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Demonstrating Microbial Contamination Routes in Chiropractic Clinics Using Glo-Germ™ as a Surrogate for Microbial Pathogens

A dissertation submitted to the Faculty of Health Sciences, University of Johannesburg, in partial fulfilment of the requirements for the Degree of Masters of Technology: Chiropractic

by

Devin Ramsden

(Student number: 201106502)

Supervisor: Prof T.G. Barnard

Co-Supervisor: Dr C. Yelverton

Co-Supervisor: Dr A. Singh
DECLARATION

I, Devin Ramsden, declare that this dissertation is my own, unaided work, except where otherwise indicated in the text. It is being submitted for the Master’s Degree in Technology: Chiropractic at the University of Johannesburg. It has not been submitted before for any degree or examination in any other University.

Signature of Candidate: _____________________

On this ______ day of _____________ 2018.
DEDICATIONS

“Don't worry about the pressure or the responsibility. Just live in it, have fun, and when everything seems to be going right, just stay humble and remember your family.” – Roman Reigns

I dedicate this research to my parents and brothers, Howard, Belinda, Rayne and Liam.

Thank you for your belief and support.

UNIVERSITY OF JOHANNESBURG
ACKNOWLEDGEMENTS

“Success is no accident. It is hard work, perseverance, learning, studying, sacrifice and most of all, love of what you are doing or learning to do” - Pele

To my supervisor Prof TG Barnard, you are a champ. Thank you for your ongoing support. I am truly grateful for all the time and dedication that you have put in, in order for me to achieve this humungous milestone.

To my co-supervisors, Dr Chris Yelverton and Dr Atheesha Singh, thank you for your patience and your guidance.
ABSTRACT

OBJECTIVE

Within the chiropractic profession there may be the possibility that microorganisms can be transmitted between the chiropractor, the patient and the treatment bed. This transmission could potentially lead to further infection. With the identification of potential routes of transmission within the chiropractic profession, the transmission and risk of infection from pathogenic microorganisms may be reduced. The purpose of this study was to explore and describe the possible routes of microbial transmission between a chiropractor, patient and treatment bed using Glo-Germ™ cream (fluoresces when exposed to Ultraviolet (UV) lights) as a surrogate for microorganisms.

METHODOLOGY

The study design was a qualitative, descriptive study. Glo-Germ™ cream was applied to either the chiropractor, patient or treatment bed depending on the route studied. Following a mock treatment, which consisted of an initial greeting (handshake) and three Chiropractic manipulation set-ups, the spread of the Glo-Germ™ cream was visualized with black lights which emit long-wave UVA radiation and little visible light in order to observe fluorescence. Transmission of the Glo-Germ™ in the treatment room between the chiropractor, patient and treatment bed was noted. This was done in triplicate for each contamination source tested.

RESULTS

The results showed that there was transfer of the Glo-Germ™ cream between the chiropractor, patient and treatment bed. The transfer routes were determined by the visual transmission of Glo-Germ™ from the area of the application to the area being tested. The intensity and the amount of Glo-Germ™ that was transmitted determined the level of risk for the
transmission of microorganisms. The results also showed that a fluorescent substance can be used as a surrogate for microorganism transmission.

CONCLUSION

In conclusion, this study was able to visually portray, with the use of Glo-Germ™ as a surrogate for microorganisms, the routes for microorganism transmission that exist between a chiropractor, a patient and the treatment bed. All of the routes between the practitioner, patient and treatment bed, that were under investigation, were shown to be potential routes for transmission. With the use of an adapted, chiropractic, version of the World Health Organisations 'Five Moments of Hand Hygiene,' these routes may be used to illustrate the moments that hygiene could possibly be practiced by chiropractors in order to prevent any further transmission of microorganisms within a chiropractic health environment between practitioner, patient and treatment bed.

With possible inclusion of Chiropractic into hospitals in the future, it is important for the profession to follow safe hygiene practices, as the prevention of microorganism transmission and possible infection is of utmost importance within a hospital health setting.
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LIST OF ABBREVIATIONS AND ACRONYMS

DAP - Daptomycin

ECDC – European Centre for Disease Prevention and Control

HAIs – Healthcare-acquired infections

ICU – Intensive care unit

ISCR – In-Situ Chemical Reduction

RIF - Rifampin

UV - Ultraviolet

UVA – Ultraviolet

WHO – World Health Organization
1.1 Introduction

It is globally accepted that healthcare-acquired infections are a burden in the healthcare environment. In 2006 the World Health Organization (WHO) described five key points of contact between practitioner and patient within a typical healthcare environment that could lead to pathogen transfer, namely: before touching a patient, before clean/aseptic procedures, after body fluid exposure/risk, after touching a patient, and after touching patient surroundings. These points were described to portray the particular times that pathogen transfer between the practitioner, patient and the environment could potentially occur, resulting in possible healthcare-acquired infection. The five moments described by the WHO are applicable to a hospital environment. Whether or not these moments can be translated into Chiropractic clinics is unknown, as the routes of microorganism transfer within these private clinics have only recently been identified, therefore the moments to practice hygiene are yet to be defined. Understanding the moments of hygiene practice within Chiropractic clinics is essential as the potential for future inclusion of Chiropractic into public health centres and National Health Insurance would mean inclusion of Chiropractic into a hospital setting, and consulting patients that are exposed to the ‘Five Moments of Hand Hygiene’ in the hospital environment.

Past research done on chiropractors has reported on the occurrence of pathogenic bacteria and fungi on Chiropractic treatment beds as well as on chiropractor’s hands (Bifero et al., 2006; Evans et al., 2007; Evans et al., 2008). Studies done at the University of Johannesburg confirmed that treatment beds and practitioner’s hands are potential reservoirs for pathogens, thus making understanding of possible transmission routes important (Eves et al., 2017; Kruger et al., 2017; Perdijk et al., 2017; Wyer et al., 2017).
With the above in mind, some of the key moments described previously by the WHO for a hospital could be seen as possibly relevant to Chiropractic private clinics, while other moments mentioned by the WHO may not be as applicable for this type of healthcare profession. Although studies on the occurrence of pathogens on practitioner’s hands and on the treatment beds within private clinics have been done, there is still not enough research as to where the potential routes of microorganism transmission exist between chiropractor, patient and the treatment bed.

1.2 Aim of the study

The aim of this study was to explore and describe the possible pathogen transmission routes between the chiropractor, patient and treatment bed. The objectives were to use a typical chiropractic consultation with a Glo-Germ™ cream as a surrogate for microorganisms at the University of Johannesburg Chiropractic-teaching Clinic in order to demonstrate the transmission routes. The objectives also included the adaptation of the WHO’s ‘Five Moments of Hand Hygiene’ to be more specific for the chiropractic health profession.

1.3 Possible benefits of the study

The study will contribute towards describing and exploring the potential transmission routes of microbes, using Glo-Germ™ as a surrogate, between the chiropractor, the patient, and the treatment bed. The dissertation proposes also proposes an adaptation of the WHO ‘Five Moments of Hand Hygiene’ to chiropractic.

The information gathered from the study will be distributed in the form of possible publication in an accredited Medical Educational Journal.
2.1 Introduction

This chapter aims to provide the reader with an understanding of the cause of Healthcare-acquired infections (HAIs), the importance of hygiene practice in order to prevent HAIs and how Chiropractic can be an environment where microorganisms can be spread, potentially causing HAIs.

2.2 Healthcare-acquired infections

2.2.1 What is a Healthcare-acquired infection?

Healthcare-acquired infections, or 'nosocomial infections', are infections that occur following exposure to healthcare environments and are often, but not always, as a result from this exposure. HAIs are defined as infections that occur during a stay at a healthcare facility for more than 48 hours, that was neither present nor incubating at the time of patient admission (Cardoso et al., 2014). HAIs are deemed the most frequent adverse consequences of healthcare worldwide and threaten both the health of the patient and healthcare worker (Currie et al., 2018).

According to the European Centre for Disease Prevention and Control (ECDC, 2015), of 141 955 patients staying in intensive care units (ICU) for more than two days, 11 788 (8%) presented with at least one HAI. The concern of HAIs worldwide needs to be highlighted for various factors, not only because of the vast number of patients that are affected each year and the attributable mortality, but because of the large impact that HAIs have in terms of prolonged stays at healthcare facilities and the excess financial costs associated with them (Arefian et al., 2016; Rattanaumpawan et al., 2017).
2.2.2 Common Healthcare-acquired infection pathogens (ESKAPE pathogens)

Of all the microorganisms associated with causing HAIs, there are a few microorganisms that are responsible for a large percentage of HAIs in hospitals. Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa and Enterobacter species make up a group of pathogens called the ESKAPE pathogens (Santajit and Indrawattana, 2016).

2.2.2.1 Healthcare-acquired infections and antimicrobial resistance

The ESKAPE pathogens are well known for their antimicrobial resistance causing serious therapeutic difficulty for healthcare physicians (Rice, 2015; Santajit and Indrawattana, 2016). The different mechanisms of drug resistance can be separated into several broad categories, these include drug inactivation/alteration, modification of drug binding sites/targets, changes in cell permeability resulting in reduced intracellular drug accumulation, and biofilm formation (Santajit and Indrawattana, 2016).

Antimicrobial resistance is influenced by the type of mechanism used by the microorganism, the microorganisms discussed and the stage of adaptation. As a summary, the various methods used are shown in Table 1.1 to give the reader a broad understanding of the different antimicrobial resistance approaches used by bacteria.

Antimicrobial resistance genes, carried on the bacterial chromosome, plasmid, or transposons, is the most common way antimicrobial resistance is acquired (Giedraitiene et al., 2011). Mobile genetic elements mentioned above, have the potential to move from one bacterial cell to another, while other elements can move from one genetic location to another in the same cell. Resistance transposons, gene cassettes and In-Situ Chemical Reduction (ISCR)-promoted gene mobilization are included as part of the latter. Plasmids and conjugative transposons transfer from one cell to
another by mechanisms that involve replication. Gene cassettes, transposons and ISCR-mediated gene transfer between sites on the same or on different DNA molecules requires some form of recombination. This could include some form of replication as well. Plasmids can accumulate antibiotic resistance genes as a consequence of the activities of at least three of these recombination systems (Bennett, 2009).
<table>
<thead>
<tr>
<th>Antimicrobial resistance method</th>
<th>Explanation and examples</th>
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<tbody>
<tr>
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<td></td>
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<td>1) Mutational resistance</td>
<td>Mutations in gene(s) often associated with the mechanism of action of the compound</td>
</tr>
<tr>
<td>2) Horizontal gene transfer</td>
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</tr>
<tr>
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</tr>
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</tr>
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</tr>
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<td>Examples include methicillin resistance in <em>S. aureus</em> due to the acquisition of an exogenous PBP (PBP2a) and vancomycin resistance in enterococci through modifications of the peptidoglycan structure mediated by the van gene clusters</td>
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The ESKAPE organisms represent paradigms of resistance, pathogenesis, and disease transmission. Antimicrobial resistance of these pathogens is proving to be a major threat to public health systems worldwide and it seems that as resistance profiles change, antimicrobial resistance will likely increase in the near future (Santajit and Indrawattana, 2016).

Over the years more and more evidence of contamination with these microorganisms is being uncovered in varied healthcare environments, some of these outbreaks are listed below (Table 2.2), further proving that hospitals and other outpatient health environments are potential reservoirs for HAIs.

### 2.2.3 Microorganism transmission and survival

Microorganisms may potentially be spread amongst patients and healthcare personnel through five routes of transmission. The five routes are explained below:

a) Contact transmission is one of the most frequently seen modes of transmission of HAIs and can be divided into direct and indirect contact. Direct contact involves direct body surface to body surface contact and the physical transfer of microorganisms from an infected person to another by touch. Indirect contact is transfer of microorganisms between a person and an object which has become contaminated due to previous contact with an infected person (Alipour et al., 2017; Lopez-Urrutia et al., 2018).

b) Respiratory droplet transmission of microorganisms is generated during coughing, sneezing and talking. The microorganisms are propelled through the air and land on another person and enter their system through contact with their conjunctiva, nasal mucosa or mouth (Nicas and Sun, 2006).

c) Airborne transmission of microorganisms occurs when dust particles and other small airborne particles are suspended in the air for extended
periods of time and are dispersed by air currents to contaminate a person (Eames et al., 2009).

