists were asked their reasons for compliance, partial compliance, or non-compliance with infection control practices, dental technicians and technologists provided the following explanations: those who complied did so because it is more cost-effective to prevent diseases than to treat them, because they are concerned about their own health, their families, and their patients, because it is ethical and essential. Those who were partially compliant did so because following infection control procedures is safer. Those who did not comply did so because they were trying to meet deadlines and did not adhere to infection control protocols (refer to Figure 4.42).

5.3 Summary of findings

The aim of the study was to assess the level of knowledge, behaviour, attitude, and compliance of the dental technicians and technologists working in selected dental laboratories in Cape Town with regards to infection control practices. The study had the following objectives:

- Assess, the knowledge, behaviour, and attitude of the dental technicians and technologists on infection control.
- Identify the possible infection control protocols and practices utilised in the dental laboratories.
- Determine the extent of compliance among dental technicians and technologists towards infection control practices.

The research utilised mixed-method research and employed descriptive research design and triangulation. The questionnaire was structured by the researcher with guidance from related literature and comprised two (2) sections. Section A captured socio-demographic information, while Section B(i) addressed personal protective clothing (PPC) and B(ii) focused on infection control. The semi-structured interview guide comprised Six (6) open-ended questions. The results of the study revealed the following:

5.3.1 Research objective one

The study revealed that the dental technicians and technologists at the dental laboratories in Cape Town had a moderately good understanding of infection control, as evidenced by their attitude, behaviour, and compliance practices from the results. The study also revealed that dental technicians and technologists had good knowledge about infection with 42.34% defining it as a disease, 28.83% as exposure to micro-organisms, 13.51% as the growth of infectious agents in the body, and 13.51% as illnesses (refer to Figure 4.36). Proper infection control starts with understanding what infection is all about. Figure 4.38 showed that the dental technicians and technologists understood that handling dental impressions and prosthetic materials, as well as working in health facilities (dental laboratories) put them at risk of infection. This knowledge allowed them to take necessary precautions to prevent exposure to infection. Additionally, Figure 4.40 indicated that dental technicians and technologists were aware of the benefits of infection control, which included boosting confidence and productivity, ensuring workers' safety, promoting good health and longevity, preventing cross-contaminations, and avoiding exposure to micro-organisms. Their ability to enumerate these benefits shows their understanding of the topic.

5.3.2 Research objective two

According to the findings of the study, dental technicians, and technologists in the dental laboratories in Cape Town follow various protocols to prevent the transmission of infectious diseases. Some of these protocols include:

- More than half of the dental technicians and technologists had hepatitis B vaccine, (Figure 4.5).
- 90.99% of the dental technicians and technologists wore personal protective clothing (PPC), (Figure 4.9).
- Almost all dental laboratories disinfected impressions when received, (Figure 4.28).
- 84.68% had specific areas in the dental laboratories for disinfection, (Figure 4.30).
- Hand hygiene was performed in the dental laboratories using hand sanitisers, automated dispensers, disinfecting wipes, and antibacterial soaps (Table 4.4).
- Disinfecting solutions and sprays were used in the dental laboratories (Table 4.4).
- More than half of the laboratories cleaned and disinfected the laboratories daily or periodically (Table 4.6).
- Disinfectants used in some of the dental laboratories include glutaraldehyde, sodium hypochlorite, quaternary ammonium compound, chlorine, iodophors, phenol, isopropyl alcohol, citri-Clean, didecyldimethyl ammonium chloride, distal high, hydrochloric acid, impra dip, trichophyton chlorhexidine, zeta1 ultra, (Table 4.7).
- 62.16% disinfected work areas, (Table 4.8).
- 68.47% disinfected prosthetic materials before sending to the dental clinics, (Figure 4.31).
- 67.57% disposed of wastes by ensuring that all prosthetic materials from dental clinics were disposed of in sealed bags and have them removed as medical waste while models, wax, etc were disposed of in the bin.

5.3.3 Research objective three

From the results of the study more than half of the dental technicians and technologists were fully compliant, about a quarter were partly compliant and a fraction did not follow infection control protocols in the dental laboratories, (Figure 4.42). Furthermore, those who fully adhered to infection control protocols in the dental laboratories were fully compliant for the following reasons (Figure 4.41): they fully adhered to infection control protocols because, they cared about themselves, their loved ones as well the patients they make prostheses for, they believe prevention is cheaper, because it is ethical and essential and for safety.

For the people who were partially compliant, the reasons why they were not fully compliant was because they had to meet up with deadlines and therefore had no time most times to follow infection control protocols. Additionally, they also disclosed that the times they adhered to infection control protocols was because it was ethically the right thing to do.

Those who were not compliant to infection control was because they believed following infection control protocols wasn't necessary in dental laboratories because they worked with models and not patients directly.

5.4 Conclusions

The survey indicated that more than half of dental technicians and technologists who participated in the study had a moderate level of knowledge and understanding of infection control practices. This was evident from their attitudes towards infections and their perception towards the benefits of infection control. The study also showed that dental technicians and technologists had an average level of compliance with infection control protocols, which was demonstrated by their actions to prevent infections in the dental laboratories.

5.5 Implications of the study

The educational and health implications of the study will be discussed.

5.5.1 Health implications of the study

The application of infection control protocols such as changing pumice slurry after any procedure, disinfecting rag wheels for polishing, disinfecting impressions, wearing of PPC, and cleaning or disinfecting laboratories regularly would prevent cross-contamination and spread of infectious organisms in dental laboratories. This would provide a safe environment for dental technicians and technologists to work in and enhance productivity.

5.5.2 Educational implications of the study

Continuous Professional Development, training or workshops and infection control guidelines would make a significant impact in improving the knowledge of dental technicians and technologists on the best infection control practices.

5.6 Recommendations

i. The South African Dental Technicians Council should organise Continuing Professional Development on infection control twice or thrice a year. This would give dental technicians and technologists the option to choose a convenient time that suits their schedule.

In a case where the SADTC may not be able to organise CPDs or training or workshops, they should make it a requirement that dental laboratories should organise training for their dental technicians and technologists at least yearly or biannually to keep them updated on new practices and protocols on infection control where necessary.

ii. The South Africans Dental Technicians Council should form an infection control committee whose role would be to develop infection control policies and guidelines based on the needs of dental laboratories in South Africa. This should include,

- drafting infection control policies and agreements between dentists and dental technicians and technologists which would be used in dental laboratories.
- Developing infection control guidelines for dental laboratories.

The Committee should also include compliance officers whose responsibilities would be to pay dental laboratories unannounced visits to ensure that they have infection control policy agreements with dentists or clinics they receive dental prostheses. That they have infection control manuals or guidelines, signs, or posters on infection control in the laboratories and that they follow the protocols stated in the guidelines or manual.

The compliant officers also ensure that dental technicians and technologists are up to date with their training or workshops or continuing professional development.

5.7 Summary of chapter

The purpose and objectives of the study were achieved. The findings of this study added to the pool of knowledge on infection control and prevention which is a global concern. The recommendations of the study are feasible, applicable, and relevant.

