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THE EFFECT OF FORCED-AIR WARMING BLANKET POSITIONING DURING SPINAL SURGERY ON INTRAOPERATIVE BODY TEMPERATURE

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Submitted in fulfilment of the requirements for the degree
MNurs (Clinical)

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DEDICATION

To my mother, wish you were here.

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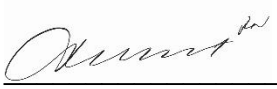
DECLARATION

I, Natasha Joubert, declare that this dissertation, titled '***The effect of forced-air warming blanket positioning during spinal surgery on intraoperative body temperature',*** is my own work. All sources referenced and quoted have been mentioned and acknowledged in a complete reference list. Furthermore, I declare that this work has not been submitted for any other degree at any other institution.

06-12-2022

Researcher signature Date



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TITLE

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ABSTRACT

Intraoperative hypothermia is a common complication experienced in nearly all surgical patients, as general anaesthesia inhibits the body's thermoregulation. Intraoperative hypothermia increases the patient's risk for postoperative complications such as coagulopathy, surgical site infections and cardiac events. The most effective intraoperative warming system used is forced-air warming blankets. Limited evidence is available on the effect of forced-air warming blankets on the intraoperative body temperature during spinal surgery.

Spinal surgery is performed on patients positioned in the prone position on a specialised spinal table. As the spinal table is an open frame and a greater skin surface area of the patient is exposed to the cold theatre environment, more body temperature is lost. Two forced-air warming blanket options are most commonly used during spinal surgery; the surgical access forced-air warming blanket and the full underbody forced-air warming blanket.

The research design was a quantitative, prospective, randomised, comparative experimental design. Data collections were done during real-time procedures. The study was conducted in a single setting where four Orthopaedic surgeons perform spinal surgery using the spinal table. Convenience sampling from the population was conducted, and the spinal surgery patients (n=60) who satisfied the inclusion criteria and participated in the study were randomised into two groups. Data were collected using a structured data collection sheet. The data were analysed using General Linear Model: Multivariate test, Pillai's trace statistical tests.

Results showed that the full underbody forced-air warming blanket had higher overall intraoperative temperature readings when compared to the surgical access forced-air warming blanket.

It is recommended that when spinal surgeries are performed when using the spinal table (Jackson table), the full underbody forced-air warming blanket is more effective in maintaining the intraoperative core temperature.

Keywords:
Forced-air warming blanket, intraoperative hypothermia, spinal surgery, spinal table.

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ABBREVIATIONS

AD	Anno Domini (After Death)
ANOVA	Analysis of Variance
ASA	American Society of Anaesthesiologists
BMI	Body Mass Index
COVID-19	Coronavirus disease 2019
HSRC	Human Sciences Research Council
IBM	International Business Machines Corporation
mmHg	millimetres Mercury
PHC	Primary Health Care
SASA	South African Society of Anaesthesiologists
WHO	World Health Organization
˚C	Degrees Celsius

CONTENTS

INTRODUCTION

"Research is seeing what everybody else has seen and thinking what nobody else has thought".

ALBERT SZENT-GYÖRGYI

1.1. INTRODUCTION AND BACKGROUND

Hypothermia develops in nearly all patients undergoing surgery (Sessler 2019). Approximately two hours after induction of general anaesthesia, the body temperature can decrease by as much as 2.8°C as general anaesthesia inhibits the body's thermoregulation (Sessler 2019; Yanaral and Ertugrul 2019; Ralph 2019). Hypothermia is a common complication that patients experience during surgery and causes vasoconstriction decreasing the oxygen supply to the body tissues (Cluett 2019; Croke 2019). Intraoperative hypothermia increases the patient's risk of developing postoperative complications such as coagulopathy, surgical site infections and cardiac events (Ralph 2019). International anaesthesia societies recommend that active warming of patients during surgical procedures become standard practice (Sagiroglu, Ozturk, Bayasal et al. 2020). It has been determined that forced-air warming is the most effective and preferred warming system intraoperatively (Gupta, Bharti, Kumar, Garg et al. 2019; Brodshaug, Tettum and Raeder 2019). Different types of forced-air warming blankets are available for different surgical requirements, such as surgical access, lower body, upper body, and full body blankets (Arizant Healthcare Inc.). The effectiveness of forced-air warming blankets during surgery has been established for various abdominal surgeries, Caesarean sections, and laparoscopic surgeries (Baradaranfard, Jabalameli, Ghadami et al. 2019). The surgeries mentioned in Baradaranfard et al. (2019) are performed with patients in the supine position on a solid base surgical bed.

Limited evidence exists on the effectiveness of forced-air warming blankets on patients undergoing spinal surgery in a prone position when using a specialised spinal table, also known as the Jackson table (Buraimoh, Nash, Howard et al. 2019). The spinal table is an open frame on which the patient is placed, with only the chest, face, hips, and legs supported (Mizuho ISO® 2016)

Using the spinal table improves surgical access, and visualisation as the table provides easier access to the patient's surgical site (Mizuho ISO® 2016). The spinal table, however, exposes larger skin surface areas to the theatre environment, resulting in more body heat loss due to environmental exposure (see figure 1.1).

In addition, spinal surgery procedures can take between four to eight hours, exposing patients to a cold environment for a prolonged time (Hartline, Nolan, Kelly et al. 2019).

Figure 0.1: Spinal Table

1.2. PROBLEM STATEMENT

For spinal surgery, the two preferred forced-air warming blankets used are surgical access (placed on top of the patient) or the full underbody (placed underneath the patient). In the private hospital where the study was conducted, medical schemes only pay for one blanket per surgery and the type of blanket entrusted to the surgeon's preference. There is limited evidence available of the forced-air warming blankets' effects on the intraoperative body temperature during spinal surgery when performed on the spinal table (Buraimoh et al. 2019).

Patients undergoing spinal surgery are at greater risk of developing intraoperative hypothermia due to the length of the procedure and the increased body surface being exposed to the environmental temperature (Granum, Kaasby, Skou et al. 2019). Intraoperative hypothermia increases the risks of postoperative complications, contributing to prolonged recovery time and length of hospital stay, increasing the financial burden on health care (Ralph, Gow, Conway et al. 2019).

1.3. RESEARCH QUESTION

The research question of this study focused on the following:
What is the effect of the full underbody and the surgical-access forced air-warming blankets' positioning during spinal surgery on intraoperative body temperature?

1.3.1. AIM AND OBJECTIVES

This study aimed to determine the effect of forced-air warming blanket's positioning on intraoperative body temperature in patients undergoing spinal surgery when positioned on the spinal table.

The objectives set out for this study were:

1. To investigate the effect of the surgical access (on top of) forced-air warming blankets on intraoperative body temperature during spinal surgery.
2. To investigate the effect of the full underbody (below) forced-air warming blankets on intraoperative body temperature during spinal surgery.

1.3.2. HYPOTHESIS

The null hypothesis to be tested was that:

H_0: The positioning of the surgical-access forced-air warming blanket and the full underbody forced-air warming blanket have similar intraoperative body temperature readings in patients during spinal surgery.

1.4. DEFINITION OF KEY TERMS

The following terms are defined to clarify the application of terms used in the study.

Table 0.1: Conceptualisation and application of key terms

Key Terms	Theoretical definition	Application of Definition (Conceptualisation)
Normothermia	A core temperature of 36.5 ºC – 37.5 ºC (Smith, Abernethy, Allgar et al. 2019).	For the body system to function at its best, the body's core temperature needs to be maintained within the 36.5 ºC and 37.5 ºC temperature ranges. This is seen as the perfect temperature range to maintain during surgery.
Hypothermia	A core body temperature of less than 36 ºC (Granum et al. 2019).	This definition is accepted for this study.
Forced-air Warming Blanket	A form of active warming that circulates warmed air through a specialised blanket with an external electric heat pump (Smith et al. 2019).	This definition is accepted for this study.
Surgical access Forced-air Warming Blanket	A forced-air warming blanket covers the patient and has surgical window access to perform surgery (Arizant Healthcare Inc.).	This definition is accepted for this study. (See Chapter 2 fig. 2.1)
Full Underbody Forced-air Warming Blanket	A solid forced-air warming blanket is positioned underneath the patient and secured under the patient's torso and legs (Buraimoh et al. 2019).	This definition is accepted for this study. (See Chapter 2 fig. 2.5)
Intraoperative	Perioperative is divided into three phases: Preoperative, which is seen at least twelve hours before the surgery; Intraoperative, which is from anaesthesia induction up to when the patient wakes up and postoperative, which is seen as the first twenty-four hours after the surgery has been completed (Clemmesen, Palm and Foss 2019).	Intraoperative starts from the moment when the patient is anaesthetised and ends when the surgical procedure is done.

1.5. ASSUMPTIONS

The researcher's assumptions for this study were as follows:

- The equipment used to record intraoperative patient core temperatures gave correct readings when connected to the anaesthetic machines used in the selected hospital theatre complex.
- All patients would be normothermic before the start of the surgery, as vitals were completed during admission on the morning of surgery.
- Spinal surgery would be performed in the designated spinal theatres with the environment's ambient temperature set to a constant 18 °C (daily environmental checks are done and recorded in the theatre environmental cleaning booklet).
- Forced-air warming devices were switched on after draping have been completed and devices set to 43˚C as per Anaesthetist's preferrence.

1.6. DELINEATION

The study was limited to one private hospital in Gauteng, where four orthopaedic surgeons performed spinal surgeries on patients using the spinal table. Forced-air warming is the only warming system used in the selected hospital. For spinal surgery, only the surgical access (on top) and the full underbody (below) forced-air warming blankets were used by the surgeons and therefore included in this study.

1.7. SIGNIFICANCE

The study's findings suggested that the best forced-air warming blanket to be used for patients undergoing spinal surgery when performed on the spinal table was the full underbody forced-air warming blanket (see Chapter 4). Decreasing the risk of developing intraoperative hypothermia could affect the occurrence of postoperative complications, thereby reducing the length of stay, and having fewer financial implications for the patient and the healthcare organisation. In addition, there could be a potential to re-look at theatre-specific training in nursing education to align with the practice.

1.8. CONCEPTUAL FRAMEWORK

For this study, a conceptual framework was used. A conceptual framework is a structure that guides the research; it identifies and describes the relationship between the key concepts (LoBiondo-Wood and Haber 2018).

A conceptual framework presents the interconnections between independent, extraneous, and dependent variables (Muguzi 2019). Extraneous variables identified for the study were gender, age, body mass index, co-morbidities, and the duration of the surgery. The researcher could control extraneous variables but couldn't influence the relationship between the dependent and independent variables (Aggarwal and Ranganathan 2019; Muguzi 2019). The identified variables were associated with developing intraoperative hypothermia (Zangmo, Chatmongkolchart and Sangsupawanich 2019; Sagiroglu et al. 2020).

The positioning of the forced-air warming blanket was the intervention variable, either the surgical access forced-air warming blanket or the full underbody forced-air warming blanket. There is evidence that positioning the forced-air warming blankets could influence the development of intraoperative hypothermia; however, only upper- and lower-body forced-air warming blankets were used (Buraimoh et al. 2019). The dependent variables that developed as a consequence of the exposure to the intervention were measured in the form of intraoperative temperature readings.

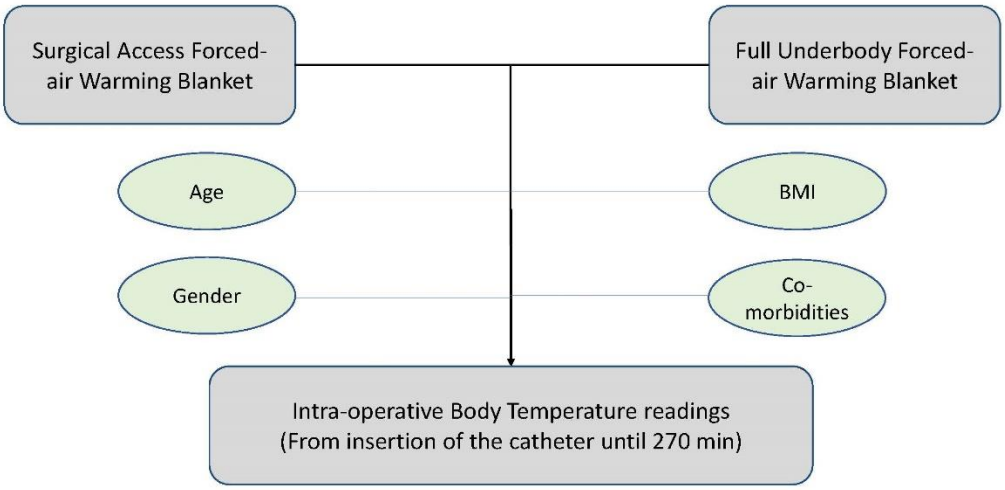

Figure 0.2: Conceptual Framework for the proposed model

1.9. OVERVIEW OF THE RESEARCH DESIGN

The study aims to gain information on the elements of the study to provide a situational picture as it happened (Grove and Gray 2019).

