‘Giving Birth on a Beach’
Women’s Experiences of Using Virtual Reality in Labour
A Pragmatic Mixed Methods Approach

Lorna Massov

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ABSTRACT

Birth is a normal physiological process, and many women want a natural birth. However, there is worldwide concern over the increasing use of epidural analgesia and other pharmacological pain relief methods for women in labour. This tendency renders birth non-physiological by increasing the use of obstetric interventions with associated risks. Women use a range of non-pharmacological pain relief methods to reduce labour pain intensity, to help manage labour pain and to induce relaxation. The purpose of this study was to explore the experiences of women using virtual reality (VR) as a non-pharmacological method of pain relief in labour and to determine whether there was an effect on labour pain intensity. Virtual reality has been shown to be an effective distraction technique in other acute pain settings and also reduces anxiety.

This study used a pragmatic mixed method approach with a sequential exploratory design, combining in-depth antenatal and postnatal interviews with an intervention study in labour in a cross-over within-subjects trial. Thematic analysis was used to analyse the qualitative data.

Twenty-six pregnant women were recruited to the study. Fourteen participants reported their pain and had their heart rate and blood pressure measured during active labour while using and not using VR. There were significantly lower reported pain scores (6.14 compared to 7.61, $p = <.001$) and maternal heart rate (79.86 beats per minute compared to 85.57, $p = .033$) and mean arterial pressure (88.78 mmHg compared to 92.61 mmHg, $p = .022$) were lower when using VR during active labour. These differences were all statistically significant. Findings from qualitative postnatal

interviews indicated a positive response to the use of VR in labour. Several themes were identified in the data. The first theme, *Impact of VR on Labour*, described the impact of VR on labour in terms of distraction, relaxation, enjoyment and a positive birth experience. The second theme, *Managing the Pain*, describes how VR was used by the women to manage their labour pain using breathing techniques and gaining a sense of control. In the third theme, *The Challenges and Surprises of Using VR in Labour*, women's narratives recounted the various challenges of using the VR technology. Despite these challenges, ninety-four percent of women reported that they would use VR in labour again and would recommend it to a pregnant friend.

This study provides a unique and original contribution to the field of VR in labour and birth. It is consistent with other recent findings of reduced pain with the use of VR, and links decreased pain scales to heart rate and blood pressure, the physiological markers of pain. It also identifies VR as an acceptable and positive experience in the management of labour pain. Results from this study have the potential to inform design for future labour specific VR environments and expand its application in the field of biomedical technology.

Key words: birth, labour, pain, anxiety, virtual reality, VR

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ABBREVIATIONS

ACC	Anterior cingulate cortex
CAM	Complementary alternative therapies
CNSC	Central nervous system control
CSE	Combined spinal epidural
DHB	District health board
DNIC	Diffuse noxious inhibitory control
FER	Fetal ejection reflex
FHR	Fetal heart rate
fMRI	Functional magnetic resonance imaging
GCT	Gate control theory
IAPS	International affective picture system
IV	Intravenous
LMC	Lead maternity carer
MBP	Maternal blood pressure
MHR	Maternal heart rate
NFR	Nociceptive flexion reflexes
NZCOM	New Zealand College of Midwives
NZ	New Zealand
PAG	Periaqueductal grey
RCT	Randomised controlled trial
USA	United States of America
VE	Virtual environment
VR	VR

CHAPTER 1: INTRODUCTION

Nationally and internationally different interventions and strategies are adopted and trialled, to mitigate the need for epidural analgesia during labour and birth and to accommodate women's needs and desires to use non-pharmacological methods of pain relief during labour. This thesis reports on a study undertaken to explore the potential benefits of virtual reality (VR) as another non-pharmacological tool that women might use in labour to manage their pain and to aid relaxation. This chapter begins by reporting on incidence rates for epidural analgesia both in New Zealand and internationally. It then discusses the reasons for these high and rising rates and the side-effects of epidural analgesia and its interference in physiological birth. The rationale for the use of non-pharmacological methods of pain relief in labour is then explored with the incidences of its use by women both in New Zealand and internationally. The next part of the chapter introduces the topic of VR and its use in pain attenuation, both in general acute pain and specifically labour pain. The study is discussed within the context of the New Zealand maternity system and regarding my own personal position as a midwife. Finally, the research questions, aims and objectives are described, the significance of the research and an outline of the chapters.

1.1 The clinical issue - epidural analgesia rates

There is worldwide concern about high and rising intervention rates for women in childbirth, including the use of pharmacological methods of pain relief such as epidural analgesia in normal physiological birth. A normal birth is defined as a

spontaneous vaginal birth without obstetric interventions in labour or birth (Ministry of Health, 2015). One recent study which collected retrospective birth record data from a study population of 2.6 million women who gave birth in hospitals in the United States of America (USA) in 2015, calculated that 71.3% of women used neuraxial (either epidural, spinal or combined) analgesia (Butwick et al., 2018). This was an increase of 10% from a 2008 study (Osterman & Martin, 2011). In Europe, rates vary. For nulliparous¹ women the rate is 19% in the United Kingdom (UK), 45% in Sweden, 51% in Norway and 83% in Finland. For multiparous² women, the rates are 11% in the UK, 19% in Sweden, 23% in Norway and 59% in Finland (Seijmonsbergen-Schermers et al., 2020). France has one of the highest rates of epidural/spinal analgesia, of 83.8% (Blondel et al., 2017). In Canada, overall the national rate was 57.8% in 2015-2016, an increase from 53.2% in 2006-2007 (Public Health Agency of Canada, 2018). While Australia and New Zealand (NZ) have lower rates, of 40% and 26.5% respectively, a steady rise in epidural rates continues; previously in Australia the rate was 31.8% in 2011, and in NZ the rate was 24.9% in 2010 (The Australian Institute of Health & Welfare, 2020; Li et al., 2013; Ministry of Health, 2010; 2017).

1.1.1 Reasons for rising epidural analgesia rates

The likely reasons for the rising epidural analgesia rates are multi-faceted and reflect the complexities and dichotomies inherent in maternity systems. The provision of 24 hour/7 days a week, on-demand epidural services in tertiary³ level hospitals is

¹ Nulliparous describes a woman who has not previously experienced childbirth.

² Multiparous is defined as a woman who has experienced one or more previous childbirths.

³ Tertiary maternity services are additional maternity care provided to women and babies with highly complex clinical needs requiring consultation with and/or transfer of care to a multidisciplinary specialist team.

common practice in most Western countries, due to the establishment of the profession of obstetric anaesthesia as a subspecialty (Walsh, 2009; Wolf, 2009). These epidural services have been available for at least two generations of childbearing women. Anecdotal evidence from midwives indicates that mothers of childbearing women now, more commonly recommend epidurals to their daughters than occurred a generation ago (Walsh, 2009). Many maternity models, such as private obstetrician led care and public hospital care offer fragmented services. A lack of, or a loss of, midwifery led continuity of care is a contributing factor in greater uptake of pharmacological methods of pain relief (Hodnett et al., 2011). There is a dichotomy between the medical and midwifery model of care with different paradigms of managing labour pain. The medical model considers pain as treatable and seeks to 'obliterate' it (Lowe, 2002) and proposes medical solutions to clinical symptoms including pain (Walsh, 2007). The midwifery model of care emphasises the purposeful nature of labour pain, a 'rite of passage' meaning to childbirth. In contrast, in maternity services the pain relief paradigm is paramount (Leap & Anderson, 2008, p. 120), birth is institutionalised and dominated by a risk discourse which encourages intervention in birth including pharmacological methods of pain relief (Walsh, 2007).

1.1.2 Side effects of epidural analgesia

Epidural analgesia is an effective form of pain relief (Anim-Somuah et al., 2018; Koyyalamudi et al., 2016) that can have side-effects that are sometimes

Secondary services are provided where women and their babies expect complications that need additional maternity care involving specialists and a secondary care team. Primary maternity services are provided to women and their babies for an uncomplicated pregnancy, labour and birth and in the postnatal period (Ministry of Health, 2012).

serious for women and their babies (Anim-Somuah et al., 2018; Lieberman & O'Donoghue, 2002). These include hypotension, urinary retention, maternal pyrexia (Anim-Somuah et al., 2018), and an increase in third and fourth-degree perineal tears (Loewenberg-Weisband et al., 2014) for mothers, increased rates of hypoglycaemia for the neonate (Lieberman et al., 2002) and diminished breastfeeding behaviours after birth (Wiklund et al., 2009; Ransjö-Arvidson et al., 2001).

1.1.3 Interference in physiological birth

The use of epidural analgesia in normal physiological birth interferes with hormonal and physiological processes that work harmoniously together towards what is considered an instinctive act, birth as “an elaborate pattern of actions occurring as a whole in response to stimuli...” (Buckley, 2009, p. 13). The consequence of this interference in a normal physiological process is the rendering of birth as non-physiological. Epidural analgesia has been associated with an increase in the length of both first and second stages of labour (Anim-Somuah et al., 2018; Cheng et al., 2014), increased use of instruments such as forceps or ventouse for delivery (Srebnik et al., 2020; Turner et al., 2019) and increased use of exogenous oxytocin to augment labour (Anim-Somuah et al., 2018). Epidural analgesia is one of childbirth's most obvious examples of iatrogenesis (Walsh, 2007), and is concomitant with the rise in morbidity associated with these interventions (Leap & Anderson, 2008).

1.2 Non-pharmacological birth

Labour and birth are momentous, life changing experiences that impact not only on the woman, her family, and supporters, but also her extended community. It also causes one of the most severe forms of pain a woman is likely to experience (Lowe, 2002; Melzack et al., 1984). The experience of labour pain is also highly variable and subjective. Women's descriptions of their labour pain vary from unbearable to pleasurable, for some women these extremes are experienced concurrently (Karlsdottir et al., 2013; Lundgren, 1998).

However, the experience of labour is more than solely physiological, it is a complex emotional and psychological experience producing feelings of accomplishment and fulfilment (Hardin & Buckner, 2004; Salmon et al., 1990). Efficacy of pain relief is not necessarily associated with maternal satisfaction (Hodnett, 2002; Lindholm & Hildingsson, 2015) and many women strive for a natural birth, free from unnecessary medical interventions including non-pharmacological pain relief. Many women wish to avoid or delay the use of pharmacological methods, such as epidural analgesia, or use non-pharmacological methods together with pharmacological methods.

1.2.1 Rates of non-pharmacological birth

In NZ in 2016, 52.5% of a cohort of 30,165 mothers, representing over half the annual births in NZ, did not use pharmacological pain relief during their labour and 64.4% did not have any anaesthetic products such as epidural analgesia, general anaesthesia, pudendal block, or spinal analgesia (Dallenbach et al., 2016). Similarly, around the world, the use of complementary and alternative (CAM)

therapies is increasingly common in pregnancy and labour. In 153 women surveyed at a medical centre in the USA (a response rate of 74.3%) 69% used therapies, such as herbal medicine, relaxation therapies and aromatherapy as common modalities. 57% of women in the UK and 51% in Germany use these therapies (Hall & Jolly, 2014; Kalder et al., 2011; Strouss et al., 2014). In a 2013 Australian survey, 48.1% (n = 623) of women consulted a CAM practitioner and 52% (n = 842) used CAM products in their pregnancy (Frawley et al., 2013).

The use of non-pharmacological methods of pain relief in labour, designed to foster physiological birth, have a variety of benefits beyond pain attenuation. Non-pharmacological pain relief can help labouring women relax and remain in control of the pain, increasing self-confidence and satisfaction with the birth experience (Simkin & Bolding, 2004). An undisturbed birth environment which promotes physiological birth has the potential to increase breastfeeding rates and enhance mother-infant attachment (Bonapace et al., 2018; Buckley, 2009). Non-pharmacological methods women use in labour range from position changes, heat packs, water immersion, massage, and acupuncture, to the use of distraction techniques that include music therapy, visualisation, and hypnobirthing. Like meditation, hypnobirthing is a deep state of relaxation which includes techniques such as visualisation, relaxation, breathing and affirmation; it is used to help women in labour, dispel fear and manage pain (Wright & Geraghty, 2017).

1.3 Virtual Reality

Virtual reality is a novel non-pharmacological technique that has been shown to be effective in the management of acute pain and anxiety in a diverse range of clinical settings (Chan et al., 2018; Eijlers et al., 2019; Gold & Mahrer, 2018; Li et al.,

2011; Smith et al., 2020; Spiegel et al., 2019). Virtual reality possesses many of the elements of other natural therapies, such as distraction and visualisation and meditation and hypnotic features. Virtual reality technology allows users to enter an immersive three dimensional (3D) computer-generated world using a headset.

Virtual reality is an environment, either real or simulated, in which the user experiences presence; the sense of being in that world (Steuer, 1993). Distinct from traditional forms of distraction such as listening to music or watching television, VR has emerged as an effective and powerful distraction tool, generating multi-sensory input (sight, sound, touch, and more rarely taste and/or smell). It is this convergence of sensory input and interactivity that provides users with the illusion of entering a virtual world (Hoffman et al., 2004a). This illusion of presence and immersion are considered central to the therapeutic value and efficacy of VR as analgesia (Triberti et al., 2014).

1.3.1 Virtual reality and pain attenuation

Virtual reality has historically been recognised for its entertainment value, for example, in the area of console games. It is now used in education, training (simulation) and healthcare settings due to the availability of affordable, portable, and high-quality headsets and software (Colloca et al., 2020; Garrett et al., 2018; Gold et al., 2007). Virtual reality is used in a variety of healthcare settings focusing on pain attenuation, anxiety and distress while undergoing painful medical procedures for paediatric and adult patients such as burn wound care, physical therapy, chemotherapy, dental procedures and routine procedures such as venipuncture and intravenous placement (Aminabadi et al., 2012; Gold et al., 2006; Hoffman et al., 2011; Piskorz & Czub, 2017; Schneider & Workman, 2000; Tashjian

et al., 2017). Very recently, VR has been used in labour and birth (Cowles et al., 2019; Frey et al., 2018; Pratiw et al., 2017; Wong et al., 2020) due to its combination of visualisation, hypnotic and meditative features which are regarded as optimising relaxation and pain attenuation and decreasing anxiety in labouring women.

1.4 The Aotearoa New Zealand context

The Aotearoa New Zealand maternity model of care is based on the concept of partnership between women and their caregivers, informed choice, consent, and decision-making in all aspects of care related to their pregnancy. It is also underpinned by a philosophical belief in normal physiological birth. Women in NZ nominate a Lead Maternity Carer (LMC) to coordinate their pregnancy care through the antenatal, intrapartum, and postpartum periods. The LMC can be a midwife, general practitioner, or obstetrician. In 2017 most women (94.2%) chose a midwife as their LMC to provide this care (New Zealand Ministry of Health, 2017). This model of care is also referred to as continuity of care, the development of a trusted relationship with the LMC throughout all three stages of childbirth. Articulating their philosophy and code of ethics, the New Zealand College of Midwives (NZCOM) states, “continuity of care enhances and protects the normal process of birth” (New Zealand College of Midwives, 2020).

Midwives in NZ practice autonomously, a right that was restored to them with an amendment to the New Zealand Nurses Act (1977) in 1990. This legislated autonomy enabled them to offer primary maternity care to women alongside their GP and obstetrician. Primary care is generally defined as care of women who are low risk with uncomplicated pregnancies. Midwives can access all District Health Board (DHB) facilities and services within their scope of practice, are permitted to order

scans and laboratory tests and independently prescribe medicines related to pregnancy and birth.

Lead maternity carer (LMC) midwives (case loading⁴) work in a variety of environments. Many are employed by a hospital, others are self-employed and work in community-based midwifery practices that usually consist of four to six midwives, depending on their number of clients.

Lead maternity carer midwives provide labour and birth care in a variety of settings, at home, in midwifery-led birthing units and in large secondary and tertiary obstetric hospitals, in line with the women's wishes and needs. Midwives can offer a fully integrated maternity service, seamlessly transitioning across the childbirth continuum and alongside the woman in whatever setting is necessary to provide optimal care.

1.5 My interest in virtual reality use in labour and birth

I am an experienced midwife working as a core hospital midwife in a tertiary hospital. In a tertiary setting I primarily provide antenatal, labour, and postpartum care to both high and low risk women in a delivery suite. Women have highly individualised experiences of labour, and their experience of labour pain is subjective and variable. Some women request early epidural analgesia, some appear to feel no pain, and others and some accept that labour will be painful and want to manage their labour with a range of non-pharmacological methods that may affect pain intensity and help them to relax and remain calm. Many of this last group of women

⁴ A model of midwifery care where women have a primary midwife assigned to them throughout pregnancy, labour, birth and postnatally. Each midwife has an agreed annual number (caseload) of women and acts as second or "back-up" midwife for women who have another midwife as their LMC.

are highly motivated to use a variety of coping strategies which they refer to as their 'toolbox'. They squeeze combs in their hands, to feel that pain as a distraction, and as an acupressure method; listen to music; and/or utilise hypnobirthing techniques which combine distraction with meditation and hypnotic relaxation by way of visualisation, soothing sound, and controlled breathing. Many women who use non-pharmacological methods of pain relief in their labour have a strong desire to feel in control of the process, they strive for a physiological birth with little or no medical intervention, to feel a sense of personal achievement and accomplishment.

My role as a midwife is to support women in labour, to provide encouragement and affirmation, and to attempt to ensure that they have a positive birth experience. Midwives are also referred to as the 'guardians of normal birth', our role is to facilitate the physiological process of birth as much as possible, avoiding the use of unnecessary medical interventions. This is a challenge in the contemporary birth environment, particularly in a tertiary hospital where there is an epidural service on demand 24 hours a day, high rates of induction and augmentation of labour.

In my own practice I utilise several techniques in collaboration with the labouring women to help manage labour pain, to reduce fear and anxiety and induce relaxation and calm. One of the techniques is hypnosis, commonly referred to as hypnobirthing, which uses imagery, visualisation, and meditative relaxation to distract from the intensity of contractions but also to induce positive thoughts and increase self-confidence in the ability to manage pain. In my practice I encounter many women using hypnobirthing apps on cell phones as antenatal preparation for their labour and birth. They use images associated with relaxation which have

hypnotic qualities, such as the gentle movement of trees swaying or rolling waves to represent the ebb and flow of contraction pain, changing colours or soothing sounds.

The possible use of VR in labour became apparent to me after experiencing VR in an entertainment setting and I was impressed with the distraction and feeling of absorption it evoked. Some background research revealed the use of VR in a range of healthcare settings for acute pain and anxiety. The first literature I read related to the use of VR for burn-injured patients (Hoffman et al., 2011). When I began my initial research, I was unable to find published research into the use of VR in labour. There was, however, one case study of a woman who had used VR during her labour and birth in an American hospital

(<https://www.theguardian.com/technology/206/dec/09/virtual-reality-childbirth-pain-relief>). I discussed this amongst my midwifery colleagues who were interested, viewing VR as a potentially effective distraction for use in labour and birth. Virtual reality could provide a non- invasive intervention, easily removable if unpleasant and, with advances in the technology, headsets are now wireless, cheaper, lighter, and more comfortable.

1.6 Research questions

Based on my professional experience as a midwife and the results of an initial literature search, I determined that there was a significant deficiency in research on VR use during labour. I believe that this dearth of research could be addressed by my research idea and that a study of this kind will contribute original knowledge to this field. The following questions, aims and objectives were formulated:

What are women's experiences of using VR antenatally?

What is the effect of VR on labour pain intensity?

What are women's experiences of using VR during labour?

Aims: The aims of this mixed method study were to determine whether women will use VR in labour, to measure variables of labour pain intensity and to explore women's experience of using VR during labour.

Objectives:

1. Conduct a feasibility study with participants antenatally to determine whether VR is acceptable for use in labour.
2. Test the planned intervention of VR in a within-subjects quasi-experiment with these participants in labour.
3. Conduct in-depth semi-structured postnatal interviews with these participants.

1.7 Significance of research

The research undertaken in this thesis has significance for both theory and practice for VR as distraction for labour and birth. It contributes knowledge to the literature around distraction theory and to the literature on the effect of VR on labour pain intensity and physiological variables of labour pain intensity. Findings from the qualitative data also add to knowledge on the use of VR for the management of labour pain, its use as a non-pharmacological pain relief method to induce relaxation and enjoyment in labour, and to increase self-efficacy and birth satisfaction. Findings

from this research may also be useful in health technology and computer science to inform the design of VR environments for use in labour.