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APPENDICES

APPENDIX A: QUESTIONNAIRE

Cape Peninsula University of Technology

Laboratory Number: ………………

Sequence Number: ………………

INFECTION CONTROL, KNOWLEDGE, BEHAVIOUR, ATTITUDE, AND COMPLIANCE PRACTICES IN SELECTED DENTAL LABORATORIES IN CAPE TOWN, SOUTH AFRICA.

SECTION A: SOCIO-DEMOGRAPHIC CHARACTERISTICS

Please tick (√) in the appropriate box for each question below. Please ignore the codes (numbers in grey) next to the options.

1. Gender

1.1	Male	1
1.2	Female	2
1.3	Prefer not to say	3

2. Age

2.1	18-24	1
2.2	25-64	2
2.3	65-above	3

3. How long have you practised as a dental technologist or dental technician?

3.1	1-5 years	1
3.2	6-10 years	2
3.3	11-20 years	3
3.4	>20 years	4

4. How long has the dental laboratory you are working for been in existence?

4.1	1-5 years	1
4.2	6-10 years	2
4.3	11-20 years	3
4.4	>20 years	4

5. Kindly indicate your highest qualification.

5.1	National Diploma Dental Technology	1
5.2	B Tech Dental Technology	2
5.3	MTech/MHsc Dental Technology	3
5.4	PhD Dental Technology	4
5.5	Other (Specify)	5
5.5.1	Specification:	

6. Are you immunized against Hepatitis B?

6.1	Yes	1
6.2	No	2
6.3	Not sure	3

7. Have you attended a refresher course, training, or workshop on infection control in the past 2 years?

7.1	Yes	1
7.2	No	2

8. If your answer to Question 7 was no, would you be interested in attending a training, workshop, or course on infection control if such an opportunity is presented to you?

8.1	Yes	1
8.2	No	2

9. How many dental impressions does your laboratory receive in a week?

9.1	<20	1
9.2	20-30	2
9.3	30-50	3
9.4	>50	4

SECTION B

I. PERSONAL PROTECTIVE WEAR

1. **Do you wear personal protective clothing while working in the laboratory?**

1.1	Yes	1
1.2	No	2

2. **Are these personal protective clothing supplied by your employer?**

2.1	Yes	1
2.2	No	2

3. **Please specify the personal protective clothing you use on a daily basis.**

		No	Yes
3.1	Laboratory/dust coat		
3.2	Mask		
3.3	Goggles/Visor		
3.4	Gloves		
3.5	Other(specify)		
3.5.1	Specification:		

4. **How often do you change face masks?**

4.1	Immediately after working on a prosthesis	1
4.2	Daily	2
4.3	Weekly	3
4.4	Not a specific time	4
4.5	I do not change at all	5
4.6	Other (specify)	6
4.6.1	Specification:	

5. **How often do you change gloves?**

5.1	I dispose immediately after any prostheses is completed	1
5.2	Daily	2
5.3	Weekly	3
5.4	Not a specific time	4
5.5	I do not use gloves	5
5.6	Other (specify)	6
5.6.1	Specification:	

6. How often do you clean your goggles or visors?

6.1	Immediately after working on a prosthesis	1
6.2	Daily	2
6.3	Weekly	3
6.4	Not a specific time	4
6.5	I do not clean at all	5
6.6	Other (specify)	6
6.6.1	Specification:	

7. How often do you replace/wash your laboratory or dust coat?

7.1	Daily	1
7.2	Weekly	2
7.3	Monthly	3
7.4	Not a specific, time as needed	4
7.5	Other (specify)	5
7.5.1	Specification:	

8. Is the dental laboratory responsible for cleaning your personal protective wear?

8.1	Yes	1
8.2	No	2

II. INFECTION CONTROL PRACTICES

1. Does your dental laboratory have an efficient infection control plan?

1.1	Yes	1
1.2	No	2
1.3	Not sure	3

2. Do you have an infection control manual or guideline document in the laboratory?

2.1	Yes	1
2.2	No	2
2.3	Not sure	3

3. Are there infection control brochures or pamphlets in the dental laboratory or pamphlets/posters/signage displayed on the walls in the dental laboratory?

3.1	Yes	1
3.2	No	2
3.3	Not sure	3

4. **Do you know if there are infection control measures or practices at the dental clinics you receive dental impressions from?**

4.1	Yes -all dental practices	1
4.2	Yes -for some practices	2
4.3	No	3
4.4	Not sure	4

5. **Do you receive information on the disinfection status of incoming impressions from dental practices and clinics?**

5.1	Yes- all dental practices	1
5.2	Yes-for some practices	2
5.3	No	3
5.4	Not sure	4

6. **Are you confident with the disinfection protocols undertaken by the dental practices and clinics?**

6.1	Yes	1
6.2	No	2
6.3	Not sure	3

7. **Do the dental practices inform you if the impression is from a high-risk patient?**

7.1	Yes	1
7.2	No	2
7.3	Not sure	3

8. **Do the dental clinics inform you if impressions from a patient have a known blood-borne virus?**

8.1	Yes – all dental practices	1
8.2	Yes – for some	2
8.3	No	3
8.4	Not sure	4

9. **Have you received blood-contaminated impressions from dental clinics and practices?**

9.1	Yes	1
9.2	No	2
9.3	Not sure	3

10. Have you received impressions containing saliva debris from dental clinics and practices?

10.1	Yes	1
10.2	No	2
10.3	Not sure	3

11. Do you have an infection control policy and practices agreement with a dentist?

11.1	Yes	1
11.2	No	2
11.3	Not sure	3

12. How do you receive impressions from dental clinics and practices?

		No	Yes
12.1	In a specific type of bag		
12.2	In a bag and well wrapped		
12.3	In a bag unwrapped		
12.4	Without a bag		
12.5	With a bag only wet wrapped		
12.6	In a container		
12.7	Differs from dental clinics		
12.8	Not sure		
12.9	Other (specify)		
12.9.1	Specification:		

13. How do you receive impressions or prostheses in the laboratory?

		No	Yes
13.1	Bare hands		
13.2	Gloves		
13.3	Bare hands sometimes /gloves sometimes		
13.4	Not sure		
13.5	Other (specify)		
13.5.1	Specification:		

14. Once the dental impressions are received by your dental laboratory are they disinfected upon receipt?

14.1	Yes	1
14.2	No	2
14.3	Not sure	3

15. Do you believe that dental impressions brought to the dental laboratory to be completed in a shorter than normal time may compromise the infection control barrier system?

15.1	Yes	1
15.2	No	2
15.3	Not sure	3

16. Do you have specific areas for infection control in your dental laboratory for disinfection?

16.1	Yes	1
16.2	No	2

17. If your answer to question 16 is yes, specify the means of disinfection that is employed by your dental laboratory by selecting all options that apply to your dental laboratory.