Table 0.2: Summary of Research Design

Research Design	The study was a quantitative, prospective, randomised, comparative experimental design.
Population	Patients undergoing spinal surgery in the selected hospital. 200 spinal surgeries were performed in the selected hospital in 2019.
Sampling	Convenient sampling was used for the study.
Sample Size	A sample size of sixty patients was determined with the assistance of the statistician. Central Limit Theorem was used to determine sample size.
Data Collection	Data collected in real-time spinal surgery and temperature readings were entered into an excel spreadsheet for data analysis.
Data Analysis	The data was analysed using descriptive statistics, followed by the General Linear Model: Multivariate test, Pillai's trace to evaluate the temperature difference between the two forced-air warming blankets used for the study.

1.10. ETHICAL CONSIDERATIONS

'Codes of ethics' were developed in response to human rights violations throughout history, which started with the Nuremberg Code (1949); others include the Declaration of Helsinki (1964) (P and Beck 2018). Belmont Report (1979) is the framework for many international research commissions (Beauchamp 2020).

In research, there are moral principles governing the manner in which the research takes place. As this study involved people, it was the researcher's aim to protect those patients (Holloway and Wheeler, 2002). Careful attention had to be given to ethical considerations. According to Saunders, Lewis and Thornhill (2001), ethics refers to the suitability of our behaviour in conjunction with the rights of others, who are affected or become the subject of the study. Most authors categorise ethics into issues (Watkins 2012) that cover the following four categories namely: protection from harm, informed consent, right to privacy, and honesty (Leedy and Ormrod 2010).

Compliance with ethical principles was crucial. Before the research could commence, a letter of approval was obtained from the private hospital group after the approval from the University of

Pretoria, the Faculty of Health Sciences Research Ethics Committee was granted (881/2020). See Annexure E. The researcher pursued the following ethical principles.

1.10.1. RESPECT FOR PATIENTS

Informed consent is both an ethical and legal requirement as it provides authorisation for the implementation of a procedure or intervention (Bester 2020). The right to privacy and confidentiality meant that all patients' personal identifying information was kept confidential (Gray and Grove 2020). The researcher respected the autonomy of the patients who agreed to participate and obtained informed consent (Annexure A) in writing (HSRC, 2021).

Informed consent was obtained from all patients. The patient's confidentiality was acknowledged and protected according to the Belmont Report of 1979. Only the researcher had access to the list containing the patient's identification and corresponding study number. All data was anonymised during data capturing and dissemination.

1.10.2. BENEFICENCE

Beneficence is the principle to do good and not harm, implying that the benefits must outweigh the risks (Boswell and Cannon, 2020). Beneficence gives a responsibility to the researcher to ensure maximum benefit to the patients during the study (Polit and Beck 2018). Beneficence is an ethical principle that focuses on the obligation of the researcher to take action to promote a patient's well-being (Bester 2020). This study was conducted and aimed to protect patients from any discomfort or harm and strived to benefit the patients (Gray and Grove 2020). The principle of beneficence ensures that the patient's well-being is a priority, including their physical and emotional well-being. Even though the position of the forced-air warming blanket differed, the participant's well-being remained uncompromised throughout the study, and all participants received a forced-air warming blanket during spinal surgery on a spinal table.

1.10.3. JUSTICE

The final principle of justice pertains to the fairness of the study, ensuring that no patients experience discrimination (LoBiondo-Wood and Haber, 2018). Being treated with fairness entails that each participant is treated fairly and without prejudice (Gray and Grove 2020). A convenience sampling of the patients ensured that bias or prejudice towards all prospective patients was limited.

1.11. LAYOUT OF THE STUDY

The layout of the study is presented in Table 1.3

Table 0.3: Study Layout

Chapter	Description
Chapter 1	An overview of the study and a summary of each chapter of the study.
Chapter 2	A literature review of what is known regarding surgery, spinal surgery and how the body temperature reacts to anaesthesia.
Chapter 3	The research methodology discussed in detail how the patients were chosen to be part of the study and how the data were collected and analysed.
Chapter 4	Data collected for the study were analysed and the results were presented for interpretation.
Chapter 5	The findings were discussed, and a conclusion was drawn. The limitations were identified as well as recommendations for further studies, as well as training to theatre staff to the most effective choice of the forced-air warming blanket.

1.12. SUMMARY

In Chapter 1, an overview of the study was provided as to what to expect throughout the study. In Chapter 2, the literature related to the study is discussed.

LITERATURE REVIEW

"The review of scientific literature is necessary to understand the accumulated knowledge of the chosen topic"

JUDITH GERRAD (2016).

2.1. INTRODUCTION

Chapter 1 highlighted that intraoperative hypothermia is a common complication experienced in nearly all surgical patients, as general anaesthesia inhibits the body's thermoregulation. When gathering information regarding the study topic, it was established that surgical patients' risk for postoperative complications such as coagulopathy, surgical site infections and cardiac events are increased due to intraoperative hypothermia (Sessler 2021). It has been shown that the most effective intraoperative warming system used is forced-air warming blankets (Gupta et al. 2019; Brodshaug et al. 2019). Limited evidence is available on the effect of forced-air warming blankets on the intraoperative body temperature during spinal surgery (Buraimoh et al. 2019). Spinal surgery is performed on a specialised spinal table with patients in the prone position. The spinal table is an open frame, and a larger skin surface area of the patient is exposed to the cold theatre environment, and more body temperature is lost (Mizuho OSI®, 2016).

Chapter 2 will focus on the literature available to clarify the effect of general anaesthesia on patients, how the decrease in body temperature affects surgery and the practices in place to try and prevent intraoperative hypothermia. This chapter also identifies the literature gaps concerning spinal surgical patients.

2.2. HISTORY OF THE OPERATING THEATRE

"In the operating tent, the amputation of a very bad-looking leg was witnessed. The surgeons had been labouring since the battle to save the leg, but it was impossible. The patient, a delicate-looking man, was put under the influence of chloroform, and the amputation was performed with great skill by a surgeon who appeared quite accustomed to the use of his instruments. After the arteries were tied, the amputator scraped the end and edge of the bone until they were quite smooth. While the scraping was going on, an attendant asked: 'How do you feel, Thompson?' 'Awful' was the distinct and emphatic reply. This answer was returned, although the man was far more sensible of the effects of the chloroform than he was of the amputation."

SOLDIER DURING THE CIVIL WAR (Optimus integrated surgical environment, 2022)

Not much information is available about how operating theatres have come into existence. Most of the literature on the history of surgery starts with surgeries done in an amphitheatre venue. Modern operating theatres did not exist before the 1900s (Sampol 2021). Before surgery became a speciality, general practitioners who removed arrows or performed amputations were seen as battlefield surgeons (Optimus Integrated Surgical Environment, 2022). The idea of unifying medical and surgical practices started in Greece, where surgeons trained in a semi-formal school in Asklepieia (Sampol 2021). In Rome, during the reign of Emperor Augustus, around 65 AD., the operating tent was invented, where medical practitioners performed surgical procedures on the battlefield (Optimus Integrated Surgical Environment, 2022). The Roman operating tents are considered the foundation of the development of current operating theatres (Sampol 2021).

From 1800 to 1900, Europe and America developed the Victorian Surgical Amphitheatres, most readily associated with the history of surgery (Schlich 2018). The open amphitheatre setting remained the standard until the introduction of the sterile technique during World War I (Optimus Integrated Surgical Environment, 2022). After World War II, operating theatres were completely isolated from the rest of the hospital, in a dedicated zone (Schlich 2018). During the late 20th Century, most operating theatres no longer had viewing galleries like amphitheatre settings (Schlich 2018).

2.2.1. OVERVIEW OF GENERAL ANAESTHESIA

"General anaesthesia is a drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation."

AMERICAN SOCIETY OF ANAESTHESIOLOGISTS (ASA)

For many centuries before the discovery of general anaesthesia, people have resorted to different methods to try and achieve an unconscious state for the patient to have a surgical procedure performed on them. Gazdić's article, *'A brief history of anaesthesia'* (2020), describes the different methods of how anaesthesia and analgesia were accomplished in ancient times and different cultures. In Mesopotamia (3000 BC), anaesthesia was achieved by applying pressure on the carotid arteries on the side of the patient's neck until the patient became unconscious. Ancient Egyptians used hypothermia to accomplish analgesia during surgical procedures by applying snow to the surgery site. The Eastern Chinese people used acupuncture for analgesia when they performed surgical procedures.

Towards the end of the 18th century and the beginning of the 19th century, much research was done on using gas as anaesthesia (Gazdić 2020). Henry Hickman performed initial animal experiments in 1824 using nitrous oxide (Gazdić 2020).

On the 16th of October 1846, William Thomas Green Morton (1819 – 1868) famously demonstrated the successful administration of anaesthesia during a submandibular gland and tongue tumour excision performed by Dr JC Warren (Ahmed 2019). The first qualified Anaesthesiologist was John Snow (1813 – 1858), and the first intravenous administrated anaesthesia was done in 1872 by Pierre-Cyprien Oré (1828 – 1891) (Gazdić 2020). Anaesthetic medications, such as isoflurane, sevoflurane and propofol, were developed in the 1960s and 1970s (Kissin and Vlassakov, 2021).

Modern anaesthetic techniques are essential for modern medicine (Hemmings and Egan 2018), where general anaesthesia is administered to most patients undergoing surgery.

2.2.2. OVERVIEW OF GENERAL SURGERY

"*Surgery has been made safe for the patient; we must now make the patient safe for surgery.*"

LORD BERKELEY GEORGE MOYNIHAN (1865 – 1936)

Since primitive times, surgeries have been performed; the first surgeries recorded were circumcisions in Ancient Egypt and burr holes, going as far back as 10000 BC (Ellis and Abdalla 2019). As time progressed and the techniques evolved, the medical field had significant advances, and surgeries became more technical. Surgical development really began after *The Structure of the Human Body* by Andreas Vesalius was published in 1543, from the discovery of anaesthesia to the evolution of surgeon autonomists (Ellis and Abdalla 2019). Before modern anaesthesia, surgical procedures were limited.

2.3. THE MODERN OPERATING THEATRE ENVIRONMENT

A hospital consists of different departments and wards, of which the operating theatre complex is one of the departments. Operating theatres are specialised units where surgical procedures are performed (Yahya, Amin, Ismail et al. 2019).

The operating theatre requires specialised air-conditioning, heating, and ventilation systems as it is crucial to reduce the risk of patients acquiring surgical site infections during surgery (Yahya et al.

2019). These specialised systems provide comfort to the patients and the theatre team during surgical procedures (Yahya et al. 2019).

The ventilation within the operating theatre must be hyper-clean, which also means that the humidity and temperature must be optimal to ensure a safe environment for the patient (Mahgoub Bassuoni, Elsamondosy and Raslan 2020).

The theatre team needs to be in a state of comfort during surgery; the surgeon's comfort is essential as they are placed in a stressful situation when performing surgery (Angelova and Velichkova 2020a). The surgical team must wear additional personal protective equipment when performing surgeries, which can cause discomfort to the team during surgery. The surgical team members must wear sterile, protective, impervious gowns over their theatre clothes to prevent contamination of the surgical wound and body fluids from penetrating the surgeon's clothes (Byrne, Ludington-Hoe and Voss 2020). The surgical team also has to wear head coverings, sterile gloves, and surgical masks during surgical procedures to limit exposure to potential contaminants (Byrne et al. 2020).