Table 2.2  ESKAPE pathogens associated with outbreaks in Healthcare environments.

<table>
<thead>
<tr>
<th>Outbreak species, place and country</th>
<th>Transmission mode / source</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vancomycin-resistant Enterococcus faecium in haematology and oncology departments</td>
<td>Healthcare workers hands, Patient to patient, contaminated environment</td>
<td>Lopez-Urrutia et al., 2018</td>
</tr>
<tr>
<td>Gentamicin-resistant, methicillin-resistant Staphylococcus aureus at a neonatal unit at Ninewells Hospital, Dundee, UK</td>
<td>Incubator</td>
<td>Eldirdiri et al., 2018.</td>
</tr>
<tr>
<td>Carbapenem-resistant Klebsiella pneumoniae in a United States hospital</td>
<td>Transmission from a single patient, ventilator, sink drains</td>
<td>Snitkin et al., 2012.</td>
</tr>
<tr>
<td>KPC-3-Producing Enterobacter cloaceae and Klebsiella pneumoniae at an academic burn centre in the United States (North Carolina)</td>
<td>Transmission through Healthcare personnel</td>
<td>Kanamori et al., 2017.</td>
</tr>
<tr>
<td>Interfacility outbreak of extensively antibiotic-resistant Acinetobacter baumannii</td>
<td>Patient to patient transmission</td>
<td>Buser et al., 2017.</td>
</tr>
<tr>
<td>Pandrug-resistant Pseudomonas aeruginosa in a hospital</td>
<td>Bronchoscope</td>
<td>Alipour et al., 2017.</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa in a neonatal Intensive Care Unit</td>
<td>Contaminated water</td>
<td>Bicking Kinsey et al., 2017.</td>
</tr>
<tr>
<td>Carbapenemase-producing Enterobacteriaceae in three separate affiliated healthcare facilities</td>
<td>Patient transmission</td>
<td>O’Connor et al., 2016.</td>
</tr>
<tr>
<td>Influenza Virus</td>
<td>Fomites to hands of health care worker</td>
<td>Weinstein et al., 2003.</td>
</tr>
</tbody>
</table>

d) Common vehicle transmission applies to microorganisms that are transmitted by contaminated items such as food, water, medical devices, medications and medical equipment (Bicking Kinsey et al., 2017; Jinadatha et al., 2017).
e) Vector transmission is the transmission of pathogens in a population through a second population. An example of this type of transmission is that of a vector-borne disease being transmitted via the bite of an infected arthropod species, such as a mosquito (Schorderet-Weber, 2017).

Of these transmission routes, contact transmission is the most important and most frequent mode of transmission found within the health care setting. Microorganisms can be transferred by direct contact between an infected or colonised patient and a susceptible health care worker or another person. Alternatively, organisms may be transferred for a period of time to the intact skin of a health care worker (not causing infection), and then transferred again to a susceptible patient, who develops an infection from that organism. This can be referred to as an indirect route of transmission from a patient to another (Collins, 2008).

Healthcare workers may not only become contaminated via direct patient contact but also through contact with inanimate surfaces within the facility (Clack et al., 2017). Some medical devices frequently used by medical practitioners are constantly used in direct contact with patients’ skin and can potentially cause indirect contact transmission of infection. Some of these surfaces and equipment that have been shown to harbour microbes are described in (Table 2.3).

Common nosocomial pathogens, including multi-drug resistant bacteria and some medically important fungal species, may survive or persist on surfaces in the healthcare setting for months and with no regular preventative surface disinfection being performed, they can potentially be a source for continual transmission. Table 2.4 shows the time frames that some of these pathogens can persist on inanimate surfaces (Collins, 2008; Russotto et al., 2015).
### Table 2.3  Surfaces and equipment that can act as potential reservoirs for microorganisms.

<table>
<thead>
<tr>
<th>Surface / equipment contaminated</th>
<th>Microorganism</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doorknobs, slit-lamp headrests, chinrests, computer keyboards</td>
<td>Methicillin-susceptible and methicillin-resistant <em>Staphylococcus aureus</em></td>
<td>Reem <em>et al.</em>, 2014.</td>
</tr>
<tr>
<td>Over-bed tables, bedside rails</td>
<td>Methicillin-resistant <em>Staphylococcus aureus</em></td>
<td>Kurashige <em>et al.</em>, 2016.</td>
</tr>
<tr>
<td>Blood pressure cuffs</td>
<td>Methicillin-resistant <em>Staphylococcus aureus</em></td>
<td>Matsuo <em>et al.</em>, 2013</td>
</tr>
<tr>
<td>Ventilator buttons and circuits, suction system switches</td>
<td><em>Staphylococcus aureus</em>, <em>Pseudomonas aeruginosa</em></td>
<td>Sui <em>et al.</em>, 2012.</td>
</tr>
<tr>
<td>Medical charts</td>
<td>Coagulase-negative <em>Staphylococci</em>, <em>Acinetobacter baumannii</em>, <em>Klebsiella pneumoniae</em></td>
<td>Teng <em>et al.</em>, 2009.</td>
</tr>
</tbody>
</table>
Table 2.3 continued  Surfaces and equipment that can act as potential reservoirs for microorganisms.

<table>
<thead>
<tr>
<th>Surface / equipment contaminated</th>
<th>Microorganism</th>
<th>Reference</th>
</tr>
</thead>
</table>


Table 2.4  Persistence of clinically relevant bacteria and fungi on dry inanimate surfaces. Adapted from: (Kramer et al., 2006; Weinstein and Hota, 2004).

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Duration of Persistence</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em></td>
<td>1.5 hours – 16 months</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>7 days – 7 months</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>6 hours – 16 months; on dry floor: 5 weeks</td>
</tr>
<tr>
<td><em>Enterococcus spp.</em></td>
<td>5 days – 4 months</td>
</tr>
<tr>
<td><em>Klebsiella spp.</em></td>
<td>2 hours – more than 30 months</td>
</tr>
<tr>
<td><em>Acinetobacter spp.</em></td>
<td>3 days – 5 months</td>
</tr>
<tr>
<td><em>Clostridium difficile</em></td>
<td>5 months</td>
</tr>
</tbody>
</table>

**Fungi and Yeast**

<table>
<thead>
<tr>
<th>Fungi</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Candida albicans</em></td>
<td>1 day – 120 days</td>
</tr>
<tr>
<td><em>Candida parapsilosis</em></td>
<td>14 days</td>
</tr>
<tr>
<td><em>Torulopsis glabrata</em></td>
<td>102 days – 150 days</td>
</tr>
</tbody>
</table>

**Virus**

<table>
<thead>
<tr>
<th>Virus</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influenza virus</td>
<td>24-48 hours on nonporous surfaces</td>
</tr>
<tr>
<td>Parainfluenza virus</td>
<td>10 hours on nonporous surfaces, 6 hours on clothing</td>
</tr>
<tr>
<td>Norovirus</td>
<td>2-14 days</td>
</tr>
<tr>
<td>Hepatitis B virus</td>
<td>7 days</td>
</tr>
</tbody>
</table>

Due to the survival potential of these infectious microorganisms on inanimate surfaces within various healthcare settings, for extended periods of time, it is important that intervention programs are developed in order to limit and hopefully reduce environmental transmission of pathogens. A large focus is placed on personal and hand hygiene when battling the spread of microorganisms from surface to surface.

### 2.3 Personal and hand hygiene

As mentioned earlier, contact between people can contribute to the spread of disease (Buser et al., 2017; Kanamori et al., 2017). The human skin and
mucosa can hold a variety of microorganisms. These can be separated into two different categories: 1) the resident flora that consists of established microbes which when disturbed, re-establish themselves and 2) transient flora that consists of non-pathogenic or possibly pathogenic microbes that reside on the skin for minutes, hours or even days and that do not establish permanently. Transient flora is most frequently associated with HAIs (Brooks et al., 2010). The healthcare worker’s hands are a major reservoir for pathogenic microorganisms and are regarded as one of, if not the most, common route for pathogen transmission in a healthcare setting (Creamer et al., 2010; Paul et al., 2011). For pathogenic flora to be transferred to a patient from the healthcare worker a series of events usually must occur, these include:

- Microorganism on the patient’s skin or that have been shed from the patient onto fomites (inanimate surfaces) must be transferred to the hands of the healthcare worker.
- Microorganisms are required to survive on the healthcare workers skin.
- Hand hygiene is not practiced or is not sufficient.
- The healthcare workers contaminated hands come into direct contact with the patient, or indirect contact with the patient via the bed or medical equipment.

Healthcare professionals are in contact with patients during a consultation and any microorganisms found on the practitioner’s clothes (white coat as shown earlier) may be transferred to the patient during the consult. An individual’s personal hygiene therefore plays an important role in the prevention of transmission of microorganisms.

Some of the parts of the body where ESKAPE microorganisms have also been found include:

- Nasal carriage of *Staphylococcus aureus*. (Legese et al., 2018).
• Hand carriage of *Staphylococcus aureus*, Coagulase-positive *Staphylococcus aureus*, *Escherichia coli*, *Bacillus* spp., and *Pseudomonas* spp. (Ibeneme et al., 2017).
• White coats carriage of *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*. (Akanbi et al., 2017).

Even though the role of hand and personal hygiene in preventing infectious disease is proven to be crucial, compliance remains low.

### 2.4 Compliance towards proper hygiene practice

Hygiene behaviour is the use of regular practices and behaviours associated with the prevention of infection transmission (Nicolle, 2007). Strict adherence to hygiene behaviours protects individuals against exposure from bacterial, fungal and viral infections and is the best way to prevent the spread of infectious diseases. Proper hygiene behaviours interrupt the transmission of the microorganisms causing the infection, both in the community and in the healthcare settings (Burnett, 2009). A poor understanding and compliance to hygiene is one of the important behavioural risk factors adding to the global concern of diseases (Dorri et al., 2009).

Studies show that proper hand hygiene practice has the potential to decrease the carriage of microbes on healthcare professional’s hands (Ibeneme et al., 2017; Bhavsar et al., 2015). Ongoing education and training are essential to developing and maintaining hand-hygiene behaviour (Wilson et al., 2009). Healthcare facilities are recommended to develop multidimensional programs to improve hygiene practices. A study done in Poland by Walaszek et al. (2017), revealed that there is still great ignorance of healthcare physicians and medical students with regard to the five moments of hand hygiene.
An observational study done in the neonatal and paediatric intensive care unit in a tertiary university hospital in Istanbul, assessed the compliance of hand hygiene for the five World Health Organizations indications amongst the healthcare workers. The techniques measured were hand hygiene by hand washing or by alcohol-based disinfectant. A total of 704 hand hygiene opportunities were identified with an overall compliance of only 37% (261/704). Compliance between different roles was also recorded where nurses (41.4%) and doctors were (31.9%) compliant. The conclusion being that adherence to hand hygiene practice is very low (Karaaslan et al., 2014). Another study done at Aseer Central Hospital in Saudi Arabia also showed poor results with regards to hand hygiene compliance (Mahfouz et al., 2013).

The current study is related to illustrating the routes of transmission in order to further study and understand where and when, during a Chiropractic consultation, personal and surface hygiene practices could be applied to have an effect on the possible spread of microbial pathogens in a chiropractic clinic. These moments during the consultation could prove to be similar to those that the WHO mention in their ‘Five Moments of Hand Hygiene.’

2.5 The World Health Organisations “Five Moments of Hand Hygiene”

The World Health Organisation (WHO) launched a Global Patient Safety Challenge “Clean Care is Safer Care” in 2005. As part of the launch the WHO Guidelines on Hand Hygiene in Health Care were made available. The key areas of implementation for this strategy include:

- Raising awareness globally of the impact HAIs have on patient safety and promoting preventive strategies.
- Inviting Ministers of Health from all WHO Member States to make a formal statement committing to address HAI in their country.
• Testing the implementation of the WHO Guidelines along with selected actions from the other WHO strategies.