		No	Yes
17.1	Antibacterial soap		
17.2	Hand sanitizers		
17.3	Automatic hand sanitizing dispenser		
17.4	Disinfecting wipes		
17.5	Use of disinfecting solutions		
17.6	Use of disinfecting sprays		
17.7	Not sure		
17.8	Other (specify)		
17.8.1	Specification:		

18. How often is the hand sanitizing protocol conducted in your dental laboratory?

		No	Yes
18.1	Once per day/at the end of the day		
18.2	Between each case daily		
18.3	Before the start of a workday and at the end the day		
18.4	Monthly		
18.5	Not a specific time, as needed		
18.6	Not sure		
18.7	Other (specify)		
18.7.1	Specification:		

19. How often is the dental laboratory/workspace cleaned and disinfected?

		No	Yes
19.1	Periodically		
19.2	Daily		
19.3	Weekly		
19.4	Monthly		
19.5	Not a specific time, as needed		
19.6	Not sure		
19.7	Other (specify)		
19.7.1	Specification:		

20. What method of disinfection or infection control do you use in the laboratory?

		No	Yes
20.1	Glutaraldehyde		
20.2	Sodium hypochlorite		
20.3	Quaternary ammonium compound		
20.4	Chlorine compound		
20.5	Iodophors		
20.6	Phenolic spray		
20.7	Placing casts in an autoclave		
20.8	Do not use any		
20.9	Not sure		
20.10	Other (specify)		
20.10.1	Specification		

21. What infection control practices are followed by your dental laboratory while working on prostheses? Select all options that apply to your laboratory.

		No	Yes
21.1	Rinse all dental impressions in running water when received in the laboratory		
21.2	Disinfect all impressions upon receipt		
21.3	Disinfect working areas		
21.4	Change pumice slurry at intervals or by using different pumice slurry for different prostheses during polishing		
21.5	Disinfect casts		
21.6	Disinfect dental prostheses when they are completed by immersing them in disinfectants or by spraying disinfectants on them.		
21.7	Dispose of all waste properly		
21.8	Not sure		
21.9	Other (specify)		
21.9.1	Specification		

22. What infection control practices are followed by your dental laboratory with regard to working tools and equipment? Select all options that apply to your dental laboratory.

		No	Yes
22.1	Lathes, grinders, and laboratory handpieces are connected or used near a dust chip evacuation system		
22.2	Regular washing and sterilization of lathes brushes and burs		
22.3	Autoclave instruments		
22.4	Disinfect all mixing bowls		
22.5	Properly dispose of all wastes		
22.6	Not sure		
22.7	Other (specify)		
22.7.1	Specification		

23. Do you disinfect all laboratory work before they are sent back to the dental clinics and practices?

23.1	Yes	1
23.2	No	2
23.3	Not sure	3

24. Do you use a proper disposal method for wastes in the laboratory?

24.1	Yes	1
24.2	No	2
24.3	Not sure	3

25. **Is the dental laboratory responsible for the treatment of dental-related infections incurred by dental technicians/technologists?**

25.1	Yes	1
25.2	No	2
25.3	We have not had cases	3
25.4	Not sure	4

26. **Do you consider additional financial efforts or implications of using the cross-infection prevention methods employed in the dental laboratory?**

26.1	Yes	1
26.2	No	2
26.3	Not sure	3

27. **Is eating and drinking allowed in the dental laboratory?**

27.1	Yes	1
27.2	No	2

Please provide any other additional information, suggestions, or comments on infection control.

- -
- -
- -
- -
- -
- -

THANK YOU FOR YOUR WILLINGNESS TO COMPLETE THE QUESTIONNAIRE

APPENDIX B: INTERVIEW QUESTIONS

Cape Peninsula
University of Technology

SEMI-STRUCTURED INTERVIEW QUESTIONS

1. Explain the term “infection in the dental laboratory” in your own words.
2. How did you get to know about infection in the dental laboratory?
3. Do you think you are at risk of getting infected in your laboratory? If yes, why?
4. What precautions do you take to prevent getting infected in your laboratory?
5. Can you explain the benefits of infection control?
6. What are your reasons for compliance or non-compliance to infection control policies?

APPENDIX C: PERMISSION LETTER

Cape Peninsula University of Technology

Department of Dental Sciences,
Tygerberg Campus,
Bellville 7530.
Website: www.cput.ac.za
Email: 219495823@cput.ac.za
Phone no: +27(0)728915484

30 November 2021.

TO WHOM IT MAY CONCERN,

Dear Sir/Madam,

REQUEST FOR PERMISSION TO CARRY OUT RESEARCH INVESTIGATION IN YOUR DENTAL LABORATORY

I am a registered master's student at the Cape Peninsula University of Technology, Faculty of Health, and Wellness Sciences in the Department of Dental Sciences. The study will be done under the supervision of Dr Nicole Brooks and Mr Abduraghman A. Latief from the Faculty of Health and Wellness Sciences at the Cape Peninsula University of Technology, Cape Town, South Africa.

I am seeking permission to conduct research in your dental laboratory on the topic "**infection control, knowledge, behaviour, attitude, and compliance practices in selected dental laboratories in Cape Town, South Africa.** The study aims to determine the dental technicians' /dental technologists' knowledge of infection control, behaviour, attitude, and compliance practices in selected dental laboratories in Cape Town, South Africa.

Data will be collected through:
1. A well-structured questionnaire and
2. Interview

Participants will be given an information sheet which will provide them with detailed information regarding the process of the study. Participants will be given the opportunity to ask questions and the researcher in turn, will ensure that the participants are fully satisfied before they give their consent to take part in the study. Informed consent forms will be given to the participants to sign as this study is strictly voluntary. Participants will not take part in the study without a signed consent. The questionnaire will be sent through electronic mail to the dental technicians/technologists to be filled in online, once the signed consent is returned to the researcher following the approval to carry out the research study in your dental laboratory. The dental technicians/technologists will be given two weeks to complete the online questionnaire. Once the online questionnaire is completed and returned, an online interview will take place. Should it not be possible for the dental technicians/technologists to complete the questionnaires and interviews online, the questionnaires and interviews will be researcher administered to the dental technicians and technologists in the dental laboratory in person (face-to-face). Each participant will be given about 25-30 minutes to fill in the questionnaire and complete an interview. The whole procedure will be completed on the same day and the questionnaire will be collected on the same day. The face-to-face interview will be held in a private space (corner) in the dental laboratory.

The researcher will adhere strictly to the ethical rights of privacy and confidentiality. The researcher will ensure that the personal details of participants will not be shared with anyone, and neither will private details of the laboratory or the findings from the laboratory be disclosed to any other laboratory during the data collection or in reporting the findings from the study. During the data collection, the researcher will ensure that out of curiosity when other laboratories seek to find out information from the researcher as per the findings from a particular laboratory or any detail about them or personal details of the participants (dental technologists/dental technicians), the researcher would ensure that such information is not disclosed as part of complying to the ethical standards of privacy and confidentiality.

Furthermore, the researcher will ensure that the name of the laboratory or names of participants (dental technologists /dental technicians) will not be revealed in the data analysis or in reporting the research findings. To comply with the rules of anonymity labels will be assigned instead, where the participants are coded as P (which appears as a sequence number on the questionnaire) and the laboratory (which appears as a laboratory number on the questionnaire) will be coded as LB.

Data will be stored in an encrypted and password-protected device, computer/laptop or disc and will be locked in the Department of Dental Science/Faculty of Health and Wellness Sciences of Cape Peninsula University of Technology Cape Town. Only the researcher and the supervisors will have access to the data from this study. The written and electronic data from the study will be stored for a period of up to 5 years.