2.3.1. THE REASON FOR COLD OPERATING THEATRE ENVIRONMENT

There is no clear consensus on what the recommended operating theatre temperature should be within the complex to provide thermal comfort to all the members in the operating room (Phukubye 2019). The operating theatre temperature is determined by the type of surgery performed, but the World Health Organization (WHO) recommends that the operating theatre temperature is maintained between 18 °C – 22 °C (Can, Divarci and Buyruk 2021; Phukubye 2019). Thermo-physiological or thermal comfort is based on how the human body interacts with the environment (Angelova and Velichkova 2020b). The highest priority in operating theatres is given to the patient; the operating theatre is also specifically designed to ensure patient comfort, health, and safety (Mahgoub Bassuoni et al. 2020).

Emphasis is on the patient being normothermic during surgeries, this might mean that the operating theatre temperature needs to be increased, but this could mean that the temperature is not optimal for the surgical team to perform at their best (Karahan, Budak Ertürk, Uğurlu et al. 2020). The typical reaction to have thermo-physiological comfort would be to increase or decrease the layers of clothing according to the environmental temperature, but this is not always possible in operating theatres as the staff can only wear theatre scrubs (Karahan et al. 2020). Theatres are equipped with built in temperature thermometers which continuously measures the temperature within the theatre.

Even if the operating theatre temperature is set at 20 °C, the temperature under the operating theatre lights where the surgical team stands could increase by an average of 3 °C. (Angelova and Volichkova 2020a). The operating theatre temperature where spinal surgeries are performed is set at temperatures as low as 18 °C and even lower because of the surgical team's heavy protective gowns (Angelova and Volichkova 2020b).

Because the temperature in the wards (23.3 °C – 26.5 °C) is more thermally comfortable than in the theatres, the theatre had to implement other methods to ensure thermal comfort to the patients during the perioperative phase (Khalid, Zaki, Rijal et al. 2019).

2.4. THE NORMOTHERMIC PATIENT IN THE OPERATING THEATRE

"Temperature regulation is critical for optimal physiological functioning."

JEAN FORET GIDDENS

For the body's processes to function optimally, the core temperature needs to be maintained at a constant with a narrow range of deviance (Schlader and Vargas 2019). According to Giddens (2021), the normal range for body temperature is 36.2 °C – 37.6 °C, but Marieb and Keller (2021) states that the normal ranges are 35.8 °C – 38.2 °C. Thermoregulation is a process that maintains the core body temperature at a near-constant value (Schlader and Vargas 2019). The hypothalamus is the body's internal thermostat (Marieb and Keller 2021). The hypothalamus regulates the heat-loss and heat-gain mechanisms (Marieb and Keller 2021). In humans, temperature regulation is achieved via autonomic and behavioural thermoeffectors (Schlader and Vargas 2019). Autonomic thermoeffectors promote heat loss or heat gain controlled by the body, whereas behavioural thermoeffectors are physical actions taken to promote heat balance (Schlader and Vargas 2019). The thermoeffectors are controlled via a feedback system to maintain balance (Schlader and Vargas 2019). The body is divided into two thermal compartments; core and skin (periphery), where the core is independently maintained from the thermal environment (Schlader and Vargas 2019). Core thermoreceptors are in the abdominal organs, hypothalamus, spinal cord, and skin have peripheral thermoreceptors (Giddens 2021). Marieb and Keller (2021) state that body temperature reflects heat production and balance loss.

2.4.1. THE NORMAL PHYSIOLOGICAL RESPONSE TO HYPERTHERMIA

The body temperature rises above normal ranges when the heat-loss mechanism is initiated. Once the heat-loss centre is activated, the body responds by dilating the skin's blood vessels; the heat from the warm blood makes the heat radiate from the skin's surface (Marieb and Keller, 2021).

The sweat glands are also activated, and perspiration is secreted, which is then vaporised from the skin by the body heat, and as a result the body cools down. The heat loss centre is deactivated once the body temperature decreases to normal ranges (Marieb and Hoehn, 2022).

Hyperthermia occurs when the heat-loss processes become inactive, and the core temperature rises above normal. The increased body temperature depresses the hypothalamus function, increasing the body's metabolic rate and heat production. As a result, the skin becomes dry and hot (Marieb and Hoehn, 2022).

A complication of high body temperatures is the risk of heat strokes, which can cause permanent brain damage if not corrected in time (Marieb and Keller 2021). Controlled hyperthermia is called fever; this often results from an infection somewhere in the body (Marieb and Keller 2021). Because the metabolic rate is increased, it helps to speed up various healing processes and inhibits bacterial growth.

2.4.2. THE NORMAL PHYSIOLOGICAL RESPONSE TO HYPOTHERMIA

Marieb and Keller (2021) described the heat-gain mechanism when the hypothalamus is stimulated, and the core temperature is cooler than the hypothalamus set point. The hypothalamus activates the heat-promoting centre; the body responds by activating the skeletal muscles to shiver, causing the skin's blood vessels to constrict. Blood is then diverted from the peripheral capillaries to the deeper tissues, thus minimising heat loss from the skin surface; once enough heat is produced, and the body temperature rises until the temperature is within normal ranges, the heat-production centre is deactivated.

2.4.3. THE EFFECT OF GENERAL ANAESTHESIA ON THE NORMOTHERMIC PATIENT

General anaesthesia primarily functions by interrupting neural stimulation in the brain and body. Anaesthesia prevents the brain from processing pain and induces intraoperative amnesia (Bhargava 2020).

General anaesthesia reversibly alters the consciousness without shutting the brain down (Bonhomme, Staquet, Montupil et al. 2019). Anaesthetic agents alter thermoregulatory homeostasis in many ways (Gambús and Hendrickx, 2020). It is still unknown how anaesthetic agents impair thermoregulatory control (Sessler, 2021). It is known that anaesthetic agents blunt the hypothalamic responses to the core temperature and the environmental temperature changes (Hemmings and Egan, 2018).

Anaesthetic agents and the technique used to induce vasodilation; also obscures the body's typical shivering pattern and reduce the maximum shivering intensity (Sessler 2021). Although general anaesthesia lowers the vasoconstriction and shivering thresholds, the mechanisms are still active (Gambús and Hendrickx, 2020). When neuromuscular blocking agents are administered to induce paralysis, shivering is not possible (Sessler 2021). The combination of reduced capacity to decrease heat loss and reduce heat production leads to increased heat loss (Hemmings and Egan 2018). If there is no intervention to maintain normothermia during general anaesthesia, the patient can become hypothermic by as much as 2.8 °C (Sessler 2021; Yanaral and Ertugrul 2019; Ralph 2019). General anaesthesia affects the normal thermoregulatory mechanism, and it causes a direct effect on the body to disperse the heat from the core to the periphery (Yanaral and Ertugrul 2019). The redistribution of body heat from the core to the periphery contributes to about 65% of the total decrease in the core temperature during the first three hours of general anaesthesia.

Within an hour after induction, the core temperature rapidly decreases (0.3 °C – 1.6 °C) as the heat is distributed to the periphery. After approximately two hours, there is a slow linear decrease until a plateau is reached, which usually remains unchanged until the end of the procedure (up to 2.8 °C) (Sessler 2021). During the first thirty to forty minutes after induction, a patient's core temperature can drop below 35 °C (Laxton, Allott, Veluchamy et al. 2019). Since anaesthetic agents such as induction agents, opioids, and anaesthetic gasses (Ultane®[sevoflurane] or Suprane® [Desflurane]) can promote heat loss because they cause peripheral vasodilation, it becomes essential to monitor temperature (Miyazaki, Ishihava, Abe et al. 2019).

International anaesthesia societies recommend that it be standard practice to actively warm patients in operating theatres and that temperature monitoring should occur throughout the procedure (Sagiroglu et al. 2020). The authors, Gala, Shazah, Edhi et al. (2020), stated that factors affecting the

core temperature, other than anaesthesia and the operating theatre temperature, are associated with the type of surgery, operating theatre time, the volume of fluids administered and blood loss.

Therefore, continuous temperature monitoring could help detect temperature abnormalities before complications arise (Paik, Henker, Sereika, Alexander et al. 2019). Intraoperative hypothermia could increase the risk of patients developing postoperative complications such as coagulopathy, surgical site infection, cardiac events, and prolonged hospital stays (Ralph 2019).

Patients regain thermoregulatory control as they emerge from anaesthesia postoperatively. Should patients not be actively warmed during surgery, they resume core normothermia in approximately two to five hours (Hemmings and Egan 2018). As patients emerge from anaesthesia, they regain vasoconstriction and shivering; this enables them to decrease cutaneous heat loss, increase metabolic heat production, and thus increase core temperature (Hemmings and Egan 2018).

General anaesthesia impairs the body's thermoregulation during surgery (Kang and Park 2020). It is extensively proven that impaired thermoregulation leads to hypothermia (Alfonsi, Bekka, Aegerter and SFAR Research Network Investigators, 2019). Intraoperative hypothermia is of the most common complications patients experience during surgery (Xiao, Zhang, Ly et al. 2020).

Studies have been done, and the adverse effects of complications of intraoperative hypothermia are well-documented (Flannery, Uwmana, Nikuze et al. 2021). Experimental studies have been done since the 1990s to prevent perioperative hypothermia (Lee and Kim 2021). Complications from intraoperative hypothermia have been studied and proven that general anaesthesia inhibits the body's thermoregulation; the patient's metabolic rate and cardiac output decrease, which delays wound healing and increases oxygen consumption (Rauch, Miller, Bräuer, Wallner, Bock, Paal, 2021).

The delayed healing increases the risk of the patient having surgical site infections. Intraoperative hypothermia also induces postoperative shivering, as well as increasing the patient's pain experience. Intraoperative hypothermia also alters the body's clotting formation (coagulopathy), increasing the patient's blood loss during surgery (Xiao et al. 2020). Intraoperative hypothermia prolongs intraoperative drug effects, especially neuromuscular blocking agents, resulting in the patient's delayed emergence from the anaesthetic state (Sessler 2021). Intraoperative hypothermia may increase the length of hospital stay, thus financially impacting the patient's hospital costs (Xiao et al. 2020). Collins, Budds, Raines and Hooper (2019) conducted a literature review to asses the risk factors to develop intraoperative hypothermia and focused on the following risk factors: cold ambient temperature, cold intravenous infusion fluids, age, gender, body mass index and other comorbidities. The conclusion from Collins et al. (2019) was that there is insufficient evidence-based data to indicate

which risk factors contribute to intraoperative hypothermia, but they have indicated that identifying risk patients and taking steps to prevent intraoperative hypothermia should remain a critical aspect in theatre.

2.5. WARMING SYSTEMS IN THE OPERATING THEATRES

Most surgical patients experience surgical hypothermia; measures have been put in place to try and prevent intraoperative hypothermia. The available guidelines state that maintaining normothermia during surgery is a Category 1A recommendation as it is supported by a moderate to a high quality of evidence (Kumar, Martin, Dhanorkar, Brandt et al. 2019).

2.5.1. TYPES OF WARMING SYSTEMS USED IN THE OPERATING THEATRES

The South African Society of Anaesthesiologists (SASA) strongly recommends using active warming systems, especially for patients at risk of intraoperative hypothermia and surgery lasting longer than thirty minutes. Normothermia needs to be maintained during surgery, and there are many different approaches to preserve normothermia (Batchelor, Rasburn, Abdelnou-Berchtold et al. 2019).

Passive warming is the simplest method of managing body temperature (Kim 2019). By using cotton blankets and surgical clothes, passive warming prevents body heat loss (Őzsaban and Acaroğlu, 2020). Passive warming is proven not to be highly effective (Kim 2019).
Sessler (2021) states that passive warming reduces body heat loss by 30% in the operating theatre, and adding additional layers has few other benefits.

Active warming is achieved by using electrical blankets, forced-air warming systems, electrical mattresses, warmed intravenous fluid and irrigation fluids (Kim 2019). Active warming works by actively transferring heat from an outside source to the patient (Őzsaban and Acaroğlu, 2020). Santos, Boin, Caruy et al. (2019) compared different heating methods, and there is a significant difference among them.

2.5.2. OUTCOMES ASSOCIATED WITH THE USE OF WARMING SYSTEMS

Studies on patient warming during surgery have proven that active warming is more effective than passive warming (Thapa, Karton and Peyton 2019). Several devices and methods have been adapted in different settings to actively warm patients, such as using fluid warmers for intravenous therapy, resistive heating, and conductive and convective devices.