Then, in 2009, the WHO introduced the ‘Five Moments of Hand Hygiene’ model (shown in Figure 2.1), in an attempt to reduce the burden of Healthcare-acquired infections. Since healthcare workers could well be the source of a HAI the model aims to prompt healthcare workers to implement hand and other hygiene practices at five specific moments while caring for a patient (Chou et al., 2012; Danzmann et al., 2013). These ‘Five Moments of Hand Hygiene’ can be regarded as potential times, during a consultation, that microorganism transfer could occur between practitioner and patient.

![Figure 2.1](WHO, 2009)

The first of the ‘Five Moments of Hand Hygiene’ describes the moment before patient contact. A few examples with regards to this moment, from studies showing microorganism transfer, included: before shaking a patient’s hand, before helping a patient move around and before performing a clinical procedure or examination (Cirkovic et al., 2017; Jabbar et al., 2010; Obadia et al., 2015).
The second of the ‘Five Moments of Hand hygiene’ describes the moment before a clean/aseptic task. A few examples of this moment, from studies showing microorganism transfer, would include: before performing oral/dental care, before wound dressing, before catheter insertion and before preparation of food and medicine (Baniasadi et al., 2013; Cleveland et al., 2016; Costa et al., 2014; Eggimann et al., 2000; Eklund and Marianos, 2010; Sergent et al., 2012).

The third of the ‘Five Moments of Hand Hygiene’ describes the moment after body fluid exposure risk. Examples from studies showing microorganism transfer of this moment include: after oral/dental care, after secretion aspiration, after clearing urine or faeces, after drawing and manipulation of blood and after handling any waste (South Australia Health, 2018).

The fourth of the ‘Five Moments of Hand Hygiene’ describes the moment after touching a patient. With regards to studies showing transfer of microorganisms, this moment would include examples such as: after shaking a patient’s hand, after helping a patient move around and after a clinical examination (Thamlikitkul et al., 2003).

The fifth and final of the ‘Five Moments of Hand Hygiene’ describes the moment after contact with patient surroundings. With regards to studies showing transfer of microorganisms, examples here could be: after changing bed linen, holding a bed rail, leaning against a bed (Damani and Damani, 2012; Neely and Orloff, 2001).

Since the initiation of the campaign by the WHO in 2005, many healthcare facilities around the world have chosen to actively participate in the campaign. Germany started a campaign to improve hygiene within their healthcare facilities. Since the end of 2010, more than 700 healthcare institutions including several university hospitals have participated in the campaign, with many providing data showing that overall hygiene compliance within the facilities is increasing due to the implementation of
these campaigns based on the WHO’s ‘Five Moments of Hand Hygiene’ model (Reichardt et al., 2013).

Another successful implementation of a hygiene improvement strategy based on the WHO model was seen in China. In a traditional Chinese Medicine hospital, the rate of compliance and correctness of hygiene practice increased from 66.27% and 47.75% to 80.53% and 88.35% respectively after the intervention (Shen et al., 2017).

With the implementation of hygiene campaigns being successful in hospitals and other healthcare facilities around the world, the Chiropractic profession should implement similar strategies in private clinics in order to prevent any transfer of potentially infectious microorganisms.

Research reporting on microorganism contamination within a Chiropractic healthcare environment is very limited. The surfaces and equipment used in a Chiropractic practice are, in some instances, similar to those found in a hospital environment. Treatment beds, white coats, blood pressure cuffs, medical charts and ultrasound transducers are a few of the items used within a hospital and Chiropractic environment that can be considered as reservoirs for pathogens.

With possible inclusion of Chiropractic within the public health sector and National Health Insurance of South Africa in the future, it is important to understand where transmission between inanimate surfaces and the chiropractor and patient are. Identification of transmission routes will allow for better cleaning of high-risk areas and prevention of pathogen transfer within Chiropractic. As hygiene practice and pathogen transmission prevention is essential in a hospital environment, identifying and preventing pathogen transfer within a Chiropractic environment is an important factor with regards to possible inclusion of Chiropractic practice in hospitals.
2.6 Chiropractic

2.6.1 The Chiropractic healthcare profession

Chiropractic is rapidly becoming a common treatment for neuromusculoskeletal conditions, and in some countries chiropractors account for a large segment of healthcare practitioners (Astin et al., 2000). Chiropractic is a health care profession that is made up of a diagnosis, treatment and the prevention of disorders of the musculoskeletal system and the effects these disorders have on general health. There is a large emphasis on the use of manual techniques, including joint manipulation, with a particular focus on joint dysfunction (Chapman-Smith, 2008). This hands-on approach between chiropractor and patient includes many techniques requiring the patient to remove certain clothing and to lie down prone or supine on the treatment bed (Evans et al., 2009(a)). Information as to if chiropractors follow proper hygiene within their private practices is lacking and is yet to be studied.

Chiropractors are registered with the Allied Health Professions Council of South Africa at the present. With its transformation and recognition as a profession providing neuromusculoskeletal services, there could be an opportunity for inclusion of the Chiropractic profession into mainstream health in the future, allowing chiropractors to not only practice privately but to also practice within a hospital (Brown, 2012). This inclusion would require chiropractors to practice proper, safe hygiene methods in order to prevent transmission of any HAI causing microorganisms to and from their practice. Hygiene practice is not a large focus among the profession even though they are required to adhere to hygiene-related codes of practice (Perdijk et al., 2017).

The most recognised method of Chiropractic treatment is joint manipulation although many other therapies are also used by chiropractors as part of their treatment. Some of these treatment options are:
• Therapeutic exercises and stretches.
• Soft tissue manual therapy e.g. Active Release Technique.
• Dry Needling.
• Muscle stimulation.
• Transcutaneous Electrical Nerve Stimulation (TENS).

This study focuses on the use of joint manipulation as a treatment protocol in order to understand the routes of transmission of microorganisms between the chiropractor, patient and treatment bed. Although the use of other treatment protocols listed above may allow for further routes of microbe transfer not being studied. In order to determine the routes of transmission of microorganisms it is important to know where microorganisms have been found in a Chiropractic environment.

2.6.2 Potential reservoirs for microorganisms

Attempts to keep treatment surfaces clean and even sterile is a common practice in outpatient surgical centres and hospitals but this has only recently become a topic of research amongst chiropractic (Evans et al., 2009(b)). There are studies that suggest that areas within the Chiropractic profession that harbour microorganisms include the Chiropractic treatment bed and the hands of the chiropractor and the patient. These studies are further described below.

2.6.2.1 Chiropractic treatment bed

The typical chiropractic bed is covered with a non-porous vinyl upholstery which offers an easy to clean surface. The facial piece of the bed is usually covered with a paper barrier. Even though these sanitary measures exist, there is still potential for horizontal transmission of bacterial pathogens via contact with these contaminated surfaces. This potential contamination is of a higher risk, when the paper barrier is only partially covering the facial piece, or if the vinyl surface is not routinely disinfected (Puhl et al., 2011). A study done by Puhl et al., (2011) sampled twenty chiropractic offices located
in Southern Alberta, Canada. The hand rests and facial pieces of the Chiropractic beds were swabbed and sampled. Their results showed that hand rests and facial pieces of the Chiropractic bed do harbour bacteria. Thirty different species of gram-positive bacteria and eight different species of gram-negative bacteria were reportedly found, with *Staphylococcus aureus* being recovered in five different clinics. Bifero *et al.*, (2006) identified the presence of bacterial and non-pathogenic environmental fungal isolates, on nine chiropractic treatment beds, in a teaching clinic at the national university health centre. The arm, face, thoracic, and abdominal parts of the bed were swabbed and analysed for potential bacterial and fungal contamination. All of the surfaces that were sampled harboured microorganisms. Even though most of these were identified as harmless skin bacteria and environmental fungi, there is a significant concern as some of the surfaces were found to carry *Staphylococcus aureus* and the Methicillin-resistant strain of the bacteria.

Studies done by Perdijk *et al.*, (2017) at the University of Johannesburg Chiropractic Clinic, again found both bacterial and fungal pathogens on the headrests, face, and thoraco-lumbar pieces of the treatment beds. In their study the thoraco-lumbar piece was found to have the highest average bacterial count. Kruger *et al.*, (2017) found in the same clinic that there is no observable reduction in the number of bacteria, over a six-hour period, if no intervention protocol is applied to the beds. The above studies show that Chiropractic beds do act as reservoirs for microorganisms, some being pathogenic and others not, and that these microorganisms are found on all pieces of the bed. It is then possible that contact between any part of the bed and the patient or practitioner can be a route for microorganism transfer.

**2.6.2.2 Practitioners and patient’s hands**

As discussed earlier, the human skin (especially the hands) is known to harbour microorganisms (Brooks *et al.*, 2010; Creamer *et al.*, 2010). Evidence to show that the hands of chiropractors, specifically, harbour
pathogenic microorganisms is limited. However, studies done at the University of Johannesburg Chiropractic Clinic, showed the presence of bacterial and fungal species, *Staphylococcus epidermis*, *Vibrio cholerae/Vibrio fluvialis* and *Proteus mirabilis* on their hands (Wyer et al., 2017). Another study done by Eves et al., (2017) showed the presence and the change in microbiota of Chiropractic student’s hands during the treatment of three patients. Bacteria such as *Leuconostoc mesenteroides ssp cremoris*, *Staphylococcus warneri*, and *Staphylococcus epidermidis* were found on the student’s hands. These studies therefore show that practitioner’s hands are potential reservoirs for microorganisms, and that contact between practitioner and patient could be a possible route of transmission between practitioner and patient.

2.6.3 Chiropractic related to the “Five Moments of Hand Hygiene”

Due to the nature of chiropractic treatment, this study will be able to relate any potential moments of microorganism transmission to the WHOs model, as the moments of transmission between the chiropractor, the patient, and the treatment table have not yet been described or studied. Therefore, a model similar to the WHOs “Five Moments” could be developed, more specifically for Chiropractic, once the routes of transmission within the Chiropractic environment are studied. It is important to identify these routes in order to improve hygiene practice of chiropractors, especially since inclusion into hospitals in the future may be considered.

In order to study the routes of transmission to be able to describe these moments, a surrogate must be selected. This is necessary to visualise the transmission, as the use of actual microorganisms for the study would be unethical due to the potential that they may cause infection.

2.7 Microbial surrogates to study microbial transfer

The term surrogate is defined by Sinclair et al., (2012) as “an organism, particle or substance used to study the fate of a pathogen in a specific
environment. Pathogenic organisms, non-pathogenic organisms, and innocuous particles have been used as surrogates for a variety of purposes. The goal of selecting the most suitable surrogate is to improve public health, while limiting any unnecessary health risk towards any individual.” With regards to showing routes of transmission of microorganisms it is important to take into account the safety of the participants taking part in the study. The use of a fluorescent cream has the potential to illustrate transfer that is due to direct and indirect contact, without the need for actual microorganism transfer. This study aims to show the possible routes of transmission without being specific to any microorganism and so actual use of bacterial and fungal cultures to show the transmission is not necessary.

2.7.1 Simulation techniques

Simulation techniques have been identified as being effective as an educational method that improves the competence of health care personnel (Secomb et al., 2012). Simulation techniques have often been used in the healthcare system to bridge the gap between the importance of hygiene policies and the need for them to be implemented properly in order to protect patient safety (Jones et al., 2014). Fluorescent-based simulation methods have been used in various other studies examining medical students (Mittal et al., 2011), nursing students (Gantt and Webb-Corbett, 2010), and healthcare workers (Macdonald et al., 2006) on their adherence and correctness with regards to hand and medical equipment cleanliness. A similar study to the ones mentioned above, done at the National Taiwan University Hospital, evaluated the thoroughness of hand hygiene practice, using a simulation method in which healthcare workers rubbed their hands with a fluorescent substance, washed with water, and place their hands under an ultraviolet detector to identify any areas missed. The above studies show that by using a fluorescent substance as a surrogate for pathogens, a stress-free “seeing is believing” simulation program can be successfully used in order to improve hand hygiene education (Pan et al., 2014).
GlitterBug™ is a transparent gel which is not seen under natural light but can is easily seen glowing under black lights which emit long-wave UVA radiation and little visible light in order to observe fluorescence. A simulation study done by Pope et al., (2014) applied GlitterBug™ to a patient rooms surfaces, medical equipment, door handles, patient belongings and a manikin representing a young male patient with Cystic Fibrosis. The GlitterBug™ was used to visualise the contaminated surfaces. Students were then required to enter the room, with the appropriate gowns, gloves and masks in place, and were required to place the oxygen mask on the patient who had stated he was having trouble with breathing. Once the simulation was completed the lights in the room were turned off and black lights were used to identify contamination of the patient setting and transfer of any contaminants to the participating students’ clothing, skin, hair.