1.8 Outline of chapters

The following is an outline of the structure of this thesis, it follows the sequential nature of the research. Following on from the introduction:

Chapter Two focuses on the physiology of pain generally and labour pain specifically, and the modulation of pain. A debate on the role that distraction and emotion play in pain modulation is also included.

Chapter Three provides background to the research issue studied. Firstly, it discusses the physiological process of labour and birth, identifying the complex biological and hormonal processes involved. Secondly, the effect of epidural analgesia and opiate analgesia on the physiological process of labour and birth are outlined. Maternal and neonatal side effects of epidural analgesia are also summarised, and finally the role of epidural analgesia as a birth intervention is presented.

Chapter Four continues the background to the research topic with a discussion on the nature of labour pain and including definitions and reference to the dichotomy that exists in relation to the nature and management of labour pain within midwifery and medical discourses. This chapter ends with an historical overview of labour pain management and a discussion about non-pharmacological methods of pain relief in labour and birth.

Chapter Five is a literature review relevant to VR and pain attenuation in acute, chronic, and labour pain and anxiety reduction. This chapter also discusses the role that presence, emotion, and immersion play in the analgesic properties of VR.

Chapter Six is the methodology chapter which presents an overview of the chosen methodology and the rationale for this choice. The methods of the research are also explained, with a discussion on rigour, ethics, and cultural issues.

Chapter Seven presents the research findings from phase one qualitative antenatal interviews. These findings are discussed, interpreted, and analysed in relation to the literature.

Chapter Eight presents the research results from phase two quantitative intrapartum quasi-experiment. These results are discussed, interpreted, and analysed in relation to the literature.

Chapter Nine presents the research findings from phase three qualitative postnatal interviews. These results are discussed, interpreted, and analysed in relation to the literature.

Chapter Ten discusses triangulation of findings and results across the three phases of the research. It outlines the limitations of the study and implications for practice and future research ideas.

CHAPTER 2: PHYSIOLOGY AND MODULATION OF PAIN

This chapter describes the physiology and modulation of pain. It begins with a definition and description of the experience of pain, generally accepted as a complex, multi-dimensional, highly subjective experience which has sensory, cognitive, and affective components. It continues with an overview of the physiology of pain, both somatic and visceral, both of which are experienced in the labour and birth process.

In terms of the physiology of pain this section examines the pain pathways, the ascending pathway, and the descending pathways and their role in pain modulation. The section also refers to the 1960s landmark theory of pain, named the gate control theory of pain, which was first introduced by Ronald Melzack and Patrick Wall. The next section introduces distraction theory and further expands on mechanisms of pain modulation, such as the role of attention, emotion, catastrophising and hypervigilance.

2.1 Physiology of pain

To understand the experience of pain it is necessary to offer a working definition of pain and to incorporate three levels: pain transmission and perception; pain reception; and the pain modulation. The International Association for the Study of Pain (IASP) defines pain as an, 'unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage' (Turk & Okifuji, 2009, p. 14). The experience of pain is further influenced by cognitive and environmental factors and displayed by a combination of autonomic, psychological and behavioural reactions (Terman & Bonica, 2003). Definitions of pain have changed over history and mirror the cultural and social

norms of the time; they are reflections of the contemporary 'spirit of the age' (Cope, 2009, p. 1).

2.1.1 Somatic and visceral pain

The classification of pain takes two forms: somatic or visceral. The pain which originates from skin, muscles, or joints, which can be deep or superficial, is somatic pain. Superficial somatic pain is characterised by brevity, is highly localised and is experienced as a sharp or pricking sensation. Transmission of this pain is along large-myelinated A δ nerve fibres. In contrast, deep somatic pain is more commonly described as aching or burning, is widespread and lasts for a greater length of time, with transmission being carried along small unmyelinated C nerve fibres.

Visceral pain originates from viscera or organs in the body and is experienced as burning, gnawing, or aching. Information relating to chemical changes in the body, distention or irritation of the viscera is transmitted by afferent visceral sensory neurons together with autonomic sympathetic and parasympathetic fibres (Stables & Rankin, 2010). Labour pain, the physiological process by which the fetus, placenta and membranes are expelled through the birth canal is both somatic and visceral (Stables & Rankin, 2010).

2.1.2 Labour pain

Labour is a continuous process but is also comprised of three stages. Stage 1 begins with the commencement of regular, rhythmic contractions until the cervix is 10 cm (or fully) dilated. Stage 2 begins when the cervix is fully dilated and ends with the expulsion of the fetus from the birth canal. Stage 3 begins after the expulsion of the fetus and concludes with the expulsion of the placenta and membranes. The

dominant phase in labour is the dilatation phase (or first stage) and the pain experienced is visceral, arising from distention, and possibly ischaemia, of the lower uterine segment and cervical opening (Brownridge, 1995; Stables & Rankin, 2010). Characteristic of other forms of visceral pain, the pain of contractions is transmitted slowly, is diffused, and thus frequently felt as referred pain in the abdomen, lower back and rectum (Brownridge, 1995).

The change to somatic pain domination occurs in late first stage and in the second stage of labour, or the progression of the descent phase of labour. This experience of somatic pain occurs as a result of stretching and constriction of the pelvic anatomy adjacent to the vaginal vault, vaginal tissue and from distention of the pelvic floor muscles and perineum caused by pressure of the fetus as it descends the birth canal (Rowlands & Permezel, 1998; Wong, 2009). Pain experienced during delivery is sharp and localised to the perineum, anus and rectum but can also be felt in the thighs or legs (Rowlands & Permezel, 1998).

2.2 Pain pathways

2.2.1 Ascending pathways

Both somatic and visceral pain stimuli are detected by nociceptors⁵ located throughout the body (in skin, muscles, and organs). Their axons⁶ enter the spinal cord in the dorsal horns of the spinal cord and the first synapse of the two types of neurons; A δ and C fibres occur in the dorsal horn. These pain-carrying fibres then cross the horn and enter the anterolateral spinothalamic tracts to ascend to the

⁵ Nociceptors are sensory neurons that respond to damaging or potentially damaging stimuli by sending 'possible threat' signals to the spinal cord and the brain.

⁶ Axons are the long threadlike parts of a nerve cell along which impulses are conducted from the cell body to other cells. They are important for cellular communication.

thalamus. Both types of neurons have different transmission speeds for pain signals and different penetration abilities.

Generally, the thicker the fibre, the deeper it can penetrate. The large, myelinated A δ fibres penetrate deeply and conduct at a rapid rate of up to 30m per second; small unmyelinated C fibres conduct at a much slower speed; 0.5 - 2m per second. This transmission of afferent signals to the thalamus results in multiple synapses with other neurons to allow the pain message to be sent to the sensory cortex for interpretation. A multitude of synapses may occur in a variety of cortical regions, including the brainstem, hypothalamus, primary and secondary somatosensory cortices, the anterior cingulate cortex (ACC) and the limbic system before the thalamus is reached. This helps to explain the role of arousal and emotion in the perception of pain. The limbic system is known as the affective (emotional) area of the brain, where emotions and thoughts are interlinked (Marieb & Hoehn, 2008 as cited in Stables & Rankin, 2010).

2.2.2 Descending pathways and pain modulation

Since the discovery in the 1970s of the complex descending pain-control system, research has focused on understanding its structure and function. The descending pain-control system originates in the brain and originates with nerve fibres descending from the white matter penetrating the grey matter (periaqueductal grey - PAG) of the midbrain. The PAG is the primary control centre for the descending pain modulation system and contains enkephalin⁷-producing cells that

⁷ Enkephalins act at opioid receptors and are opioid peptides that have a widespread but selective distribution in the central and peripheral nervous system in circuits involved in pain modulation.

suppress pain perception and inhibit pain pathways at the spinal level (Mayer et al., 1971; Stables & Rankin, 2010).

2.2.3 Endogenous opioid system

Enkephalin, endorphins and endogenous opioid receptors comprise the endogenous opioid system. Endogenous opioid receptors in the dorsal horn contribute to mid-brain modulation of spinal nociceptive neurons. Activation of neurons in the mid-brain PAG inhibits spinal dorsal horn neurons and produces analgesia in humans. This release of endogenous opiates inhibits the transmission of pain and is one explanation for the mechanism of action of concentration techniques (Stables & Rankin, 2010).

Endogenous opiates inhibit prostaglandin production. Prostaglandins are considered to be prime mediators of the perception of pain (Stables & Rankin, 2010). Opioid receptors can also be initiated exogenously by alkaloid opiates, such as morphine and fentanyl. There are other inhibitory systems that act without the involvement of opioids. Originating in the medulla, it is a system of 'on-cells' and 'off-cells' that have the capacity to increase and to inhibit nociceptive transmission (Porreca et al., 2002). The cerebral cortex, though not central to pain perception, may have the ability to control and differentiate subcortical information. It is involved in the mediation of cognition and motivation and the affective parts of pain and is able to use information based on memory of pain and emotions (Bonica, 1975).

2.3 Perception of pain

The perception of pain is profoundly affected by attention and emotion. This relationship may be because PAG receives inputs from multiple regions in the brain,

significantly the cortical areas associated with attention (Vogt et al., 1993) and emotion (Davis, 1998; LeDoux, 2000; Price, 2003). Equally important to inhibiting the exchange of pain messages is the descending pain-control system which is involved in the facilitation of pain transmission. This possibly explains why people who are highly anxious and worried about pain often experience pain more intently (Gold et al., 2007).

An individual's perception and response to pain is influenced by past pain experiences, personality, gender, and cultural background. This multi-dimensional, subjective nature of pain makes response to pain complex. Pain comprises sensory, affective, and cognitive components. The sensory dimension relates to the intensity of the pain experience and is able to analyse the location, intensity, and duration of the pain stimulus. The affective dimension relates to the unpleasantness and the emotional feelings of the pain experience. Finally, the cognitive dimension relates to time spent thinking about pain and is involved in attention, anticipation and memory of past pain experiences (Peyron et al., 1999; Price, 2000).

2.4 Labour pain: a hyper analgesic effect

Labour pain, like other forms of acute pain, is complex. Although the neural mechanisms are similar, the induction and transmission of nociception and modulation at the level of the dorsal horn, labour pain is unique. During different stages of the labour process, a range of factors are activated which may modify the nociceptive impulse. This phenomenon of pregnancy-induced hypoalgesia is seen in response to both somatic and visceral pain. It is thought that some of these factors act synergistically to promote anti-nociception that is strongest during active labour (Rowlands & Permezel, 1998). Evidence has shown that women report significant

elevation of pain thresholds during labour in comparison to before or after labour, due to the activation of cervical afferents (Whipple & Komisark, 1985).

Activation of a descending spinal inhibitory system creates pregnancy-induced hypoalgesia (Sander et al. 1989). The release of opioids from descending spinal tracts bind to receptors on the spinal cord dorsal horn neuron, causing anti-nociception. The endogenous opioid, cerebrospinal enkephalin, increases in pregnant women near the end of pregnancy (Lyrenäs et al., 1987) Enhanced pregnancy-induced analgesia has resulted from endogenous levels of enkephalin increased experimentally by inhibition of their breakdown (Jayaram et al., 1995; Jayaram et al., 1997). An understanding of these mechanisms that cause hyper-analgesia in labour provides justification for the extension of these mechanisms, and the use and development of reflexive analgesic methods (Whipple & Komisark, 1985).

2.5 The gate control theory of pain

Melzack and Wall's revolutionary theory of pain, the GCT (see figure 1), introduced in 1965 and updated in 1988, further supported the idea of Central Nervous System (CNS) involvement, particularly attention, emotion, and memory in sensory pain perception. Central to their theory was the assertion that pain is not simply transmitted from peripheral nerves to the brain, but that 'nerve gates' regulate the amount of pain sensation a person feels. This gate can be either opened (transmission facilitated) or

Figure 1. Gate Control Theory. Copyright Biggs, P. Sciencephoto. Reprinted with permission

closed (transmission inhibited) within the spinal cord (Gold et al., 2007; Melzack, 1999).

This gating mechanism of the spinothalamic tract in response to C fibre activity is achieved by the stimulation of large, myelinated fibres which convey touch. The ascending pain impulse is inhibited by sensory neurons. Information from these large unmyelinated fibres and smaller A δ and C fibres carrying pain messages, converge at the level of the spinal cord in the substantia gelatinosa. The large-diameter sensory neurons enter the spinal cord at a greater speed, generally resulting in presynaptic inhibition of the slower small fibre pain impulses. This inhibitory process constitutes the 'gating' mechanism that, in its default position, is closed against small diameter fibre impulses (unless the stimulation is sufficient to override the gate) (Stables & Rankin, 2010).

2.5.1 The complexity of pain explained

Gate control theory highlights the importance of the descending pain-control system, as brain regions involved in attention, cognition and emotion activate descending neurons to shut the 'gate'; located in the dorsal horn of the spinal cord (Phumdoung & Good, 2003). This focusing on higher order thought activities can change not only a person's perception of approaching pain signals but, importantly, the quantity of pain signals permitted to enter the brain (Melzack & Wall, 1965).

It is widely accepted that Melzack and Wall's GCT of pain can explain the complex nature of pain and pain perception. Among several factors which contribute to this complexity are:

- Referred pain or pain perceived in an area separate from the area of damage.

- Continuation of pain after the tissue has healed or in the absence of injury.
- Pain produced by innocuous stimuli.
- The inability of some conditions such as arthritic pain and migraines to be treated.
- The highly subjective nature of pain between individuals.
- The multidimensional nature of pain (Stables & Rankin, 2010)

2.6 Pain Modulation

2.6.1 Distraction theory

Distraction is a non-pharmacological method of pain relief used ubiquitously across all population groups. It is defined as a redirection of attention away from a painful, unpleasant experience and engagement of attention in other activities (Verhoeven et al., 2011). A variety of distraction tasks such as listening to music, watching a movie, reading a book and activities such as meditation, acupuncture, hypnosis, and water immersion, can be at least partially conceptualised as distraction measures. In preparation for childbirth, distraction techniques have been incorporated into antenatal class programmes designed to minimise the pain experience, reduce maternal anxiety, and increase confidence.

2.6.2 Ambiguity of evidence about distraction

Common sense supports the theory that distraction would be effective in reducing perceived pain intensity, however the empirical evidence on its effectiveness is ambiguous (Van Damme et al., 2010). Individual studies and systematic reviews have found beneficial effects (Bantick et al., 2002; Birnie et al.,

2014; Bukola & Dawson, 2017; Marchand & Arsenault, 2002; Uman et al., 2008) while others reported no effects (Hodes et al., 1990; McCaul et al., 1992), and some reported even increased pain (Cioffi & Holloway, 1993; Goubert et al., 2004).

Studies demonstrate a significant reduction in pain intensity scores for participants who engaged in more cognitively demanding distraction tasks. In the mentally demanding counting Stroop task, pain was perceived at lesser levels than in the less demanding task in Bantick et al's (2002) study. The effect of odour on pain perception was studied by Marchand and Arsenault (2002) who demonstrated that pleasant odours produced a positive mood while an unpleasant odour produced a negative mood and directly affected the perceived intensity and unpleasantness of pain. This study hypothesised that the orbitofrontal cortex in the limbic centre could be responsible for the interaction between odours and somatosensory processing, thereby providing a possible explanation for the effect of odours on perceived pain.

Hodes et al's (1990) study found that affective neutral distraction only reduced sensory pain and had no effect on tolerance to pain. This contrasts with other studies that used relaxing imagery that both diverted attentional resources away from the painful stimulus and altered the person's affective state. Data from McCaul et al's (1992) study demonstrated that distraction does not always work, and authors concluded that it was necessary to identify the factors that make distraction effective or ineffective. This study used only one computer-based distraction task. The authors also suggested that the tasks that were more difficult created anticipatory arousal, which led to increased distress in relation to pain. Tasks that produce pleasant distracting effects and reduce anxiety will also reduce distress. In a study which compared mindfulness with distraction around experimental pain, Prins et al. (2014) revealed a differential effect depending on levels of pain catastrophising. For

participants who experienced high catastrophising, mindfulness resulted in lower pain ratings than those who used distraction. In the low catastrophising group, distraction resulted in lower pain ratings than those in the mindfulness group.

The avoidance of pain through attentional diversion or suppression of pain sensations was shown to prolong pain instead (Cioffi & Holloway, 1993). This study identified that distraction without the assistance of a focused distractor can result in later painful stimuli being experienced as more unpleasant. Mental avoidant strategies of physical pain such as distraction and suppression may result in pain feeling subjectively worse. This can lead to negative interpretation of a somatic event so that even a relatively small painful stimuli is experienced strongly as discomfort (Cioffi & Holloway, 1993).

Greater pain immediately following voluntary engagement with a distracting task was also demonstrated in a study by Goubert et al. (2004). Data from this study suggest that strict adherence to distraction protocols requiring too much effort for patients with chronic pain can have adverse effects of producing greater post-distraction pain. Heterogeneous findings demonstrate that the effectiveness of distraction is different for each situation (Verhoeven et al., 2011) and that other factors may influence its effectiveness. These factors include the nature and complexity of the distracting task, emotion, catastrophising and hypervigilance.

2.6.3 The nature of distraction

Distraction to reduce pain related distress relies on the controlled processing of attentional resources on the distracting task, decreasing capacity to process components of pain. Distracting tasks that require greater concentration and use of attentional resources are more effective for coping with pain (McCaul & Malott,

1984). Experimental research has attempted to identify activities demanding more attentional resources, for example, comparing viewing a pleasant image or listening to music, to more demanding tasks such as mental arithmetic or counting backwards.

2.7 Pain matrix

Bantick et al. (2002), used functional magnetic resonance imaging (fMRI) to understand the fundamental neural networks and cognitive mechanisms associated with the modulation of pain by distraction. Previous studies illustrate that painful stimulation activates a multitude of brain regions, known as the 'pain matrix' (see figure 2) (Melzack & Wall, 1965). Regions stimulated include the

somatosensory and motor cortices, the ACC, the parietal and prefrontal cortices and the insula, thalamus, and cerebellum. Regions activated while undergoing painful stimulation, such as the posterior parietal cortex, the ACC, dorsolateral prefrontal cortex, and thalamus, are also associated with attentional networks. The cognitive aspect of pain is linked to anticipation, focusing on the process of attention and memory of previous experiences of pain (Peyron et al., 1999).

The identification of brain regions began to be used to understand the complexity of the experience of pain, particularly chronic pain, and the mystery of phantom limb pain. Phantom pain and paraplegic pain is not adequately explained by the GCT as it focuses on peripheral and spinal processes (Melzack, 2001). In

Figure 2. *Pain Matrix*. Reprinted with permission from AAAS

order to progress his original theory of pain, Melzack (2001) stated that the great challenge was to understand brain function. Central to the neuromatrix theory is the concept that pain is a multidimensional experience produced in a complex pattern of nerve impulses generated by an extensive neural system within the brain. Instead of being produced directly by sensory inputs such as injury, inflammation, or other pathology, pain is produced by neural networks of the brain (Melzack, 2005).

2.8 Use of functional magnetic resonance imaging

Functional magnetic resonance imaging (fMRI) is considered a reliable instrument to study pain mechanisms in regions of the brain and has been used in a variety of experimental pain studies. Using fMRI, Bantick et al. (2002) hypothesised that areas of the pain matrix are modulated by distraction. The distraction task was adapted from the original Stroop Colour Word Task (Stroop, 1935) for use with fMRI. The counting Stroop task (Bush et al., 1998) involves the participant responding to a button press with the number of words presented on a vertical list, which would change every 1.25 seconds. The task of participants is to note the quantity of words presented on the screen as quickly and accurately as possible. There are two tasks: a neutral task and a more complex interference task. While the participants were engaged in both neutral and interference word counting tasks, experimental thermal pain was applied to the participant's hand (Bantick et al., 2002). Results from the study showed significantly lower pain intensity scores reported during engagement in the more cognitively demanding interference Stroop task, compared to the neutral condition. Reduction in pain perception was accompanied by a decrease in stimulation in prime areas of the pain matrix, including the insula, midcingulate (ACC) and thalamus. Additionally, the perigenual cingulate and orbitofrontal areas,

associated with cognition and attention, displayed increased activation when engaged in the interference Stroop task when coupled with pain (Bantick et al., 2002).