However, their effectiveness is still controversial (Xiao et al. 2020). More than 200 million patients have been warmed in surgical settings using forced-air warming systems (Kümin, Deery, Turney et al. 2019) as it has been determined that forced-air warming is the most effective and preferred intraoperative warming system (Brodshaug et al. 2019). It effectively increases the intraoperative body temperature of the patient (Lupo, Collins, Hewer et al. 2020).

Different types of forced-air warming blankets are available for distinct surgery requirements, such as surgical access (figure. 2.1), lower body (figure. 2.2), upper body (figure. 2.3) and full overbody (figure. 2.4) (Arizant, 2019). The full underbody (figure. 2.5) forced-air warming blanket has only recently been launched and is not a popular choice for use as it is more expensive than other warming blankets (Sumida, Sugino, Kuratani et al. 2019).

The effectiveness of forced-air warming blankets during surgery has been established for various abdominal surgeries, caesarean sections, and laparoscopic surgeries (Baradaranford et al. 2019). Surgeries mentioned by Baradaranford et al. (2019) are performed on patients' who are supine on flat, solid-top surgical tables. Hara, Kuroda, Matsuura et al. (2021) conducted studies with patients in the lithotomy positions and Ralte, Matue-Torres, Winton et al. (2020) conducted a study with patients in a beach-chair (sitting) position.

Figure 0.1: Surgical Access

Figure 0.2: Lower body

Figure 0.3: Upper body

Figure 0.4: Full Overbody

Figure 0.5: Full Underbody with a patient in the prone position

2.6. PATIENT UNDERGOING SPINAL SURGERY

Before modern anaesthesia, surgical procedures were limited and spinal surgery was not possible before the development of anaesthesia. Before spinal surgery was possible, early traction and immobilisation racks were used as early as 400 BC during the time of Hippocrates (Walker, Kakarla, Chang et al. 2019).

The first recorded spinal surgery was a laminectomy done by Sir William Macewen in 1886 (Walker et al. 2019), evolved through time until in the 1890s when WT Wilkins attempted the first form of fusion when he used carbonised silk ligature in a figure of eight shape to hold two herniated vertebrae together in a new-born baby with spina bifida (Virk, Qureshi and Sandhu 2020). In 1891, Dr Berthold Ernest Hadra attempted to treat a dislocation fracture of a cervical spine using a wire to hold the vertebrae together for stability (Virk et al. 2020).

As the population ages, they have a higher incidence of requiring spinal surgery (Gupta and Bridwell 2020). Adult spine surgery is more difficult as the patients have more comorbidities and their spines are more rigid, as opposed to younger patients (Gupta and Bridwell 2020). Spinal degeneration with need for surgical intervention is seen more often in patients older than 60 years of age (Shah, Kolb, Yilmaz, Halalmeh and Moisi 2019). Lower back pain is the leading symptom in the older generation (Grotle, Småstuen, Fjeld, Grøvle, Helgeland, Storheim, Solberg and Zwart 2019). Low back pain is the most prevalent symptom of intervertebral disc degeneration, which is an indication of spinal surgery to relieve the pain (Dou, Sun, Ma et al.). In the older generation category, complex spinal

surgery involving spinal fusion and disc prosthesis is more prevalent (Grotle et al. 2019). Interbody fusion with the placement of pedicle screws and rods indicates a decrease in the morbidity of spinal surgery patients (Gupta and Bridwell 2020).

2.6.1. SPECIFIC EQUIPMENT USED

When posterior accessed spinal surgery needs to be performed, the patient is placed in a prone position (Asiedu, Lowndes, Huddleston et al. 2018). In the prone position (figure 2.5), the patient is positioned face-down on their abdomen, which provides surgical access to the dorsal aspects of the patient's body (van Wicklin 2020). The prone position offers an excellent environment for a surgical approach to the spine and dorsal anatomy of the patient (Park, Kwon, Lee et al. 2020). All surgeries are performed on unique spinal theatre tables with a base, column and a flat, solid tabletop on which the patient lies (Hinton and Capoia 2020). When in the prone position on a flat solid tabletop, the thoracoabdominal compression significantly increases the patient's intra-abdominal pressure (Jin, Park et al. 2019).

The spinal table differs from the solid tabletop as it is an open frame on which the patient is placed, with only the patient's chest, face, hips and legs supported (Mizuho OSI® 2016), Chapter 1, figure.1.1.

The spinal table has minimal effects on the patient's cardiac function as it does not elevate abdominal and thoracic pressures and decreases venous congestion (Hong, Yoon, Park et al. 2019). The use of the spinal table improves surgical access; and surgical site visualisation as the table provides more accessible access to the patient-required surgical site (Mizuho OSI® 2016).

The spinal table is the most frequent table used for posterior accessed spinal surgery; however, it exposes more significant areas of the patient's skin surface to the theatre environment, which means more body heat is lost due to environmental exposure. Theatre preparation for most surgeries are universal (a solid operating bed, trollies which are sterile draped and used for usage of instruments), and only special equipment is required for specialised surgery (specialised operating tables, tourniquets for some limb surgeries, lithotomy poles for vaginal and rectal surgeries, etc.).

2.6.2. HIGHLIGHTING LITERATURE GAPS FOR KEEPING SPINAL SURGERY PATIENTS NORMOTHERMIC

There is limited evidence on the effectiveness of forced-air warming blankets on patients undergoing spinal surgery in a prone position when the patients are positioned on the spinal table (Buraimoh et al. 2019).

Granum et al. (2019) studied patients undergoing spinal surgery and compared the effect of the surgical access forced-air warming blankets with the underbody forced-air warming blanket, although the study didn't specify which operating bed was used. Their results showed that the underbody forced-air warming blanket minimised the patient's heat loss to the environment, thus being more effective in decreasing the risk of the patients experiencing intraoperative hypothermia.

Buraimoh et al. (2019) state that limited information is available to evaluate the forced-air warming blankets' positioning on intraoperative warming blankets in patients undergoing spinal surgery done on the spinal table. Although the focus was on postoperative complications and intraoperative body temperature, they compared the underbody forced-air warming blanket with the upper-body forced-air warming blanket. Their study presented evidence that a higher percentage of patients where the upper body forced-air warming blanket was used experienced a mean temperature of less than 35 °C. The authors recommended using a forced-air warming blanket to avoid surgical site infections. They also noted scanty literature regarding the use of forced-air warming blankets in spinal surgery.

2.7. SUMMARY

In this chapter, we established that literature is available on intraoperative hypothermia and the effectual methods available to prevent patients from experiencing hypothermia. There is enough literature available on the effect of different warming methods in most surgeries, but there is not much literature on spinal surgery and effective warming methods.

Chapter 3 describes the methodology of the study and the process of gathering the necessary information regarding the effects of forced-air warming blankets' positioning on the patients' temperature intraoperatively while undergoing spinal surgery. The data gathered were analysed to describe the effects of the two forced-air warming blankets on patients' intraoperative body temperatures.

RESEARCH METHODOLOGY

"Research is formalized curiosity. It is poking and prying with a purpose."

ZORA NEALE HURSTON (1942)

3.1. INTRODUCTION

Chapter 2 describes the literature review conducted for the study. Chapter 3 will focus on the research methodology of the study. This chapter will describe the research design, research methodology and quality control.

3.2. RESEARCH DESIGN

The study design sets out to gain information on elements of the study to provide a situational picture as it happens (Grove and Gray 2019). According to Polit and Beck (2018), a research design is a detailed method used to describe a researcher's strategies to test their proposed hypothesis and answer the research questions. Thus, a research design can be seen as an overall plan for the study, the methods needed, and the procedures taken for the chosen research investigation (Hedge and Salvatore 2021).

Various research designs have been developed to address the different types of research questions posed throughout the years (Hedge and Salvatore 2021). For this study, a quantitative, prospective, and randomised comparative experimental design was chosen to answer the research question.

3.2.1. QUANTITATIVE

Between quantitative and qualitative designs, the most appropriate design for this study is quantitative, as the data collected is numerical. A quantitative design is a study where the differences between the variables are being tested, and the variables are usually described in numbers (LoBiondo-Wood and Haber 2018; Grove and Gray 2019). When a theory that needs to be tested or proven has been identified, quantitative designs are helpful as they follow a logical sequence (Gray and Grove 2020).

In quantitative designs, the aim is to try and explain or predict a possible event by analysing the collected data using statistical methods (Kyngäs, Mikkonen and Kääriäinen, 2020). Quantitative studies rely on precise measurements obtained during data collection and statistical analysis to determine whether the findings are accurate to the aim of the study (Gray and Grove 2020).

3.2.2. PROSPECTIVE

When prospective research is applied or implemented, the data collected in real-time meaning that data are available immediately as the surgical procedures are performed. As with prospective studies, the researcher does not know what the outcome will be and thus follows the participants until the completion of the surgery to determine the outcome (Ranganathan and Aggarwal 2018). With prospective studies, the researcher has to be present from when the study starts until the results can be observed (Camargo, Silva and Meneguetti 2019). An intervention study is a prospective study as the researcher determines each participant's exposure and follows them to observe the outcome (Ranganathan and Aggarwal 2020). Prospective studies have advantages in that the outcomes are easy to understand and note that it can use one population group for the studies (Gaille 2020; Kumar 2019).

3.2.3. EXPERIMENTAL DESIGN

An experimental study is where an independent variable is manipulated under controlled conditions to produce systematic changes in a dependent variable (Hedge and Salvatore 2021). To predict and control phenomena, experimental research has to be conducted objectively, systematically, and in a controlled manner (Gray and Grove 2020). According to Polit and Beck (2020), experimental studies have an advantage in yielding strong evidence about the chosen intervention's effectiveness and offering greater corroboration with other similar studies. Experimental studies also have limitations as it only focuses on a handful of variables. When done in clinical settings, data can be collected by clinical staff and not just by the researcher (Polit and Beck, 2020).

During this experimental study, the position of the forced-air warming blanket during spinal surgery (independent variable) is manipulated to determine the effect on the patient's body temperature (dependent variable). The differences in the results of the two independent variables will be compared to make an objective conclusion (LoBiondo-Wood and Haber 2018).

Experimental studies are the gold standard when research data needs to be evaluated and translated into clinical practice (Cushieri, 2019). Experimental studies randomly assign patients to the two groups and receive different interventions (Hedge and Salvatore 2021; Aggarwal and Ranganathan 2019). In experimental studies, the randomisation technique is very important and is related to the selection of patients. As the interventions are compared, the groups need to be similar (Hedge and Salvatore 2021). The random assignment of the patients to the two groups is implemented without any bias (Aggarwal and Ranganathan 2019).

The position of the forced-air warming blankets were manipulated with the two prospective groups as one group received a surgical access forced-air warming blanket and the other group a full-underbody forced-air warming blanket. All patients on the list who were assigned even numbers received the full-underbody forced-air warming blanket, and those assigned uneven numbers received the surgical-access forced-air warming blanket.

To establish a good experimental study, the only difference should be the intervention when the results are compared (Aggarwal and Ranganathan 2019; Grove and Gray 2019).

3.3. RESEARCH METHODS

Research methods provide exact and detailed procedures for initiating a research project and a blueprint of how to implement and complete it (Thomas 2021). Research methods are a consistent link between all the aspects of the research study (Costley and Fulton 2019). Research methods deal with the guidelines to conduct a study and it encompasses all the strategies needed to plan, implement, and report all stages of the study (Thomas 2021).

The research method will be discussed under the following terms: setting, population, sampling method and sample size, data collection, pilot testing, organisation of data and data analysis.

3.3.1. SETTING

To conduct a study, the researcher needed to find a location conducive to the study (Grove and Gray 2019). The setting for the research is a private hospital in an urban area in Gauteng. The hospital has eight theatres where all surgeries are performed, with two spinal tables available in the complex. The operating theatres where the spinal surgeries were performed were in Laminar flow theatres, where temperatures are maintained at 18 ˚C and are checked and recorded daily in the environmental checklist files. Four surgeons perform spinal surgeries.

The surgical team consisted of the same staff members: Surgeons (orthopaedic and neuro), a surgical assistant, an anaesthetist, an anaesthetic nurse, a scrub nurse, a circulating nurse, and a representative from the spinal instrument company.