The use of GlitterBug™ as a surrogate for microorganisms during simulation techniques as learning experiences, can be useful in education in both academia and in practice. An isolation simulation scenario like the one above was able to help students visualise their patient’s setting and the potential negative effects of not performing proper infection control techniques (Boyce, 2008; Karkada et al., 2011).

2.7.2 Glo-Germ™ as a surrogate for microorganisms

As discussed earlier, microbial contamination has the potential to harm an individual with infection. Therefore, it would be unethical to apply a contaminated substance to the skin to record any possible transmission. Glo-Germ™ is a fluorescent based liquid, similar to GlitterBug™, which when applied to the skin is not visible under natural light but is visible under a black light emitting UVA radiation. As the fluorescent liquid can be transferred to another surface via physical contact and then again detected by black light, it is an ideal surrogate to demonstrate transfer from an individual to a second individual or surface. Glo-Germ™ has been used in previous studies as a surrogate and Table 2.4 includes studies showing how
Glo-Germ™ and other similar fluorescent agents can be a reliable surrogate to detect potential pathogen transfer.

Glo-Germ™ as discussed above has shown transmissible qualities between many different types of surfaces. The product has also proven to be detectable under black light once transfer between two surfaces occurred. It has also been found that the Glo-Germ™ product has particles which are the same size as microbes (0.5 to 4.0 µm in diameter) (Schirmer et al., 2018). Glo-Germ™ can therefore be used to effectively imitate the transfer that a bacterial species may exhibit.

2.8 Concluding thought

Understanding pathogen transmission routes may not always be obvious, especially since we are dealing with organisms that cannot be seen with the naked eye. This could have an impact on the hygiene behaviour of chiropractors and supported the need for a more visual representation to illustrate the possible routes for transmission of pathogens. As inadequate and poor compliance to hand and bed cleaning methods within the chiropractic clinic is still an issue (Blundell et al., 2018; Bowes et al., 2018), this study is able to use Glo-Germ™ as a surrogate in order to show those routes of transmission specifically between the chiropractor, patient and treatment bed.
Table 2.5  Studies using Glo-Germ™ as a surrogate for microorganism transfer

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>This particular study aimed to track contamination pathways through a mock retail deli market using an abiotic surrogate (Glo-Germ™).</td>
<td>Maitland et al., 2013</td>
</tr>
<tr>
<td>Glo-Germ™ in this study was used to simulate bodily fluid contamination. Glo-Germ™ powder was used to simulate Ebola Virus contamination of a mannequin.</td>
<td>Bell et al., 2015</td>
</tr>
<tr>
<td>The study made use of Glo-Germ™ during preliminary testing to identify the areas to be swabbed for bacteria on restaurant menus. This was done in order to test the rate of transfer from the menus to the consumers and to determine the survival rate of bacteria on the menus surface.</td>
<td>Alsallay et al., 2015</td>
</tr>
<tr>
<td>The objective of this study was to show that a simulated emergency department, with mannequins, using an ultraviolet tracer to represent a virus spread by bodily fluids (similar to Ebola Virus) can be an effective way to demonstrate transmission of disease in a multi-patient and multi-room setting.</td>
<td>Drew et al., 2016</td>
</tr>
<tr>
<td>A study on fifty healthcare workers used Glo-Germ™ to compare the environment and body contamination from two different personal protective equipment removal methods.</td>
<td>Guo et al., 2014</td>
</tr>
<tr>
<td>This study aimed to show the transfer of <em>Listeria monocytogenes</em> from surface-inoculated cooked ham to a slicing machines surfaces and vice versa from a contaminated slicer to clean ham. In order to identify slicing areas that came into contact with the cooked ham, Glo-Germ™ was used to identify where the contaminated areas were.</td>
<td>Chaitiemwong et al., 2014</td>
</tr>
<tr>
<td>This study shows the possible transfer and spread of <em>Escherichia coli</em> O157:H7 from leafy greens to equipment surfaces during simulated small-scale commercial processing. Glo-Germ™ was used to identify areas on the production line that were tested for the bacterial presence.</td>
<td>Buchholz et al., 2012</td>
</tr>
<tr>
<td>Glo-Germ™ was used to demonstrate any difference in the wettability of hands of two different time intervals. The Glo-Germ™ application was seen as an effective way to train hand hygiene techniques for the employees.</td>
<td>Paula et al., 2018</td>
</tr>
<tr>
<td>Glo-Germ™ was used to compare the efficacy between handwashing with a gel-based or foam-based soap. No difference was observed in efficacy between remaining soap nor in the time it took to hand wash or rinse. Glo-Germ™ was however effective in representing bacterial-like contamination of the hands in order to test the efficacy of hand washing.</td>
<td>Conover and Gibson, 2017</td>
</tr>
</tbody>
</table>
CHAPTER 3 – METHODOLOGY

3.1 Introduction

This chapter presents the description of the research process. It provides information concerning the method that was used in undertaking this research. The chapter also describes the various stages of the research, which includes the selection of participants, the equipment and Chiropractic manipulations used, the data collection process and the process of data analysis.

3.2 Study design

This was a qualitative type of descriptive study, exploring the possible transmission routes of microbial pathogens by making use of a visual tool, i.e. Glo-Germ™ that fluoresces when exposed to long-wave UVA radiation emitted by black lights.

3.3 Population and sampling

The “participants” in this study included the researcher, representing the “chiropractor/chiropractic student intern” and one other participant representing the “patient.” Simple random sampling was utilized to recruit the “patient,” whom was recruited by inviting fellow classmates at the Chiropractic Department at the University of Johannesburg until one agreed to participate in the study. The selection of the participant was based on the response time of the participants, as only one participant was needed for the study, the participant that responded first and met the inclusion criteria was selected. An information letter (Appendix A) was given to the participant and an explanation was provided on what the research entailed, how the research would be performed and what would be expected. Both the researcher and “patient” were required to sign the consent forms (Appendix B and C).
3.3.1 Inclusion criteria

Due to the nature of the study, and the proposed products produced following the study, only participants comfortable with the following were considered:

- Comfortable with being recorded during the manipulation while only wearing shorts, since the Glo-Germ™ needed to be applied to the possible contact areas during manipulation.
- Due to the previous requirement, preference was given to male participants.
- Patient participant was required to not have any contra-indications to chiropractic manipulation even though mock manipulations in the form of manipulation set-ups were used in the study eg. Vertebrobasilar Insufficiency. This was to protect the patient from any side effects that can be caused by the set-up of the mock manipulations.
- Patient participant and chiropractic student intern were required to not have any skin irritation related to the Glo-Germ™ product. This was tested by application of the product on a small part of the inner forearm, and then visually monitoring any irritation that may have developed in the area over the next week.

3.4 Materials and Chiropractic manipulations

3.4.1 Glo-Germ™ product

A white Glo-Germ™ lotion based cream was selected as the product that was used as a microbial surrogate in this study (Figure 3.1a). It was chosen as a surrogate based on its pricing, availability and past reliability with regards to previous studies mentioned in Chapter 2.

3.4.2 Black lights

Two Chauvet COREpar black lights were used for the study (Figure 3.1b). These lights were used to identify any Glo-Germ™ that had transferred.
They were both placed on stands two metres off the floor and were aimed at the treatment bed during the experiments.

Figure 3.1 The a) Glo-Germ™ and b) black light products used in the study

3.4.3 Cameras

The two cameras used during the study were a Canon7D Mark ii, Canon 5D Mark iii. All of the material was recorded with normal settings (TV and P video). All of the videos used were edited on Final Cut Pro (edited on a 2010 IMac 27-inch computer). All pictures were converted into JPEG format from the videos.

3.4.4 Manipulations used during the experiments

The manipulations used for the experiments were the set-ups of: a right and left cervical break manipulation at the vertebral level of cervical vertebra three, three set-ups of a phalangeo-metacarpal manipulation at the vertebral levels of the thoracic vertebrae four, seven, and ten, and a right and left set-up of a thigh-transverso-deltoid manipulation at the vertebral level of lumbar vertebra five. A description of the set-up positioning for these Chiropractic manipulation’s is given below.
Cervical Break

- Patient position: Supine lying with the head piece of the bed in the neutral position. The patients head is rotated to approximately 45 degrees to the contralateral side.
- Doctor position: Standing on the homo-lateral side to the listing, in a square stance, at right angles to the patient.
- Contact hand: Caudal hand, with an index contact on the articular pillar of the involved vertebra. Forearm is positioned parallel to the floor.
- Indifferent hand: Cephalad hand, with the palm cupping the ear and index and middle finger split over the sternocleidomastoid muscle. This induces lateral flexion and only slight rotation of the patient's head as well as cephalad traction.
- Repeated on both sides (Craig and Moodley, 2012).

Phalangeo-Metacarpal

- Patient position: Lying prone with the headpiece slightly lowered.
- Doctor position: Standing on the right-hand side of the bed in a fencer’s stance facing cephalad.
- Contact hand: Right phalangeo-metacarpal contact on the right transverse process of the involved segment. The fifth digit is extended and parallel to the spine, with the rest of the fingers interlaced.
- Indifferent hand: Left phalangeo-metacarpal contact on the left transverse process of the involved segment. The fifth digit is extended and parallel to the spine, with the rest of the fingers interlaced (Craig and Moodley, 2012).

Thigh-Transverso-Deltoid

- Patient position: Lying in the lateral recumbent position with the lesion side uppermost. The pelvis is positioned close to the edge of the bed with the dorsum of the foot of the uppermost leg placed in the popliteal
fossa of the lower limb which is kept straight. The arms are placed so as to balance the patient.

- Doctor position: Grasp patients knee between thighs and when correct amount of hip flexion is achieved, the doctor then turns into fencer stance and adducts the patients leg.

- Contact hand: Caudal hand, with a pisiform contact with a chiropractic arch is taken on the involved mammillary process. Fingers are parallel to the spine and do not cross it. The forearm is perpendicular to the contact hand.

- Indifferent hand: Cephalad hand contacts the upper shoulder and provides cephalad traction.

- Repeated on both sides (Craig and Moodley, 2012).

With Chiropractic being taught in many educational institutions worldwide, the Chiropractic manipulation techniques and philosophies that are taught certainly differ across these institutions. The Chiropractic manipulation techniques that were chosen for this study are not necessarily practiced by all chiropractors and therefore routes of transmission may differ for chiropractors that use other manipulation techniques. The set-up of the Chiropractic manipulations in this study were done according to specific contact points that are taught at the University of Johannesburg.

### 3.5 Ethical considerations

Approval for this study was obtained from the Higher Degrees Committee (Appendix D) and Research Ethics Committee (Appendix E) of the Faculty of Health Sciences, University of Johannesburg.

The “participants” in this study included the researcher, representing the “chiropractor,” and one other participant representing the “patient.” The participant that agreed to partake in this study was requested to read the information form (Appendix A) and sign the consent forms to participate in the study (Appendix B) and to be video recorded (Appendix C). Any risks,
benefits and discomforts pertaining to the treatments involved were also explained and it was explained that the participant’s safety would be ensured (prevention of harm). The information and consent form also explained that the participant’s personal information would not be shared or publicised in any accredited educational journals that arose from this study. The participant was informed that their participation was on a voluntary basis and that they were free to withdraw from the study at any stage. Should the participant have any further questions, these would be explained by the researcher; whose contact details were made available. The participant was informed that no invasive procedures would be performed and that post treatment stiffness or soreness from the spinal manipulation set-ups could be a normal response and may be present for a few days.