It is important to note that the research will not in any way bring harm to the participants or the dental laboratory as this research is strictly for academic purposes. The participant's participation in the research is strictly voluntary as the participant will not receive remuneration for choosing to take part in the study or be penalised for choosing not to take part in the study. The participants have the right not to allow a recording device at any stage of the study.

Thank you for your anticipated response.

Yours faithfully,

Makua Lilian Madubugwu.

APPENDIX D: PARTICIPANTS' CONSENT FORM

Cape Peninsula University of Technology

Department of Dental Sciences,
Tygerberg Campus,
Bellville 7530.
Website: www.cput.ac.za
Email: 219495823@cput.ac.za
Phone no: +27(0)728915484

30 November 2021.

Dear Sir/Madam,

CONSENT FORM

Project Title: Infection control, knowledge, behaviour, attitude, and compliance practices in selected dental laboratories in Cape Town, South Africa.

Statement of Agreement of your participation in the research study:

- I hereby confirm that I have been informed by the researcher, Makua Lilian Madubugwu, about the nature, conduct, benefits, and risks of this study,
- I declare that I have read the information sheet and that I understand the contents thereof. The details of the study have been explained to me and my questions satisfactorily answered, and I understand I may ask further questions at any time.
- I understand that my participation in the study is entirely voluntary as I have not been forced to participate and I have the right to withdraw from the study at any time without being penalised.
- I agree to provide information for the study on the understanding that my identity or that of the dental laboratory I work for will not be disclosed or used without permission and that the information will be strictly used for the study and for publications that might arise from the research project.
- I consent to complete the questionnaire and agree to partake in the interview.
- I am aware and agree that the interview may be recorded using a recording device on the understanding that I have the right to ask for the recording device to be turned off at any time during my participation in the study.
- I am aware that the results of the study will be anonymously processed into a study report.

- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I understand that significant new findings developed during this research which may relate to my participation will be made available to me.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

By completing this form, you are agreeing to participate in this study.

______________________	______________	__________________
Full Name of Participant	**Signature**	**Date**

____

Witness

I, Makua Lilian Madubugwu, herewith confirm that the above participant has been fully informed about the nature and conduct of the above study, has taken time to fully answer his/her questions and that he/she fully understands what the study entails.

______________________	______________	__________________
Full Name of Researcher	**Signature**	**Date**

____

Witness

APPENDIX E: PARTICIPANTS' INFORMATION SHEET

Department of Dental Sciences
Tygerberg Campus,
Bellville 7530.
Website: www.cput.ac.za
Email: 219495823@cput.ac.za

30 November 2021.

PARTICIPANT'S INFORMATION SHEET

Project Title: Infection control, knowledge, behaviour, attitude and compliance practices in selected Dental Laboratories in Cape Town, South Africa.

Dear Participants,

My name is Makua Lilian Madubugwu, I am a registered master's student at the Cape Peninsula University of Technology, Faculty of Health, and Wellness Sciences in the Department of Dental Sciences. I am currently researching the topic: Infection control, knowledge, behaviour, and compliance practices in Dental laboratories in Cape Town, South Africa. I welcome you to be a part of this research.

PURPOSE OF THE STUDY

The purpose of the study is to determine the dental technologists'/ dental technicians' knowledge of infection control in the selected dental laboratories in Cape Town. Furthermore, to determine the type of infection control protocols the dental technologists/dental technicians apply in their daily activities in the dental laboratories, and to find out their compliance to infection control protocols.

HOW WOULD YOU PARTICIPATE?

You will be given a questionnaire to complete online and take part in an interview. You will be given a maximum of 2 weeks to return the online questionnaire. Alternatively, an appointment can be scheduled where the questionnaire and interview will be researcher administered to you in person in the dental laboratory. The interview will be held in a private space (corner) of the dental laboratory and recorded, when necessary, with a Philips recorder which has an inbuilt storage capacity. The whole procedure is expected to be completed in about 25-30 minutes.

DESCRIPTION OF STUDY PROCEDURE

A letter of permission to carry out a research study in the dental laboratory will be sent to your dental laboratory. Once the dental laboratory approves the request, the information sheet and the consent form will be mailed to you. The information sheet contains the information on the research study while the consent form will be your signed agreement to voluntarily take part in the study. Once the signed consent is duly signed/ completed and returned to the researcher (through electronic mail). There would be a follow-up call to schedule an appointment for the online interview and to send the online questionnaire which can be returned within 2 weeks upon completion.

Alternatively, the questionnaire and the interview may be researcher-administered in the dental laboratory which would take about 25-30 minutes to complete. The questionnaire will be collected on the same day. The researcher may have to take notes during the interview and record the interview using a Philips recorder that has an inbuilt storage capacity, the reason for this, is to allow the researcher to analyse the responses, to be able to listen to the interview more than once and to share the data obtained with only the supervisors. It is important to note that you have the right to ask that the recording device be turned off at any time or withdraw interest in taking part in the study.

RISKS OR DISCOMFORT

There are no anticipated risks, discomfort, or dangers of any sort, be it physical, legal, emotional, or psychological to participants in the study as data will be collected using the questionnaire and interview only. No referral will be necessary as there is no anticipated harm/risk in this study. You are free to withdraw from this study at any stage.

BENEFITS TO PARTICIPANTS

The research will contribute to the knowledge on infection control, protocols and compliance practices in dental laboratories and therefore will greatly be of benefit to the dental profession.

PRIVACY AND CONFIDENTIALITY

The researcher will ensure that privacy and confidentiality as part of the ethical standards are maintained. The researcher will not share Your personal information or discuss it with any other person during or after the research. The researcher will ensure that the outcome/results from any of the dental laboratories will not be disclosed to another laboratory or the dental technologists/dental technicians working in the laboratory during or after the research. Findings from the laboratory and personal information will be kept confidential and private. Only the researcher and the supervisors will have access to data from the research. The data will be encrypted, and password devices and hardware/discs will be locked in a drawer in the Dental Sciences Department and Faculty of Health and Wellness Sciences, Cape Peninsula University of Technology, Cape Town. The data will be kept for 2-5 years and will be destroyed afterwards.

ANONYMITY

The researcher will ensure that the names of the participants (dental technologists/ dental technicians) and the dental laboratories are kept anonymous during the study and in reporting the results of the study. The names of participants or laboratories will not be disclosed. Information from participants will be Labelled as P1, P2, and P3 where P refers to participants and LB-1, LB 2 for the dental laboratories where LB refers to laboratories.

CONDITIONS OF PARTICIPATION

To ensure or minimize potential coercion or the appearance of coercion it is important to note that your participation in the study is strictly voluntary. You will be provided with detailed information about the study and the study process will be explained thoroughly to you. You will be given an opportunity to ask questions and the researcher will ensure that your questions are satisfactorily answered before you consent to take part in the study.
You will not be allowed to take part in the study without properly signing the consent form. You have the right to either allow or disallow a recording device or demand that the recording device be turned off at any stage of the data collection procedure without any penalty.

Inclusion criteria:

The following inclusion criteria for dental laboratories will apply to this study:

(i) Only dental laboratories registered and approved by the SADTC will be considered.