2.9 Pain dimensions

Adopting a multi-dimensionality model of pain acknowledges that sensory aspects of pain (the area, intensity, and type of pain) are separate to cognitive and affective aspects. Each of these dimensions is independently capable of variation: this has been demonstrated by hypnosis, in both behavioural and physiological ways. Studies showed that hypnotic suggestions change the sensory, but not the affective dimension leading to activation in the primary somatosensory cortex. however, affective changes without sensory changes were associated with activation in the anterior cingulate cortex (Rainville et al., 1997). These results indicate a relationship between emotional factors and unpleasantness of pain without necessarily a change in pain intensity (Villemure & Bushnell, 2009; Villemure et al., 2003). A negative emotional state is associated with an increase in perceived unpleasantness of the pain without a change in the intensity of pain (Roy et al., 2008; Villemure & Bushnell, 2009; Villemure et al., 2003).

2.9.1 Emotion and pain

While pain perception is influenced by cognitive loading involved in attentional processes, the role of emotion is also significant. Viewing a pleasant image or watching a movie is a form of distraction that has the additional potential to invoke an emotional response. The field of psychology has used a variety of techniques to investigate emotion in laboratory settings ranging from film to static images. The

International Affective Picture System (IAPS), a set of static images based on a dimensional model of emotion, is most often used. These images contain scenes such as mutilations, snakes, accidents, illness, pollution, puppies, babies, and landscape vistas. Studies using the IAPS have contributed to understanding the complex dimensional aspects of emotion (Mikels et al., 2005). Changes in heart rate and facial electromyographic activity, for example, demonstrate differences between negative and positive valence, whereas increased arousal produces increased skin conductance (Bradley & Lang, 2000; Lang et al., 1998). Valence indicates the positive or negative affectivity of the emotional value associated with the stimulus. Arousal identifies the intensity of the emotional activation; that is, how calming or exciting the stimulus is. Further studies have demonstrated the inhibition of the startle reflex when positive pictures were shown and accentuation by negative pictures, thus highlighting the difference between positive and negative affect (Cuthbert et al., 1998).

2.9.2 Positive and negative emotions and pain modulation

Evidence supports the concept that emotion, whether positive or negative, modulates pain. In general, positive emotions reduce pain, whereas negative emotions increase pain (Roy et al., 2011). An experimental study using fMRI has shown that subjective pain intensity of predictable and unpredictable pain can be modulated by a series of evocative emotional pictures averaged by picture valence (unpleasant, neutral, pleasant) from the IAPS (Rhudy et al., 2006). While the exact mechanisms as to how emotion modulates pain remain unclear, a number of authors have hypothesised that emotion engages descending pain pathways and as a consequence modulates ascending nociception at the spinal level (Melzack & Wall,

1965; Rhudy & Meagher, 2001; Villemure et al., 2003). Other research has shown that cognitive-affective pain modulation occurs outside of the spinal structures. Rather than involving modification of spinal nociceptive transmission, the pain modulation is based on cortico-cortical or cortico-subcortical interactions (Rhudy et al., 2006).

Rhudy et al's (2006) study supports the hypothesis that emotion engages descending modulation. Nociceptive flexion reflexes (NFR) and pain were inhibited when pleasant pictures were shown and conversely heightened with unpleasant pictures. Significantly the effects of emotion were large, 62% of the variance in pain scores and 43% of the variance in NFR. The findings from this study demonstrate that affective valence, rather than arousal related to NFR modulation.

The finding that positive emotions can reduce pain, has been replicated in other studies (Meagher et al., 2001; Villemure et al., C, 2003; Weisenberg et al., 1998; Zelman et al., 1991; Zillmann et al., 1996). The mechanism of action is likely to be inhibition of the portion of the amygdala (the primary structure of the limbic system) that facilitates pain by positive emotions which results in analgesia (hypo-analgesia) (Neugebauer et al., 2004). Studies have also shown that negative emotions (e.g. anxiety, depression) accentuate pain (hyper-analgesia) (Rhudy & Meagher, 2000) by activation of the amygdala, a structure in the medial temporal lobe that has a central role in emotional processing and affective disorders such as anxiety and depression (Neugebauer et al., 2004).

2.9.3 Fear and stress

Evidence on the effects of emotion on pain is complicated; other negative emotions (fear, stress) stimulate one particular area within the amygdala which

inhibits pain (Neugebauer et al., 2004). It is thought that fear or the threat of injury inhibits pain due to the body's diversion of nociceptive reflexes used in pain-associated behaviours or defensive actions such as escape (Rhudy & Meagher, 2000).

That negative emotions can attenuate pain is paradoxical and has been explained in terms of the circumstances where a negative emotion is influenced by the degree of threat or arousal elicited by the emotion (Rhudy & Meagher, 2001; Rhudy et al., 2005). Often referred to as 'stress-induced analgesia' (Flor & Grüsser, 1999; Martenson et al., 2009), this connects high threat with intense negative affect, high arousal and decreased sensitivity to pain (Wiech & Tracey, 2009). Picture-viewing, as used in Rhudy et al. (2006) study, does not as a rule elicit highly arousing negative emotions, however there are currently new technologies that may be capable of conveying more intense emotional stimuli to influence nociception.

2.9.4 Attention and emotion in pain modulation

Evidence from experimental and clinical studies shows the relationship between attention and emotion in pain modulation. Diverting attention away from painful stimuli and creating a positive mood generally decreases the perception of pain. The reverse is true when attention is focused on pain or a negative mood is induced, thus pain perception is increased (Villemure et al., 2003). However, recent debates in the literature argue that attention and emotion influence pain differently, and that the nature and mechanisms of pain modulation differ (Bushnell et al., 2013).

An experimental study by Villemure and Bushnell (2009) showed that pleasant odours, separate from attentional focus, produced a positive mood and decreased pain unpleasantness. Concentrating on a painful stimulus has been

shown to increase the pain intensity, while a negative emotional state increases the affective component of the pain experience, that is, unpleasantness of the pain without changing the intensity. Results from fMRI imaging also showed that independent neuro-modulatory circuits exert influence on the emotional and attentional modulation of pain (Bushnell et al., 2013) and, that emotion and attention impact pain differentially through spinal and supra-spinal processes (Roy et al., 2011). In their study which examined pain and spinally mediated nociceptive flexion reflex (nociceptive flexion reflex or RIII reflex); Sandrini et al. (2005) demonstrated that the effects of emotional valence and attention on pain perception and RIII were different and independent of each other. The concept that the effects of emotion on pain are partially independent of the effects of attention, are significant from a clinical practice viewpoint. This concept lends support to the use of emotion induction as an effective stand-alone non-pharmacological intervention in the treatment of acute pain. It also recognises the importance of emotional factors in the management of both acute and chronic pain (Roy et al., 2011).

Literature on pain modulation has a tendency to differentiate emotional factors from cognitive factors such as attention, expectation or catastrophising, however other authors have argued that these factors are impossible to separate and are strongly interdependent (Wiech & Tracey, 2009). These authors make the point that negative mood invariably influences our ability to process information and is coupled with cognitive distortion and dysfunctional beliefs. Similarly, cognitive processes are influenced by emotional components. If an intervention or substance is believed to increase pain (nocebo expectation) a logical assumption is that, as well as changing expectations, a state of high anticipatory anxiety will exist (Wiech & Tracey, 2009).

2.9.5 Pain-related fear, pain catastrophising and hypervigilance

The concept of attention is prominent in many theories of pain perception in the areas of acute and chronic pain. Pain demands attention, it 'is an evolutionary alarm signal of bodily threat' (Van Damme et al., 2010, p. 205-206), designed to motivate action (escaping or avoiding it) (Linton & Shaw, 2011). Some studies have found that excessive attention to painful stimulus or hypervigilance increases pain intensity, and not attending to the pain reduces pain perception (Van Damme et al., 2010), whereas other studies have failed to find this or have found the opposite (Seminowicz & Davis, 2007).

Patients who have a greater fear of pain and catastrophic thinking about pain, showed more attention to pain, or hypervigilance, and were less able to respond to distraction tasks (Goubert et al., 2004). 'Pain catastrophising' is defined as an exaggerated, negative response to pain, essentially the worst possible scenario is imagined and accepted as reality (Linton & Shaw, 2011). Research findings by Rhudy and Meagher (2000) were consistent with attentional factors being influential in the mediation of fear and anxiety on pain. Here, moderate levels of fear/anxiety accentuate attention to prominent events, for example, pain, which intensifies the experience of pain or hyper analgesia. The recognition of the role of anticipatory fear/anxiety in exacerbating pain is important in clinical settings. Techniques to reduce anxiety and the use of anxiolytic drugs have been successfully incorporated clinically to improve pain related medical procedures (Ploghaus et al., 2001).

2.9.6 The role of the mind in controlling pain

The role of the mind in controlling pain has largely been ignored in Western medicine. While pharmacological treatments dominate practices, there is growing

interest and acceptance of mind-body techniques or cognitive behavioural interventions such as hypnosis, yoga, meditation and visualisation (imagining oneself without pain on a tropical island; listening to music, or watching a video) and evidence of success for both chronic and acute pain (Bushnell et al., 2013; Hoffman et al., 2000; Mallori et al., 2019). Central to their mechanisms of action are both a cognitive component (for example, avoidance or distraction), and an emotional component (Bushnell et al., 2013). The popularity of distraction as an attentional strategy lies in its intuitive appeal (Elomaa et al., 2009; Leventhal, 1992; Van Ryckeghem et al., 2018) and the range of techniques available; from the simple (e.g. looking through distraction cards during a phlebotomy procedure) (Inal & Kelleci, 2012) to the complex (e.g. the use of VR) (Malloy & Milling, 2010).

2.10 Summary

An understanding of the physiology and neurobiology of pain modulation assists in comprehending and applying the mechanisms of action of non-pharmacological interventions in pain management and specifically labour pain management. A recognition of the role that cognitive and affective dimensions of pain such as attention and emotion have on pain modulation is also critical to understanding how non-pharmacological interventions work in the clinical setting of labour and birth.

Non-pharmacological interventions can influence the sensory component of pain and promote a positive mood in terms of relaxation and a reduction in anxiety (an emotion which has been shown to exacerbate pain). Although the evidence concerning the relationship between distraction and pain attenuation is equivocal, there is evidence of the efficacy of distraction in clinical settings, particularly for

children and adolescents. There are, however, demonstrated factors which impact the effectiveness of distraction, such as the amount of cognitive load provided by the distraction method, emotion, and hypervigilance (which is a heightened form of anxiety and attention to pain).

The next chapter provides background to the research issue under study. It begins with discussion of the physiological process of labour and birth, identifying the complex biological and hormonal processes involved. The chapter also describes the effect of epidural analgesia and opiate analgesia on the physiological process of labour and birth.

CHAPTER 3: UNDISTURBED BIRTH AND EPIDURALISED BIRTH

This chapter describes and discusses in detail the nature of undisturbed birth and epiduralised birth. Firstly, undisturbed birth refers to the normal physiological process of birth, which involves the complex but harmonic relationship between hormones, emotions, and the physical body. The chapter then introduces pharmacological methods of analgesia, in particular epidural analgesia and opiates and their effects on this physiological process. A discussion of the relationship between epidural analgesia and interventions in childbirth, and their associated morbidities then follows. The next section details a range of maternal and neonatal side effects, from mild to severe, particularly in reference to epidural analgesia; and discusses the impact of epidural analgesia on breastfeeding.

The final section covers birth involving epidural intervention, in which epidural analgesia is central to the birth experience. The section also outlines systematic, industrialised birth in contemporary society, in reference to the use of interventions such as pharmacological methods of pain relief.

3.1 Physiological birth

Giving birth is a momentous, life changing experience for women that impacts upon the woman, her family and community. It is a normal physiological process, and many women want a natural, non-pharmacological birth, free from unnecessary medical interventions. Using the term 'normal' in the context of childbirth is problematic and controversial according to Kennedy (2010). Normal as defined by the Oxford Dictionary is: 'regular, usual, typical, ordinary, and conventional; physically and mentally sound; free from any disorder, healthy'. It is a term that

dichotomises women and their birth experience; the opposite of normal is abnormal, irregular, atypical, disordered, or unhealthy, words that no women would want used. However, midwives often refer to normal birth when describing the process that is the opposite to the common and burgeoning rate of interventions in current birth environments (Kennedy, 2010).

3.2 Defining normal birth

The World Health Organisation (1997) defines normal birth as ‘spontaneous in onset, low risk at the start of labour and remaining so throughout labour and delivery, with the infant being born spontaneously in the vertex position between 37 and 42 completed weeks of pregnancy’. The concept of normal refers to a non-interventionist approach, ensuring that there is no disturbance to the process or women’s experience of birth (Anderson, 2003). The term physiological may be a more appropriate term, reflecting this innate ability of women to birth without intervention, without disturbing the natural birth process (Aune et al., 2017; Kennedy, 2010). Throughout this thesis the term physiological birth will be used.

3.3 Undisturbed birth

This idea of ‘undisturbed’ birth is used freely in literature about childbirth. It refers to the understanding of the interplay of hormones in the birth process and the need to not disrupt this process. Odent (2009), in his discussion around privacy and birth, bemoans the ‘socialisation’ of childbirth, which he argues interferes with the reduction in activity of the neocortex (the seat of all inhibitions). The neocortex is described as the most important aspect of the physiology of birth among humans. Buckley (2009) refers to undisturbed birth and the hormonal balance required to

ensure this. This orchestration of hormones, oxytocin, beta-endorphins, catecholamines, adrenaline, noradrenaline and prolactin are the hormones of love, transcendence, excitement, and mothering, and are necessary to optimise birth. Any disruption to this delicate orchestral balance may make birth more difficult, painful and potentially unsafe (Buckley, 2009).

3.4 Hormonal balance

There are dynamic changes to multiple hormones responsible for maintaining pregnancy, initiating labour, and supporting changes that occur following birth to facilitate breastfeeding. These complex endocrine changes affecting hormonal synthesis and secretion are controlled by regions within the brain, with input from hormones and sensory nerves affecting muscles, ducts, and glands. This process is described below.

3.4.1 Oestrogen and progesterone

The steroids progesterone and oestrogen (there are three distinct types: oestrone, oestradiol and oestriol) are critical in the activation, inhibition and re-organising of hormone systems involved in pregnancy (Buckley, 2009). Plasma concentrations change throughout pregnancy; progesterone, produced in the placenta, increases plasma concentrations ten to eighteen times higher than pre-pregnancy levels. Placental production of oestriol, the key oestrogen in pregnancy, has a one-thousand-fold increase, peaking close to the commencement of labour (Russell et al., 2001). It is these variations in levels and ratios of hormones that are critical to the initiation of labour (Buckley, 2009): the change from progesterone to

oestrogen dominance, an increased sensitivity to oxytocin, and increased levels of prostaglandins (Weiss, 2000).

In late pregnancy the increased levels of oestrogen prepare the uterus for regular coordinated labour contractions by increasing the number of uterine oxytocin receptors (Jackson & Dudley, 1998) and gap junctions that facilitate electrical conduction between the muscle cells in the uterus (Weiss, 2000). Both oestrogen and progesterone are also important in terms of pregnancy and analgesia in labour. Working together, they activate endogenous opiate pain modulating pathways in the brain and spinal cord to reduce pain perception (Russell et al., 2001).

3.4.2 Endogenous oxytocin

Oxytocin is associated with sexual activity, orgasm, birth, and breastfeeding. It has been described as the hormone of love or the altruistic hormone (Odent, 1999, 2001). This hormone is synthesised in the hypothalamus, and it is the main communicator between the nervous system and the endocrine system. Large quantities are stored in the posterior pituitary and released in pulses into the bloodstream at the initiation of labour. The frequency of pulses increases to every three to five minutes, increasing in strength in the later stages of labour, generating rhythmic uterine contractions (Buckley, 2009).

Oxytocin mobilises the final powerful uterine contractions that assist the mother to birth her baby relatively effortlessly. The mechanism of the descent of the fetus's head in the birth canal stimulates stretch receptors located in a woman's lower vagina, proximal to the cervix. Sensory nerve fibres relay messages to the hypothalamus which, in turn, activate increased endogenous oxytocin release from the pituitary. This in turn stimulates additional uterine contractions which lead to

greater fetal descent, causing more stimulation of stretch receptors and consequently more pituitary oxytocin release (Dawood et al., 1977). This positive feedback loop in labour is known as the Ferguson reflex and significantly, if labour is left undisturbed, this reflex combined with adrenaline and noradrenaline (see later discussion) leads to a magnification of this mechanism which is referred to as the fetus ejection reflex (FER) (Odent, 1987).

After the birth, maternal plasma oxytocin concentrations remain elevated (Buckley, 2009). When the baby touches, licks or nuzzles the mother's breast to initiate breastfeeding, and skin-to-skin or eye-to-eye contact between mother and baby occurs, endogenous oxytocin release occurs, which mediates the milk-ejection or let-down reflex, and involutes the uterus to prevent postpartum haemorrhage (Matthiesen et al., 2001).

3.4.3 Beta-endorphins

Beta-endorphins are endogenous peptides synthesised in the brain and pituitary gland that work on the same opiate receptors of the brain as pethidine, morphine, and fentanyl. When the body is subject to pain or stress, beta-endorphins are secreted from the pituitary gland and provide greater tolerance to pain. Similar to addictive opiates, beta-endorphin acts to reduce stress, increasing feelings of pleasure, euphoria, and dependency. It is involved in the activation of the meso-corticolimbic dopamine reward system which creates a mutual pleasurable dependency for both mother and baby, rewarding breastfeeding interactions and physical contact, ensuring health and wellbeing (Buckley, 2009).

In labour, elevated levels of beta-endorphin in the woman's limbic system allow her to transcend pain, creating an altered state of consciousness, a key

characteristic of undisturbed birth. Beta-endorphins also have an important role in breastfeeding, facilitating the release of prolactin during labour which prepares the mother's breasts for lactation (Buckley, 2009).

Beta-endorphins have a complex and unclear relationship with other hormones during pregnancy (Laatikainen, 1991). High levels of beta-endorphins hinder the release of oxytocin, which slows or even stops labour contractions. This mechanism is thought to be necessary in times of stress (either environmental or social) to halt the process of birth until more safe and comfortable conditions are found (Douglas et al., 2002).

3.4.4 Catecholamines

Collectively known as catecholamines, this group of hormones is made up of the fight-or-flight hormones adrenaline and noradrenaline, which are endogenous in reaction to stresses such as pain, fear, hunger, cold and excitement. Working in tandem, they prepare the body for fight or flight via the sympathetic nervous system (Buckley, 2009).

During the exertion of labour, maternal catecholamines dramatically increase due to pain and emotional stress. High adrenaline levels activated by the woman's flight or fight response to fear or perceived danger have a tocolytic effect, slowing down or even stopping uterine activity (Segal et al., 1998). Noradrenaline causes vasoconstriction of uterine vessels, reducing blood flow to the placenta and thereby the baby (Segal & Wang, 2008). Concomitant effects of these catecholamines are longer labours and fetal distress due to adverse changes in fetal heart rate patterns associated with reduced oxygen (hypoxia) to the fetus (Lederman et al., 1985).

Paradoxically, adrenaline and noradrenaline elevations can stimulate uterine contractions via differential receptor effects when the labouring woman perceives stress or danger in late labour (Buckley, 2009). This is thought to contribute to the fetal ejection reflex (FER) which, according to Odent (2003), occurs at transition⁸ and inevitably follows an undisturbed birth. During the last contractions before the birth of the baby, the pregnant woman experiences a peak of catecholamines, is energised, wants to be upright, displays symptoms of physiological stress such as a dry mouth and shallow breathing, and has a sudden urge to grasp something. There is often fear, anger or excitement as the mother experiences a surge in catecholamines coupled with high oxytocin concentrations associated with the Ferguson reflex. She experiences several very strong contractions and the overwhelming urge to push which results in the expeditious birth of her baby (Odent, 2002b).

The baby has also experienced the exciting and stressful event of labour and the increased levels of catecholamines have an important role in assisting the baby adapt to extrauterine life. They assist newborn metabolism by increasing circulatory amounts of glucose and free fatty acids (Hagnevik et al., 1984) essential for protection of the newborn brain from hypoglycemia; which can occur with loss of placental glucose supplies in the newborn period (Colson, 2002).