3.3.2. POPULATION

A population defines as a large number of individuals with distinct characteristics from which a sample is taken to represent the study (Hedge and Salvatore 2021). The population identified were patients undergoing spinal surgery within the selected hospital. From January 2020 to December 2021, 200 spinal (Cervical and Lumbar) surgeries were performed at the researcher's hospital as opposed to the almost 180 spinal cases in 2019 alone.

In 2020 when COVID-19 was identified throughout the world, South Africa went into Level-5 lockdown, and all elective surgeries halted for approximately a year which had a notable influence on the number of surgeries performed during the lockdown.

3.3.3. SAMPLING AND SAMPLE SIZE

Within a population, a smaller number of individuals with distinct characteristics relevant to the study are seen as a sample (Hedge and Salvatore 2021; Gray and Grove 2020).

With the assistance of the statistician, a sample size of sixty patients over five or six months for the study were advised. During the proposal phase of the study, it was determined that around 180 spinal surgeries per annum were done at the selected hospital. The statistician used the Central Limit theorem to determine the sample size, which states that if the sample size is big enough (>30), the sampling distribution of the mean was of normal distribution (Turney 2022). There is no formula to determine the central limit, but it relies on the standard deviation and the sample means (Ganti 2022).

Participating patients were allocated an identification number for the study, and the numbers were then added to a list and numbered for record keeping.

The method used for sampling from the population is convenience sampling. This method of sampling is easier as the data is immediately available (Gaille 2020).

To ensure the participants provided the appropriate information, the following inclusion and exclusion criteria were set:

The inclusion criteria for the study were as follows:

- Adult patients (18 years and older) who required spinal surgery in prone positioning.
- A Jackson Spinal table was used as the surgical bed.
- A posterior approach spinal surgery lasting more than three hours.

The exclusion criteria were as follows:

- Patients booked for cervical spinal cases with operating times are less than two hours, and patients are positioned on the solid surgical bed).
- Patients for anterior approach spinal cases and surgery was done on the solid bed.
- Spinal surgeries, e.g., spinal wound debridement and seroma drainage, lasting less than two hours.

All patients undergoing spinal surgery had a temperature-sensing urinary catheter inserted by the surgical assistant (medical doctor). The product used for this study is the Rüsch Sensor transurethral catheter, which has a temperature probe on the tip for measuring the temperature in the bladder. According to the company, the catheter is silicone, and the measurement accuracy is +0.1 ˚C, -0.2˚C. The catheter is connected to the anaesthetic machine with an adapter cable to record the temperature continuously. The anaesthetic machine has a default setting to record all vital data every five minutes. When surgery was completed, the patients' vital data with intraoperative temperature readings. These printouts were kept by the researcher as part of the data collection phase. The forced-air warming blankets preferred by the surgeons during surgery were the upper surgical access and full underbody forced-air warming blankets. The forced-air warming blankets were switched to 43°C after the scrub nurse completed draping the patient as per Anaesthetist's preference. All patients received intravenous fluid infusions kept in specific fluid ovens, set at 37 °C and administered throughout the surgery. The fluid ovens are situated in the theatre, stocked up the previous evening with sufficient fluids for the next day's theatre cases.

Figure 3.1 illustrates the flow of the study. Of the 200 patients booked for spinal surgery, 160 patients were excluded from the study as thirty patients declined participation and did not give consent, forty-five surgeries were shorter than two hours, eighty cases were anterior approach surgery, and five surgeries were for haematoma or seroma drainage. Sixty patients were divided randomly into two groups, one for surgical access and the other for the full underbody.

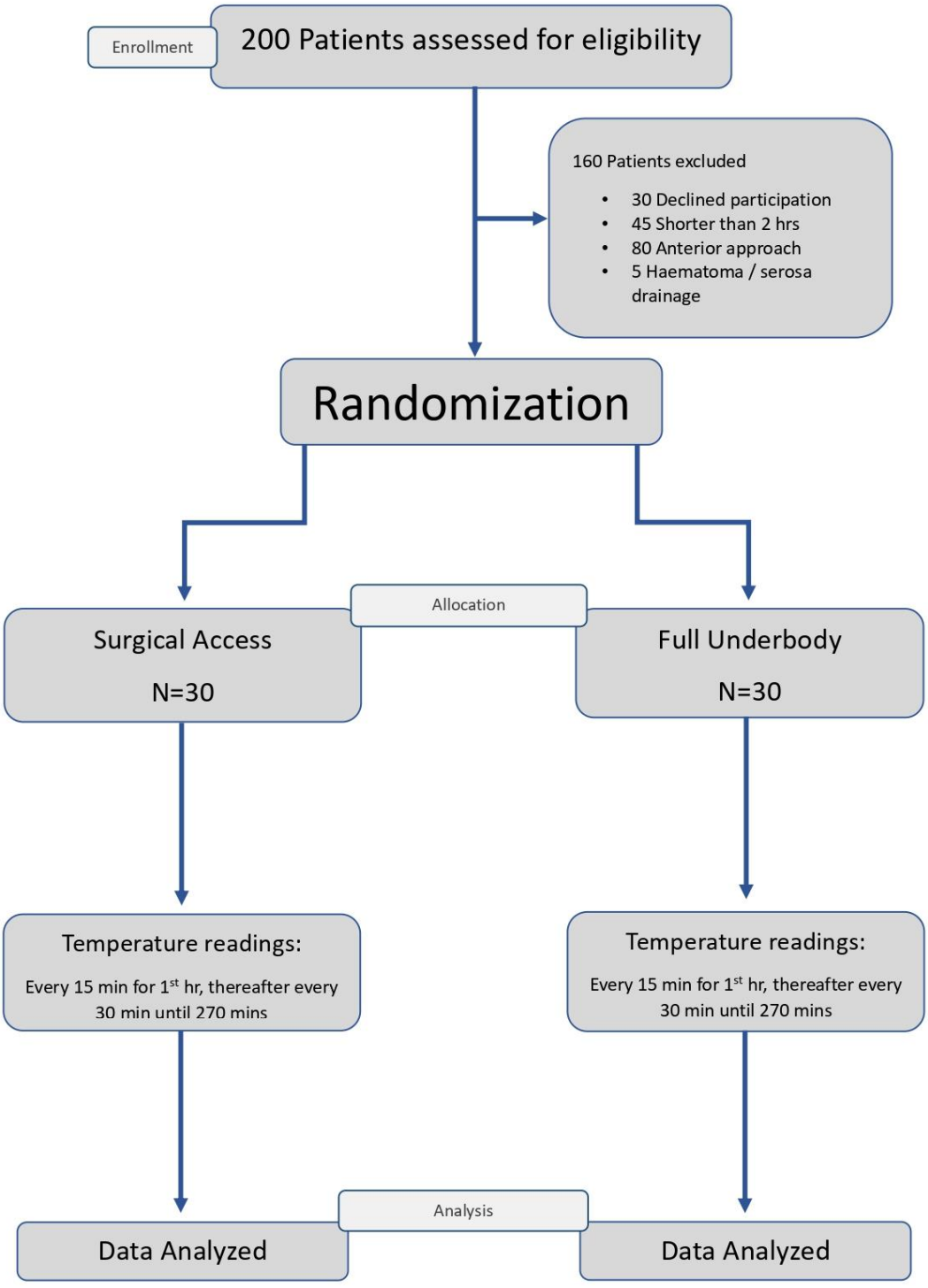

Figure 0.1: Study flow chart

3.3.4. VARIABLES

Variables identify as specific properties of events that can be changed (Hedge and Salvatore 2021). In experimental studies, one or more variables are altered, and their effects on other variables are examined (Rogers and Révész 2020). Dependent variables are influenced by the independent variable, which introduces change in the dependent variables (Rogers and Révész 2020).

- Demographic variables:

Demographic variables are used to describe the characteristics of the sample group (Liamputtong 2019), which for this study includes the booked procedure, the number of spinal levels fused and the operating room temperature, and the following patients' characteristics: Gender, age, body mass index, and co-morbidities.

- Dependent

Dependent variables can be measured and monitored but cannot be directly manipulated by the researcher (Hedge and Salvatore 2021). The dependent variable for the study is the core body temperature readings at different time points.

- Independent

A variable that can be manipulated is the independent or intervention variable whose effect is studied (Hedge and Salvatore 2021; Ranganathan and Aggarwal 2018). The independent intervention of this study is the position of the forced-air warming blankets (full underbody forced-air warming blanket and surgical access forced-air warming blanket) used to determine the effect on the dependent variable.

3.3.5. DATA COLLECTION

Data collected results from a systematic observation (Hedge and Salvatore 2021). Data collections are done in a precise, systematic method of gathering information relevant to the study's hypothesis (Gray and Grove 2020).

The corporate office, hospital management, and theatre management were informed of the study before commencement. During the patient's consultation in the surgeon's room, the surgeon informed the patient about the study.

On the morning of the admission, the researcher approached the patient and explained to the patient again that the study was safe and that the patient will not be harmed in any way. Should the patient agree to participate, the patient signed the informed consent to participate in the study (see Annexure A).

The data was collected using a standardised data collection instrument the researcher created.

The data collection instrument (Annexure B) consists of the following:

- Demographic data:
    - File number
    - Gender
    - Age
    - Body Mass Index
    - Co-morbidities
    - Pre-operative temperature reading
- Intraoperative phase:
    - Forced-air warming blanket type.
    - Intraoperative continuous temperature readings
        - First reading upon insertion of temperature probe urinary catheter (Rüsch sensor)
        - Every 15 minutes, readings for the first hour
        - Every 30 minutes until 270 min (End temperature)

The pre-operative temperature readings were used as a baseline average reading for the study. The average of times and temperature readings from the first to the last readings were used to give statistical data to analyse the effect of the two forced-air warming blanket positions on the patient's body temperature intraoperatively.

The data collection instruments (Annexure B) were printed out and placed in a designated place at the theatre reception area, marked ‘temperature data.’ The scrub nurse and the anaesthetic nurse who forms part of the surgical team of the participating surgeons were informed as to where the data collection instruments were kept. Annexure C is an example of a completed data collection sheet.

If the researcher could not collect the data, the scrub nurse would be able to obtain consent from the patient during the pre-operative visit and the data during the surgery.

3.3.6. PILOT TESTING

A pilot test defines as a smaller version of the study, and for this study, a proposed size of five patients was prepared to assess the data collection tool for accuracy (Gray and Grove 2020).

The researcher consulted the four surgeons that performed spinal surgery, a scrub nurse and the supervisors who assessed the data collection sheet for limitations. The data collected was sent to the statistician for analysis. The statistician looked at the data from the pilot study and collected data from the remaining fifty-five patients without any alterations to the instrument. The data collected during the pilot study were:

3.3.7. ORGANISING DATA

All the information collected from the data collection instruments was entered into an Excel spreadsheet to make analysis easier. All the anonymised data collection instruments and the Excel spreadsheet were digitally saved and sent to the statistician for analysis.

3.3.8. DATA ANALYSIS

The data were analysed using IBM statistics version 28 and Microsoft Excel Office 2019 to create the study's graphs. Statistical analysis was used to test, explain, and guide the researcher to a conclusion on the hypothesis of the study (Kygnäs et al. 2020). Descriptive statistics were used to describe the data and provide a summary of the study (LoBiondo-Wood and Haber 2018). Descriptive statistics comprised mean and median values as well as minimum and maximum values of the data collected.

A mean is an average of all the values (temperature readings) within the study, showing the researcher what is happening at the centre of the data distribution (Cooksey 2020). The median is when the data values are arranged from the lowest to the highest temperature reading; the temperature reading at the halfway mark was identified, which also gave a picture of what was going on in the middle of the data distribution. Both mean and median provided a generalised view of what happened in the middle of the data distribution and were used with the standard deviation.

Standard deviation was applied to determine the average deviation of the values from the mean (Liamputtong 2019). The range is the difference between the minimum and maximum temperature readings used only for reporting. It does not give detailed information on the data analysis and is just used to help determine the mean values (Gray and Grove 2020).

The descriptive data collected, i.e., the mean and standard deviations were also used to construct a frequency table. The frequency table comprised all the different categorical variables in a table form, which categorises data and provides a summary of the compared variables, e.g., age, gender, etc. (Cooksey 2020).