3.6 Study procedure of illustrating Glo-Germ™ ‘pathogen’ transfer

A private room situated in the Chiropractic Clinic at the University of Johannesburg was booked for the duration of the project. The room had a window which was covered with a black-out curtain. Two black lights (as seen in section 3.3.2) were setup on either corner of the back of the room, they were both facing the chiropractic bed on the opposite side of the room. Two cameras for video recording and photographic purposes were also setup in front of the ultraviolet lights. The treatment room was setup as shown in Figure 3.2. Chiropractors do on occasion treat patients with a T-shirt on, when using various manipulations, although the manipulation set-ups selected for use in this study require the patient to remove the T-shirt for the treatment.
Figure 3.2 Layout of Chiropractic treatment room used for the study, showing placement of the black lights (BL), Video cameras (VC) and the bed.

With the normal room lighting on, the Glo-Germ™ cream was first applied to the hands of the practitioner as shown in (Appendix F).

The chiropractor then greeted the patient with a handshake and the patient was asked to then lie down on the treatment bed in a supine position. A series of Chiropractic manipulation set-ups were used by the chiropractor as a treatment protocol on the patient, with the normal room lights staying on. A manipulation set-up was used but the manipulations were not completed with a high velocity thrust. The set-up of the manipulations and the completed manipulation with a high velocity thrust delivered use the same contact points, therefore the use of just a set-up of the manipulations was sufficient to show possible transmission routes. These manipulation set-ups used are further described in section 3.5.1. The cervical manipulation set-up was first done on the one side and then repeated on the other side. The patient was then asked to turn over and lie prone on the bed for the setup of the thoracic manipulations. The patient was then asked to turn over and lie supine once again in order to setup the lumbar manipulations. This manipulation set-up was also done on both sides. Data
will be explained in terms of the transmission routes illustrated in (Figure 3.3) between the chiropractor, patient and the treatment bed.

![Diagram of potential routes for transmission](image)

**Figure 3.3** The potential routes for transmission being studied

After the treatment the patient and practitioner stood in front of the bed and the lights were turned off. The black lights were turned on and any areas where the fluorescent cream was visible on the practitioner were recorded on a template (Figure 3.4). The transfer of fluorescent cream to the patient was recorded on the template, followed by the recording of any fluorescent cream transfer to the bed being recorded on the template. Photos and videos were also taken of the practitioner, patient and treatment bed at this point. Once all of the data had been recorded the Glo-Germ™ cream was cleaned from the practitioner, patient and the treatment bed.
The same process was repeated in the same steps for the rest of the applications shown in (Appendix F). The data of the transfer of Glo-Germ™ from the patients neck and face, front, back, and treatment bed was recorded in the same way as in the first experiment (Appendix G). This concluded all of the first application experiments. This process was repeated two more times in order to get a total of three experiments for each type of Glo-Germ™ application (Appendix G).

3.7 Data analysis

The data recorded on the templates during the experiments, were compared to the photos and videos taken during the experiments. The results were then transferred onto a grid (Appendix H) (see example shown in Figure 3.5). The grids show the areas where Glo-Germ™ was transferred during the experiment, as well as the amount of Glo-Germ™ that was transferred. The amount of Glo-Germ™ transfer was given a grading, developed by the researcher, and corresponding colour, which are further described in Table 3.1.
Table 3.1   Grading used to illustrate and define the transfer of the Glo-Germ™

<table>
<thead>
<tr>
<th>Transfer Grading</th>
<th>Colour</th>
<th>Example</th>
<th>Definition</th>
</tr>
</thead>
</table>
| 0/4              | Blank  | ![Image](image1.png) | No evidence of contamination  
0% Glo-Germ™ visible in corresponding area  
No evidence of Glo-Germ™ transfer |
| 1/4              | Blue   | ![Image](image2.png) | Minimal contamination  
1%-20% Glo-Germ™ visible in corresponding area  
Underlying skin is completely visible  
Area has minimal speckled coverage of Glo-Germ™ |
<table>
<thead>
<tr>
<th>Grade</th>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/4</td>
<td>Green</td>
<td>Moderate contamination. 40%-59% Glo-Germ™ visible in corresponding area. Underlying skin is largely visible. Area has large parts with a speckled coverage of Glo-Germ™.</td>
</tr>
<tr>
<td>3/4</td>
<td>Orange</td>
<td>Severe contamination. 60%-79% Glo-Germ™ visible in corresponding area. Underlying skin is visible. Area has large parts with a continuous coverage of Glo-Germ™, as well as parts with a speckled coverage.</td>
</tr>
<tr>
<td>Grading</td>
<td>Total contamination</td>
<td>Underlying skin</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>4/4 Red</td>
<td>80%-100% Glo-Germ™ visible in corresponding area</td>
<td>Underlying skin is largely not visible</td>
</tr>
</tbody>
</table>
Figure 3.5  Example of the grid used to record the Glo-Germ™ transfer

Once this was completed for each experiment application, three experiments that were from the same application type, e.g. Experiment one, two and three of the face and neck application, were analysed to form a heat map which revealed the risk of contamination based on all three experiments. An area that was recorded as having any grading of Glo-Germ™ transfer in one out of the three experiments was recorded as a yellow colour (mild risk for transfer). An area that was recorded as having any grading of Glo-Germ™ transfer in two out of the three experiments was recorded as an orange colour (moderate risk for transfer). An area that was recorded as having any grading of Glo-Germ™ transfer in three out of the three experiments was recorded as a red colour (high risk for transfer). An
example of how this data was transferred onto the heat map is shown in (see example shown in Figure 3.6).

**Figure 3.6** Example of a heat map (Patient heat map from application of Glo-Germ™ to practitioner’s hands)

### 3.8 Limitations of the study method

This study includes only three types of manipulation technique and therefore doesn’t represent the entire treatment protocol that can be used by a chiropractor. The other types of manipulation techniques may give different findings with regards to the transfer of Glo-Germ™ between surfaces as the points of contact will differ amongst different techniques.
3.9 Conclusion

This chapter outlined how the research was conducted, illustrating the process used to select the participants, the method used to collect data as well as the approach that was used in analysing the texts. The next chapter describes the findings of the research.
CHAPTER 4 – RESULTS

4.1 Introduction

This chapter provides the findings, analysis and observations based on the data collected by the researcher, to better understand the possible microbial contamination routes in a Chiropractic clinic between the chiropractor, patient and the treatment bed.

The definitions that will be used are provided below as a quick reference guide for the reader (Text box 4.1).

Text box 4.1 Definitions used throughout chapter 4

<table>
<thead>
<tr>
<th>Definitions:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimal transfer</strong></td>
</tr>
<tr>
<td>Area has minimal speckled coverage of Glo-Germ™.</td>
</tr>
<tr>
<td><strong>Moderate transfer</strong></td>
</tr>
<tr>
<td>Area has large parts with a speckled coverage of Glo-Germ™.</td>
</tr>
<tr>
<td><strong>Severe transfer</strong></td>
</tr>
<tr>
<td>Area has large parts with a continuous coverage of Glo-Germ™, as well as parts with a speckled coverage.</td>
</tr>
<tr>
<td><strong>Total transfer</strong></td>
</tr>
<tr>
<td>Area is completely covered with a continuous layer of Glo-Germ™.</td>
</tr>
<tr>
<td><strong>Mild risk</strong></td>
</tr>
<tr>
<td>An area where any grading of Glo-Germ™ transfer was recorded during one of the three experiments.</td>
</tr>
<tr>
<td><strong>Moderate risk</strong></td>
</tr>
<tr>
<td>An area where any grading of Glo-Germ™ transfer was recorded during two of the three experiments.</td>
</tr>
<tr>
<td><strong>High risk</strong></td>
</tr>
<tr>
<td>An area where any grading of Glo-Germ™ transfer was recorded on all three of the three experiments.</td>
</tr>
<tr>
<td><strong>Patient front</strong></td>
</tr>
<tr>
<td>Chest and abdomen only.</td>
</tr>
<tr>
<td><strong>Patient back</strong></td>
</tr>
<tr>
<td>Upper and lower back of the patient including the back of the neck.</td>
</tr>
</tbody>
</table>

4.2 Data analysis

4.2.1 Application of Glo-Germ™ to the practitioner’s hands

This section describes the results seen over the three experiments where the Glo-Germ™ was applied to the practitioner’s hands. The results in this
section describe transfer of the Glo-Germ™ from the practitioner’s hands to the patient and to the treatment bed. These results are summarised in a summary/heat map, which was created based on the results obtained from the three repeats for this experiment (Figure 4.1).

A heat map based on three experiments showing the transfer of Glo-Germ™, when applied to the practitioner’s hands, from a) the practitioner to b) the patient and c) the treatment bed. Red indicates an area of high risk for transfer, orange indicates an area of moderate risk for transfer and yellow indicates an area of mild risk for transfer.

The interactions which allowed for potential routes of transfer of Glo-Germ™ between the practitioner, patient and the treatment bed in this study were the initial greeting (handshake), the set-ups of the cervical, thoracic and lumbar manipulations. Figure 4.2 illustrates the areas where transfer was seen and at what point during the treatment transfer occurred, across the three experiments, from the practitioner to the patient and treatment bed.
Figure 4.2 Transfer routes between a) the practitioner and the patient during a cervical manipulation set-up, b) the practitioner and the treatment bed during all manipulation set-ups and c) the practitioner and the patient during the initial greeting, thoracic and lumbar manipulation set-ups, when Glo-GermTM was applied to the practitioner’s hands.
The results showed that there was severe transfer from the chiropractor’s hands to the patient’s neck, jaw, ear and side of the head on the right and left sides across all three repeats of this experiment. This indicates that it was an area for high risk and high transfer between practitioner and patient (Figure 4.1). Transfer here was due to the contact between the practitioner’s hands and the patient’s head, face and neck during the set-up of the cervical manipulations (Figure 4.2).

The patients right hand was an area of high risk and an area of severe transfer for all three repeats of this experiment (Figure 4.1). This transfer was seen during the handshake of the practitioner and the patient during the initial greeting (Figure 4.2). The results also showed that the patient’s back was a high risk area, as transfer to the patient’s back was seen on all three experiments and was seen to have transfer graded as either moderate or severe on all of the experiments (Figure 4.1).

An area of total transfer was seen during only the first repeat, to the patient’s left forearm (Figure 4.1). The transfer to the patient’s back and forearm described above and to the rest of the patient’s body was either from direct contact with the practitioner’s hands during the manipulation set-ups or via the patient’s own hand to their body, once placed in the manipulation set-up position (Figure 4.2).

Grading of the transfer to the inner aspect of the middle third of the left and right head pieces ranged from minimal to severe transfer, with transfer seen on all three repeats of this experiment making the head piece a high risk area for transfer (Figure 4.1). The transfer recorded on the head piece was due to the contact of the practitioner’s hands with the head piece as well as the contact between the patient’s neck and head and the bed once the set-ups of the cervical manipulations were complete (Figure 4.2).

The transfer to the thoracic piece was from contact between the patient’s back and the bed post set-up of the thoracic manipulations (Figure 4.2). Areas of minimal to severe transfer were seen over the upper half of the
thoracic piece just right of the midline, and the lower third of the thoracic piece, left to the midline. Transfer to these areas of the thoracic piece was seen on all repeats of this experiment showing that the thoracic piece is also high risk area for transfer from the practitioner (Figure 4.1).

From these results the study was able to illustrate the possible routes of transmission, observed in this study, between the practitioner, patient and treatment bed when Glo-Germ™ was applied to the practitioner’s hands (Figure 4.3). With regards to the WHO’s ‘Five Moments of Hand Hygiene’ model, the moments that are applicable to the transfer routes seen here would include i) before touching a patient and ii) before a clean/aseptic procedure, as there is a risk of transfer seen from the practitioner to the patient and the treatment bed.

![Figure 4.3](image)

Figure 4.3 Routes of transmission post application of Glo-Germ™ to practitioner’s hands

4.2.2 Application of Glo-Germ™ to the patient’s neck and face

This section describes the results seen over the three repeats of this experiment where the Glo-Germ™ was applied to the patient's neck and face. The results in this section describe transfer of Glo-Germ™ from the
patient’s face and neck to the practitioner and to the treatment bed. These results are based on a summary/heat map, which was created based on the three repeats for this type of application (Figure 4.4).