Additionally, catecholamines have an important role in aiding the newborn's respiratory adaptation to life outside the womb by stimulating the release of surfactant (critical for the inflation of lungs) and increasing the absorption of amniotic fluid from the lungs (Iresedt et al., 1984). Catecholamines also have important roles in the newborn shift to non-shivering thermogenesis (heat production), stimulation of

⁸ Transition or the transitional stage of labour is described as the most painful part of labour, as the body transitions from the cervix opening to the body getting ready for the pushing stage. Women often experience the transitional stage at approximately 7-10 cm dilation.

breathing, cardiac contractility and increased responsiveness and tone of the baby at birth (Lowe & Reiss, 1996).

The high levels of catecholamines at birth ensure that the baby is wide-eyed, alert, and responsive for its first contact with the mother, ensuring the initiation of breastfeeding and the development of the relationship necessary for its survival and wellbeing. Mothers are entranced by this first gaze of their new-born and as Odent (2002b) describes it, “it is as if the baby were giving a signal” (p. 3). This eye-to-eye contact is an important factor that contributes to bonding and the growth of this new relationship between mother and baby.

3.4.5 Prostaglandins

Prostaglandins have a pivotal role in the following five separate, but integrated physiological phases related to labour and birth: rupture of fetal membranes, cervical dilation, uterine contractility, separation of the placenta and involution of the uterus. Myometrial contractility at birth is a consequence of intensified uterine activation and higher levels of contractile stimulators. An elevated level of uterine prostaglandins triggers myometrium contraction (Olson & Ammann, 2007).

3.4.6 Prolactin

Prolactin is known as the hormone of mothering (or nesting) and is secreted from the anterior pituitary gland during pregnancy and lactation. It is critical in the preparation of a woman’s breasts for breastfeeding and has a lactogenic (milk producing) effect in the postnatal period (Buckley, 2009).

The role of hormones in breastmilk synthesis begins after placental delivery when high levels of progesterone fall, allowing prolactin to commence the production of milk. The human placenta also produces human placental lactogen (hPL) which, like prolactin, rises steadily throughout pregnancy and is responsible for preparing the new mother's brain for motherhood (Grattan, 2001).

Prolactin reaches peak levels in the first two to three hours postpartum. This maternal surge in prolactin has a maximum effect on the brain and body in the initial hour after birth. It is likely that this rise is important to optimise maternal behaviour in the immediate postpartum period and to assist in successful initiation of breastfeeding (Buckley, 2009). Release of prolactin is directly associated with newborn suckling at the breast, and intensity, duration and frequency between episodes. The stimulus of suckling is the most powerful stimulus in prolactin release (Grattan, 2001). For women, breastfeeding their babies produces a calmness, an elevation in mood and reduction in anxiety because of the post lactation surges of oxytocin and prolactin. This attenuation of the stress response has several protective functions for breastfeeding; to ensure mothers are not distracted by environmental stimuli and prevention of inhibition of lactation due to stress (Heinrichs et al., 2001).

Prolactin has over 300 known effects on the human body; (Harris et al., 2004) including effect on appetite and food intake, suppression of fertility, reduction of the stress response, regulation of body temperature, release of oxytocin, motor activity, increase in rapid eye movement (REM) sleep, changes in the sleep-wake cycle, analgesic effects and onset and maintenance of maternal behaviour. Key to human reproduction and survival is positive maternal behaviour and prolactin is a crucial hormone in the induction and regulation of this behaviour (Grattan, 2001).

3.5 Evolutionary hormones

All of the hormones of physiologic birth are part of the 'ecstatic cocktail' of evolutionary hormones that aid human birthing mothers and all mammalian species (Buckley, 2009). Confirming the evolutionary nature of birth, these hormones are produced primarily in the middle or mammalian brain, known also as the limbic system or emotional brain. During undisturbed birth there is a recognition that for birth to proceed optimally this more primitive part of the brain needs to overrule our more rational part, the neocortex, or higher brain. For women in labour, the release of birthing hormones such as beta-endorphins allow a shift in consciousness to occur, many women describe it as 'going to another planet' (Buckley, 2009).

3.5.1 Instinct and the fetal ejection reflex

In a phenomenological study which examined midwives' concepts of 'normalcy' in childbirth, women who had the ability to experience this highly mammalian process, free of inhibitions, in an instinctual way, had a greater chance of a normal, physiologic birth. One midwife commented: "...and your mind, if it's willing will be able to help it [the birth process], instead of getting in its way. Nature has a well-designed way, if the women can get her head out of the process" (Davis, 2010, p. 212).

The relevancy of the term 'instinct' is discussed by Odent (2009) in terms of the FER, the epitome of the reduction of control of the neocortex. The term 'fetal ejection reflex', first coined by Niles Newton in her 1960 study of environmental factors that can disturb the birth process of mice was virtually removed until revival by Newton and Odent twenty years later. Its significance lies in the fact that after

years of 'culturally controlled childbirth', an authentic FER is possible in contemporary birth (Odent, 2009), characterised by involuntary, overwhelming contractions resulting in the birth of the baby. Women allowed to experience this FER often appear to have cut themselves off from the world, they appear irrational in a way that normally would be unacceptable, shouting, swearing, adopting unusual, often mammalian quadrupedal postures to give birth (Odent, 2009).

The inhibition of neocortical activity, as evidenced by the FER, is the evolutionary processes' answer to the dominance of the rational mind and the preoccupation of methods and institutions in the process of human birth today. Human birth is fraught with difficulty compared to other mammals and this is perhaps due to the huge neocortical development in our species (Odent, 2009). Neocortical stimulation and disturbed birth are linked with environmental factors such as bright lighting, conversation and lack of privacy or the 'feeling of being observed', and the release of catecholamines due to maternal fear or anxiety in labour (Lederman et al., 1985; Lederman et al., 1978; Odent, 2001; Segal & Wang, 2008; Wadhwa et al., 1996).

3.5.2 Contemporary birth and hormonal disruption

The evolutionary role of catecholamines was hypothesised to protect females birthing in the wild, where the threat of danger would initiate the fight or flight response, thus slowing or halting labour to allow the mother to fight or flee to safety (Buckley, 2009). Aspects of contemporary birth care risk unintentionally increasing stress and anxiety which elevates maternal stress hormones such as adrenaline, noradrenaline, and cortisol, disrupting the process of labour. This leads to the use of interventions which cause hormonal disturbances to physiologic birth.

These disturbances can be magnified, as an intervention designed to treat or monitor one aspect of the labour necessitates a further intervention. As an example, the administration of epidural analgesia is usually accompanied by a reduction in maternal endogenous oxytocin which needs to be compensated for by the administration of exogenous oxytocin (Buckley, 2015). Contemporary birth for many women is characterised by a lack of release of the hormones necessary for physiological birth (Odent, 2001). Epidural analgesia and opiate analgesia have significant effects on all the labour and birth hormones discussed here and, through these effects, disrupt the hormonal balance necessary for physiologic birth (Buckley, 2009).

3.6 Epidural analgesia

The term neuraxial blockade includes spinal, epidural, or combined spinal-epidural techniques. The procedure begins with an epidural injection of a small dose of local anaesthetic (bupivacaine and lidocaine), followed by introduction of a catheter into the epidural space, followed by opioids such as fentanyl or morphine for analgesia (Koyyalamudi et al., 2016). Anatomically, the epidural space refers to the space outside the bony spinal canal but just outside the dura matter (dura). In contact with the inner surface of the dura is another membrane called the arachnoid mater. The arachnoid mater contains the cerebrospinal fluid that surrounds the spinal cord. In adults, the spinal cord terminates around the level of the disc between L1 and L2, below which lies the bundle of nerves known as the cauda equine (Koyyalamudi et al., 2016).

Conventionally, injections into the epidural space cause loss of sensation or motor block (anaesthesia) and removal of pain (analgesia) (Akbas & Akcan, 2011). An epidural is a very effective analgesic for labour due to the blocking of both sensory and motor nerves. The introduction of 'walking epidurals' sought to reduce the motor blockade experienced by labouring women by using lower doses of local anesthetic drugs and combining them with local anesthetics and opiates (Buckley, 2009).

3.7 Spinal analgesia

Spinal analgesia refers to the procedure whereby medication is injected through the dura into the intrathecal space, with resultant rapid onset and effective short-term analgesia. Spinal analgesia is used in labour to reduce the motor blockade and allow women to mobilise during labour. However, as the analgesic effect is very short-term, combining spinal and epidural techniques, known as combined spinal epidural (CSE), is preferred to prolong the analgesic action for labour (Buckley, 2009).

3.8 Decrease in endogenous oxytocin

Production of endogenous oxytocin (the natural uterotonic responsible for rhythmic contractions of labour) is decreased in plasma when epidural analgesia is administered (Rahm et al., 2002) with the normal increase in labour inhibited (Stocche et al., 2001). A possible hypothesis for this observation is linked to the administration of the epidural fluid bolus that inhibits the release of antidiuretic hormone produced in the posterior pituitary gland and which sequentially results in a transient decrease in endogenous oxytocin production (Cambric & Wong, 2009).

Women who receive epidural analgesia also, do not experience the endogenous oxytocin surge in the late second stage of delivery, during full dilation or the crowning stage (Goodfellow et al., 1983; Rahm et al., 2002). This results in the absence of the Ferguson reflex and the powerful expulsive contractions that result in the birth of the baby (Dawood et al., 1977).

3.8.1 Labour dystocia

As a consequence of reduced circulating endogenous oxytocin and prostaglandins during labour, the negative effect of epidural analgesia is thought to be a slowing of both the first and second stages of labour. In meta-analysis studies, the length of the first stage of labour is both statistically and clinically longer in duration in women who had epidural analgesia (Halpern et al., 1998; Zhang & Klebanoff, 1999). Leighton and Halpern (2002), found that the average length of the first stage of labour was 26 minutes longer in women who received epidural analgesia. However, there is data conflict and controversy related to the relationship between the progress of first stage labour and epidural analgesia, versus non-epidural analgesia. A Cochrane review of 11 randomised controlled trials (RCTs) did not find a significant difference in the average length of the first stage of labour in women, randomised to epidural analgesia, compared to women without epidural analgesia (average mean difference 18.51 minutes 95% CI 12.91 to 49.92) (Anim-Somuah et al., 2011).

Many difficulties exist in designing and conducting sound clinical trials investigating the effect of neuraxial analgesia on labour and delivery outcomes. Ideally, a randomised clinical trial would have a control group of women who received no, or placebo, analgesia. This, however, raises ethical concerns and the

number of crossovers to the analgesic group may be so high as to render the data uninterpretable. The majority of trials, therefore, compare epidural analgesia to another type of analgesia such as systemic opioids, as in the Cochrane review above (Cambric & Wong, 2009). This design also has problems, namely the possibility of high crossover due to the superior analgesic qualities of epidural analgesia and ironically, few investigations have been conducted on the effect of systematic opioids on labour progress and delivery outcomes. Evidence also exists of differences amongst the opioids, and a variety of opioids (morphine, pethidine, fentanyl, buprenorphine and tramadol) have been evaluated among the various trials (Sivalingam & Pleuvry, 1985; Yoo et al., 2001).

3.8.2 Instrumental deliveries

The loss of the endogenous oxytocin surge and the birth reflex at the end of the second stage of labour when epidural analgesia is used, is associated with a prolonged second (or pushing) stage and increased risk of instrumental delivery. A Cochrane meta-analysis of 13 RCTs acknowledged that use of epidural analgesia significantly increased the average duration of the second stage of labour compared with no epidural analgesia (average mean difference in second stage length is 13.66 minutes, 95% CI 6.67 to 20.66) (Anim-Somuah et al., 2011).

The American College of Obstetricians and Gynecologists (ACOG) and the Society for Maternal-Fetal Medicine (SMFM) collaborated on a consensus statement on obstetric care (Caughey et al., 2014) regarding second stage labour. They declared that it is important to consider not only the average or median length of second stage labour with epidural analgesia, but also the 95th percentile duration. A recent, large retrospective cohort study of 33,239 participants compared nulliparous

and multiparous women with and without epidural analgesia use. For nulliparous women, second stage labour averaged 197 minutes without epidural analgesia and 336 minutes with epidural analgesia, a significant difference of over two hours. For multiparous women this difference was greater: second stage duration was 81 minutes without epidural analgesia and 255 minutes with epidural analgesia, a significant difference of almost three hours (Cheng et al., 2014).

Prolonged second stage labour is often the indication for intervention in the form of instruments, either forceps or ventouse, to deliver the baby. Studies have shown that epidural analgesia is associated with an increased rate of operative delivery (Leighton & Halpern, 2002; Srebnik et al., 2020; Turner et al., 2019). In the single-centre retrospective study by Srebnik et al. (2020), epidural analgesia use had significantly higher instrumental deliveries; (19.8%) compared to non-epidural analgesia (6.8%). Turner et al. (2019) retrospective study of women delivering at term found that instrumental rates were also significantly greater in the epidural analgesia group, versus the non-epidural analgesia group both with prolonged second stage labour (53.4% vs 45.1%) and without prolonged second stage labour (32.2% vs 8.5%). A 2011 Cochrane review (Anim-Somuah et al., 2011) found the risk of instrumental delivery as reported in 23 trials with 8,212 women was greater in women randomised to the epidural analgesia group, than in the non-epidural analgesia group. However, the recent (2018) Cochrane review of epidural analgesia found that, overall, women using epidural analgesia may be more likely to require forceps or ventouse assistance at birth. However this effect was not observed in studies conducted since 2005, and the authors considered this to be due to the use of lower concentrations of local anesthetic and the introduction of modern epidural

techniques such as patient controlled epidural analgesia (PCEA) (Anim-Somuah et al., 2018).

The use of lower concentrations of local anesthetic or CSE is used by anaesthetists to reduce the use of instruments at delivery. UK researchers who conducted a large RCT (the COMET study – Conventional Obstetric Mobile Epidural Trial) found that 37% of women with a traditional epidural experienced an instrumental delivery, compared to 29% of women using a low-dose epidural infusion, and 28% using CSE. Less motor block encourages ambulation in all stages of labour (which a third of the women in this study chose to do) and increases a woman's ability to push (Shennan, 2001). However, in a study by Collis (1999) that examined the effect of maternal ambulation on labour using low-dose CSE analgesia, only 44% of women labouring spontaneously, and 51% who were induced, achieved the goal set by the study of 30% of block time out of bed. Despite the low-dose regime, sixteen of the group developed motor block, which prevented mobilisation, standing or walking.

3.8.3 Mechanisms of action

There are likely to be several mechanisms involved in the association of instrumental deliveries with epidural analgesia. Firstly, as discussed previously, decreased plasma levels of endogenous oxytocin reduce uterine contractions and the loss of the birth reflex due to the depleted endogenous oxytocin surge. The loss of this birth reflex is also due to local anaesthetic blockade of the small diameter autonomic nerve fibres susceptible to this effect, and the pelvic parasympathetic afferent fibres entering the spinal cord at the lower level. The afferent and efferent tracts are referred by spinal cord level (Goodfellow et al., 1983).

Decreased efficacy of maternal expulsive efforts in second stage labour is also linked to relaxation of abdominal wall muscles in women with dense local anaesthetic-induced motor (efferent fibre) blocks. High concentrations of epidural local anesthetic which result in maternal motor block have the further effect of relaxing the pelvis and pelvic floor muscles, consequently interfering with the rotation of the fetal head during descent. Finally, more an influencing factor than a mechanism, is the recognition that obstetricians are more likely to use instruments in women with effective epidural analgesia than women without (Cambric & Wong, 2009). The force used by an obstetrician to deliver a baby with forceps in women with epidural analgesia is double the force used when there is no epidural analgesia (Poggi et al., 2004).

3.8.4 Malposition of the fetus and increased risk of episiotomy, vaginal and perineal tears

An increased incidence of malposition of the fetus in second stage labour has been associated with epidural analgesia. Lieberman et al. (2005) found a strong association (13% compared to 3% for women without epidural analgesia), with persistent occiput posterior position (POP or face up) as opposed to the occiput anterior (OA or face down) position in the late stages of labour. There is an increased chance of achieving a spontaneous vaginal delivery when the fetus is in the occiput posterior position. Results from a study found that only 26% of nulliparous women and 57% of multiparous women proceeded to a spontaneous vaginal delivery when their baby was in the POP position. Persistent occiput posterior position was associated with prolonged first and second stages of labour, third and fourth-degree perineal tears (fourth degree tears are associated with anal

sphincter damage), operative vaginal deliveries and caesarean section deliveries (Ponkey et al., 2003).

Instrumental deliveries without malpresentation affect the integrity of perineal structures. There is an increased risk of episiotomy, vaginal and perineum tears, with (Loewenberg-Weisband et al., 2014) with up to triple the risk in one study by Carroll et al. (2002). Trauma to the perineum can have serious long-term consequences for the mother, both physically and emotionally. Major perineal tears damage the anal sphincter which can lead to issues of bowel incontinence, recto-vaginal fistulas and dyspareunia (painful sexual intercourse) (Buckley, 2009; Carroll et al., 2002).

3.8.5 Risk to babies

For babies, instrumental deliveries can also have an impact on health and wellbeing. These are inevitably short term but can be distressing, such as bruising, facial injuries and movement of cranial bones. A Cochrane review of 32 studies comprising 6,597 women found that forceps were more likely to be associated with facial injury of the newborn (O'Mahony et al., 2013). More serious injuries for babies are the result of cephalohematoma (blood clots in the scalp) and intracranial haemorrhage (bleeding inside the brain). One study found that babies delivered by forceps were four times more likely to develop intracranial bleeding compared to those born spontaneously (Jhavar et al., 2005).

A study that specifically looked at ventouse-assisted birth, reported that the rate of neonatal intracranial haemorrhage was more than six times greater in newborns delivered by ventouse (19.0 per 10,000 births) compared with babies delivered spontaneously (2.8 per 10,000) (Ekéus et al., 2014). However, generally

subdural haemorrhages are benign with no long-term developmental consequences in children followed up to 2 years of age (Towner et al., 1999).

3.9 Augmentation and induction of labour

A decrease in circulating endogenous maternal oxytocin due to epidural analgesia and administration of opiates (Clarke, 1984; Morris et al., 2010) results in the corresponding need for exogenous oxytocin to improve uterine contractility. There is limited research on the effects of opiate administration on oxytocin secretion in women during labour or while breastfeeding. Augmentation of labour is the stimulation of the uterus during labour to increase the frequency, duration, and strength of the contractions. Induction of labour is the process of artificially stimulating the uterus to initiate labour, commonly through administration of exogenous oxytocin or prostaglandins. Several studies report an increase in augmentation of labour with exogenous oxytocin; up to three times for women with epidural analgesia compared to women without (Leighton & Halpern, 2002; Sharma et al., 2002). Results from a prospective cohort study compared labour and birth outcomes between nulliparous women who used epidural analgesia and those who did not. A total of 1,221 women participated in the study, 958 received epidural analgesia and 263 who did not. Women who received epidural analgesia had an increased risk of having a ventouse or forceps delivery (RRR (ratios of relative risk) 3.35, CI 2.36, 4.76, $p < 0.01$ and RRR 11.69, CI 6.15, 22.23, $p < 0.01$). It was demonstrated that 25% of women who had epidural analgesia had a ventouse delivery compared to 22% who did not use epidural analgesia. Seventeen percent of women who received epidural analgesia had a forceps delivery compared to 4% who did not receive epidural analgesia. Women who used epidural analgesia had an

increased likelihood of receiving exogenous oxytocin (OR 9.38, CI 6.36-13.85), equating to 67% of women who received epidural analgesia, compared to 14% of women who did not (Newnham et al., 2020).

Regarding exogenous oxytocin, there are difficulties in titration and high concentrations in the maternal bloodstream often lead to early intervention with epidural analgesia (Kaul et al., 2004). Induced labour may be less efficient than spontaneous labour (NICE Guideline, 2008). A study which examined both endogenous and exogenous oxytocin found that the administration of exogenous oxytocin produced flat oxytocin levels in the maternal bloodstream. It is hypothesised that these flat levels are a contributing factor to the uterine contraction patterns and influence the hyperstimulation that results from high doses of exogenous oxytocin. This study further reported that prolonged exposure to exogenous oxytocin can lead to reduced contractility of the muscles of the uterus because of sensitising of the oxytocin receptors (Uvnas-Moberg et al., 2019). Induced labour is associated with stronger contractions (Romano & Lothian, 2008), increased labour pain and a more arduous labour (Antonakou & Papoutsis, 2016; Romano & Lothian, 2008; Schwarz et al., 2016), thus exogenous oxytocin and epidural analgesia are often used together in labour.