The statistician used a General Linear Model: Multivariate test, Pillai's trace to evaluate the differences in intraoperative temperature between the two forced-air warming blanket positions (Grove and Gray 2020). Pillai's trace was used to analyse the demographics between the two groups in the study. Another test the statistician used to compare the data was by putting all the recorded variables in ranks (Jacobsen 2021). This test reduced the complexity of measuring the data and made it easy to interpret and understand the data (Cooksey 2020).

3.4. QUALITY CONTROL

According to Grove and Gray (2019), quality control increases the probability of the findings accurately reflecting the current reality by following a design to decrease the possibility of error. For a study to be of good quality, the data collected needed to be trustworthy, which included reliability and validity of the data obtained from the study (Boswell and Cannon 2020). Gray and Grove (2020) states that validity and reliability are not defined as an all-or-nothing phenomenon but are established by degree.

To enhance the study's quality and minimise bias, variables that could influence the result of the study were controlled (Polit and Beck 2020). The environmental temperature was kept at a constant 18 °C, and all the patients received pre-warmed fluid held at 37 °C, per the manufacturer's guidelines.

The data collected from the tool needed consistency to improve the study's trustworthiness (LoBiondo-Wood and Haber 2018). Validity focuses on how truthful the study results are (Boswell and Cannon 2020). Reliability or truthfulness in this research is the degree to which the temperature readings can be collected the same way, under the same condition and with the same unit of analysis. In short, it is the repeatability of the measurement. Hymczak, Golab, Mendrala et al. (2021) showed that recoding body temperature with an indwelling urinary catheter is an exceptionally reliable method.

The more accurate the results are, the better the reliability of the research will be. Bräuer, Fazliu, Perl et al. (2020) compared bladder temperatures with a cutaneous skin probe. Their results showed that an indwelling temperature-sensing catheter was more accurate in reading the core temperature.

3.5. ACTIONS AND COMPETENCE OF THE RESEARCHER

The researcher should have capable skills and knowledge before conducting a study, during as well after the study (Thomas 2021). The researcher is functionally qualified within the theatre environment and holds a postgraduate qualification in Operating Theatre Nursing. To conduct the research, the researcher completed a postgraduate module as part of the master's study in research methodology. Continual meetings and discussions with expert supervisors ensured further competency.

3.6. PUBLICATIONS OF THE FINDINGS

"Put it before them briefly so they will read it, clearly so they will appreciate it, picturesquely so they will remember it and, above all, accurately so they will be guided by its light."

JOSEPH PULITZER

Publishing research is one of the essential parts of the study to share obtained findings with the research community (Bairagi and Munot 2019). The researcher and the expert supervisors ensured that the final research report was impartial, transparent, and exact (Thomas 2021). The hospital group will be informed about the research findings within the set policy framework and communicate the researcher's gratitude.

3.7. SUMMARY

Chapter 3 discussed in detail the research design and methodology implemented in the study. A quantitative, prospective, randomised comparative experimental design was followed to explore the effect of positioning the forced-air warming blanket during spinal surgery.

A justification for using a quantitative analysis method and sources was given, and a methodology review was provided. The approach for selecting participants and the data analysis methods have also been explained. The methods to ensure validity and reliability related to this research were presented.

The next chapter will present the findings of the study based on the data collected using the data collection sheet.

RESULTS AND DISCUSSION

"Data are just summaries of thousands of stories – tell a few of those stories to help make the data meaningful."

DAN HEATH.

4.1. INTRODUCTION

In Chapter 3, the methodology used for gathering the necessary data for the study was discussed regarding the research design and the research methodology. Chapter 4 focuses on the data collected and analysed. The chapter reports the demographics of the patients who participated in the study and the results from the descriptive and inferential statistics obtained from the data collected during the peri-operative phase. In addition, the results will be discussed with existing literature.

The study aimed to determine the effect to show whether there was a difference in temperature readings between the surgical-access forced-air warming blanket and the full underbody forced-air warming blanket or whether the two forced-air warming blankets produced similar intraoperative body temperature readings during spinal surgery.

4.2. PATIENTS' DEMOGRAPHICS

The demographic data provided an overview of the patients who participated in the study. The demographic data contained the participating patients' age, gender, body mass index (BMI) and co-morbidities.

Sixty patients (N=60) participated in the study and were randomly divided into two groups (n=30) which represented the two forced-air warming blanket positions: the surgical-access forced-air warming blanket group and the full underbody forced-air warming blanket group.

The demographic data was tabulated to provide an overview and summary of the patients in the two groups (Table 4.1).

Table 0.1: Demographic Data of participants

Characteristics	Total group (N=60)	Surgical Access Group (n=30)	Full Underbody Group (n=30)	P-Value*
Age (years) mean ±SD	62.2 11.9	62.2 10.8	62.2 13.1	0.542
BMI (kg/m^2) mean ±SD	29.7 4.6	29.8 4.4	29.6 4.9	0.948
Male-to-female Ratio	23:37	15:15	8:22	0.001
Co-morbidities %				
Hypertension	43% (N=26)	47% (n=14)	40% (n=12)	0.606
Smoking	7% (N=4)	3% (n=1)	10% (n=3)	0.309
Diabetes	7% (N=3)	3% (n=1)	17% (n=2)	0.309
Asthma	10% (N=4)	3% (n=1)	10% (n=3)	0.090
None	43% (N=26)	50% (n=15)	37% (n=11)	0.307

4.2.1. DIFFERENCE BETWEEN THE TWO GROUPS

There was no significant difference in age between the groups (p=0.542). As the average age was the same between the two groups, age was disregarded in the possibility of affecting the temperature readings. The BMI of the two groups were 29.8 kg/m^2 for the surgical-access forced-air warming blanket group and 29.6 kg/m^2 for the full underbody forced-air warming blanket (p=0.948). As the difference in the BMI between the two groups was insignificant, it was disregarded in the possibility of affecting the temperature readings. Although all patients who participated were randomly assigned, randomisation was not done according to gender.

The surgical-access forced-air warming blanket group was equally divided into a 15:15 male-to-female ratio. In contrast, the full underbody forced-air warming blanket group was unevenly divided by an 8:22 male-to-female ratio, which differed significantly from the surgical access forced-air warming blanket group (p=0.001).

The co-morbidities were merely reported to describe the participant group, and there were no significant differences in co-morbidities prevalence between the two groups. The most prevalent co-morbidity in the study group was hypertension, with 47% (n=14) in the surgical-access forced-air warming blanket group and 40% (n=12) in the full underbody forced-air warming blanket group. In the surgical access group, only 3% (n=1) was smoking, as to the 10% (n=3) in the full underbody group. Only 3% (n=1) of the surgical access group had diabetes, as the 17% (n=2) in the full underbody group.

With asthma, only 3% (n=1) were in the surgical access group, whereas 10% (n=4) had asthma in the full underbody group. In the surgical access group, 50% (n=15) of the patients did not have co-morbidities, whereas only 37% (n=11) didn't have co-morbidities.

The most common co-morbidity of hypertension is in line with data from the South African population Ware, Chidumwa, Charlton et al., 2019). Ware, Chidumwa, Charlton et al. (2019) stated that South Africans have the highest numbers of patients with hypertension globally, where only one in four South Africans have normal blood pressures. Normal blood pressure readings are recorded as a pressure reading less than 120/80 mmHg and hypertension is seen as a blood pressure reading of more than 130/80 mmHg (Flack and Adekola 2020). In a South African study, done by James, Sewpaul, Reddy et al. (2020) assessed early detection, care, and control of hypertension in South Africa, the sample size of 663 participants in the clinic showed that 71.8% of the patients were diagnosed with hypertension.

Yoo, Ok, Kim et al. (2022) noted that the mean age of their patients was sixty-nine years when they compared the patient demographics from their study. The mean ages from other studies were all older than sixty years (Yagi, Hosogana, Fujita et al. 2019; Buraimoh et al. 2019). The data from other studies suggest that it is more prevalent that patients who require spinal surgery are 60 years and older. The studies show that more female patients require spinal surgery than male patients (Yoo et al. 2022; Yagi et al. 2019; Odonkor, Kwak, Ting et al. 2020).

4.3. INTRAOPERATIVE TEMPERATURE DURING SPINAL SURGERY

With laminar flow ventilation, cool air moves in one direction from the roof cluster over the patient and then gets diffused out through the lower wall vents (Phillips and Hornacky 2020). The ambient temperature was set at 18 ˚C for both forced-air warming blanket position groups.

Table 4.2 demonstrates the different temperature readings at various points during spinal surgery from the two different forced-air warming blanket groups.

The two forced-air warming blanket positions will be reported separately; Section 4.3.1 explains the surgical-access forced-air warming blanket temperature readings and section 4.3.2 explains the full underbody forced-air warming blanket temperature readings.

4.3.1. SURGICAL ACCESS FORCED-AIR WARMING BLANKET TEMPERATURE READINGS

From Table 4.2, the data for the surgical access group temperature readings suggest that the pre-operative mean temperature reading is below the normal ranges (36.5 ˚C – 37.5 ˚C) but not below 36 ˚C which is seen as hypothermic. From the first reading, the temperature keeps gradually decreasing until a plateau is reached at 120 minutes with a temperature reading of 35.5 ˚C. The end temperature is 0.1 ˚C higher than the plateau but is still below 36 ˚C, suggesting that the patient is hypothermic after the spinal surgery. Ralph (2019) stated that intraoperative hypothermia has postoperative complications such as cardiac events, coagulopathy, surgical site infections, as well as prolonged hospital stays.

4.3.2. FULL UNDERBODY FORCED-AIR WARMING BLANKET TEMPERATURE READINGS

Table 4.2 describes the full underbody group, where the pre-operative temperature reading is 36.3 ˚C, below the normal ranges, but not hypothermic. However, the baseline reading is below 36 ˚C, and the temperature increases to 36.3 ˚C. At sixty minutes, the temperature decreased by 0.1 ˚C and again at ninety minutes, and only increased by 0.1 ˚C at 150 minutes. At 210 minutes, the temperature increased again from 0.1 ˚C to 36.3 ˚C, the same as the pre-operative reading. The end-time temperature reading was 36.5 ˚C, which falls within the normal range of 36.5˚C – 37.5 ˚C. The multinational company 3M®, released information on their website in 2022 – '*the advantages of being normothermic',* and identified that the patient experienced a decrease in blood loss, a reduction in surgical site infection and a reduced possibility of experiencing a cardiac event.

Table 0.2: Comparison of intraoperative temperature during spinal surgery between groups

Variable	Surgical Access (n=30)	Full Underbody (n=30)	p-Value
	Mean (±SD)	Mean (±SD)	
Pre -Operative	36.3 (0.37)	36.3 (0.22)	0.889
Baseline	36 (0.43)	35.8 (0.99)	0.575
15 min	36 (0.45)	36.3 (0.36)	0.002
30 min	35.9 (0.56)	36.3 (0.39)	<0.001
45 min	35.8 (0.52)	36.3 (0.46)	<0.001
60 min	35.7 (0.62)	36.2 (0.51)	<0.001
90 min	35.5 (0.63)	36.1 (0.52)	<0.001
120 min	35.5 (0.69)	36.1 (0.53)	<0.001
150 min	35.5 (0.70)	36.2 (0.54)	<0.001
180 min	35.5 (0.73)	36.2 (0.51)	<0.001
210 min	35.5 (0.75)	36.3 (0.53)	<0.001
240 min	35.5 (0.78)	36.3 (0.53)	<0.001
270 min (End temperature)	35.6 (0.74)	36.5 (0.49)	<0.001

4.4. EFFECT OF FORCED-AIR WARMING BLANKET POSITIONING ON INTRAOPERATIVE BODY TEMPERATURE

The hypothesis of the study was as follows:

H_0: The positioning of the surgical-access forced-air warming blanket and the full underbody forced-air warming blanket have similar intraoperative body temperature readings in patients during spinal surgery.

To test the study's hypothesis, the multivariable test, Pillai's trace, was used to determine whether there was a significant difference in temperature reading between the two forced-air warming blankets used in the study (Table 4.2).

From Table 4.2, the data shows no significant differences in the pre-operative (p=0.889) and baseline temperatures (p=0.575) between the two forced-air warming blankets positions. But, from 15 minutes, there was a significant difference in the temperatures between the two forced-air warming blankets, and the difference remained until the End Temp at 270 minutes (p<0.001). Therefore, the hypothesis that the positioning of the two forced-air warming blankets does not affect intraoperative body temperature during spinal surgery is repudiated.