(ii) Dental laboratories need to be in operation for at least one year.

(iii) Dental laboratories should not necessarily provide all four disciplines of dental technology.

For the participants (dental technologists/technicians) the following inclusion criteria will apply:

(i) Only qualified dental technologists/dental technicians (ND, BTech, master's etc.) registered with SADTC and comply with the conditions of CPD will be used.

(ii) Only dental technologists/ dental technicians who have practised for at least one year will be allowed to participate in the study.

Exclusion criteria:

The following exclusion criteria will apply:

(i) Dental laboratories that offer only CAD/CAM services

For participants (Dental technologists/dental technicians) the following exclusion criteria will apply and will exclude:

(i) Non-qualified dental technologists/dental technicians.

(ii) Dental technology students.

REMUNERATION

You will not receive any form of payment to partake in this study.

COSTS OF THE STUDY

You will not incur any expenses should you partake in the study.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY?

The results will be written into a research report that will be assessed. Results may also be published in a scientific journal. In either case, you will not be identifiable in any document, report, or publication. You will be given access to the study results if you would like to see them through the South African Dental Technicians Council or by contacting me.

WHO TO CONTACT?

The research is reviewed and approved by the Health and Wellness Sciences Research Ethics Committee (HWS-REC) at the Cape Peninsula University of Technology. A committee whose responsibility is to ensure that the research participants are protected and that researchers comply with research ethics. To find out more about HWS-REC or about the research contact.

Researcher:

Ms. Makua Lilian Madubugwu
0728915484
Email; 219495823@mycput.ac.za

Supervisor:
Dr Nicole Brooks.
0214603563
Email; brooksn@cput.ac.za

The Secretariat:
Ms Nomathemba Seth
0219596917
Email; sethn@cput.ac.za

APPENDIX F: LETTER OF REQUEST FOR VALIDATION

Cape Peninsula
University of Technology

Department of Dental Sciences,
Tygerberg Campus,
Bellville 7530.
Email: 219495823@mycput.ac.za
Phone no: +27(0)728915484

22 September 2021.

Dear Sir/Ma'am,

REQUEST FOR FACE AND CONTENT VALIDATION

I request your expert service in validating my research instruments (questionnaire and interview questions), which will be used for data collection. These instruments have been designed to collect, measure, and analyse data on **infection control, knowledge, behaviour, attitude, and compliance practices in selected dental laboratories in Cape Town, South Africa.**

The Validation sheet, questionnaire, interview questions, objectives of the study and research questions are attached for ease of reference. Your suggestions and recommendations for the improvement of the research instruments will be appreciated.

Thank you.

Yours faithfully,

M.Makua
____

Makua Lilian Madubugwu.

VALIDATION SHEET

Name of Validator…………………………………………………………………………….

Position………………………………………….

No. of years in practice…………………………

Please tick √ the appropriate box for rating

Scale: 5-Excellent 4-Very Good 3-Good 2-Fair 1-Poor

	5	4	3	2	1
1. **Clarity of instruction to the research subject.** The concepts presented by the items are clear, simple and understandable to avoid ambiguity.					
2. **Language of the items.** The vocabulary, structure and language of the items are presented and organised in a logical order.					
3. **Appropriateness and adequacy of the items in addressing the purpose and problem of the study.** The items of the instruments can appropriately measure all the areas of the study, fulfil the objectives of the study, and address the research problem.					

This is to certify that, I…………………………………………………. validated the attached instrument and made corrections/suggestions in the following areas:

……
……
……
……
……
……
……
……
……
………………………..…

After the amendments/suggestions, I consider the instrument fit for the study for which it was designed.

Sign…………………………….

Date…………………………….

RESEARCH OBJECTIVES:

The main objective of the study is to examine the dental technicians'/technologists' knowledge, behaviour, attitudes regarding infection control as well as and the compliance practices in the selected dental laboratories in Cape Town, South Africa. Specifically, the study sought to:

3 Assess the knowledge, behaviour, and attitude of the dental technicians and technologists on infection control.
4 Identify the possible infection control protocols and practices employed in the dental laboratories.
5 Determine the dental technicians' and dental technologists' compliance to infection control practices in the dental laboratories.

RESEARCH QUESTIONS:

The study was guided by the following research questions:

1. What are the dental technicians' and technologists' understanding, knowledge, and insight regarding infection control in the dental laboratories in Cape Town?

2. What are the current measures and infection control protocols in place to prevent the transmission of infectious diseases in the dental laboratories?

3. What are the dental technicians' and technologists' compliance to infection control protocols in the dental laboratories?

APPENDIX F(i): VALIDATOR 1

VALIDATION SHEET

Name of Validator......Russel van den Heever......

Position......Owner......

No of years in practice......31 years

Please tick √ in the appropriate box for rating

Scale: 5-Excellent 4-Very good 3-Good 2-Fair 1-poor

	5	4	3	2	1
1. **Clarity of instruction to the research subject.** The items of the instruments are written in a clear, simple, and understandable order to avoid error.		√			
2. **Language of the items.** The vocabulary, structure, and concept of items are presented and organised in logical order.		√			
3. **Appropriateness and adequacy of the items in addressing the purpose and problem of the study.** The item of the instruments can appropriately cover/measure all the areas of the study. The item can fulfil the objectives of the study and address the research problem.		√			

This is to certify that, I......Russel van den Heever...... validated the above instrument and made corrections/suggestions in the following areas:

1. Question should refer to question 7
2. Section B.

Question 7: Washing the laboratory dont sound right, must be removed. The cleaning of the laboratory are being addressed in question 19 of the infection control practices.

After the amendments/suggestions, I consider the instrument fit for the study for which it was designed.

Sign......[signature]......

Date......26/10/21

APPENDIX F(ii): VALIDATOR 2

VALIDATION SHEET

Name of Validator: Carmen Moses

Position: Dental Technologist

No of years in practice: 14 years

Please tick √ in the appropriate box for rating

Scale: 5-Excellent 4-Very good 3-Good 2-Fair 1-poor

	5	4	3	2	1
1. Clarity of instruction to the research subject. The items of the instruments are written in a clear, simple, and understandable order to avoid error.		√			
2. Language of the items. The vocabulary, structure, and concept of items are presented and organised in logical order.		√			
3. Appropriateness and adequacy of the items in addressing the purpose and problem of the study. The item of the instruments can appropriately cover/measure all the areas of the study. The item can fulfil the objectives of the study and address the research problem.				√	

This is to certify that, I Carmen Delicia Moses validated the above instrument and made corrections/suggestions in the following areas:

Firstly: Congratulations Lilian Madubugwu, for getting this far with your research. The topic seems very interesting especially now with fresh developments affected by Covid-19 in the environment of occupational health and safety.

With the information that you have sent me, I gather your data collection includes a *mixed-method* approach (quantitative and Qualitative). You will definitely collect a vast range of data, as you probably noticed during your literature review. I therefore assume that you do have already identified your *variables*, and defined your *problem statement and hypothesis* of your study. I mention these important factors, to highlight how broad your collected data/answers for your topic could be, unless you require more specific/measurable answers to support the *reasons* for your study, and to develop your main argument (the research *Gap*)... What is its significance?