3.9.1 High alert medication

Administration of exogenous oxytocin in labour is the most common medical intervention in childbirth in both developed and developing countries (Odent, 2013). It also has the distinction of being included in the list of high alert medications, one of only 11 other drugs, designated by the Institute for Safe Medication Practices as 'bearing a heightened risk of harm when they are used in error' and potentially

requiring 'special safeguards to reduce the risk of error' (Institute for Safe Medical Practices as cited by Clark et al., 2009).

Difficulties exist with the administration of exogenous oxytocin in that recommendations can be vague in relation to clinical indications, timing, dosage and monitoring of mother and baby. The ranges of initial infusion rates used to induce labour can vary by up to one hundredfold, with dosing intervals that vary by threefold (Clark et al., 2009).

3.9.2 The problematic use of oxytocin titration

The use of exogenous oxytocin is problematic as there are no universal or evidence-based guidelines on dosages which can be highly variable, responsive to individual patients and determined according to individual obstetrician preferences (Prasad & Funai, 2012). According to Clark et al. (2008), exogenous oxytocin continues to be the drug most commonly linked with preventable obstetric adverse events such as fetal hypoxia and uterine rupture due to uterine hyperstimulation. In litigation focused countries such as the USA, almost half of all paid litigation claims are based on allegations of exogenous oxytocin misuse.

3.9.3 Exogenous oxytocin and beta-endorphins

The use of exogenous oxytocin to induce or augment labour makes contractions stronger and more difficult to tolerate, requiring the use of epidural analgesia. During the labour and birth process, endogenous oxytocin is released in the brain, directly from nerves within the brain. Oxytocin in the circulation does not pass into the brain, thus exogenous oxytocin does not cross the blood-brain barrier.

The release of endogenous oxytocin within the brain and spinal cord during labour and birth influences the release of endogenous opiates (beta-endorphins), thus decreasing the experience of pain (Uvnas-Moberg et al., 2019). Beta-endorphins are the endogenous opioid neuropeptides that bind to opioid receptors and help the labouring woman transcend pain, resulting in an altered state of consciousness, often referred to as 'being on another planet', a state that is also affected by epidural analgesia. The administration of epidural analgesia results in a dramatic reduction of beta-endorphins released during labour (Browning et al., 1983; Scull et al., 1998).

3.10 Epidural analgesia effect on adrenaline and noradrenaline

Catecholamines in blood concentrations naturally rise throughout the physiologic labour process (Costa et al., 1988), culminating at the end of an undisturbed labour in a powerful surge which energises the woman in the pushing stage. The baby is born, and the new mother is alert and eager to interact with and breastfeed her new baby (Buckley, 2009).

In early labour, high catecholamine levels slow or inhibit the progress of labour (Lederman et al., 1985) when the woman is anxious due to pain, cold, hunger, fear or feeling unsafe in her environment (Buckley, 2009; Neumark et al., 1985). The use of epidural analgesia reduces the release of adrenaline in labouring women, which may be beneficial in early labour if stress is slowing the labour. In active labour, however, this lack of adrenaline can be detrimental to the physiologic process (Buckley, 2009). A study by Neumark et al. (1985) showed up to 75% reductions in plasma adrenaline levels in women who received epidural analgesia, compared to women with other forms of labour analgesia. Women in this study who

used pethidine in their labour showed an increase in plasma adrenaline levels, the mean level at birth was approximately 5 times higher than at 5-6cm dilated.

In terms of noradrenaline, there is little effect due to epidural analgesia, however there is a change to the adrenaline-noradrenaline ratio in labour that may result in an imbalance in catecholamines (Buckley, 2009). Adrenaline has an immediate inhibitory effect on uterine activity, while noradrenaline has a stimulating one. Noradrenaline excretion is predominantly associated with increased (though uncoordinated and dysfunctional) uterine activity, which may result in hyperstimulation, and on its own noradrenaline may lead to premature labour (Buckley, 2009; Fuchs & Fuchs, 1984; Omer, 1986). Stress in labour has the effect of increasing both adrenaline and noradrenaline, however in the first few hours, adrenaline increases at a greater rate, resulting in decreased uterine activity. Eventually a rebound reaction develops to adrenaline and both catecholamines work together in stimulating uterine contractions (Omer, 1986).

3.11 Exogenous oxytocin infusions and breastfeeding

There is evidence that exogenous oxytocin infusions during labour influence endogenous oxytocin secretion in response to breastfeeding. Jonas et al. (2009) demonstrates a negative correlation between the amount of exogenous oxytocin infused during labour and median endogenous oxytocin blood concentrations in women during breastfeeding on day two postpartum. This indicates the continued presence of a negative feedback mechanism inhibiting endogenous oxytocin release still evident when exogenous oxytocin would be metabolised and eliminated (Jonas et al., 2009; Lindow et al., 1999).

The administration of exogenous oxytocin, which crosses the placenta, may also have adverse effects on neonatal behaviour, including breastfeeding (Odent, 2013).

3.12 Epidural analgesia and effect on breastfeeding

In the hours following birth the newborn is normally primed and alert in preparation for the first breastfeed and interaction with the mother. When placed on their mother's chest immediately after birth, newborns of mothers who did not use analgesia showed innate pre-feeding cues. After the first cry after birth, newborns are relaxed, then gradually they develop rooting and sucking actions. The newborn in a typical fashion moves towards the mother's breast, locates the nipple and commences suckling at the breast. This is accompanied by massage of the breast by newborns that is associated with maternal endogenous oxytocin release (Matthiesen et al., 2001). Epidural analgesia is thought to depress the neuro-behaviour of the newborn through several mechanisms which can impact the initiation and success of breastfeeding (Buckley, 2009).

One of the first mechanisms that may prevent the baby from behaving in this way, potential neuro-behavioural deficits because of drug exposure due to epidural analgesia. In a study that measured the breastfeeding capabilities of 129 babies using the Infant Breastfeeding Assessment Tool (IBFAT), unmedicated babies achieved the highest scores. Scores were lower for babies who had been exposed to epidural analgesia or IV opiates, and lowest for babies exposed to both. Breastfeeding was discontinued earlier for infants who scored lower, however, similar numbers in all groups of babies were breastfeeding at six weeks (Riordan et al., 2000).

A further study looked at the breastfeeding behaviours, interscapular skin temperature, and crying behaviour in newborns of mothers who had not received any labour analgesia, mothers who had received mepivacaine via pudendal block, mothers who had received pethidine intramuscularly and mothers who had received bupivacaine via epidural analgesia. All infants of mothers who had received analgesia exhibited disturbed and depressed breastfeeding behaviour. This may adversely affect the endogenous oxytocin release in the mother post birth, interfering with milk ejection, uterus involution and the establishment of the mother-infant bond (Ransjö-Arvidson et al., 2001).

3.13 Epidural analgesia side effects

In addition to epidural analgesia disrupting the hormonal balance required for a physiological birth, maternal and infant side effects may also occur, due to the medications injected into the epidural space. These side effects can range from mild to life threatening, dependent on the dose and medications used.

Local anaesthetic medications such as lignocaine, bupivacaine and ropivacaine, depress conduction of nerve impulses which results in loss of sensation below the injection site. When injected into the epidural space, these medications act on sensory nerve fibres exiting the spinal cord through this space. Opiate medications, such as morphine and fentanyl are also co-administered and target opiate receptors in the dorsal horn of the spinal cord (Buckley, 2009).

The injection of medications into the epidural space potentially risks creating a systemic effect on the mother, due to entry into the bloodstream. This is due to the risk of accidental catheterisation of the epidural venous plexus at insertion, or through migration of the catheter. The risk of inadvertent catheterisation of the epidural venous

plexus is 9% (Souza et al., 2016). Once systemically absorbed by the mother, these medications can then cross the placenta with potential side effects for the fetus. Possibly the greatest universal exposure of the developing fetal brain to central nervous system active agents occurs at birth (Golub, 1996). President of the American Foundation for Maternal and Child Health Doris Haire (2005 as cited in May, 2014), commented on the use of medications in labour:

Obstetricians, midwives, and nurses who care for women during childbirth need to know that there is no obstetric related drug that has been proven safe for the neurologic development of the fetus. There have been no adequate and well-controlled studies to determine the delayed, long-term effects of bupivacaine or any other epidural drug on pregnant women, or on the neurologic, as well as general, development of children exposed to the drug in utero or during lactation. (p. 34)

On the approval label for bupivacaine, the USA Food and Drug Administration (2012) warns that it rapidly crosses the placenta into the circulatory system of the foetus and, when used in epidural, caudal and pudendal block can cause varying degrees of maternal, fetal, and neonatal toxicity, potentially leading to adverse reactions involving damage to the central nervous system. Medications used in epidural administration are routinely used in labour without unambiguous evidence as to their safety and little discussion around these issues within the obstetric community (May, 2014).

3.13.1 Maternal hypotension

One of the most common, almost universal side effects of the administration of epidural analgesia is maternal hypotension. It can have serious effects on

maternal circulation, causing women to feel faint and, in rare cases experience seizures or cardiac arrest (Akbas & Akcan, 2011). Protocols designed to pre-empt these adverse reactions are the administration of intravenous (IV) fluids before the epidural is sited, however, even with this fluid bolus, there are significant incidents of maternal hypotension. In a study by Mayberry et al. (2002), up to 50% of all labouring women with epidural analgesia experienced hypotension especially in the minutes immediately preceding the drug bolus. Hypotension is primarily due to the blockade of the sympathetic nervous system which results in arterial and venous vasodilation and a concomitant 'functional hypovolemia' (Holte et al., 2004). Sudden, severe maternal hypotension (more than a 20% drop in blood pressure (BP)) can reduce utero-placental blood flow to the fetus, resulting in decreased oxygen delivery and fetal distress (Anim-Somuah et al., 2018).

There is belief among some researchers that the hypotensive effect of epidural analgesia is also due to the sudden abolition of pain which reduces plasma adrenaline, causing an imbalance of adrenaline and noradrenaline. Together, these hormones have a role in maintenance and equilibrium of maternal blood pressure (MBP) and maternal heart rate (MHR) and impact the strength of uterine contractions. A reduction of adrenaline leads to uterine hyperstimulation and altered fetal heart rate patterns indicative of fetal distress (Buckley, 2009). Signs of fetal distress can lead to emergency caesarean section or instrumental delivery.

3.13.2 Caesarean section birth

The effect of epidural analgesia on risk of caesarean section birth has been controversial for decades (Goer, 2015). Retrospective studies initially showed an increased risk of caesarean section birth for women using epidural analgesia; more

recent RCTs have contradicted this (Bofill et al., 1997; Clark et al., 1998; Kotaska et al., 2006; Longhnan et al., 2000; Sharma et al., 2002; Sharma et al., 1997). The most recent Cochrane meta-analysis comparing epidural analgesia with opioid analgesia found that the caesarean section rate was no different between the groups (Anim-Somuah et al., 2018). The reasons for the controversy surrounding epidural analgesia on the risk of caesarean section birth are multi-factorial. Firstly, observational studies are unable to determine causation, that is, whether epidural analgesia leads to more caesarean births. Women who are experiencing painful, prolonged labours are at greater risk of requiring caesarean delivery but are more likely to be using epidural analgesia. Another difficulty with determining direct causation between epidural analgesia and caesarean birth is that epidural analgesia in itself increases the likelihood of factors associated with caesarean birth, such as malpositioning of the fetus, increased use of exogenous oxytocin and fetal distress due to maternal hypotension (Goer, 2015).

3.13.3 Maternal pyrexia

A recent meta-analysis has indicated that women receiving epidural analgesia in labour are two and a half times more likely to experience pyrexia (i.e. a fever above 38°C) (Anim-Somuah et al., 2018). This phenomenon of pyrexia, typically affecting 15-25% of women receiving epidural analgesia, is only seen in labouring women, not in non-pregnant women or even in women receiving epidural or spinal anaesthesia for elective caesarean delivery. Recent results from translational studies propose that epidural-related maternal fever (ERMF) is probably related to administration of local

anaesthetics which trigger the inflammatory response that is observed in ERMF (Sultan & Segal, 2020).

Maternal pyrexia has a diverse range of effects on both the woman and her baby. As a result, the management of labour alters, lowering the threshold of surgical intervention with admission of neonates of febrile mothers to intensive care with suspected sepsis (Segal, 2010).

3.13.4 Effect of maternal fever on the neonate

Raised temperatures in women using epidural analgesia have an effect on the fetus, even if they are not associated with infection. There is difficulty in differentiating the effect of maternal fever from that of the underlying cause; this is particularly pertinent when there is high suspicion of chorioamnionitis or other infection. The fetus is susceptible to developing hyperthermia if the mother is febrile, as the fetus is dependent on heat transfer to the mother to avoid this condition (Segal, 2010).

A study by Macaulay et al. (1992) examined the thermoregulatory effect of epidural analgesia during labour in women measuring oral, intrauterine and fetal skin temperatures. Women self-selected to four control groups: 33 received epidural analgesia and 24 received nitrous oxide, systemic opioids, or no analgesia. A maximum fetal skin temperature of $>38^{\circ}\text{C}$ was observed in a third of the epidural group but none in the non-epidural groups. In the epidural group, three fetuses developed approximate core temperatures of $>40^{\circ}\text{C}$. Clinical measures of neonatal wellbeing, APGAR scores and umbilical blood gas and lactate measurements were not affected by the type of analgesic chosen.

However, immediately after birth, several adverse effects associated with maternal fever have been documented by researchers. A systematic review by

Lieberman et al. (2000), studied the birth records of 1,218 nulliparous women who were afebrile when admitted to hospital. Out of this group, approximately 10% became febrile with a temperature of 38°C, and 5% with a temperature of 38.3°C. Most of the women who developed a fever had epidural analgesia. Babies of mothers who had a moderate fever had poor tone at birth and 1-minute Apgar scores <7. In the group of mothers who had a high fever, babies needed bag-mask ventilation at birth and required supplemental oxygen in the neonatal unit and there was a weak link with neonatal seizures.

Currently, there is a more debilitating and sinister prospect of concern, than the short-term neonatal issues identified above. Maternal hyperthermia is associated with adverse neonatal outcomes including neonatal seizures, neonatal encephalopathy (Impey et al., 2001; Pearlman, 2006), cerebral palsy (Grether & Nelson, 1997; Pearlman, 2006) and neonatal mortality in preterm and term infants (Pearlman, 2006). Studies have shown a fourfold increased risk of developing encephalopathy in the newborn (Impey et al., 2001) and an increased rate of mortality, 1.3 times higher in babies whose mothers were febrile during labour (Petrova et al., 2001). Significantly, Impey et al's (2008) research, which found an association between maternal fever and neonatal encephalopathy, identified that affected babies rarely had neonatal sepsis, suggesting that an inflammatory response rather than infection per se is the etiologic process.

Long term sequelae of maternal intrapartum fever, not evident at birth, are cognitive deficits in childhood. A study by Dammann et al. (2003) found that nonverbal intelligence scores of <2 standard deviations below the age-adjusted average were associated with maternal pyrexia at birth (odds ratio 3.8). Maternal fever may be linked to the development of autism (Previc, 2007), schizophrenia

(Meyer et al., 2009) and Parkinsons disease (Snyder-Kellar & Stark, 2008) later in life.

3.13.5 Epidural headache, severe side-effects

In rare cases, side effects of epidural analgesia are caused by the accidental puncture of the dura (post-dural puncture headache), which can cause severe headache for 1% of women (Anim-Somuah et al., 2018). This headache can be debilitating for women in the postpartum period. They are confined to strict bed rest for several days and have difficulties in breastfeeding and caring for their newborn baby.

Severe side effects such as slurred speech, sedation, and convulsions due to the inadvertent injection of epidural drugs such as local anaesthetics into the mother's bloodstream are rare but do occur at a rate of one in 2,800 epidural insertions (Paech et al., 1998). Life-threatening reactions in general affect one in 34,000 women (Crawford, 1985; Paech et al., 1998; Scott & Hibbard, 1990; Scott & Tunstall, 1992), including death by cardiac, respiratory arrest. The long-term development of an epidural abscess, although extremely rare (Reynolds, 1989), is still a risk that is discussed with all women prior to administration.

3.14 Neonatal side effects of epidurals

3.14.1 Fetal heart rate changes

Following the administration of epidurals, fetal heart rate (FHR) changes indicate distress. This effect happens within the initial 30 minutes of administration and can last up to twenty minutes. Such changes are strongly associated with the

use of opiates in epidural analgesia. The fetal heart usually drops suddenly to very low levels (bradycardia), potentially a pathological decrease (Buckley, 2009).

Bradycardia and FHR pattern abnormalities are associated with maternal hypotension due to epidural administration and potentially also the sudden decrease in maternal catecholamine hormones which results in hypotension and uterine hyperstimulation. Combinations of drugs which produce hyperstimulation such as exogenous oxytocin and prostaglandins together with epidural drugs, increase the risk to the fetus of reduced placental blood flow and oxygenation resulting in foetal distress (Capogna & Camorcia, 2004).

3.15 Opioids and opiates

Presently she cast a drug into the wine of which they drank
to lull all pain and anger and bring forgetfulness of every sorrow.

The Odyssey, Homer

The earliest literature in the 9th century refers to the use of opium to ease pain in the middle and Far East. In 1806 the active ingredient in opium was separated and named after the God of dreams, Morpheus (Smith & Morgan, 1997). The term opiate refers to a natural compound such as morphine, whereas the term opioid refers to something made similarly in the lab, a synthetic compound, for example, pethidine and fentanyl (Westhoff, 2019).

The popularity of these medications for use in labour has decreased significantly since the rise in availability and use of epidural analgesia. In the USA, only 22% of women reported using opiates during labour (Declacq et al., 2007). In a UK survey that randomly sampled 4,571 women who gave birth over a two-week

period, during 2014, 25% of women used pethidine or a similar opioid medication during labour (Redshaw & Henderson, 2015). This reflects a decreasing trend in opioid use from 33% of women similarly surveyed in 2006 (Redshaw et al., 2007).

Despite this downward trend, most obstetric units in middle-and-high income countries offer parenteral (intramuscular, intravenous, or patient-controlled intravenous) opioids, as well as offering facilities for epidural analgesia. Opioid medications are relatively inexpensive and opioids such as meptazinol, diamorphine and pethidine are used commonly in obstetric and midwifery practice in many countries (Smith et al., 2018). Pethidine is the most common opioid medication used worldwide (Bricker & Lavender, 2002; Wong, 2009), however in NZ, pethidine, morphine and fentanyl are the only medications that a midwife can prescribe to a labouring woman (Amendment to Misuse of Drugs Regulations 1977, 2014).

Opioids have sedative-like effects that alter pain perception and have analgesic qualities. In this way opioids are often used in latent or early labour but are discouraged from use in active labour, due to the sedative effects. A New Zealand College of Midwives Consensus Statement (2019) does not advocate the use of routine opioid analgesia for intrapartum pain relief. Opioids are considered an ineffective analgesic and maternity practitioners voice concerns about the sedative effects on women and babies (Smith et al., 2018).

A Cochrane Review concluded that opioids provide women some pain relief during labour, however a 'substantial' number of women still report moderate or severe pain (Smith et al., 2018). The results of sedation lead to an impaired ability to make decisions in labour relating to care (Smith et al., 2018), and a loss of mobility due to increased drowsiness which can potentially lead to a longer and more painful labour (Lawrence et al., 2013).

Other side effects of opiates in labour can include nausea, vomiting, pruritus, hypotension, and respiratory depression. Opioids easily cross the placental barrier by passive diffusion and compromise the fetus during labour. This effect is shown as FHR abnormalities on the cardiotocograph (CTG) monitor, reduced FHR variability and accelerations, and the presence of decelerations (Reynolds, 2011; Solt et al., 2002; Sosa et al., 2006)

3.16 Epidural analgesia – not a benign intervention

Although administration of epidural analgesia is considered the gold standard treatment to ameliorate pain in childbirth, it is not a benign intervention. Its disturbance of physiological birth is such that the World Health Organisation (1997) notes, ‘epidural analgesia is one of the most striking examples of the medicalisation of normal birth, transforming a physiological event into a medical procedure’ (p. 16).