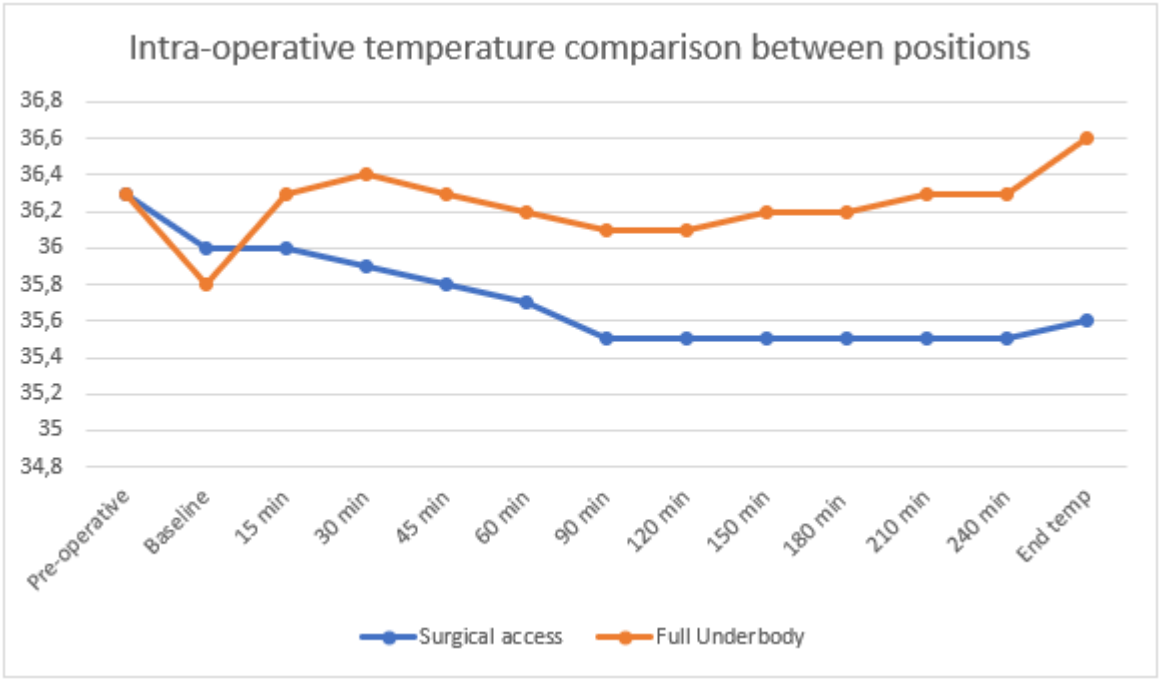

Figure 0.1: Intraoperative temperature comparison between two positions of forced-air warming blankets.

Figure 4.1 depicts the mean intraoperative temperature readings between the two forced-air warming blanket positions. There was a significant difference in the temperature reading starting around fifteen minutes, which remained as such until the end temperature at 270 minutes. The graph suggests that the surgical-access forced-air warming blanket reaches a plateau in the temperature readings. In contrast, the full underbody forced-air warming blanket indicates a steady increase in temperature readings from 150 minutes until the end temperature at 270 minutes. Although the surgical-access forced-air warming blanket does start to increase in temperature around the end temperature, it does not reach the normal range of 36.5 ˚C – 37.5 ˚C.

Hara et al. (2022) compared the underbody forced-air warming blanket with the overbody blanket while patients were in the lithotomy position. The study showed that the underbody blanket showed a significant difference in temperature ($p<0.001$ from 60 minutes) and maintenance in intraoperative body temperature readings.

Granum et al. (2019) compared the surgical-access forced-air warming blanket and full underbody forced-air warming blanket, which provided results that the full underbody forced-air warming blanket was also more effective in maintaining the intraoperative body temperature (as six patients had hypothermia at the start of the surgery and only one patient at the end of the surgery). The data from this study showed that the full underbody forced-air warming blanket was more effective in maintaining the intraoperative body temperature than the surgical-access forced-air warming blanket when the patients are positioned on the spinal table. Hara et al. (2022) study showed that after induction, there was a decrease in body temperature within the first hour. Granum et al. (2019) study showed that after induction, the body temperature dropped before the temperature started to increase after the first hour. The decrease in body temperature after induction could be associated with the heat distribution from the core to the periphery due to the anaesthesia effect. Studies have also shown that although there is a decrease in body temperature (Hara et al., 2022), the full underbody forced-air warming blanket is the most effective active warming system to reduce the risk of intraoperative hypothermia (Granum et al. 2019).

Sumida et al. (2019) compared the full underbody forced-air warming blanket with other types of patient warming methods; the results suggested that the full underbody forced-air warming blanket had a higher temperature reading of 0.5 ˚C than the other warming methods. Sumida et al. (2019) also suggested that using the full underbody helps reduce the incidence of intraoperative hypothermia. Lee and Kim (2021) studied intraoperative temperature readings from the upper and lower forced-air warming blanket, although the graph showed a higher temperature reading of 0.3 ˚C – 0.4 ˚C from the lower body forced-air warming blanket. Lee and Kim (2021) concluded that both options were effective

in maintaining core temperature in patients undergoing laparoscopic colorectal surgery. Alparslan, Kus, Hosten et al.(2018) studied the effects of the upper forced-air warming blanket and the underbody forced-air warming blanket in patients undergoing lower abdominal surgery; and they found no difference in the body temperature readings. Buraimoh et al. (2019) compared forced-air warming blanket positioning on body temperature and postoperative complications. The full underbody forced-air warming blanket and the upper-body forced-air warming blanket were compared and found that there was no difference in the incidence of hypothermia (Buraimoh et al. 2019). With the comparison of the over-body forced-air warming blanket and the underbody forced-air warming blanket, the results suggested that there were no significant temperature readings (Gulia, Gupta, Kumar et al. 2022).
Results from referenced studies in this section have different results in different theatre procedures and situations. All abdominal and laparoscopic surgeries referenced in this section were done on a solid base surgical table, which could influence the temperature readings when underbody forced-air warming blankets are used.

The studies of Buraimoh et al. (2019) and Gulia, Gupta, Kumar et al. (2022) concluded that there was no significant difference in the temperature readings from the warming devices they used, but the results from the researcher's study suggested that there is a significant difference in the temperature readings.

4.5. SUMMARY

Chapter 4 focused on the results and discussion of the study. The data showed a significant difference in temperature readings from the two forced-air warming blankets used for the study. The results suggested that the full underbody forced-air warming blanket more effectively maintains intraoperative body temperature during spinal surgery above 36 ˚C.

Chapter 5 will conclude and provide recommendations for future studies and implementations of forced-air warming blankets during spinal surgery when patients are positioned on the spinal table (Jackson table).

CONCLUSION

“Research is creating new knowledge.”

NEIL ARMSTRONG

5.1. INTRODUCTION

The findings described in Chapter 4 were obtained from the data collected during the intraoperative phase of spinal surgery. This chapter will conclude the study by summarising the key research findings concerning the research aims and questions. The chapter will also discuss the value and contribution thereof and review the limitations of the study,

5.2. AIMS AND OBJECTIVES

The study aimed to determine the effect of the two different forced-air warming blankets positioning on the intraoperative body temperature in patients undergoing spinal surgery when positioned on the spinal table.

The study set the following objectives:

- Investigate what effect the surgical-access forced-air warming blanket has on the intraoperative body temperature during spinal surgery.
- Investigate the full underbody forced-air warming blanket's effect on the intraoperative body temperature during spinal surgery.

The researcher used a quantitative, prospective, experimental design for this study. An ethics approval certificate was obtained from the University of Pretoria, the Faculty of Health Sciences Ethical Committee (Annexure E - G), and the selected hospital (Annexure H). The researcher developed a data collection sheet (Annexure B) to obtain all the necessary patient data and the intraoperative body temperature readings from the sixty participating patients. Random sampling was employed to select the patients and then divided them into two groups for the two forced-air warming blanket positions.

5.3. DISCUSSION OF FINDINGS

Intraoperative hypothermia is a common complication of general anaesthesia (Alfonsi et al., 2019). Literature regarding intraoperative warming methods focused on abdominal surgery, caesarean section, and laparoscopic surgeries (Baradaranford et al. 2019). Baradaranford et al. (2019) compared the upper body forced-air warming blanket with administrating warmed intravenous fluids during surgery and found no difference in the mean temperature.

Santos et al. (2019) stated that several studies have been conducted comparing the different methods of intraoperative warming and they focused on Gastroenterology. Santos et al. (2019) suggested that the underbody forced-air warming blanket was the most effective method to prevent intraoperative hypothermia. Shariffuddin, Hasan, Chang et al. (2016) suggested that the underbody forced-air warming blanket was the most effective warming method in patients who underwent spinal surgery. Using a forced-air warming blanket is the most effective method for warming a patient intraoperatively (Thapa et al. 2019). The current study set out to contribute to the research on the spinal table and the effect forced-air warming blanket positions have on the intraoperative body temperature.

As stated in Chapter 2, there is a literature gap with regarding the use of the forced-air warming blanket with the spinal table during spinal surgery. It is also noted that numerous studies have been conducted to evaluate the effect of the forced-air warming blanket during other surgeries such as abdominal and laparoscopic surgeries. Studies mentioned in Chapter 2 compared different warming methods and some of the different forced-air warming blankets were compared with each other. These studies assisted in identifying the most effective warming method as active warming, thus using the forced-air warming blanket.

5.4. CONCLUSION

The study's conclusion is based on the research questions and objectives. The data from the current study suggests that the full underbody forced-air warming blanket is an effective choice for patients undergoing spinal surgery when positioned on the spinal table, as the intraoperative temperature reading is higher in the full underbody group than the surgical access group (Chapter 4, figure 4.1). The current results showing that the full underbody forced-air warming blanket is the most effective method for intraoperative warming.

Current data suggested that although both groups had a decrease in temperature from the pre-operative reading to the 1st reading, the temperature increased within the first 15 min. The current data

indicated that the full underbody forced-air warming blanket had the highest increase in temperature readings and maintained a close grouping of the readings. In contrast, the surgical-access temperature readings never recovered the same as the full underbody, as discussed in Chapter 4.

5.5. LIMITATIONS

The researcher identified the following limitations regarding the study:

- COVID-19 was initially identified at the beginning of 2020, and the country went into Level 5 lockdown, which halted all elective surgeries for most of the year.
- When elective surgery could recommence, most patients feared surgery and cancelled their surgeries more often than before COVID-19.
- During the COVID-19 pandemic, there have been instances where the temperature reading urinary catheters needed for collecting the temperature readings were out of stock or on back order, which affected collecting data for the study and delayed data collection.

5.6. RECOMMENDATIONS FOR FURTHER STUDIES

Based on findings from the study, the researcher has the following recommendations for further research:

- A repeat of the study under the same conditions with a larger sample size to determine if the findings can be replicated as it could strengthen results.
- Methods can be implemented to warm the patients pre-operatively and during induction of anaesthesia to try and prevent the fall in temperature noted in the study.
- Theatre staff receive training in using the most effective forced-air warming blanket option and position for patients undergoing spinal surgery while positioned on the spinal table.
- Hospital group to be informed of the findings of the study which could lead to recommendation protocols for theatre when considering the most effective forced-air warming blanket option to use during spinal surgery when positioned on the spinal bed.

5.7. SUMMARY

This chapter summarised previous studies that contributed to the study and also identified literature gaps as identified in Chapter 2.

This study with other studies that focused on hypothermia in patients undergoing spinal surgery when positioned on the spinal table, can guide practice to writing a protocol for the best warming method with the use of the spinal table. The data from the study can provide a reference to future studies regarding the spinal table and intraoperative hypothermia during spinal surgery.

The results show that the full underbody forced-air warming blanket is more effective than other warming blankets in preventing intraoperative hypothermia. This chapter also identified the limitations the researcher experienced during the study and recommendations for future studies, training to theatre staff as well as implementing a standard protocol for the use of the full underbody forced-air warming blankets for patients undergoing spinal surgery on the spinal bed.