I made a few suggestions on minor issues that could influence the context of some of your questions (on the document: see comments & track changes), and you can decide on its appropriateness. To ensure that you collect rich and valuable data during your qualitative process (interviews), I suggest you create additional open-ended and prompting questions (sub-questions), that will initiate conversation and avoid short answers.

Remember: depending on your sampling of participants, the research topic and its questions could easily place a participant in an awkward/offensive position, if certain safety protocol is ignored or neglected. This might influence the duration and validity of your data collection process. Subsequently, you can consider triangulation or member-checking after transcription.

Good luck with the next level of your research study.

After the amendments/suggestions, I consider the instrument fit for the study for which it was designed.

Sign...Moses........................

Date: 26/09/2021

APPENDIX F(iii): VALIDATOR 3

VALIDATION SHEET

Name of Validator...Marlene Bezuidenhout.......................................

Position...HOD Dental Sciences............

No of years in practice...5+.........

Please tick √ in the appropriate box for rating

Scale: 5-Excellent 4-Very good 3-Good 2-Fair 1-poor

	5	4	3	2	1
1. **Clarity of instruction to the research subject.** The items of the instruments are written in a clear, simple, and understandable order to avoid error.			x		
2. **Language of the items.** The vocabulary, structure, and concept of items are presented and organised in logical order.				x	
3. **Appropriateness and adequacy of the items in addressing the purpose and problem of the study.** The item of the instruments can appropriately cover/measure all the areas of the study. The item can fulfil the objectives of the study and address the research problem.		x			

This is to certify that, I **Marlene Bezuidenhout** validated the above instrument and made corrections/suggestions in the following areas:

Section A

....

Q1 and 2. Gender and age seems irrelevant to the objectives of this study.

Q4 implies that a Dental laboratory owner is being questioned, however in Section B Q2 it refers to your employer? Rephrase to "**the** employer" or clarify **if** only Laboratory owners are being interviewed? There would be two different perspectives.

Q5: MTech qualification should be added.

Q8 should read if your answer in **Q7** was no......

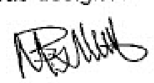
Q9. Rephase. **How many impressions** ....

Section B

II. Infection control Practices

Q4. Rephrase. .... at **the** dental clinics you receive **impressions** from?

After the amendments/suggestions, I consider the instrument fit for the study for which it was designed.



Sign.................................

Date...23 September 2021............

APPENDIX G: ETHICS CERTIFICATE

Cape Peninsula University of Technology

HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE (HWS-REC)
Registration Number NHREC: REC- 230408-014

P.O. Box 1906 • Bellville 7535 South Africa
Symphony Road Bellville 7535
Tel: +27 21 959 6917
Email: sethn@cput.ac.za

21 June 2021
REC Approval Reference No:
CPUT/HW-REC 2021/H18

Faculty of Health and Wellness Sciences

Dear Ms L Madubugwu

Re: APPLICATION TO THE HW-REC FOR ETHICS CLEARANCE

Approval was granted by the Health and Wellness Sciences-REC to **Ms L Madubugwu** for ethical clearance. This approval is for research activities related to research for **Ms L Madubugwu** at Cape Peninsula University of Technology.

TITLE: **Infection control knowledge, behaviors, attitude, and compliance practices in selected dental laboratories in Cape Town, South Africa**

Supervisors: Dr N Brooks and Mr A Latief

Comment:

Approval will not extend beyond 22 June 2022. An extension should be applied for 6 weeks before this expiry date should data collection and use/analysis of data, information and/or samples for this study continue beyond this date.

The investigator(s) should understand the ethical conditions under which they are authorized to carry out this study and they should be compliant to these conditions. It is required that the investigator(s) complete an **annual progress report** that should be submitted to the HWS-REC in December of that particular year, for the HWS-REC to be kept informed of the progress and of any problems you may have encountered.

Kind Regards

Carolynn Lackay
Chairperson – Research Ethics Committee
Faculty of Health and Wellness Sciences

APPENDIX H: APPROVAL FROM SADTC FOR LIST OF DENTAL LABS

THE SOUTH AFRICAN DENTAL TECHNICIANS COUNCIL
DIE SUID-AFRIKAANSE RAAD VIR TANDTEGNICI

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Ref/Verw:

OFFICE OF THE REGISTRAR
09TH OF NOVEMBER 2020

louise@sadtc.org.za

MS. M.L. MADUBUGWU
NO 32 10TH AVENUE
BOSTON
BELLVILLE
7530

PER E-MAIL: lillygolddc@yahoo.com

To whom it may concern,

RE: LIST OF REGISTERED DENTAL LABORATORIES IN THE WESTERN CAPE

I hereby confirm that Ms. Makua Lilian Madubugwu with Passport number A09457312 requested and obtained a list of the registered dental laboratories in the Western Cape province from the South African Dental Technicians Council (the Council). Her request for the list was approved by the Registrar of the Council and payment of R822 for quotation number QU100108 was received on 29 October 2020 via direct deposit. The payment made was as per the gazetted price list of Board Notice No. 43192 of 03 April 2020.

The list of dental laboratories was sent to her in Excel format on the 30th of October 2020 for the purpose of using the list to assist her with a survey for her Masters in Dental Technology qualification.

Yours faithfully

MISS BM MKHONZA
HEAD: INSPECTORATE & ADMIN

Regulating to protect the public and assisting the profession to evolve

All correspondence to be addressed to the Registrar • Alle briewe moet gerig word aan die Registrateur

President (C Mokgatle-Makwakwa), Vice President (I Noorshib), Registrar (PT Nkuna)

APPENDIX I: RELIABILITY TEST RESULT

Descriptive Statistics

	Mean	Std. Deviation	N
Period 1	1.9996	1.82715	80
Period 2	1.9547	1.81499	80

Correlations

		Period1	Period2
Period 1	Pearson Correlation	1	.994**
	Sig. (2-tailed)		<,001
	Sum of Squares and Cross-products	263.738	260.297
	Covariance	3.338	3.295
	N	80	80
Period 2	Pearson Correlation	.994**	1
	Sig. (2-tailed)	<,001	
	Sum of Squares and Cross-products	260.297	260.240
	Covariance	3.295	3.294
	N	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.997	.997	2

Item Statistics

	Mean	Std. Deviation	N
Period 1	1.9996	1.82715	80
Period 2	1.9547	1.81499	80

Inter-Item Correlation Matrix

	Period1	Period2
Period 1	1.000	.994
Period 2	.994	1.000

Inter-Item Covariance Matrix

	Period1	Period2
Period 1	3.338	3.295
Period 2	3.295	3.294

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.977	1.955	2.000	.045	1.023	.001	2
Item Variances	3.316	3.294	3.338	.044	1.013	.001	2
Inter-Item Correlations	.994	.994	.994	.000	1.000	.000	2

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Period 1	1.9547	3.294	.994	.987	.
Period 2	1.9996	3.338	.994	.987	.