3.16.1 Epiduralised birth

Epidural analgesia is considered an intervention that leads to other interventions, the so-called ‘cascade of interventions.’ This useful term has been applied for at least three decades, by academics and clinicians, to analyse the crippling effects of sequential medical practices (May, 2017; Pincus, 2006). The origin of the term cascade of interventions, is likely from the work of Suzanne Arm’s book *Immaculate Deception* (1975 /1981). Rather than use the term ‘cascade of interventions’, she describes a ‘merry-go-round’ of interventions.

Of course, not every doctor nor every hospital is so technologically dependent as to subject all normal birth to all

interferences. The point is that generally one intervention leads to another in a kind of merry-go-round that not only increases risk to the baby, but also strips the birth mother of control of her own birth. (1975/1981, p. 109)

May (2014), in her ethnographic analysis, coined the term ‘epiduralised birth’, which she says is a more accurate reflection of the role of epidurals in contemporary births. She argues that we have moved beyond the cascade of interventions, to the entirety of interventions, a complex set of interventions that work in alignment with each other, culminating in a complete whole. The epidural is placed firmly at the centre of these interventions. The word *Gleichschaltung*⁹ is used in relation to this concept, a word associated with uniformity, mechanisation and industrialisation (May, 2014/2017). The idea of equating contemporary birth practices with industrialisation and uniformity is not new. In a reference to the intensification of the use of technology in birth in the developed world, Odent (2002b) uses the term ‘industrialised birth’ in reference to the intensification of technology in labour and birth in the developed world. In Newnham et al.’s (2017) ethnography research in an Australian labour ward, reference is made to the centrality of the ‘Journey Board’ as organisational technology. This large whiteboard behind the midwives’ station includes a variety of information about the women and is colour coded to signify the varying statuses of pregnancy and labour progress. It is a mechanism of surveillance that provides continuous monitoring of the women’s progress in labour by gathering of information and observation from midwifery and medical staff. This mechanism of surveillance has a dual effect. It both restricts midwifery practices and

⁹ *Gleichschaltung*, although used in a political sense during fascist Germany, refers to a mechanical state where all the pieces work together so that the whole operates in unison. In terms of epiduralised birth, it refers to a process where each intervention serves to create a uniformity of birth (May, 2014/2017, p. 4).

the period of time in which women are able to labour. As Newnham et al. (2017) note, this focus on the 'Board' dehumanises birth practices and shifts the focus from the women to the institution. Walsh (2006) describes the 'assembly-line' of birth and uses the term 'Fordism', terms which evoke the sense of contemporary birth as standard, routine and managed. The experience of birth is highly variable for each woman and cannot be standardised.

3.16.2 Standardising birth

The idea of standardising birth is also linked to the concept of efficiency in birth and a pre-occupation with labour progress and length. This need to measure the progress in labour, stems from a clinical concern in relation to long labours. The origin of the Friedman curve of labour (Friedman, 1954) was to provide statistical norms for length of labour, allowing potential to distinguish between 'normal' and 'abnormal' labour lengths (Albers et al., 1996). The requirement to keep women moving through the hospital system, like a factory, necessitates the use of interventions in birth and continued interference in the physiological process of birth.

Epidural analgesia and its associated obstetric interventions influence the physiological process of birth, and it is appropriate to challenge its role in the labour and birth process. Current debates identify the potential iatrogenic risk of this type of analgesia in relation to prolonged labour and instrumental vaginal birth (Kotaska et al., 2006; Lieberman & O'Donoghue, 2002) and link epidural analgesia directly with the rise in morbidity associated with obstetric interventions (Leap & Anderson, 2008). The need to avoid this disturbance of birth and this rise in interventions is perhaps best summarised in the words of Dutch professor of obstetrics, G. Kloosterman (1982):

Spontaneous labour in a normal woman is an event marked by a number of processes so complicated and so perfectly attuned to each other that any interference will only detract from the optimal character. The only thing required from the bystanders is that they show respect for the awe-inspiring process by complying with the first rule of medicine – *nil nocere* [do no harm]. (p. 40)

3.17 Summary

This chapter began with a discussion of the term ‘normal’ in relation to birth, a term that is still controversial in discourses on labour and birth. The chapter then outlined the complex interplay of physiological and hormonal factors that are necessary for the process of physiological labour and birth. I argue that it is necessary to understand the physiological process of labour and birth in order to understand the effects of pharmacological methods of pain relief in labour in relation to epidural analgesia and opiates (which was then discussed). An extensive array of potential side effects attributed to epidural analgesia and opiates was included. The final section of this chapter was a discussion on the role of epidural analgesia as an intervention in physiological birth and the idea of epiduralised birth and systematic birth in current maternity settings.

The following chapter continues with the process of labour, focusing on the nature of labour pain and the management of labour pain from a medical and a midwifery discourse. The management of labour pain and the dichotomy that exists is outlined in an historical overview. The final section is an outline of non-pharmacological methods of pain relief available to women in labour and their mechanisms of action.

CHAPTER 4: THE NATURE AND MANAGEMENT OF LABOUR PAIN

Having outlined the physiology of labour, this chapter discusses the debates around the nature and management of labour pain. It begins with an historical overview of this controversial subject, a controversy that likely began when the first woman gave birth. This discussion starts in the 19th century but references the Judeo-Christian attitude to labour and pain. It moves through the ages until present day attitudes to labour and labour pain are referenced. Naturally arising from this historical overview, is a debate about the dichotomy that exists in relation to the nature of labour pain and its management and the medical and midwifery paradigms.

Following on from the analysis of the midwifery paradigm, the concepts of birth satisfaction, self-efficacy and control, fear, and anxiety are discussed in relation to the labour and birth experience. The next section extensively reports on the non-pharmacological methods of pain relief available to birthing women and their mechanisms of action. Finally, at the end of this chapter, the nature of undisturbed birth and birth environments is evaluated.

4.1 Contradictory nature of labour pain

At the heart of debates around managing labour is the debate about the management of labour pain and whether it should be managed at all. Labour pain is one of the most severe types of pain a woman is likely to experience (Melzack et al., 1984). It is however, like all pain, experienced differently by every woman; some women do not experience labour contractions as 'painful', but rather as pleasurable, even orgasmic, sensations (Gaskin, 2003; Trout, 2004). Women describe their experiences of labour in contradictory terms, as both unbearable and empowering and for some women these extremes are experienced concurrently (Karlsdottir et al.,

2013; Lundgren, 1998; Whitburn et al., 2017). In the study by Whitburn et al. (2017) one woman captured this contradiction: “I think it’s a happy pain, though it is hell...” (1998, p. 107).

Why this physiological process is painful is the subject of much debate. It is thought that pain may act as a warning signal to enable the pregnant woman to escape to a safe place to give birth. This pain of labour is linked with the basic and fundamental nature of the experience of life; ‘the bringing forth of new life’ as opposed to pain associated with disease and pathology (Lowe, 2002, S16). This association with a physiological process has been described as a paradox that is reflected in the diametrically opposed viewpoints encapsulated by the medical and the midwifery models of childbirth.

4.2 History of childbirth – dichotomy of views

In the 19th century the views of two physicians, Charles Meigs and James Young Simpson, exemplified these two diametrically opposed views. One argued that birthing chambers were largely scenes of ‘cheerfulness and gaiety’. The other physician’s description of labour was as ‘terrible torture, hopeless of relief’ (Wolf, 2009, p. 1). In the 20th and 21st century, women’s views of labour pain are similarly contradictory.

One woman described her drug-free birth in terms of feeling ‘happiness’ and ‘joy’ (Leap et al., 2010, p. 239). The poet, Sylvia Plath, described her labour as a ‘long, blind, doorless and windowless corridor of pain waiting to open up and shut her in again’ (as cited in Caton, 1999, p. 4). These proponents of labour as ‘cheerful’ and ‘joyful’ declare that obstetric anaesthesia is completely unnecessary and dangerous; whilst in contrast, the proponents of labour as ‘terrible’ and a ‘long

corridor of pain' argue that obstetric anaesthesia is an unequivocal necessity and should be mandatory for all women who care about their comfort and health (Wolf, 2009).

These disagreements about the use of analgesia in childbirth persist into the present day and as Wolf (2009) argues, "of all the bitterly contested obstetric treatments of the past 160 years, the administration of anaesthesia for labour pain has prompted the longest lasting disagreement" (p. 1).

4.2.1 Pain, suffering and chloroform

In Judeo-Christian societies, suffering and pain in labour was something to be endured by women and testament that they were God-given and carrying out their religious duty. James Young Simpson challenged these traditional ideas of the church and the 'curse of Eve' in the 19th century (Mander, 2010, p. 127). Simpson had demonstrated the anaesthetic properties of chloroform¹⁰ to his peers in 1847, and the use of ether and chloroform began to be used in childbirth as well as surgery. Wolf (2009) argues that "the controversy generated by that move has been a hallmark of obstetrics ever since" (p. 1).

Aware of the anaesthetic qualities of chloroform, Queen Victoria petitioned her doctors for its use in her labours, but she was cautioned against using it. On, medical grounds it was feared that its use would slow the progress of labour and, on theological grounds, chloroform was, as a clergyman advised, a 'decoy of Satan' that would 'harden society and rob God of the deep earnest cries which arise in time of

¹⁰ Chloroform was an inhalation anaesthetic first discovered by American physician, Samuel Guthrie in 1831, when he combined whiskey and chlorinated lime and determined chlorine's affinity for alcohol. Chloroform can cause heart, kidney, and liver damage (Wolf, 2009).

trouble for help', (Bourke, 2014, p. 1289). Charles Meigs, a prominent American obstetrician of the time, was opposed to the use of chloroform. His opposition 'was certainly not without reason when scarcely a week passes but we hear a death from chloroform' (Thoms, 1926, p. 1054). He further warned against the use of anesthesia as it lessened or stopped labour pains and was therefore contrary to normal physiology, an indictment that was probably correct in many instances (Thoms, 1926). Finally, in 1853 before the birth of her 8th child, Prince Leopold, Queen Victoria was permitted by her physician, John Snow, to inhale chloroform from a handkerchief (Wong, 2009). She enjoyed it, declaring it to be 'soothing, quieting and delightful beyond measure' (Barry, 2019).

The use of pharmacological pain relief in childbirth, however, only slowly gained popularity among women. This resistance to its introduction, it is suggested, is based on three main reasons. Firstly, is the theological opposition to interference with God-given pain, moral assertions that ether aroused the sexual passions of women, and medical concern that such narcotic agents would harm the mother and fetus (Downe, 2010).

4.2.2 Fear of dying in childbirth

Women feared birth, they feared dying in childbirth and spent a large part of their time worrying and preparing for the possibility of not surviving their pregnancy. Historians have difficulty in determining with a high degree of confidence whether this fear is exaggerated or a true reflection of the reality of high maternal morbidity. In Leavitt's (1986) history of childbirth in the USA, an analysis of graphs constructed from available data showed that deaths from maternity-related causes at the turn of the 20th century were approximately 65 times greater than they were in the 1980s, a

sobering comparison that allows us to appreciate the dangers women faced. In contrast, Wolf's (2009) history of analgesia and anaesthesia in childbirth in the USA, contends that fear of dying in childbirth was an exaggerated belief, culturally ingrained in women. She reports a maternal death rate of 0.5% of births from 1785 to 1812 which is extremely high by today's standards, but minuscule in comparison to 18th and 19th century perceptions.

What is agreed however, is that as the march towards the mid 19th century continued, women exhibited a greater fear and apprehension about the pain of childbirth than the possibility of dying during childbirth. Women wanted relief from pain that was 'debilitating, feared and not understood' (Wolf, 2009, p. 17). Women undergoing childbirth had little idea what was happening to them anatomically or physiologically, they had scant knowledge of the mechanisms of labour, the stages or phases of labour, or the possible means to alleviate their agony (Thompson & Varney-Burst, 2015). It was these fears of unmitigated suffering that led women away from the traditional ways of birthing to search for safer and less painful childbirth (Thompson & Varney-Burst, 2015).

4.2.3 Painless childbirth

The period of the early 1900s was characterised by the 'painless childbirth' movement, led by women who lobbied to demand that physicians use pharmaceuticals to provide pain relief during childbirth (Wolf, 2009). In New Zealand, as in other Western countries, this desire for pain relief in labour was instrumental in the medicalisation of childbirth. Like women in the UK, New Zealand women actively petitioned for access to hospitals and anaesthesia during childbirth (Clarke, 2012). Hand-in-hand with these demands was the shift from birthing at home to the hospital

environment, allowing for the administration of necessary medications in a safer, more controlled environment (May, 2017). By 1926 in New Zealand, more than half of Pākehā births took place in institutions and by 1938, a total of 87% of all New Zealand babies were born in a hospital. There was a greater reluctance amongst Māori to birth in hospitals, with just 17% of Māori births in hospital in 1938. However, by 1962, this rate had increased and caught up with the Pākehā rate and 95% of New Zealand babies (both Māori and Pākehā) were born in hospitals (Clarke, 2012).

Accompanying this move from home to hospital was the change in management of birth from traditional female companions and midwives to male doctors. The presence of male doctors became accepted practice, and no longer associated only with obstructed labour, destruction, and death, leading to a shift in practice. The role of medicine in birth became associated with both progress and elevated social status. The rise of obstetric medicine in 19th century Europe was inextricably tied to the development of hospitals as the new place to give birth (McCourt & Dykes, 2010).

4.2.4 Twilight sleep: the amnesia of birth

A manifestation of this period of history in terms of analgesia and childbirth is 'twilight sleep', the administration of scopolamine¹¹-morphine, a drug cocktail that produces a strong amnesic effect. The introduction of 'twilight sleep' in New Zealand in the 1920s was promoted by the medical profession as being able to offer 'painless childbirth' (Stojanovic, 2008). Women preferred twilight sleep to ether or chloroform as there was no need to wear a mask, no odor, and the whole of the birth experience was a blank (Wolf, 2009). Journal articles of the time began to report side effects of

¹¹ Scopolamine is a central nervous system depressant that causes amnesia and, at times, delirium.

twilight sleep such as prolonged labour, fetal asphyxia, haemorrhage and delirium (Wolf, 2009). Using the intricate protocols around the administration of twilight sleep as an impetus, the obstetric community was able to elevate the status of the obstetrician and the specialty of obstetrics. Prior to this it had been disregarded as a valued and legitimate medical specialty by other colleagues (Wolf, 2009).

4.2.4 Pharmacological pain relief in birth: a humanistic ideal

The advent of pharmacological pain relief in childbirth was simultaneously applauded and opposed by the medical profession and women from all classes of society. In England, in 1924, the National Childbirth Trust formed to promote the idea of “natural” childbirth, recognising the work of obstetricians Dick Read and Ferninand Lamaze. There was concern and recognition that the majority of drugs used in childbirth had little specific analgesic actions, working largely as sedatives, causing drowsiness and respiratory depression of mother and baby (Downe, 2010).

The beginning and the end of the 19th century in Western society is characterised by a cultural shift in belief systems about pain relief in labour. Pain and suffering began to be seen in a new light: it was inhumane to let women suffer and served no useful purpose. The alleviation of pain was upheld as a humanistic ideal by many women and obstetricians (May, 2017).

In order to achieve this ideal physicians deemed it necessary to use ‘increasing doses of various drugs administered by a variety of new techniques’ (Caton et al., 2002, p. S25). In the 1950s and 1960s women in labour were routinely administered multiple injections of opioid analgesics (often combined with scopolamine) throughout the first stage of labour, followed by nitrous oxide, cyclopropane, ether or regional analgesia close to birth time (Wolf, 2009).

4.2.5 Predictable birth and the rise of synthesised oxytocin

The move from home to the confines of the hospital birthing room was associated with the need to make birth more predictable and systematic, due to the large case-loads physicians were managing (Wolf, 2009). The identification of oxytocin at the turn of the 20th century, and a method for synthesis in the mid 20th century, allowed this medication to be used to induce labour (Wolf, 2009). Combined with the above array of injectable, inhalation and regional anaesthetic medications this made childbirth 'convenient' (Wolf, 2009).

Exogenous oxytocin and anaesthesia became inextricably linked and gave women a pre-planned, highly controlled hospitalised birth (Wolf, 2009). This cultural change in the management of labour and labour pain helps to explain how opioids and epidurals, both known for their negative side effects, have been incorporated so seamlessly into modern obstetric care (May, 2017).

4.2.6 Biomedical model of childbirth

The rise of the biomedical model of childbirth with its focus on technology and institutions was also a product of the post-industrial science of observation, measurement and objective enquiry (Downe, 2010). The Western world embraced positivist science; the assertion that the development of knowledge is through rational and rigorous scientific processes, as opposed to the use of speculation or metaphysical means (Crotty, 1998). Positivist science underpins modern medicine, and it is modern medicine that spawned the biomedical discourse of childbirth.

Central to this discourse is the alleviation of all pain and suffering in childbirth by the feckless pursuit of new obstetric drugs and techniques (Caton et al., 2002).

4.2.7 The backlash and natural birth

However, by the 1970s, women had had enough of this systematic and technocratic approach to childbirth and a backlash occurred. They rejected the dehumanising, impersonal and even dangerous medical routines associated with obstetric practice, rejected anaesthesia, and embraced natural childbirth. This birth reform movement coincided with two broader crusades at the time, the women's movement in the 1970s and 1980s and the consumer movement of the 1970s. As women became more active politically, socially and economically in all aspects of their lives, the image of women unwillingly strapped to delivery room tables, unconscious from unnecessary and unwanted medications, became reprehensible (Wolf, 2009).

Two prominent obstetricians, Grantley Dick-Read (English) and Fernand Lamaze (French), advocated for a humanitarian approach to birth that informed the growing militancy of women demanding reforms. Helen Heardman, Dick-Read's collaborator, developed exercises for women to help alleviate labour pain that included breathing, relaxing, squatting, and pelvic rocking. These exercises were based on work by Jacobson from 1929 which found that extreme relaxation mitigated negative reactions to sudden pain. The rise of the natural birth movement had turned the pendulum once again, and as Wolf (2009) comments,

While mothers once compared their agonising, unmedicated births with their subsequent heavily anaesthetised births, they now did the opposite,

contrasting their dizzy, nauseating, anaesthetised births with their thrilling, invigorating, natural births. (p. 163)

4.2.8 Epiduralised birth

As contentious as the issue of analgesia in childbirth is, so too is the debate about natural childbirth. As one woman commented on her 'natural' birth, "everything had gone beautifully except for one thing; it hurt like hell, more than anything I had ever experienced" (Wolf, 2009, p. 164). There was still the desire to experience pain free birth. By the 1990s epidural analgesia appeared to be the ideal choice of pain relief for childbirth; it provided women with a painless birth but was also a stress-free, even relaxing way to give birth. The question once again was asked: why would anyone be foolish enough to choose natural childbirth? (Wolf, 2009).

The introduction of epidural analgesia with the absence of obvious side effects, such as neonatal respiratory depression and the complete obliteration of pain, made it appear the perfect answer to the obstetric pain management problem. Early proponents of the epidural recommended its use in labour only when labour was well-established, it wasn't to be used throughout the entire labour process. Routine use of the epidural led to debates about the timing of the administration in labour, with research into the impact on the length of first stage labour. These studies, however, were largely inconsistent and inconclusive and as a consequence, epidural analgesia was administered earlier in labour.

4.2.9 The rise of the obstetric anaesthetist

Before the mid 1980s most women still had not heard of epidural analgesia, however if a woman was aware of the treatment and requested it, it was not readily available on the floor of the labour and birth rooms in most hospitals. If a woman was able to have epidural analgesia, an obstetrician rather than an anaesthetist administered it. Many anaesthetists were unwilling to work in obstetrics as they did not like being disturbed in the middle of the night. In the 1960s, a survey conducted in the USA demonstrated that a board certified anaesthetist attended only 14% of epidural births (Wolf, 2009).

This situation changed however, and a sharp increase in the number of obstetric anaesthetists encouraged women's interest in, and increased their access to, epidural analgesia. Between 1981 and 2001 the rate of epidural administration almost tripled at one of America's largest hospitals (increasing from 22% to 61% of births) and almost quadrupled at small hospitals (increasing from 9% to 35% of births) (Bucklin et al. as cited in Wolf, 2009). Obstetric anaesthetists are now firmly established in the landscape of maternity services and offer a viable subspecialty. In the present day, 38,000 physicians in the USA are specialist obstetric anaesthetists, almost four times the number in 1970 (Wolf, 2009).