![Figure 4.4](image)

**Figure 4.4** A heat map based on three repeats of this experiment showing the transfer of Glo-Germ™, when applied to the patient’s neck and face, from a) the patient to b) the practitioner and c) the treatment bed. Red indicates an area of high risk for transfer, orange indicates an area of moderate risk for transfer and yellow indicates an area of mild risk for transfer.

High risk, with a grading of severe transfer was recorded on the practitioners left and right hands, seen on all three repeats of this experiment (Figure 4.4). The transfer recorded on the practitioner’s hands was due to contact between the patient’s neck and the practitioner’s hands during the set-up of the cervical manipulations (Figure 4.5).
Figure 4.5  Transfer routes between a) the patient and the practitioner, b) the patient and the treatment bed, when Glo-Germ™ was applied to the patient's neck and face

A small area of severe transfer was noted on the third repeat to the back of the patient's head (Figure 4.4). The transfer to the back of the patient’s head was from contact with the head piece of the bed when the patient was supine lying during the set-up of the lumbar manipulations (Figure 4.5). Moderate risk of transfer was recorded over the lower back of the patient (Figure 4.4), this transfer was from contact between the patient and the
practitioner’s now contaminated hands during the set-ups of the lumbar manipulations (Figure 4.5).

The transfer to the head pieces was between the head pieces and the position of the patient’s face during the set-up of the thoracic manipulations. The transfer lower down on the head pieces was from contact with the practitioner’s hands during the set-up of the cervical manipulations (Figure 4.5).

Figure 4.6 summarises the routes of transmission observed between the practitioner, patient and treatment bed when Glo-Germ™ was applied to the patient’s neck and face. With regards to the WHO’s ‘Five Moments of Hand Hygiene’ model, the moments that are applicable to the transfer routes seen here would include i) before a clean/aseptic procedure and ii) after touching a patient as there is a risk of transfer to the practitioner and the treatment bed seen after contact with the patient.

**Figure 4.6** Routes of transmission post application of Glo-Germ™ to patient’s neck and face
4.2.3 Application of Glo-Germ™ to the patient’s front

This section describes the results seen over the three repeats of this experiment where the Glo-Germ™ was applied to the patient’s front chest and abdomen. The results in this section describe transfer of Glo-Germ™ from the patient’s front to the practitioner and to the treatment bed. These results are based on a summary/heat map, which was created based on the three repeats for this type of application (Figure 4.7).

![Heat map image]

**Figure 4.7** A heat map based on three repeats of this experiment showing the transfer of Glo-Germ™, when applied to the patient’s front, from a) the patient to b) the practitioner and c) the treatment bed. Red indicates an area of high risk for transfer, orange indicates an area of moderate risk for transfer and yellow indicates an area of mild risk for transfer.
Moderate transfer to the practitioner’s left and right hands was recorded on all three experiments. Although the transfer to the practitioner’s hand’s was only a moderate grading, the fact that transfer was seen on all three experiments indicates that it is an area of high risk for microorganism transfer between the patient and the practitioner (Figure 4.7). This transfer was due to the contact between the practitioner’s hands and the patient’s chest during the set-ups of the lumbar manipulations (Figure 4.8).

Figure 4.8  Transfer routes between a) the patient and the practitioner, b) the patient and the treatment bed, when Glo-Germ™ was applied to the patient’s front.
High risk of transfer was seen over the patient’s right hand and moderate risk to the left hand, with total transfer to the right hand for all three of the experiments and total transfer to the left hand seen on two of the experiments (Figure 4.7). The transfer to the hands of the patient was due to contact with the patient’s hands on the patient’s chest during the set-ups of the lumbar manipulations (Figure 4.8). The patients back showed a large area of contamination when looking over all three experiments, with severe transfer of Glo-Germ™ on repeat three (Figure 4.7). The transfer to the back in this section of experiments is important as it was caused by contact between the patient’s front and the treatment bed when the patient turned prone for the thoracic manipulations and then the contact between the back and the treatment bed when the patient was required to turn into a supine position after the set-ups of the thoracic manipulations were completed (Figure 4.8).

The bottom inside corners of the left and right head pieces as well as large areas of the thoracic pieces of the bed both had recorded transfer on them during all three experiments. The transfer was graded as being moderate to severe transfer across the three repeats of this experiment (Figure 4.7). Transfer to the treatment bed head pieces and the thoracic piece was due to contact with the patient’s front, when the patient was required to lie prone for the set-up of the thoracic manipulations (Figure 4.8).

Figure 4.9 summarises the routes of transmission, observed between the practitioner, patient and treatment bed when Glo-Germ™ was applied to the patient’s front. With regards to the WHO’s ‘Five Moments of Hand Hygiene’ model, the moments that are applicable to the transfer routes seen here would include i) before a clean/aseptic procedure and ii) after touching a patient as there is a risk of transfer to the practitioner and the treatment bed seen after contact with the patient.
4.2.4 Application of Glo-Germ™ to the patient’s back

This section describes the results seen over the three repeats of this experiment where the Glo-Germ™ was applied to the patient’s back. The results in this section describe transfer of Glo-Germ™ from the patient’s back to the practitioner and to the treatment bed. These results are based on a summary/heat map, which was created based on the three repeats for this type of application (Figure 4.10).

Severe transfer to both of the practitioner’s hands was recorded during all three of the experiments and was therefore considered as an area of high risk for transfer (Figure 4.10). The transfer to the practitioners hands was due to contact between the practitioners hands and the patient’s back during the set-ups of the thoracic manipulations (Figure 4.11).
Figure 4.10 A heat map based on three repeats of this experiment showing the transfer of Glo-Germ™, when applied to the patient’s back, from a) the patient to b) the practitioner and c) the treatment bed. Red indicates an area of high risk for transfer, orange indicates an area of moderate risk for transfer and yellow indicates an area of mild risk for transfer.

The patient had a large area of severe transfer surrounded by areas of moderate transfer to the chest and abdomen on all three experiments, making these areas a high risk for transfer (Figure 4.10). The transfer to the patients chest and abdomen was due to the patient having to lie prone for the set-ups of the thoracic manipulations, after the set-ups of the cervical manipulations were completed. The transfer from the patient’s back to the treatment bed was then transferred to the patient’s chest and abdomen (Figure 4.11). The back of the patient’s forearms were recorded as a high risk area, as moderate to total transfer was seen over the three repeats of
this experiment (Figure 4.10). The transfer was caused by contact of the patient’s forearms with the treatment bed when required to turn over for the set-ups of the thoracic manipulations (Figure 4.11). Transfer was seen near either one or both of the arm pits during the three experiments, this transfer was graded as being either moderate or severe (Figure 4.10).

![Diagram](image)

**Figure 4.11** Transfer routes between a) the patient and the practitioner, b) the patient and the treatment bed, when Glo-Germ™ was applied to the patient’s back.
Transfer to the bed was recorded as being severe and of high risk to the bottom inside corners and slightly above on the right and left head pieces. Transfer was also found as being severe to the majority of the thoracic piece of the bed on all three experiments (Figure 4.10). The transfer to the treatment bed resembled the transfer to the bed where the Glo-Germ™ was applied to the patient’s chest and abdomen in section 4.2.3. This transfer was due to the contact between the patient’s back and the treatment bed when lying in a supine position for the set-up of the cervical manipulations (Figure 4.11). The position of the patient for these manipulations allows for contact between the upper part of the patient’s back and the head pieces of the bed, which explains how the head pieces were involved.

Figure 4.12 summarises the routes of transmission observed between the practitioner, patient and treatment bed when Glo-Germ™ was applied to the patient’s back.

![Diagram showing routes of transmission](image)

**Figure 4.12** Routes of transmission post application of Glo-Germ™ to patient’s back

With regards to the WHO’s ‘Five Moments of Hand Hygiene’ model, the moments that are applicable to the transfer routes seen here are the same...
as those mentioned for section 4.2.3, as the same routes of transmission were seen during these experiments as was seen when the Glo-Germ™ was applied to the patient’s chest and abdomen.

4.2.5 Application of Glo-Germ™ to the treatment bed

This section describes the results seen over the three repeats of this experiment where the Glo-Germ™ was applied to the treatment bed. The results in this section describe transfer of Glo-Germ™ from the treatment bed to the practitioner and to the patient. These results are based on a summary/heat map, which was created based on the three repeats for this type of application (Figure 4.13).

Moderate transfer of Glo-Germ™ was seen to the practitioner’s hands on all three repeats of this experiment, thus the practitioner’s hands are an area for high risk of transfer (Figure 4.13). The transfer to the practitioner’s hands was from contact with the patient’s back during the set-up of the thoracic manipulations which, was contaminated due to contact between the patient’s back and the treatment bed. Contamination of the practitioner’s hands was also due to contact between the practitioner’s hands and the head pieces of the bed during the set-ups of the cervical manipulations (Figure 4.14). Transfer seen over the practitioner’s legs, forearm and abdomen during any of the three experiments was graded as being minimal to moderate and was not consistent over the three experiments (Figure 4.13), but was caused by contact between the practitioner and the patient’s thighs and the treatment bed during the set ups of the lumbar manipulations (Figure 4.14).

Areas of severe transfer over the patients eyes and cheeks, back, hands, front of the hips, buttocks and abdomen were seen on all three of the experiments. These areas are high risk areas for transfer between the patient and the treatment bed (Figure 4.13). This transfer occurred due to the contact of the patient with the head, thoracic and lumbar pieces of the
bed when the patient is lying down, either prone or supine, receiving treatment (Figure 4.14).

\[ \text{Figure 4.13} \quad \text{A heat map based on three repeats of this experiment showing the transfer of Glo-Germ™, when applied to the treatment bed, from c) the treatment bed to a) the patient and b) the practitioner. Red indicates an area of high risk for transfer, orange indicates an area of moderate risk for transfer and yellow indicates an area of mild risk for transfer.} \]

The area surrounding the patient’s armpit had a range of minimal to severe transfer to the area. Transfer from this range was seen during all three of the experiments (Figure 4.13), this transfer was between the patient and the bed and was due to contact with the patients prone and supine lying position during the set-ups of the manipulations (Figure 4.14).
Figure 4.14  Transfer routes between the treatment bed and a) the practitioner during the set-ups of the thoracic and lumbar manipulations, b) the patient during the set-ups of the thoracic and lumbar manipulations and c) the treatment bed and the patient during a set-up of a cervical manipulation, when Glo-Germ™ was applied to the treatment bed.
Figure 4.15 summarises the routes of transmission observed between the practitioner, patient and treatment bed when Glo-Germ™ was applied to the treatment bed. With regards to the WHO’s ‘Five Moments of Hand Hygiene’ model, the moments that are applicable to the transfer routes seen here would include i) after touching patient surroundings and ii) after touching a patient as there is a risk of transfer to the practitioner and the patient seen after contact with the treatment bed with further possible transfer from the patient to the practitioner. The transfer demonstrated here could be prevented if proper hygiene practice during these moments is followed.

![Diagram showing primary and secondary transmission routes](image)

**Figure 4.15** Routes of transmission post application of Glo-Germ™ to the treatment bed

### 4.3 Conclusion

From this study the most significant findings are the routes of transfer of the Glo-Germ™ which were observed, as these routes can now be analysed in order to further determine the moments where hygiene practice may be used in order to prevent any transfer.
CHAPTER 5 – DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Introduction

The purpose of this study was to explore and describe the possible pathogen transmission routes between the chiropractor, patient and treatment bed using Glo-Germ™ cream as a surrogate for microorganisms. It has been demonstrated in previous studies that Glo-Germ™ can be effectively used as a surrogate to demonstrate microorganism transfer without the risk of exposure to pathogenic bacteria making it ideal for this study (Bell et al., 2015; Drew et al., 2016).

Previous literature suggests that most infections arise from within the body, which means that the human microbiome (both internal and external) are able to provide a major source of infection (Wenzel, 2010). There is also the possibility that the external environment could serve as a source for microorganism contamination. Contamination of inanimate surfaces has been identified and associated with outbreaks and cross-transmission of pathogens, and can possibly contribute to HAIs (Carling and Huang, 2013; Seki et al., 2013; Weber et al., 2010).