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ANNEXURES

ANNEXURE A – CONSENT

ICD 1A

PARTICIPANT'S INFORMATION and INFORMED CONSENT DOCUMENT

STUDY TITLE: The effect of forced-air warming blanket positioning during spinal surgery on intraoperative body temperature

Principal Investigators: N Joubert

Institution: Mediclinic Kloof Hospital

DAYTIME AND AFTER-HOURS TELEPHONE NUMBER:

Daytime number: 0722705297

Afterhours number: 0722705297

DATE AND TIME OF FIRST INFORMED CONSENT DISCUSSION:

			:
date	**month**	**Year**	**Time**

Dear Prospective Participant

Dear Mr. / Mrs. .....

1) INTRODUCTION

You are invited to volunteer for a research study. I am doing research for a master's degree purpose at the University of Pretoria. This information in this document is to help you to decide if you would like to participate. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this document, do not hesitate to ask the researcher. You should not agree to take part unless you are completely happy about all the procedures involved.

2) THE NATURE AND PURPOSE OF THIS STUDY

The aim of the study is to determine the effect of the forced-air warming blanket positioning on intraoperative body temperature in patients undergoing spinal surgery when positioned on the spinal table.

3) EXPLANATION OF PROCEDURES AND WHAT WILL BE EXPEXTED FROM PARTICIPANTS.

This study involves collecting and analysing your temperature readings measured during the spinal surgery.

4) POSSIBLE RISKS AND DISCOMFORTS INVOLVED

There are no medical risks associated with the study.

5) POSSIBLE BENEFITS OF THIS STUDY

Although you may not benefit directly. The study results may help us to assist with implementing a standard for forced-air warming blanket positioning when using the spinal table in healthcare facilities and nursing practice. The postoperative complications associated with intraoperative hypothermia could be decreased for patients undergoing spinal surgery when effective positioning is determined.

6) COMPENSATION

You will not be paid to take part in the study. There are no costs involved for you to be part of the study.

7) YOUR RIGHTS AS A RESEARCH PARTICIPANT

Your participation in this trial is entirely voluntary and you can refuse to participate or stop at any time without stating any reason. Your withdrawal will not affect your access to other medical care.

8) ETHICS APPROVAL

This Protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, telephone numbers 012 356 3084 / 012 356 3085 and written approval has been granted by that committee. The study has been structured in accordance with the Declaration of Helsinki (last update: October 2013), which deals with the recommendations guiding doctors in biomedical research involving human/subjects. A copy of the Declaration may be obtained from the investigator should you wish to review it.

9) INFORMATION

If I have any questions concerning this study, I should contact:

Tasha Joubert Cell: 0722705297

Dr CJ Filmalter Tel: (012) 329 – 9680

10) CONFIDENTIALITY

All information obtained during this study will be regarded as confidential. Each participant that is taking part will be provided with an alphanumeric coded number e.g., 001. This will ensure confidentiality of information so collected. Only the researcher will be able to identify you as participant. Results will be published or presented in such a fashion that patients remain unidentifiable. The hard copies of all your records will be kept in a locked facility at Mediclinic Kloof Archive department.

11) CONSENT TO PARTICIPATE IN THIS STUDY

- I confirm that the person requesting my consent for myself to take part in this study has told me about the nature and process, any risks or discomforts, and the benefits of the study.
- I have also received, read, and understood the above written information about the study.
- I have had adequate time to ask questions and I have no objections to participate in this study.
- I am aware that the information obtained in the study, including personal details, will be anonymously processed, and presented in the reporting of results.
- I understand that I will not be penalized in any way should I wish to discontinue with the study and that withdrawal will not affect my further treatments.
- I am participating willingly.
- I have received a signed copy of this informed consent agreement.

_____ _____

Participant's name (Please print) Date

_____ _____

Participant's signature Date

_____ _____

Researcher's name (Please print) Date

_____ _____

Researcher's signature Date

AFFIRMATION OF INFORMED CONSENT BY AN ILLITERATE PARTICIPANT

(If suitable)

I, the undersigned, ……..…, have read and have explained fully to the participant, named ……, the informed consent document, which describes the nature and purpose of the study in which I have asked him/her to participate. The explanation I have given has mentioned both the possible risks and benefits of the study. The participant indicated that he/she understands that he/she will be free to withdraw from the study at any time for any reason and without jeopardizing his/her standard care.

I hereby certify that the patient has agreed to participate in this study.

_____	_____
Participant's name (Please print)	Date
_____	_____
Participant's signature	Date
_____	_____
Investigator's Name (Please print)	Date
_____	_____
Investigator's Signature	Date
_____	_____
Name of the person who witnessed the informed consent (Please print)	Date
_____	_____
Signature of the Witness	Date

ANNEXURE B – COLLECTION SHEET

CLINICAL DATA CHECKLIST: Patient Spinal Surgery

Section A: Patient Demographic

1. File Number ☐

2. Gender

Male ☐

Female ☐

3. Age

_____ yrs

4. BMI (kg/ m²)

Weight: _____kg

Height: _____m

5. Comorbidities

	Y/N
Hypertension	
Diabetes Mellitus	
Asthma	
Smoking	

8. Pre-operative temperature readings (°C) _____ °C

Section B: Intra-operative Phase

1. Position of Forced-air Warming Blanket

Full underbody ☐

Surgical access ☐

2. Temperature readings (°C)

2.1 Intra-Operative:

Insertion of catheter: _____ °C (First reading)

Interval readings during surgery (15min for first hour, thereafter 30 min until end of surgery)

15 min: _____ °C

30 min: _____ °C

45 min: _____ °C

60 min: _____ °C

90 min: _____ °C

120 min: _____ °C

150 min: _____ °C

180 min: _____ °C

210 min: _____ °C

240 min: _____ °C

End temp: _____ °C

ANNEXURE C – COLLECTION SHEET WITH RAW DATA

CLINICAL DATA CHECKLIST: Patient Spinal Surgery

Section A: Patient Demographic

1. File Number 95182

2. Gender

Male	
Female	X

3. Age

73 yrs

4. BMI (kg/ m²)

Weight: 57.4 kg
Height: 1.6 m

5. Comorbidities

	Y/N
Hypertension	N
Diabetes Mellitus	N
Asthma	N
Smoking	N

6. Booked Procedure

L1/L2 - L2/L3 Laminectomy, Discectomy, Inclusion fusion & TLIF

7. Spinal Fusion Levels

1 level	
2 levels	
3+ levels	X

8. Pre-operative temperature readings (°C) 36.1 °C

Section B: Intra-operative Phase

1. Position of Forced-air Warming Blanket

Full underbody	X
Surgical access	

2. Temperature readings (°C)

2.1 Intra-Operative:
Insertion of catheter: 36,3°C (First reading)
Interval readings during surgery (15min for first hour, thereafter 30 min until end of surgery)

15 min:	36 °C	270 min:	36 °C
30 min:	35.9 °C	(End temp)	
45 min:	35.4 °C		
60 min:	35.2 °C		
90 min:	35.2 °C		
120 min:	35.2 °C		
150 min:	35.4 °C		
180 min:	35.6 °C		
210 min:	35.7 °C		
240 min:	36 °C		

ANNEXURE D – DATA SPREADSHEET

	Demographic data																							
Patient allocation numbering	Gender		Age	BMI	Comorbidities				Temp	Position of blanket														
	F	M			Hypertension	Diabetes	Asthma	Smoking	Pre-operative	Full underbody	Surgical Access	1st reading	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min	210 min	240 min	End temp.

ANNEXURE E – ETHICS APPROVAL LETTER 2020

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

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04 December 2020

Faculty Ethics Committee

Faculty of Health Sciences

University of Pretoria

To whom it may concern,

Evaluation of a protocol for the following student:

Student Joubert N - Department of Nursing Science (MCur); student number: 14439868

Title: The effect of forced – air warming blanket positioning during spinal surgery on intra – operative body temperature

This letter serves to confirm that the above mentioned protocol was discussed by the Postgraduate Committee of the School of Health Care Sciences during the On- line meeting of 11 November 2020.The proposal was accepted with minor changes, and the corrections were effected. It is hereby referred to your committee for ethical clearance.

Sincerely yours,

JDMothabeng.

Professor DJ Mothabeng

Chairperson: Research and postgraduate committee

School of Health Care Sciences

ANNEXURE F – ETHICS APPROVAL LETTER 2021

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

Institution: The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved old 22 May 2002 and Expires 03/20/2022.
- IORG #: IORG0001762 OMB No. 0990-0279 Approved for use through February 28, 2022 and Expires: 03/04/2023.

28 January 2021

Approval Certificate
New Application

Ethics Reference No.: 881/2020
Title: The effect of forced-air warming blanket positioning during spinal surgery on intra-operative body temperature

Dear Miss N Joubert

The **New Application** as supported by documents received between 2021-01-04 and 2021-01-27 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on 2021-01-27 as resolved by its quorate meeting.

Please note the following about your ethics approval:

- Ethics Approval is valid for 1 year and needs to be renewed annually by 2022-01-28.
- Please remember to use your protocol number (881/2020) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

Dr R Sommers
MBChB MMed (Int) MPharmMed PhD
Deputy Chairperson of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health)

Research Ethics Committee
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www.up.ac.za

Fakulteit Gesondheidswetenskappe
Lefapha la Dikaense tša Maphelo

ANNEXURE G – ETHICS APPROVAL LETTER 202

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

Institution: The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved dd 22 May 2002 and Expires 03/20/2022.
- IORG #: IORG0001762 OMB No. 0990-0279 Approved for use through February 28, 2022 and Expires: 03/04/2023.

Faculty of Health Sciences **Research Ethics Committee**

11 February 2022

Approval Certificate
Annual Renewal

Dear Miss N Joubert,

Ethics Reference No.: 881/2020 – Line 2
Title: The effect of forced-air warming blanket positioning during spinal surgery on intra-operative body temperature

The **Annual Renewal** as supported by documents received between 2022-01-13 and 2022-02-09 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on 2022-02-09 as resolved by its quorate meeting.

Please note the following about your ethics approval:

- Renewal of ethics approval is valid for 1 year, subsequent annual renewal will become due on 2023-02-11.
- Please remember to use your protocol number (881/2020) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

On behalf of the FHS REC, Dr R Sommers
MBChB, MMed (Int), MPharmMed, PhD
Deputy Chairperson *of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria*

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health)

Research Ethics Committee
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Gezina 0031, South Africa
Tel +27 (0)12 356 3084
Email: deepeka.behari@up.ac.za
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Fakulteit Gesondheidswetenskappe
Lefapha la Disaense tša Maphelo

ANNEXURE H – HOSPITAL APPROVAL LETTER

MEDICLINIC

MEDICLINIC CORPORATE OFFICE
25 OUTOII STREET
STELLENBOSCH
7600
SOUTH AFRICA
PO BOX 456
STELLENBOSCH
7599
SOUTH AFRICA

01 April 2021

Ms N Joubert
51 Tipperary Mews
Tipperary Road
Faerie Glen
0084

E-mail: tashajoubert@gmail.com

Dear Ms Joubert

PERMISSION TO CONDUCT RESEARCH AT MEDICLINIC KLOOF

Your research proposal entitled "the effect of forced-air warming blanket positioning during spinal surgery on intra - operative body temperature", refers.

It is in order for you to conduct your research at Mediclinic Kloof and I wish you success with this project.

Yours sincerely

pp.
Mjo Stallick

DR CHRIS DU PLESSIS
General Manager Clinical Services

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MEDICLINIC (PTY) LTD
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ANNEXURE I – EDITOR'S LETTER

N Sutherland
21 Aero Rd
Valhalla
0185

January 2023

I, Nicolette Sutherland (ID 740711 0250 081), hereby confirm that I have edited the proposal to engage in the presentation of the master's thesis noted below. The utmost care will be taken to ensure that the Final Document is free of spelling and grammatical errors, however, the accuracy of the final work remains the responsibility of the author.

Author: Natasha Joubert

Title: The effect of forced-air warming blanket positioning during spinal surgery on intraoperative body temperature

The edit includes the following:

- Spelling
- Vocabulary
- Punctuation
- Grammar
- Consistency in terminology, numbering, font style.
- Sentence construction
- Suggestions for text with unclear meaning
- Logic: Relevance, clarity, and consistency
- Checking the list of references against in-text sources.

Nicolette Sutherland
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