4.2.10 Choice and reproductive rights

With the reciprocal partnership of epidural analgesia with exogenous oxytocin, women came to think of labour as a meticulously planned event that they could organise around other parts of their lives, careers, husbands, and other children. Wolf (2009) describes the change in the meaning of control in birth for women with

the popularity of epidural analgesia. Where previously women had praised natural childbirth to control their labour and birth, women now gave epidural analgesia that accolade. Epidural analgesia allowed labouring women to maintain their composure and to socialise in a normal way.

Epidural analgesia in this new era of childbirth was seen as a matter of choice, linked with empowerment and the reproductive rights rhetoric of the birth reformers. These new birth reformers invoked the concept of choice, women had the right not only to refuse treatment but the right to access whatever birthing option they chose (Wolf, 2009). This rhetoric around choice is formalised in the 1993 joint committee opinion of the American College of Obstetrics and Gynecology (ACOG) and the American Society of Anaesthetists (ASA) which stated that maternal request for an epidural is sufficient justification for pain relief during labour. This embodiment of a woman's right to choose epidural analgesia has paved the way for further interventions to be included as part of maternal choice in childbirth. The terms and practice of induction of labour and caesarean section by maternal request are routinely used in obstetrics in many Western countries today (Wolf, 2009).

The use of pharmacological pain relief in labour continues to rise in Western countries as a result of this focus on choice and in spite of woman-centered care and evidence-based research directly linking epidural analgesia to the rise in morbidity associated with obstetric interventions (Leap & Anderson, 2008). In May's (2017) ethnographical study of a birthing unit in the USA, she writes about the informed consent process for mothers prior to being administered epidural analgesia, as pro forma. The midwives, she writes, 'knew that the mothers were determined to have 'my epidural' and were generally acquiescent to the woman's decision despite their

professional belief in physiological birth. It is after all a matter of the mother's choice' (May 2017, p. 66).

4.3 An illusion of choice

Is there an illusion of choice in maternity? The Oxford Dictionary defines informed consent as 'permission granted in full knowledge of the possible consequences typically that which is given by a patient by a doctor to treatment with knowledge of the possible risks and benefits.' A systematic review by Huntley et al. (2004) found that a third of survey respondents either had a limited idea, or no idea of their legal right to plain and comprehensive information regarding tests, medications or procedures and the right of refusal of treatment. As with any medical procedure, it is important that women be fully informed of the inherent risks of epidural analgesia. However, in a study by Heizne and Sleight (2003), of women surveyed, only 2% had an awareness of the side effects associated with epidural administration, and only 1.3% were aware of the effects on the newborn.

Discourses in medical literature attempt to explain the rise in medical interventions such as epidural analgesia and caesarean sections as being attributable to women choosing these interventions. Explanation by way of 'maternal request' or the discourse of 'personal choice' suggests that women, as opposed to medical professionals or the maternity health system, are responsible for the rise in surgical births (Young, 2006). The presumption here is that pregnant women have equal status and power to clinicians and can implement clinical decisions. 'The ethic of consent presumes equality of power...and in advanced pregnancy the disparities in power between health care providers and consumers are marked' (Cherniak & Fisher, 2008, pp. 271, 276). In their discussion of ethics in midwifery care and the

humanisation of birth, Newnham, and Kirkham (2019) advocate for the reinsertion of politics in midwifery theory and practice. Their purpose is to acknowledge the existence of power relationships, and to actively work to equalise these power relationships by emphasising attentiveness in a care relationship over an adherence to institutional policy.

4.4 Risk and birth

Women confronted with having to make choices in their labour and birth care are presented with risks in order to make informed choices. The use of risk factors in maternity care is fallible as it relies on deductive methods, namely, statistics and probability, which are unreliable predictors of pregnancy outcomes. Women considered low risk may have a rapid, emergency event and those women designated high risk throughout their pregnancy may birth without adverse events. This is the ultimate paradox, the identification of risk factors through probability, guided by protocols, and unconsciously assimilated by women, creates fear and distrust around birth without necessarily safeguarding against the uncertain event, which in any case may never happen (Newnham et al., 2015).

Childbirth in the Western world is dominated by a risk discourse, maternity care is the quintessential example of the influence of the risk discourse on health. Childbirth, 'straddles an ambiguous divide between the perception of birth as essentially a physiological event and as a pathology waiting to happen' (Walsh et al., 2008, p. 18). Such opposing concepts of the nature of birth are conceptualised into two contrasting paradigms of maternity care: a biomedical or technocratic model of care, and a social or midwifery model of care (Davis-Floyd, 2001).

In a technocratic model, giving birth is risky until proven otherwise. This paradigm has little belief in the normalcy of labour physiology and anticipates managing and intervening in labour to prevent morbidity (Walsh et al., 2008). In this model there is a narrow window of normality, and outcomes are measured in terms of what goes wrong in birth. Morbidity and mortality are valued above psychosocial outcomes for mother and baby (such as birth satisfaction and breastfeeding rates on hospital discharge) (Downe & McCourt, 2008). Technology is worshipped in this culture of birth, and pregnant women are told that devices and medications can eliminate risk in birth to 'guarantee safety, provide *real* 'choice' and *real* 'control' (Pincus, 2006, p. 250).

4.5 Medical and midwifery paradigms: attitude towards labour pain

No matter the century, the debates around the nature and management of labour pain continues to reflect the dichotomy between the medical and midwifery paradigms and the dominant risk discourse. Labour pain is a complex, highly subjective, multi-dimensional phenomenon. It is more than just a sensory experience, and is composed of emotional, motivational and cognitive dimensions (Lowe, 2002; Melzack, 1999). Wolf (2009) argues that, 'while the physiology of birth is fundamentally the same for all women, the experience of birth is not' (p. 3). Lowe (2002), situates labour pain in the context of a woman's physiology and psychology and also the sociology of her surrounding culture. Central to this culture are the beliefs and morals of the woman, her family and community and also the dominant values of the health care system and professionals.

4.5.1 Pain relief paradigm

Attitudes towards labour pain can be separated into two distinct paradigms, 'working with pain' and 'pain relief'. The medical model aligns itself with the pain relief paradigm. The dominant biomedical discourse considers pain, including labour pain, as part of a pathologic process, 'an unpleasant sensory and emotional experience associated with actual or potential tissue damage' (Turk & Okifuji, 2009, p. 14). Similar to other forms of acute pain, labour pain is recognised as having two components: both a sensory and an affective dimension. However, in research and clinical practice, the main focus is purely on the physical transmission of pain stimuli, ignoring pain as a sensory and affective experience (Lowe, 2002).

Labour pain management reflects these thought processes by focusing on the 'obliteration' of all sensation of pain through pharmacologic methods, indeed it is considered the only, or the most rational and prized modality of care (Lowe, 2002). The central tenet of the pain relief paradigm is the belief that women should not have to suffer the pain of labour, and it is an act of benevolent kindness to alleviate this pain using whatever pharmacological methods possible (Leap, 2010). The array of pharmacological methods is presented as a menu of pain relief options for women in labour.

4.5.2 Pain and suffering

The elimination of labour pain is a goal which assumes that pain is inextricably linked with suffering. In addition to analgesia, the achievement of such a goal requires other medications to control any accompanying side effects, interventions, and technologies to monitor such effects. It is also necessary to have a

birth environment designed to have the necessary safety features accessed as quickly as possible. In this medical model of care, the burden of control over pain is solely in medical professionals' hands. In this environment, care givers are needed to assist women in basic human actions such as using the toilet and moving position in bed (Simkin & Bolding, 2004).

As labouring women rely on others in the management of pain relief, there comes a feeling of dependence and powerlessness in all aspects of the labour and birth process. In this model it is not possible to be an active participant in one's own care and women are unable to develop self-confidence and belief in their own abilities and resources. The irony is that the desire to eliminate pain may lead to an increase in aspects of suffering. Suffering can include psychological factors perceived to threaten the physical body and/or psyche, such as helplessness, distress, loss of control and lack of resources to cope with a distressing event (Simkin & Bolding, 2004).

4.5.3 Working with pain paradigm

Pain and suffering undeniably often co-exist, however a person may suffer without pain or have pain without suffering. Pain in labour is proof that it is possible to have pain coexisting with feelings of enjoyment, empowerment and satisfaction (Simkin & Bolding, 2004). The working with pain paradigm, which is aligned with the midwifery model of childbirth, describes the pain of labour as a productive pain which marks the progress of labour and allows her to transition to motherhood; she experiences the intensity of labour pain together with the joy and achievement of becoming a mother (Leap, 2010).

This model acknowledges the role that pain plays in the physiology of birth, where pain is necessary in order for beta-endorphins to be released to produce an analgesic and euphoric effect similar to exogenous opiates (Buckley, 2010). Undisturbed birth is not necessarily birth without pain (Buckley, 2009). It is not the goal to make the pain disappear, but rather midwives and other caregivers, such as doulas or support people, help the women cope with the pain, to decrease the affective dimension of labour pain, and increase her self-confidence and self-efficacy in the birth process (Lowe, 2002; Simkin & Bolding, 2004).

4.6 Birth satisfaction

The wellbeing of the mother in childbirth is determined not only by the birth outcome, but by the entirety of the pregnancy and birth experience. There are long term benefits for women and babies in promoting physiological birth, and the health and wellbeing of a mother and child has an impact on the future health and wellbeing of the family. It is the birth experience which shapes her relationship with her child and her future childbearing experiences (Gottvall & Waldenström, 2002; Hauck et al., 2007). Satisfaction with the birth is considered the most important qualitative outcome when evaluating women's experiences of childbirth (Lomas et al., 1987).

Several research studies have evaluated women's satisfaction with their birth and identified a variety of factors worthy of study. A study of a self-selected cohort of Western Australian women by Fenwick et al. (2006) concluded that involvement and participation in the birth experience had a significant positive influence on their childbirth experience. In a systematic review by Hodnett (2002), four main factors were identified as being associated with women's satisfaction with their birth experience: (1) personal expectations, (2) the amount of support from caregivers, (3)

the quality of the caregiver-client relationship, and (4) involvement in decision-making. The importance of these factors was such that they outweighed the influence of age, socio-economic status, ethnicity, childbirth preparation, the physical birth environment, immobility, medical intervention, continuity of care and pain, when women assess their birth experience.

A complex relationship exists between childbirth satisfaction, labour pain and analgesia (Hodnett, 2002). It is assumed that efficacy of labour analgesia is essential to maternal birth satisfaction. However, studies show a negative birth experience is associated with the administration of epidural analgesia and high maternal satisfaction with labour is related to non-pharmacological pain relief methods.

A study by Waldenström et al. (2004), compared women with less than 'worst imaginable' pain who did not have epidural analgesia, with women with similar pain scores who used epidural analgesia. They found that the epiduralised group almost doubled their risk of experiencing birth negatively. Hodnett (2002) reported on a large prospective UK study on the expectations and experiences of pain for women in labour. The women who were most satisfied with their birth experience were those who used no pain relief during labour, demonstrating that women can tolerate severe labour pain accompanied by feelings of positivity, joy and self-confidence (Simkin & Bolding, 2004). For many women in labour, their belief that they can manage and tolerate pain outweighs trying to avoid it (Klomp et al., 2014).

4.7 Self-efficacy and control

The concept of being in control in labour is an important issue identified by women. It is associated with birth satisfaction and is a contributory factor to the subsequent wellbeing of the mother. There is a diversity of meaning in the literature

concerning the concept of control, with discussions attempting to define its meaning and the ideas of 'external' and 'internal' control. Green and Baston's (2003) study reported three senses of control. The first two measures, control of the actions of the staff and control of their own behaviour, were external and internal respectively. The third measure asked about control during contractions, clearly internal control (control of one's body) but perhaps categorised as physiological rather than social. Results from this study found that all three different types of control were important to women and contributed psychologically to a sense of wellbeing. Worry about pain and the side effects of pain relief were the primary threats to internal control.

A lack of control of the labour and birth experience is a strong predictor of a negative birth experience, whether it is a physiologic vaginal birth or a highly medicalised birth (Waldenström et al., 2004). In a study which examined the childbirth choices of women, there was both an active participant and a passive participant in the childbirth process. Women who chose epidural analgesia in their labour had a high fear of childbirth, an external locus of control, and passively complied with procedures and treatments during labour and birth. Women who chose to labour without epidural analgesia and to manage their pain, had a low fear of childbirth, an internal locus of control, and a desire to be an active participant in all aspects of the childbirth process (Heinze & Sleigh, 2003).

4.8 Fear and anxiety in childbirth

Women continue to fear childbirth. Paradoxically, contemporary birth reflects an era in which maternal and perinatal morbidity and mortality rates in developed countries are on the downward trend: it has never been safer to have a baby. However, women appear to have never been more frightened of the process of birth

(Walsh, 2009). Pain is experienced more severely when women feel afraid (Haines et al., 2012; Saisto et al., 2001), and fearful and anxious women have a greater requirement for analgesia (Adams et al., 2012; Waldenström et al., 2004). The desire for women to use techniques to assist in relaxing them in labour and birth, to reduce anxiety and increase their ability to manage labour pain, is the impetus for the use of non-pharmacological methods in childbirth. A non-pharmacological approach to labour pain utilises a range of therapeutic techniques which manages the sensory components of pain, together with the alleviation of suffering and distress by enhancement of the psycho-emotional components of care. The woman in labour is supported by non-pharmacological self-comforting techniques to increase her level of confidence in her ability to cope with labour (Lowe, 2002) and to trust her body to give birth (De Vries, 2012).

4.9 Non-pharmacological methods of pain relief

There are a variety of non-pharmacological methods of pain relief which women, their midwife and other caregivers have at their disposal in labour and birth. Their effectiveness needs to be assessed, not purely in terms of relieving labour pain, but also in terms of aiding relaxation, reducing anxiety and in the prevention of suffering, the feeling of powerlessness, being out of control and feeling overwhelmed (Simkin & Bolding, 2004).

Non-pharmacological methods of pain management include continuous support during labour, alternate medical practices (acupuncture, acupressure, homeopathy), mind-body techniques (yoga, hypnosis, and relaxation therapies which include music, aromatherapy, and guided imagery) manual healing methods (massage, reflexology) water immersion, and transcutaneous electrical stimulation

(TENS) therapy. Women report mixed experiences with different non-pharmacological pain management methods (Smith et al., 2006).

4.9.1 Mechanisms of action

In a recent systematic review, Challiet et al. (2014) addressed the influence of non-pharmacological methods of labour pain management on obstetric interventions and outcomes. This meta-analysis divided the techniques according to three neurophysiological mechanisms of pain-modulation: (1) light stimulation of the painful area (Gate Control Theory, GCT), (2) painful stimulation anywhere on the body during a contraction (Diffuse Noxious Inhibitory Control (DNIC) and (3) Central Nervous System Control (CNSC) facilitated by such means as continuous labour support and other psychological methods. All three methods act on the nervous system to attenuate potentially painful stimuli (nociceptive) signals before they reach the brain which interprets them as pain. (Chapter Four has a more detailed discussion of the physiology of pain and pain modulation mechanisms).

4.10 Gate control theory techniques: non-painful stimulation of the pain site

In a meta-analysis, women who used GCT techniques (pain management techniques which rely on the blocking at 'nerve gates' of pain messages to be transmitted to the brain), such as ambulation and change of position experienced a reduction in operative caesarean section birth. Women who used these techniques also had reduced use of exogenous oxytocin during labour and reported decreased anxiety during labour, compared to standard care (Challiet et al., 2014).

Techniques such as low density transcutaneous electrical stimulation (TENS), massage, water immersion, heat, and ambulation work via the GCT, inhibiting control via non-nociceptive stimuli mechanisms. This mechanism activates during non-painful gentle massaging of the painful area. The activation of large afferent fibres blocks the smaller fibres, thus blocking transmission of the pain signal. Modulation of perception of pain intensity is achieved through this action (Bonapace et al., 2018).

4.10.1 Water immersion

The use of water immersion during labour relaxes labouring women, aiding in the release of endogenous oxytocin and endorphin hormones (Bonapace et al., 2018; Cluett & Burns, 2009). The use of birthing pools reduces the perception of pain, reducing the need for epidural/spinal analgesia use. It also shortens the length of the first stage of labour, promotes physiologic birth, and facilitates women to have a greater sense of control and comfort during birth. Birthing pools thus increase, women's birth satisfaction (Cluett et al., 2018; Cluett & Burns, 2009; Lewis et al., 2018; Maude & Foureur, 2007; Richmond, 2003).

4.10.2 Heat/cold towels

The application of warm or cold towels at the site of the pain blocks part of the pain signal in the spine in line with GCT (Bonapace et al., 2018). The use of cold compresses has been shown to reduce pain, tissue swelling and bruising (Simkin & Bolding, 2004).

4.11 Diffuse noxious inhibitory control (DNIC) techniques: painful stimulation during a contraction

The mechanism of action of this method is by painful stimulation at a site usually some distance away from the painful area. Endorphins are released and the body's response is to inhibit pain at all painful areas apart from the site receiving the painful stimuli. Techniques that activate this pain mechanism include acupuncture and corresponding deep tissue massage (acupressure), TENS (high-density), application of ice and sterile water injections (Bonapace et al., 2018). The GCT and the DNIC mechanisms are found to mainly reduce the sensory pain dimension or the intensity of pain, primarily the physical aspect of pain. In a recent meta-analysis, this effect is shown in a reduction in epidural analgesia rates, but not obstetric intervention rates (Challiet et al., 2014).

4.11.1 Acupuncture

Acupuncture, an ancient and important form of traditional Chinese medicine, involves the insertion of fine needles into the skin at certain points in the body. It is used in labour to advance contractions to assist in cervical dilation, to help the baby move down the birth canal, to aid perineal relaxation, and to relax and alleviate labour pain (Bonapace et al., 2018). Electro-acupuncture involves the use of a mild electrical current between the needles. Acupressure, or Shiatsu, is a simple alternative to acupuncture that involves the use of finger pressure on acupuncture points. The painful stimulation of acupuncture points is synchronised with the pain of the labour contractions, which facilitates the DNIC mechanism of action (Bonapace et al., 2018; Simkin & Bolding, 2004).

A randomised controlled study by Ramnero et al. (2002) evaluated pain and relaxation with and without acupuncture in a group of labouring women. There were no differences in pain assessments between the two groups based on an 11-point rating scale, however a significant improvement in relaxation was found in the acupuncture group. The women who used acupuncture also required less epidural analgesia than the group not using acupuncture. A further randomised controlled study by Nesheim et al. (2003) compared the use of pethidine in three control groups: with acupuncture, without acupuncture and a second control group. In the acupuncture group, pethidine was used by 11% of women, compared to 37% in the no acupuncture group, and 29% in the control group.

4.11.2 Transcutaneous electrical nerve stimulation (TENS)

Transcutaneous electrical nerve stimulation (TENS) involves the transmission of low voltage electrical impulses from a handheld battery powered device to the skin via electrodes placed on the skin surface. TENS devices are available to hire without a prescription via pharmacies and medical company websites. The technique works to alleviate labour pain by the placement of electrodes on the lower back and the electrical pulses are thought to stimulate nerve pathways in the spinal cord which block pain signals (Dowswell et al., 2011). The woman controls the intensity of the electrical current by the use of a dial and is able to vary the stimulation pattern. The

TENS machine (see figure 3) produces a buzzing or prickling, painful sensation (DNIC) that helps to distract women from contraction pain (Simkin & Bolding, 2004).

A Cochrane meta-analysis found that overall women did not report any significant reduction in pain intensity perception with TENS, aside from women who used it on acupressure points. However women enjoyed

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Figure 3. TENS machine

using it and would use it again in labour (Dowswell et al., 2011). A systematic review by Carroll et al. (1997) found that women did not perceive less pain intensity while using the TENS machine than usual care, however the use of analgesics was less by TENS users and women would use it again in labour.

The use of TENS is recommended in early labour as it is thought to allow for a build-up in endorphin production before the pain progresses in severity. Women may find using the TENS machine in labour appealing as they are able to be in control of its use, are able to mobilise, and it is minimally invasive with few side-effects for healthy women (Simkin & Bolding, 2004).