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
3.9542	13.222	3.63627	2

APPENDIX J: PUBLISHED ARTICLE

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Infection Control Protocols and Practices in Dental Laboratories: A Review

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ABSTRACT

Infection control and prevention is one of the most efficient and economical interventions against diseases in health care. Infectious diseases can be transmitted in dental laboratories through direct or indirect contact; hence infection control ought to be an essential aspect of dental laboratory practice to prevent dental laboratory personnel from exposure to infectious diseases. The aim of this review is to upgrade our knowledge on possible infection control protocols/practices in dental laboratories and to emphasize their importance.

Key words: Dental laboratory technicians, Disinfection, Immunization, Personal Protective Equipment (PPE)

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INTRODUCTION

The need for infection control in dental practices can never be Overemphasized. The conveyance of diseases in the dental lab is well documented. It is therefore imperative that dental technicians and technologists strictly adhere to the standard protocols to prevent potential risks of cross-contamination, by that means, producing a safe environment for patients and staff [1].

An infection has been defined as an invasion of the host organism by microorganisms, toxins, or parasites that can cause pathological conditions or diseases [2]. Cross-infection is defined as the transmission of microbial agents between patients and healthcare workers [3]; while cross-contamination is defined as the transfer of a contaminant from a source, specimen, etc., to a different or uncontaminated one [4].

Infection control is vital in dental practice. It encompasses the efforts taken to prevent and control the spread of infections within dental health facilities or those primarily involved in the provision of dental care. About 1 ml of saliva sample from the oral cavity of an average healthy person comprises an estimated 750 million microorganisms; consequently, it is one of the most debated topics in dentistry and has become a constituent of the practice that dental health workers no longer question its necessity [5].

Preventing harm to patients from care aimed at helping them (*i.e.*, patient safety) is one of the determinants which describe quality in healthcare. As stated by Vazquez-Rodriguez et al. [6], prevention of care-related contagion is reported the most common detrimental effect on care delivery and hence, is a key issue.

As dentistry is mainly a field of surgery which involves exposure to saliva/blood and other potentially infectious materials, it ultimately requires a high standard of infection control and safety in regulating cross-contamination and occupational exposures to blood and saliva borne diseases. Dental care professionals are unarguably at an increased risk of cross infections while treating patients. However, as opposed to the dental treatment rooms and surgical operatories where infection control measures are sternly recommended and enforced, the dental laboratories are often overlooked. This constitutes a threat and is hazardous to the safety of dental technicians and technologists, who may acquire pathogenic microorganisms from contaminated impressions, prostheses, and by inappropriate handling of clinical materials in the dental laboratory [7].

In as much as infection control protocols in dental laboratories differ globally, and whilst a lot of guidelines have been issued and revised periodically, hygiene in many dental laboratories unfortunately still continue to be dissatisfactory, which hints at the need for more rigid control measures. Hence, this review is aimed to upgrade our knowledge and highlight the infection control protocols and practices in dental laboratories, to prevent cross-contamination and the spread of infectious diseases.

LITERATURE REVIEW

An extensive review of literature relating to infection control, protocols, and practices in dental laboratories from 2017 to 2022 was carried out, using Google scholar, Science direct, Medline, PubMed and, Wiley Online Library data base. Few literatures between 2013 and 2015 were also reviewed because they were found relevant. A search of literature located within the academic databases was conducted using the keywords, infection control, dental laboratory technicians, dental impressions, and dental laboratories. A total of 49 articles were identified of which 35 were included for the purposes of this review.

Infection transmission in dental laboratories

Since the dental office and the laboratory are usually not in the same physical facility and given the high potential for cross-contamination between the two settings, excellent communication between the two is vital for effective infection control [8].

Generally, infection is spread if the following conditions or criteria are available: The presence of a pathogenic micro-organism (pathogen), the presence of a susceptible host (immunocompromised), portal of entry for the pathogen (to the susceptible host), reservoir or source that allows the pathogen to survive and multiply (e.g., blood), and a mode of transmission from the source to the host [9].

In as much, exposure to micro-organisms cannot be avoided; however, exposure will not cause disease unless the five previously mentioned criteria are present. The absence of any one of these conditions will prevent the transmission of an infectious disease. Consequently, the main goal of infection control is to remove one, two, or all of these criteria [10].

Miller stated that the primary route of infection transmission from the patient to the dental technician is through contaminated impressions, prostheses, and clinical materials as a result of being in direct contact with patient's mouth, saliva, and perchance, blood [11]. On the other hand, cross infection from the dental technician to the patient(s) is a possibility. This can occur when the pumice slurry used in prostheses polishing is not properly disinfected and changed at regular intervals. The pumice has to be changed daily, and the machines must be disinfected regularly as well. This also applies to polishing paste [12].

In further clarification, Volgenant and de Soet outlined the route of infection transmission of pathogens as direct contact, indirect contact, inhalation or contact *via* oral mucosa [13]. Direct contact transmission takes place when the transfer of microorganisms occurs as a result of direct physical contact between an infected or colonized individual and a susceptible host. This can occur as a result of contact with oral secretions or blood in the patient's mouth.

Indirect contact involves the latent transfer of an infectious pathogen to a susceptible host *via* an intermediate object. This exposure occurs when in contact with instruments, materials, prostheses, and other contaminated laboratory equipment or items.

Inhalation is another possible route of transmission and involves infectious agents that are distributed through droplet nuclei (*i.e.* remnants from evaporated droplets) containing infective microorganisms. They can survive outside the body and remain suspended in the air for long periods of time. Infection occurs *via* the upper and lower respiratory tracts.

Contact of conjunctival, nasal, or oral mucosa with droplets generated from an infected person (e.g. by talking, coughing, or sneezing) can also be a possible route of infection as the actions can send infectious droplets into the air. If healthy people inhale the infectious droplets, or if the contaminated droplets land directly in their eyes, nose or mouth, they risk becoming infected [14].

Micro-organisms can remain both inside and on the surface of the impressions, and oral bacteria can stay viable for as long as one week even in set gypsum. This makes it difficult to disinfect dental casts than impressions because the microorganisms seep into the inner parts of these casts hence making disinfection difficult. A number of potentially infectious biological agents like *Mycobacterium tuberculosis*, Hepatitis B and C, Herpes simplex viruses and HIV have been documented. For instance, it has been documented that dental personnels have a 5–10 fold possibility of contracting hepatitis B infection than the general population [15,16].

Infection control practices and protocols in dental laboratories

Dental laboratories are often overlooked as regards strict infection control measures and this poses a threat to the safety of dental technicians and technologists, who are at risk of acquiring pathogenic microorganisms from contaminated impressions, prostheses, and by improper handling of clinical materials after arrival at the dental laboratory. Every dental setting (*i.e.*, clinic, unit or laboratory, centre) should have an infection control program aimed to avert the transmission of disease from patient to dental team, from dental team to patient, or from patient to patient.

Infection control in dental laboratories was pioneered by American Dental Association (ADA) through its recommendations and guidelines of the Centres for Disease Control (CDC). It was first published in 1986 and then revised in 1993 [17].

In as much as contaminated items from the dental laboratory may not get to the patient, as they could be disinfected on arrival at the clinic (which is not assessed in this review), the high percentages (60%) of contaminated items not disinfected before leaving the dental office [18], and the scarce communication between laboratories and clinics [19] make cross-contamination control practices for preventing cross-infection in the dental laboratory a matter of concern as regards quality of care and occupational hazard [20].