According to South Australia Health (2017), treatment/procedure rooms are treated as having a moderate risk status for a HAI outbreak with regards to their proposed cleaning standards and procedures. This was due to the rooms graded as having a moderate chance for contamination and spread of microorganisms to the patient or practitioner, with a low chance of population susceptibility to this contamination or infection. These rooms do however have a high chance for exposure to microbial contamination. The current study shows that transfer of microorganisms is a possibility in this type of treatment room and that the route for contamination does not necessarily rely on one source, but can be spread from the practitioner, the
patient or the surrounding environment (in this case the treatment bed) to one another.

The spread of pathogens can be prevented through strict efforts of cleaning and disinfecting healthcare facilities. This is however not always successful as multi-drug-resistant microorganisms are still being identified on surfaces close to the patient and on surfaces distant to the patient, after these hygiene practices are completed (Dolan et al., 2011; Wille et al., 2018). The contamination of the healthcare environment may be spread by pathogen transmission via a healthcare workers’ hands or by infected or colonised patients (Otter et al., 2011). A better understanding of the moments when the transmission of pathogens between healthcare workers and patients occurs, allows us to follow hygiene protocols at these stages in order to hopefully prevent further transmission.

Before the routes that were observed in this study are discussed, it is important to again note that with Chiropractic being taught in many educational institutions worldwide, the Chiropractic manipulation techniques and philosophies that are taught certainly differ across these institutions. The Chiropractic manipulation techniques that were chosen for this study are not necessarily practiced by all chiropractors and therefore routes of transmission may differ for chiropractors that use other manipulation techniques or other ways of treating their patients. Another important aspect that must be considered when discussing these results is that the set-up of the Chiropractic manipulations in this study were done according to specific contact points that are taught at the University of Johannesburg and these contact points may differ for qualified chiropractors as they adjust their manipulation techniques to suit their individual patient and treatment protocols. An example here would be the use of an index finger indifferent hand contact instead of a split sternocleidomastoid contact for the cervical manipulation. This could change the amount of Glo-Germ™ transfer to the patient’s neck and face, as the contact point is a smaller surface.
The routes of transfer seen in this study showed that transfer occurred from direct and indirect contact between the practitioner and the patient, the practitioner and the treatment bed, the patient and the practitioner, the patient and the treatment bed as well as the treatment bed and the practitioner and the treatment bed and the patient. These routes allow for the possible transmission of the ESKAPE bacteria and other microorganisms that could potentially cause further infection (Santajit and Indrawattana, 2016).

With this in mind, it is possible to identify some key areas of potential transmission of microorganisms between the practitioner, patient and treatment bed.

5.1.2 Important routes of transmission identified and reasons for concern

a) Patient transfer

The results showed that the patient is most frequently involved in the transfer of Glo-Germ™ when compared to the transfer seen on the practitioner and the treatment bed during all the experiments. The transfer was found over many different areas of the patient, with large areas of transfer recorded over the patient’s chest, abdomen, upper and lower back. Some of the areas that showed more interesting results with regards to possible risk and exposure to microorganisms will be described below.

i) Patients head, neck and face

The transfer between the practitioner’s hands and the patient’s neck, jaw, ear and sides of the head (Figures 4.1 and 4.2) needs to be highlighted because of the potential transfer of pathogens to the mucous membranes of the face. Some pathogenic microorganisms that cause infections affecting the face and head area include *Staphylococcus aureus*,
Streptococcus pyogenes, Haemophilus influenza, Tinea and Herpes simplex virus (Ki and Rotstein, 2008; Tull and Morris Jones, 2017).

Similarly, the transfer seen from the head pieces of the treatment bed to the patient’s head and face (Figures 4.13 and 4.14) must be highlighted for the same reasons. Clostridium difficile is an example of a pathogen that may be associated with this route of transmission, as it has been found on hospital surfaces, patient’s hands and practitioner’s hands and can be transmitted by touching contaminated surfaces and then the patient touching their mouth or mucous membranes (Barker et al., 2017; Centers for Disease Control and Prevention, 2011; Weber et al., 2010). The survival time of microorganisms on the treatment bed and other inanimate surfaces is important due to the possibility of transmission of microorganisms from the treatment bed to the patient, and because of the numerous patients that could be required to lie on the treatment bed for that particular period of time. Candida albicans for example, can exist on human skin and can survive on inanimate surfaces for up to 120 days, contaminating multiple patients if proper bed hygiene isn’t practiced (Kramer et al., 2006; Weinstein and Hota, 2004).

ii) Patient’s hands

The transfer seen to the patient’s hands is important due to the potential for microorganisms to further spread and contaminate other surfaces and individuals (Khan et al., 2017; Wyer et al., 2017). The patient’s hands were seen to have transfer of Glo-Germ™ to them from the practitioner’s hands (Figures 4.1 and 4.2) and from the treatment bed (Figures 4.13 and 4.14). It is important to educate patients about the potential for microorganism spread during the consultation, and the need to practice hand hygiene properly to prevent any further transmission of pathogens to family members from patient contact.
iii) **Patients chest, abdomen and back**

The large areas of Glo-Germ™ Transfer seen over the patient’s chest, abdomen and back (Figure 4.13 and 4.14), was due to the patient having to lie in both a supine and a prone position on the treatment bed. This large area of contact between the patient and the treatment bed is of concern because of the amount and type of pathogens that have been found existing on these types of surfaces, and the potential they have to survive and transfer to the patient (Bifero *et al*., 2006; da Silva Aquino *et al*., 2016; Perdijk *et al*., 2017).

Another important area of transfer was that recorded around the armpit area of the patient (Figure 4.13). The armpit is considered a moist body surface and is an ideal area for microbial contamination, especially species like *Staphylococcus* and *Corynebacterium spp.* (Grice and Segre, 2011).

b) **Practitioner transfer**

The amount of transfer to the practitioner was less than the transfer seen to the patient and the treatment bed, with the majority of the transfer to the practitioner being found over the hands.

i) **Practitioners Hands**

This study showed many occasions where Glo-Germ™ was seen to transfer to the practitioner’s hands (Figures 4.4; 4.5; 4.7; 4.8; 4.10; 4.11; 4.13; 4.14). It has been proven that healthcare worker’s hands are a major factor contributing to HAI pathogen transmission (Creamer *et al*., 2010; Kanwar *et al*., 2017; Paul *et al*., 2011). The healthcare worker’s hands are in contact with many different surfaces between their patients and studies are showing how even handling personal items like mobile phones result in possible spread of HAI’s (Katsuse Kanayama *et al*., 2017; Kurli, 2018). A study done by Landelle *et al*., (2014) compared the contamination of healthcare worker’s hands who were caring for patients with *Clostridium difficile*
infection, and the hands of those who were unexposed to the microorganism. The study found that a quarter of the hands, of Healthcare worker’s working with patients with \textit{Clostridium difficile} infection, were contaminated with \textit{Clostridium difficile} spores.

It is therefore important that healthcare workers follow an effective hand hygiene cleaning/disinfecting process throughout their day of consulting with patients to prevent any transmission. Studies are discovering more and more as to what can be used as an effective hand cleaning and disinfecting medium (Yildirim \textit{et al.}, 2014). More specifically to Chiropractic it is important that a practitioner’s hands be cleaned and disinfected at two specific moments, these are the moments before and after patient contact as potential transfer is shown at both of these moments in this study.

\textbf{c) Treatment bed transfer}

The treatment bed had transfer recorded to both head pieces (Figures 4.1; 4.2; 4.4; 4.5; 4.7; 4.8; 4.10; 4.11), the thoracic piece, the lumbar piece (Figures 4.1; 4.2; 4.7; 4.8; 4.10; 4.11) and the foot piece (Figures 4.7; 4.8; 4.10; 4.11). The pieces more often involved during the tests with regards to transfer of Glo-Germ\textsuperscript{TM} were the head pieces and thoracic piece of the bed. The leg piece recorded the least transfer and the arm pieces showed no evidence of transfer in this study.

The transmission routes shown in this study between the treatment bed to the practitioner and to the patient must be highlighted, due to the fact that bacterial pathogens such as \textit{Pseudomonas spp.}, \textit{Klebsiella spp.}, \textit{Escherichia coli}, \textit{Enterobacter} spp. and fungal pathogens such as \textit{Aspergillus} spp., and \textit{Fusarium} spp. are being found on the headrests, face, and thoraco-lumbar pieces of Chiropractic treatment beds (Bifero \textit{et al.}, 2006; Perdijk \textit{et al.}, 2017). Due to the detection of multidrug-resistant microorganisms on inanimate surfaces in the healthcare environment it is important to draw attention to the need for proper practice of cleaning and disinfecting inanimate surfaces which are potential sources for the spread
of pathogenic microorganisms (Okamoto, 2018). Many cleaning/disinfecting methods are being used in healthcare facilities, but further research is needed in order to achieve improved results of these methods (Ferreira et al., 2015).

An area of the patients body that was seen to frequently contact the treatment bed was the patients forearms (Figures 4.7; 4.10; 4.13; 4.14; ). The forearm is known to harbour a variety of pathogenic microorganisms like Escherichia spp, Salmonella spp, Vibrio spp and Helicobacter spp. Transmission between the patient’s forearms and the treatment bed may allow for further transmission of these pathogens to other patients when they come into contact with the treatment bed (Grice and Segre, 2011; Madigan et al., 2009). This perfectly demonstrates the two moments where healthcare hygiene should be applied. These two moments are cleaning/disinfecting treatment beds after patient contact as well as appropriate cleaning/disinfecting after coming into contact with the patients surroundings ie. the treatment bed.

5.1.3 World Health Organisations ‘Five Moments of Hand Hygiene’ model, adapted for Chiropractic

If the WHOs ‘Five Moments of Hand Hygiene’ model is considered, it is possible to relate aspects of their model to that of a Chiropractic setting in private and training clinics. With regards to a typical Chiropractic treatment protocol that includes an initial greeting, cervical, thoracic and lumbar manipulations, a similar model can be made for Chiropractic as to where the moments for hygiene practice are (Figure 5.1).

If the model that has been adapted to suit Chiropractic (Figure 5.1) is considered, the model shows that there are four moments where cleaning and disinfecting could be practiced in order to prevent any spread of pathogens.
The first moment that is described is the moment before touching a patient. Examples here would be before greeting the patient with a handshake or helping the patient to sit or lie down on the bed. Any diagnostic and treatment procedures including taking blood pressure and delivering Chiropractic manipulations, can also be included during this moment.

**Figure 5.1** The WHO’s ‘Five Moments of Hand Hygiene’ adapted for Chiropractic into four steps

The second moment that is described is that before a clean/aseptic procedure. This moment includes the use of any invasive treatment methods, such as dry needling, or any wound dressing that may need to be carried out during the treatment.

The third moment that can be described for Chiropractic is that of after touching a patient. This is the moment after coming into contact with the
patient during the treatment or possibly after a handshake when greeting the patient goodbye.

The fourth moment that is described is the moment after touching patient surroundings. This moment includes having any contact with the treatment bed and any other surfaces that may have come into contact with the patient during the consultation.

With possible inclusion of Chiropractic into hospitals, it is important for the profession to follow safe hygiene practices, as the prevention of microorganism transmission and possible infection is of utmost importance within a hospital health setting. With the model for Chiropractic described above (Figure 5.1) being adapted from the WHOs model, inclusion of Chiropractic into a hospital setting may be easier as this model fits with the moments that have already been established in hospitals.

5.2 Limitations of the study

This study only sampled three certain types of Chiropractic manipulations. Therefore, the findings may differ with Chiropractors using various other types of manipulations. The findings may not affect the routes of transmission that were demonstrated in this study but the certain areas on the surfaces that were recorded as having Glo-Germ™ transferred onto them could differ.

5.3 Recommendations

5.3.1 Recommendations regarding future studies

1. Additional testing of the Glo-Germ™ transmission could be done to increase accuracy of the results, with the addition of more than one practitioner included in the study as well as the inclusion of a female practitioner. As chiropractors may use the same manipulation technique but their contact areas and positioning on the patient may
differ to the positions seen in this study depending on their body size and the slight alterations they may use to setup for the manipulation.

2. The areas of transfer could differ if a different sequence of manipulation set-ups were used. For example, if the Glo-Germ™ was applied to the back of the patient and the thoracic manipulation set-ups were done first then the cervical manipulation set-ups, the results could have shown more transfer of Glo-Germ™ to the patient’s neck and head. Transfer to specific areas of the body may differ to those found in this study.

3. The use of other Chiropractic manipulation techniques including extremity manipulations could be used to show additional routes for Glo-Germ™ transfer. As well as the application of Glo-Germ™ to the treatment beds arm rests and foot piece in order to study other specific routes of transfer to the practitioner and the patient.

4. The use of Glo-Germ™ application to therapeutic machines used by chiropractors could show further routes of transfer between the practitioner, patient and inanimate environment e.g. Application of Glo-Germ™ to a therapeutic ultrasound transducer.

5. The use of Glo-Germ™ in order to determine possible routes of transmission between other inanimate surfaces and the practitioner and the patient. Examples of the surfaces that could be studied could include mobile phones, white coats and patient files.

This study has shown when hygiene practice could be applied within a Chiropractic setting in order to prevent further microorganism transmission between the practitioner, the patient and the treatment bed and potentially decrease the burden that is Healthcare-acquired infections.

5.4 Conclusion

In conclusion this study was able to visually show, with the use of Glo-Germ™ as a surrogate for microorganisms, the potential routes for microorganism transmission that may exist between a chiropractor, a
patient and the treatment bed. These routes may be used to illustrate the moments that hygiene could possibly be practiced in order to prevent any further transmission of microorganisms within a Chiropractic health environment between practitioner, patient and treatment bed.
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Kurashige E, Oie S and Furukawa H. (2016). Contamination of environmental surfaces by methicillin-resistant *Staphylococcus aureus*


Good Day

My name is Devin Ramsden. I WOULD LIKE TO INVITE YOU TO PARTICIPATE in a research study on the Routes of Microbial Contamination During a Chiropractic Treatment Session, Using Glo-Germ as a Surrogate for Microbial Pathogens.

Before you decide on whether to participate, I would like to explain to you why the research is being done and what it will involve for you. I will go through the information sheet with you and answer any questions you have. This should take about 10 to 20 minutes. The study is part of a research project being completed as a requirement for a Master's Degree in Chiropractic through the University of Johannesburg.

THE PURPOSE OF THIS STUDY is to provide details on the potential transfer of pathogens from the practitioner to the patient and vice versa, during the initial interaction as well as during the manipulation as a form of chiropractic treatment.

Below, I have compiled a set of questions and answers that I believe will assist you in understanding the relevant details of participation in this research study. Please read through these. If you have any further questions I will be happy to answer them for you.

DO I HAVE TO TAKE PART? No, you don’t have to. It is up to you to decide to participate in the study. I will describe the study and go through this information sheet. If you agree to take part, I will then ask you to sign a consent form.
WHAT EXACTLY WILL I BE EXPECTED TO DO IF I AGREE TO PARTICIPATE? You will be the only participant in the study. The study will take place over a period of two weeks. The inclusion criteria must be met to partake in this study and you must not have any contraindications to the cervical thoracic or lumbar spine manipulations. The chiropractic manipulation is a safe, non-invasive treatment technique. You will be required to remove all clothing except sports shorts for the treatment. During the treatment you will be video recorded and this will be published on various platforms for educational purposes. You will be required to sign all consent forms as well as the information form to participate in the study.

WHAT WILL HAPPEN IF I WANT TO WITHDRAW FROM THE STUDY? If you decide to participate, you are free to withdraw your consent at any time without giving a reason and without any consequences. If you wish to withdraw your consent, you must inform me as soon as possible.

IF I CHOOSE TO PARTICIPATE, WILL THERE BE ANY EXPENSES FOR ME, OR PAYMENT DUE TO ME: You will not be paid to take part in this study and you will not bear any costs either.

RISKS INVOLVED IN PARTICIPATION: The possible risks include post treatment stiffness; however this is a normal response.

BENEFITS INVOLVED IN PARTICIPATION: The study will be utilized to form an educational video on the routes of microbial contamination during a consultation. This will then be used to educate health care students and/or professionals as to the importance of hygiene within the healthcare profession.

WILL MY TAKING PART IN THIS STUDY BE ANONYMOUS? No. As a part of the study, you will be required to be video recorded throughout the consultation process. This video will then be available for further educational publishing on various platforms.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY? The results will be written into a research report that will be assessed. In some cases, results may also be published in a scientific journal as well as in the form of a video recording. You will be given access to the study results if you would like to see them, by contacting me.

WHO IS ORGANISING AND FUNDING THE STUDY? The study is being organised by me, under the guidance of my research supervisor at the Department of Chiropractic and the Water and Health Research Centre in the University of Johannesburg. This study has received funding from the Water and Health Research Centre.

WHO HAS REVIEWED AND APPROVED THIS STUDY? Before this study was allowed to start, it was reviewed in order to protect your interests. This review was done first by the Department of Chiropractic, and then secondly by the
Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg. In both cases, the study was approved.

WHAT IF THERE IS A PROBLEM? If you have any concerns or complaints about this research study, its procedures or risks and benefits, you should ask me. You should contact me at any time if you feel you have any concerns about being a part of this study. My contact details are:

Devin Ramsden  
0736073588  
devin.ramsden453@gmail.com

You may also contact my research supervisor:

Prof. Tobias Barnard  
Email: tgbarnard@uj.ac.za

Dr. Chris Yelverton  
Email: chrisy@uj.ac.za
If you feel that any questions or complaints regarding your participation in this study have not been dealt with adequately, you may contact the Chairperson of the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg:

Prof. C Stein  
Tel: 011 559-6564  
Email: cstein@uj.ac.za

FURTHER INFORMATION AND CONTACT DETAILS: Should you wish to have more specific information about this research project information, have any questions, concerns or complaints about this research study, its procedures, risks and benefits, you should communicate with me using any of the contact details given above.

Researcher:

Devin Ramsden
Appendix B: Consent Form

DEPARTMENT OF CHIROPRACTIC
RESEARCH CONSENT FORM

A Study to Illustrate the Routes of Microbial Contamination During a Chiropractic Treatment Session, Using Glo-Germ as a Surrogate for Microbial Pathogens.

Please initial each box below:

☐ I confirm that I have read and understand the information sheet dated October 2017 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

☐ I understand that my participation is voluntary and that I am free to withdraw from this study at any time without giving any reason and without any consequences to me.

☐ I agree to take part in the above study.

________________                     ___________________                   __________
Name of Participant                  Signature of Participant                          Date

________________                     ___________________                   __________
Name of Researcher                   Signature of Researcher                           Date
Appendix C: Video-taping Consent Form

DEPARTMENT OF CHIROPRACTIC
RESEARCH CONSENT FORM OR INTERVIEWS TO BE VIDEO-TAPED

A Study to Illustrate the Routes of Microbial Contamination During a Chiropractic Treatment Session, Using Glo-Germ as a Surrogate for Microbial Pathogens

Please initial each box below:

☐ I hereby give consent for my interview, conducted as part of the above study, to be audio-taped.

☐ I understand that my personal details and identifying data will be changed in order to protect my identity. The audio tapes used for recording my interview will be destroyed two years after publication of the research.

☐ I have read this consent form and have been given the opportunity to ask questions.

☐ Released onto several social media sites in order to be used for training material.

________________                      __________________                  _________
Name of Participant                    Signature of Participant                  Date

________________                     __________________                  __________
Name of Researcher                    Signature of Researcher                  Date
Appendix D: Higher Degrees Committee approval letter

TO WHOM IT MAY CONCERN:

STUDENT: RAMSDEN, DC
STUDENT NUMBER: 201100502

TITLE OF RESEARCH PROJECT: Demonstrating Microbial Contamination Routes in Chiropractic Clinics Using Glo Germ™ as a Surrogate for Microbial Pathogens

DEPARTMENT OR PROGRAMME: CHIROPRACTIC
SUPERVISOR: Prof TG Barnard
CO-SUPERVISOR: Dr C Veilertion
CO-SUPERVISOR: Dr A Singh

The Faculty Higher Degrees Committee has scrutinised your research proposal and concluded that it complies with the approved research standards of the Faculty of Health Sciences; University of Johannesburg.

The HDC would like to extend their best wishes to you with your postgraduate studies

Yours sincerely,

Prof BS Shaw
Chair: Faculty of Health Sciences HDC
Tel: 011 559 6891
Email: brandons@uj.ac.za
Appendix E: Research Ethics Committee approval letter

[Letter content]

The Faculty Research Ethics Committee has scrutinised your research proposal and confirm that it complies with the approved ethical standards of the Faculty of Health Sciences; University of Johannesburg.

The REC would like to extend their best wishes to you with your postgraduate studies.

Yours sincerely,

[Signature]

Prof C Stein
Chair: Faculty of Health Sciences REC
Tel: 011 559 6564
Email: cstein@uj.ac.za
Appendix F: Areas of Glo-Germ™ cream application

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<th>Grid example</th>
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Patients
Front:

Patients
Back:
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Appendix G: Templates showing the transfer of Glo-Germ™ for the different application areas for all three experiments.

Dye applied to: Practitioners hands

Date: 27/01/2019
Dye applied to: Practitioner
Repeat: 1

Date: 24/03/2018
Dye applied to: Practitioner
Repeat: 2

Date: 26/01/2019
Dye applied to: Practitioner
Repeat: 3
Dye applied to: Patients Face and Neck
Dye applied to: Patients Front

- Date: 23/6/2018
- Dye applied to: Patient Front
- Repeat: 1

- Date: 25/6/2018
- Dye applied to: Patient Front
- Repeat: 2

- Date: 26/6/2018
- Dye applied to: Patient Front
- Repeat: 3
**Dye applied to: Patients Back**

Date: 25/04/2018
Dye applied to: Patient back
Repeat: 1

---

Date: 25/04/2018
Dye applied to: Patient back
Repeat: 2

---

Date: 25/04/2018
Dye applied to: Patient back
Repeat: 3

---
Dye applied to: Treatment bed
Appendix H: Templates showing the transfer of Glo-Germ™ for the different application areas over three experiments.

**Dye applied to:** Practitioners hands  
**Repeat / Trial:** 1
**Dye applied to:** Practitioners hands

**Repeat / Trial:** 2

<table>
<thead>
<tr>
<th>Practitioner</th>
<th>Patient</th>
<th>Treatment bed</th>
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![Graphs showing distribution of dye application](image_url)
**Dye applied to:** Practitioners hands

**Repeat / Trial:** 3

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<th>Treatment bed</th>
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<td><img src="image2" alt="Diagram of Patient" /></td>
<td><img src="image3" alt="Diagram of Treatment bed" /></td>
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</table>
Dye applied to: Patients Face and Neck
Repeat / Trial: 1
Dye applied to: Patients Face and Neck
Repeat / Trial: 2
**Dye applied to:** Patients Face and Neck

**Repeat / Trial:** 3

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<th>Treatment bed</th>
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<td><img src="image2" alt="Patient Diagram" /></td>
<td><img src="image3" alt="Treatment bed Diagram" /></td>
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</table>
Dye applied to: Patients Front
Repeat / Trial: 1
Dye applied to: Patients Front
Repeat / Trial: 2
Dye applied to: Patients Front
Repeat / Trial: 3
**Dye applied to:** Patients Back

**Repeat / Trial:** 1

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<th>Treatment bed</th>
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<td><img src="image2.png" alt="Patient Diagram" /></td>
<td><img src="image3.png" alt="Treatment Bed Diagram" /></td>
</tr>
</tbody>
</table>
Dye applied to: Patients Back
Repeat / Trial: 2

Practitioner

Patient

Treatment bed
Dye applied to: Patients Back
Repeat / Trial: 3
Dye applied to: Treatment Bed
Repeat / Trial: 1
**Dye applied to:** Treatment Bed

**Repeat / Trial:** 2

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<td><img src="image2.png" alt="Patient Diagram" /></td>
<td><img src="image3.png" alt="Treatment Bed Diagram" /></td>
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</table>
Dye applied to: Treatment Bed
Repeat / Trial: 3
Appendix H: Turnitin report

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This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

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Final Research By DC RAMSDEN

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