As it is not possible to diagnose all infected patients from their medical histories, readily available laboratory tests, or physical examinations, the Occupational Health, and Safety Administration (OSHA) has instituted guidelines known as "bloodborne pathogen standards". This implies that all human blood and saliva should be treated as if known to be infectious for Hepatitis B Virus (HBV), Human Immunodeficiency Virus (HIV), and other blood-borne pathogens [21].

Ultimately, there are fundamental practices which need to be strictly adhered to by the dental technicians and technologists to avoid infections in dental laboratories. These include special disinfecting area, use of Personal Protective Equipment (PPE), hand hygiene and immunisation.

Special disinfecting/receiving area: Basmaci, et al. stated that it is imperative to establish designated disinfecting and working areas [22]. All incoming cases should be first stored in this area, disinfected without delay, and transferred to work areas only after complete disinfection. All containers are to be sterilized or disinfected after every use. Also, packing materials should be thrashed immediately to avoid contamination. As opined by Sammy and Benjamin, there must be an infection control policy in the form of a poster, and displayed on the wall in this area. In addition, the policy must be renewed annually or when necessary, to take in new disinfection techniques and get rid of the outmoded ones. Laboratories should be trained prior to the introduction of any form of disinfection processes.

Disinfection: The Australian Dental Association (ADA) postulated that to make impressions contamination-free, they are thoroughly rinsed with cold running water to remove saliva and any traces of blood, and then diluted detergent is applied as disinfectant [23]. To bolster this, studies have shown that a small quantity (10%-15%) of micro-organisms remain on impressions 10-15 seconds after rinsing in water, so it is essential for it to undergo disinfection or sterilization methods. In as much as sterilisation is ideal, it is not applicable as the temperature and time required would destroy the impressions, most dentures, and appliances. It is recommended that all disinfection procedures should be carried out in the dental laboratory by well-trained technicians/technologists. The right disinfectant should be used so as to prevent corrosion in metallic components, and dimensional changes as well as surface textures for impressions [24,25]. According to Alzain, if an impression is not disinfected, it can cross-contaminate the entire laboratory area, creating an avenue for microorganisms to travel back and forth from the laboratory to the clinical area [26]. Furthermore, dental laboratories should set apart prostheses of high-risk patients from other laboratory work. The duration and disinfection technique depends on the absorbability of the impression material and the time lapse between impression-taking and disinfection.

Methods of disinfection

Basmaci, et al. explained that dental impression materials can be disinfected in two ways namely immersion and spray. The most effective is disinfection by immersion because it exposes all the surface area to the disinfectant whereas the spray tends to act only on the areas applied. The most commonly used disinfectants are chlorhexidine, glutaraldehyde (0.5%, 2%, 2.2% and 2.45%), Sodium Hypoclorite (NaOCl) (0.5%, 0.525%, 1%, 4% and 5.25%), hydrogen peroxide (0.5%), phenols (7%) and iodophores (5% and 10%), according to the type of impression material. Polysulphides, addition silicones and condensation silicones should be disinfected with disinfectants that do not cause dimensional changes to them. Polyethers are prone to dimensional changes when immersed for more than 10 minutes, whilst prolonged immersion time of hydrophilic impressions makes the material less hydrophilic. Impression compound is best disinfected with phenolic spray or iodophors [27,28].

Firoozeh, et al. are of the opinion that pumice slurry used in the polishing of prostheses could be a possible source of contamination to dental laboratory technicians when the wide variety of microorganisms in saliva and blood of patients are put into consideration [29]. Therefore, pumice slurry must be changed after the conclusion of every case. Also, the pumice and rag wheels must be disinfected daily.

DISCUSSION

Use of personal protective equipment: It is important that dental laboratory technicians and technologists working in the special disinfection/receiving area put on Personal Protective Equipment (PPE); clean laboratory coats, protective eyewear (goggles), face masks, and disposable gloves. These personal protective equipment must be used whenever there is potential for splashes, spatter, spray, or aerosols such as when operating model trimmers, polishing lathes, motors, or any other rotary equipment. Donning (put on) involves putting on the required apparel before patient contact and must be performed in the following order: Hand hygiene, gown, mask, eye or face protection, and gloves. When doffing (taking off), hand hygiene must be performed after taking off each item, starting with gloves, eye or face protection, gown and mask. If the proper procedure is not followed, blood, body substances and other potentially infectious material could be transferred to both healthcare workers and patients. Solid wastes soaked with bloody fluids should be put in sealed impervious bags and discarded following the regulations of the local or national environmental agencies [30,31].

Work surfaces in working areas and equipment should always be kept clean and disinfected daily. All materials, attachments and instruments which are to be used on new prostheses should be set aside from those used on prostheses that have already been put in the mouth [32].

Hand hygiene: Personal hygiene and care of hands have been identified as the most important infection-control precautions to prevent transmission of diseases. Furthermore, hospital-based studies have shown that noncompliance with hand hygiene practices is associated with health-care-associated infections and the spread of multi-resistant organisms. Dental technicians/technologists should wash hands before and after removing gloves. The use of alcohol-based hand-sanitizers or hand rubs is also encouraged [33,34].

The proper procedure for washing hands

The proper technique for washing hands involves:

- Wetting the hands.
- Dispensing soap and then working up a lather.
- Hands should be scrubbed for at least 20 seconds.
- Making sure to wash all surfaces, including your palms, the backs of your hands, in between your fingers and under your fingernails.
- Wash off the soap with clean water.
- Dry hands thoroughly using paper towel.
- Use towel to turn off faucet.

Immunization: Hepatitis B virus (HBV) immunization is strongly recommended for health care workers, dental technicians, and technologists inclusive. This is because HBV infection is the major infectious hazard for dental health care practitioners. Transmission of HBV is chiefly when in contact or exposed to blood or body fluids of a person with either acute or chronic HBV infection. Immunization is the best option to prevent HBV infections in dental settings, dental laboratories inclusive [35].

CONCLUSIONS

Infection control is a vital aspect of health care; hence it is essential to ensure that dental laboratory staff complies with infection control protocols and guidelines to prevent cross-contaminations and spread of diseases in the lab. Although, dental laboratory personnel may be theoretically aware of infection control guidelines and protocols, there should be;

- Infection control guidelines and protocols written in clear and simple language in the lab and updated when necessary.
- Infection control signages and posters that illustrate different ways to prevent diseases (such as, wash your hands, cover your cough, etc.,) displayed on working surfaces, walls or areas mostly used in the dental laboratory.
- There should be compulsory continuing professional development courses, seminars, and trainings on infection control regularly for the dental laboratory technicians, technologists, and other laboratory staff, to update their knowledge on the latest infection control protocols. This will greatly encourage compliance to infection control protocols.
- Importantly, there should be sufficient communications between the dentist and dental laboratory technicians/ technologists on disinfection/decontamination of items that have been shipped (they must have label stating whether they were disinfected and with which disinfectant), the dental technician and technologist on the other hand should also inform the dentists of the status of every completed dental prosthesis (dental work) sent to the dental clinics.

DECLARATION OF INTEREST

The authors report no conflict of interest. The authors alone are responsible for the content of this article.

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