4.12 Central nervous system control (CNSC)

Distracting attention away from painful stimuli is a major mechanism in the management of pain, working by modulation of the pain signal and activating the secretion of endorphins in the pain inhibition centre. Several techniques based on behavioural and cognitive approaches use this mechanism: meditation, breathing,

aromatherapy, music, support, hypnosis, relaxation and visualisation (Bonapace et al., 2018).

The CNSC mechanism was shown to be the most effective mechanism to reduce obstetric interventions. Non-pharmacological methods based on this mechanism which modulates the unpleasantness of pain are associated with a small reduction in epidural rate and a significant reduction in caesarean section and instrumental birth, decreased use of exogenous oxytocin, duration of labour and contributed to maternal satisfaction (Challiet et al., 2014).

A meta-analysis by Challiet et al. (2014), demonstrated that a combined approach to pain relief, based on continuous support in labour together with at least one other endogenous method (GCT or DNIC), significantly lowered caesarean section rates (OR = 2.17, 95% CI 1.30-3.61, 11 RCTs, 10 338 women), instrumental deliveries (OR = 1.78, 95% 1.06-2.98, 6 RCTs, 2281 women), epidural analgesia (OR = 1.42, 95% CI 1.15-1.76, 5 RCTs, 2207 women), and decreased the average length of labour by 73.8 minutes (95% CI 42.6-105.0), 4 RCTs, 1254 women).

4.12.1 Breathing

Childbirth education has focused on breathing techniques to induce relaxation, calmness and to foster a woman's sense of control in labour and birth (Simkin & Bolding, 2004). Patterned breathing is a technique used to reduce pain perception, as a distraction from the intensity of the pain (Hunter, 2008).

Coached breathing in labour assists women in their ability to cope with their contractions (Simkin & Bolding, 2004) as the breathing rhythm of inhaling and exhaling is synchronised to the intensity of her labour (Adams & Bianchi, 2008). A study by Nabb et al. (2006) found that slow, rhythmic breathing together with

massage had a 'hypnotic' effect on women. The use of breathing techniques in labour can be effective in pain reduction for primiparous women in the first stage of labour (Thomas & Dhiwar, 2011). Many women use these breathing techniques effectively in early labour only, finding as labour progresses that they need to use analgesia (Spiby et al., 2002). There are few disadvantages to breathing techniques in labour, although women may expect greater pain relief than they received, which may be disappointing (Simkin & Bolding, 2004).

4.12.2 Continuity of care in pregnancy and labour

Pregnant and labouring women have long recognised the value of being cared for by someone with whom they have developed a trusting and mutually respectful relationship. Midwife-led continuity models of care organise their care so that the same midwife or team of midwives looks after a woman during the pregnancy, birth and the postnatal period (Sandall et al., 2010). This is referred to in the literature as 'caseload care' (Benjamin et al., 2001). Women who receive care based on this model are less likely to use epidural analgesia and are more likely to have a spontaneous vaginal birth and a greater sense of control in labour (Sandall et al., 2010). The belief and confidence in the ability to labour and give birth without pharmacological analgesia is fostered throughout their pregnancy by the development of a relationship of trust with their midwives and the merit of listening to other women's birth stories in antenatal classes. The sharing of birth experiences helps women overcome their fears and uncertainties regarding coping with the pain of labour (Leap et al., 2010).

In other studies, women describe feeling reassured and supported, which reduces their stress and anxiety (Fereday et al., 2009; Huber & Sandall, 2009;

McCourt & Stevens, 2006). This support undoubtedly contributes to a building of confidence and a bio-behavioural state of calm and connectedness linked with raised endogenous oxytocin levels, a sense of wellbeing, and undisturbed birth (Buckley, 2009; Uväs-Moberg, 2003). Continuous support and empathy in labour may be provided by the midwife or doula, and/or the woman's support people, partner or friend. The individual support provided by a non-medical companion such as a doula has been shown to significantly reduce the use of pharmacological labour analgesia (Hodnett et al., 2011). The support provided in this role is both emotional (reassurance, encouragement), physical (assistance to change position, touch/massage and the provision of food and fluids), information (availability of tools to manage pain, the progress of labour) and advocacy (to be the woman's voice) (Hodnett et al., 2011; Lowe, 2002).

4.12.3 Music

Music can be used to help relax and reduce anxiety in early labour and as distraction as labour progresses. During early labour, slow and peaceful music can be relaxing, while an increase in music tempo can encourage movement in the active stage of labour (Tournaire & Theau-Yonneau, 2007). The mechanism of action of music is that it is perceived in the right hemisphere of the brain and stimulates the pituitary gland to release endorphins (Boso et al., 2006).

A randomised controlled trial of 110 primiparous women during the active phase of labour found that the group that listened to soft music had significantly reduced perceived pain ($p < 0.001$) (Phumdoung & Good, 2003). However, studies investigating the effectiveness of music therapy in labour show substantial

heterogeneity. A systematic data review by Smith et al. (2006) concluded that there was insufficient evidence to support its effectiveness in reducing pain intensity.

However, there are no drawbacks associated with the use of music. It is an inexpensive, easily accessible modality that can be used in conjunction with other non-pharmacological methods of analgesia. Women can choose their playlist and the use of earphones during labour can help to get into a calm zone which can enhance their wellbeing (Bonapace et al., 2018). Women can choose music that is personal to them, and specific to welcoming their baby into the world. This can aid relaxation, increase satisfaction and a sense of control over the labour and birth process (Browning, 2000).

4.12.4 Hypnosis and hypnobirthing

Hypnosis has been used in childbirth since the early 19th century (Simkin & Bolding, 2004). In contemporary birth, the term hypnobirthing is often used and there is a steady revival in this technique among women interested in complementary therapies (Walsh, 2007). Hypnosis, self-hypnosis, and hypnobirthing are used by women to assist in reducing the fear of labour. Women who used hypnosis in childbirth report a decrease in fear of natural childbirth and anxiety (Abbasi et al., 2009; Downe et al., 2015) and an increase in satisfaction with the birth experience (Werner et al., 2013).

The technique of hypnobirthing uses a combination of deep relaxation, breathing and visualisation to create a sense of self-efficacy around the birth process, to trust one's body and to reduce stress and anxiety, and reduce perceived pain. Such a state of deep relaxation fosters endorphin release which reduces the unpleasantness and intensity of pain, and the need for pharmacological labour

analgesia (Brown & Hammon, 2007; Cyna et al., 2004; VandeVusse et al., 2007). It is also associated with other benefits such as a decrease in the use of exogenous oxytocin for augmentation during labour, and an increased incidence of spontaneous vaginal birth, particularly amongst nulliparous women (Cyna et al., 2004). However, a comprehensive high quality randomised controlled trial, the HATCh (Hypnosis Antenatal Training for Childbirth) that focused on a cohort of 448 women, was unable to demonstrate the primary outcome, the decreased use of pharmacological analgesia during childbirth. The authors were surprised at the lack of statistically significant findings between the groups; one group received hypnosis and hypnosis on compact disc (CD), the second group received the CD only and the control group received no intervention (Cyna et al., 2013).

Studies have demonstrated that pregnant women are more receptive to hypnotic suggestions (Alexander et al., 2009; Tiba, 1990) and that many hypnotic phenomena such as dissociation from contractions, the effect of time distortion and amnesia would be advantageous during labour (Hollingworth, 2012).

4.12.5 Relaxation and visualisation

Relaxation techniques may have greater benefit in helping women cope with the pain of labour, rather than actually reducing the pain (Simkin & Bolding, 2004). They are useful in helping to prepare women psychologically for the process of labour and birth. A Cochrane review found that relaxation techniques lowered the intensity of pain during the latent phase of labour, helped women manage their labour pain, and they may have greater satisfaction with pain relief during their labour (Smith et al., 2018).

Relaxation techniques are also referred to as mind-body techniques and a form of this is guided imagery. Guided imagery has been described as a, “form of deliberate, directed daydreaming; a purposeful use of the imagination” (Bonadies, 2009, p. 44). Although it has been called ‘visualisation’ and ‘mental imagery’, these terms are considered insufficient to describe this technique, as guided imagery involves not just the visual sense, but all of the senses (Bonadies, 2009). The use of imagery may have a positive effect on anxiety during pregnancy (Marc et al., 2011) and labour (Gedde-Dahl & Fors, 2012). An improvement in mental and physical wellbeing is associated with the use of positive imagery (Urech et al., 2010).

Visualisation techniques enable women to focus on positive thoughts to increase calmness and reduce anxiety and stress. Women are encouraged to imagine a pleasant environment or a pleasant memory; images can include the use of labour associated metaphors such as the cervix opening like a flower, or the build-up of contractions being like ocean waves (Bonapace et al., 2018).

4.13 Undisturbed birth and birth environments

Most of these therapies work best when women are not disturbed in labour, which necessitates a birth environment that is private, comfortable and feels safe. Women have an inherent, mammalian need to feel safe and secure in their chosen birth space (Buckley, 2009). However, in modern obstetrics, safety is conceptualised in terms of the management of risk, which midwives and birthing women experience as surveillance and medicalisation (Annandale, 1988). Hospital birth environments have morphed into birth spaces distinguished by high levels of surveillance of the labouring woman. Although such surveillance is designed to reassure health

providers, the ability of women to labour effectively may be threatened (Stenglin & Foureur, 2013).

4.13.1 Surveillance and the ‘fear cascade’

This feeling of being surveilled results in women’s stress levels rising. As described previously, the effect of fear, stress and anxiety on labouring women is a surge of catecholamines (adrenaline and nor-adrenaline) to initiate the fright, flight or fight response (Stables & Rankin, 2010). Referred to as the ‘fear cascade’ by midwives, it is hypothesised that during labour and birth, the perception of an ‘unsafe’ environment may also trigger a sympathetic nervous system reaction and the unleashing of a cascade of neuro-hormonal events, which can have a negative impact on the health of mother and baby. The secretion of exogenous oxytocin is disrupted by adrenaline, and this may result in changes to the nature of labour contractions; they may become irregular, slow down or cease. Adrenaline also has a vasoconstrictive effect, essentially diverting blood from the mother’s abdomen, resulting in less blood available for perfusion of the placenta and thus reduced foetal oxygenation, leading to fetal distress (Foureur, 2008).

4.13.2 Optimal birth environment

Therefore, it naturally follows that providing a birth environment where women feel supported, protected, and safe, facilitates optimal physiological functioning and the potential for undisturbed physiologic birth. The release of endogenous oxytocin, crucial to effective uterine contractions and labour progress, is mediated by the perception of the physical environment. A birth space that women perceive as calm

and supportive enables this endogenous oxytocin release, as opposed to a birth space perceived as stressful and threatening (Foureur, 2008; Uväs-Moberg & Arn, 2005). As Lepori (2008) states, design of the ideal space within the hospital institution should contain elements that, rather than impeding the natural process of birth, enhance the power of the process itself. A better comprehension of the association between environments and health (Ulrich et al., 2008) has led to an increased interest in the exploration of the design of birth spaces to enhance both the psychological and physiological wellbeing of birthing women, their supporters, their midwives and other care providers (Fahy & Parratt, 2006; Foureur et al, 2010; Hammond et al., 2013a; Hammond et al., 2013b; Hammond et al., 2014).

4.13.3 Surveillance and ‘sanctum’

Two conceptualisations of birth spaces are discussed in a paper by Fahy and Parrat (2006) on birth territory and implications for midwifery practice. They refer to birth territory as the features of the birth room or the ‘terrain’. Terrain is defined as the physical features and geographical area of the birth spaces, which includes such items as furniture and accessories. Within this terrain there are two types of birth spaces: the surveillance room and the sanctum. The surveillance room is an environment designed for surveillance of the labouring woman, designed for optimum comfort and accessibility of the staff. It is a clinical-looking room, where the bed is the dominant feature of the space, spaces are well lit, white, and sanitised, and medical equipment is on display. There is no lockable door for privacy but usually a curtain covering an otherwise open doorway.

In contrast, the ‘sanctum’ is a homely and protective environment, designed for the ease and comfort of the women and for optimum privacy. There is a door that

can be kept closed to provide a sense of privacy and safety. The space provides easy access to a deep bath and the outdoors. The space is designed to create a feeling of familiarity for women which enhances the feeling of safety and confidence. The ability of women to experience birth in the 'sanctum' protects and promotes the woman's embodied sense of self, leading to optimal physical and emotional wellbeing.

4.13.4 The 'ambient' birth room

The further a birth room deviates from the concept of the sanctum, the greater the risk is that women will feel fear, distress and anxiety (Fahy & Parratt, 2006). In a pilot randomised controlled trial by Hodnett et al. (2003), a group of women were allocated a standard hospital labour room, modified to surround women and caregivers with specific types of auditory, visual and tactile stimulation, an 'ambient' environment. The room featured dimmed lighting, and equipment projected scenes of ocean beaches and mountain waterfalls on the wall. A wide selection of music was also available. The modification of this ambient room was not designed to replicate a home environment, but rather was a hybrid design based on a new concept of the optimum hospital birthing environment. Women responded positively to the ambient room, appreciating the music and the nature scenes and the general calming effect of the room. Both the use of exogenous oxytocin and the duration of its use was significantly lower in the ambient room, and while the overall sample size was too small to make broader generalisations, the room does appear to have had some impact on birth outcomes and women's birthing experience.

4.13.5 The Snoezelen birth room

A second study concerning labour and birth environments was set in an Australian hospital (Hauck et al., 2008) and explored women's experiences of using a Snoezelen room during their labour.

Snoezelen rooms expose the user to a range of sensory stimulations, combining vision, touch, sounds and aromas in the design. The Snoezelen room used in this study was based in a public hospital, had soft furnishings and rugs, was decorated in an earthy colour scheme, and had an explicit link with nature. Patterns were projected onto the wall, accompanied by music and a fish tank nearby.

Figure 4: Image reproduced with permission from author: Yvonne Hauck, 2021

Interviews were conducted with 16 women who used the Snoezelen room, and they emphasised that the experience offered distraction, relaxation, comfort, and the ability to control their environment. They were very satisfied with their experience of using the room.

4.13.6 Herning birth room

Finally, in a recent study in Herning, Denmark, Nielson and Overgaard (2020) conducted qualitative interviews with 14 women who gave birth in an environment where the focus was on physical and emotional comfort, and the deactivation of stress and anxiety. The space included furniture to relax on, a birth pool, and visual and auditory stimuli of natural landscapes were projected on three walls. These

dimly lit scenario projections were controlled by the women and their partners. Themes that emerged from this study were: emotional support, involvement of family, and physical comfort. Entering the birth environment, the women reported 'feeling welcome' and made associations with a recognisable home-like environment. This gave them a sense of emotional support, comfort and a reduction in stress and uncertainty. The use of visual and auditory stimuli was a positive distraction for some of the women, which helped them cope with labour and maintain a sense of control. The warm, dimmed lights contributed to the women's sense of physical comfort and safety. The visual and audial distractions contributed to an overall positive ambience.

Figure 5: Reprinted with authors permission, Iben Prentow, 2021

4.14 Summary

This chapter has argued that the nature and management of labour pain is controversial. These discussions about the nature and management of labour pain have been vigorously debated throughout history, right up to the present time. Women themselves describe labour pain as both a happy and hellish pain and there are huge differences in how women wish their labour pain to be managed.

This debate on the nature and management of labour pain is reflected in the discourses on the two paradigms of labour pain: the medical model, which is characterised by the pain relief paradigm, and the midwifery model, characterised by the working with pain paradigm. In discussions around the midwifery paradigm, concepts such as birth satisfaction, self-efficacy and control, fear and anxiety are articulated in narratives by labouring women. For many women who choose the working with pain paradigm, there is a range of non-pharmacological methods of pain relief which assist in reducing sensory pain but also reduce anxiety and increase relaxation and feelings of self-efficacy and birth satisfaction. The final section of this chapter returns to the concept of undisturbed birth, with a discussion on birth environments.

In the next chapter, the literature is reviewed in relation to the use of VR as a non-pharmacological intervention in the management of labour pain specifically, but also for general acute pain and reduction in anxiety.

CHAPTER 5: LITERATURE REVIEW

This chapter reviews literature relevant to the potential application of VR in labour. As there is limited literature on VR in labour, the review extends to VR in acute pain and anxiety. The section related to VR is divided into several parts. Firstly, the review examines the available literature on VR and pain attenuation in the areas of burn-wound pain, general surgical pain, oncology related procedural pain, needle-related procedural pain, dental treatment, experimental pain, and labour pain. Following on from a presentation of results into the effectiveness of VR as pain attenuation, is a discussion on possible mechanisms of action of VR and the neurobiological and psychological mechanisms. Mechanisms of action other than distraction are examined, particularly in relation to chronic pain and VR. Discussions on the mechanism of action of VR in pain attenuation and its uniqueness as an intervention, lead to the concept of presence. This relationship was reviewed extensively in the literature with discussions around definitions, measurements of presence, technological properties, the role of emotions in presence, and corresponding identified concepts of immersion and interactivity. In the final section of this chapter the literature on time perception in relation to VR and VR Hypnosis (VRH) was reviewed.

5.1 Literature Search Strategy

For the literature review, the following databases were systematically searched: CINAHL, Medline, PubMed. The following key words were used: 'VR', 'pregnancy', 'labour', 'labour pain', 'anxiety', 'childbirth', 'pain', and 'acute'. Chronic pain was not included as a search term, as labour pain is acute pain. These words

were used to search individually for concepts and then combined and extended using other key words such as 'anxiety' and 'fear'. These searches were combined using OR to given combined results for these concepts. Other databases were also searched such as: Google Scholar, ProQuest and PsycInfo. The search period was from 1998 until 2021, as there were historically significant research studies on the use of VR and burn wound pain from 1998. The search was limited to English language papers and retrieved 67 studies which measured the effect of VR on acute pain and 11 studies that measured the effect of VR on anxiety. This literature review included 27 studies on acute pain, four on labour pain, eight on burn-wound pain, two on general pain, three on cancer procedural pain, two on invasive procedure pain, four on experimental pain and seven systematic reviews. Six studies on procedural anxiety were included in this review.

5.2 Virtual Reality

When anything new comes along, everyone, like a child discovering the world, thinks they've invented it, but you scratch a little and you find a caveman scratching on a wall is creating Virtual Reality in a sense. What is new here is that more sophisticated instruments give you the power to do it more easily. Virtual Reality is a dream. (Morton Heilig, as cited in Hamit, 1993, p. 57)

Since the first representations by paleolithic people tens of thousands of years ago, purposely distorted or amorphic in manner, hunting scenes on rock formations and cave wall depressions generating three dimensional images, humans have attempted to 'render the real and magical, to create illusory deceptions and to transcend our physical and mortal existence' (Ijsselsteijn, 2004, p. 2). Throughout history people have aspired to design and replicate reality through a range of media

methods, from 'pure arts' such as painting, writing, and sculpting to 'combined arts' which include performance such as opera and theatre, to more contemporary representations such as television, computer games, cinema, and photography. Ijsselsteijn (2004) describes this historical overview as the quest for perceptual realism, a quest for increasing realism in the 'arts' and a merging of illusion and reality.

In 1962, Morton Heilig, a cinematographer, provided an immersive movie experience, with his creation of Sensorama. It was a complete sensory experience, combining full colour 3D video, audio, smell, vibrations, and atmospheric effects such as wind. Helig was confident that the Sensorama would be the 'cinema of the future', his vision was a fully immersive cinema experience (Barnard, 2019).

In 1968, Ivan Sutherland, a computer scientist and generally acknowledged as one of the founding fathers of VR, developed the original head-mounted display (HMD). This first augmented reality display system consisted of computer-generated images that could be updated via movements of the user's head. The head tracking device was nicknamed 'Sword of Damocles' and needed to be suspended from the ceiling and hang over the user's head as it was too heavy to wear. It was also primitive in that it could only show basic virtual wire-frame shapes. His classic 1965 paper is considered the fundamental blueprint for VR, and is an interesting description of his ideas of immersion in computer-generated environments (Barnard, 2019; Ijsselsteijn, 2004),

The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be

fatal. With appropriate programming such a display could literally be the Wonderland in which Alice walked. (Sutherland, 1965, p. 508)

We are still clearly some distance from Sutherland's Ultimate Display. However, rapid advances in the areas of computing power, realistic interactive computer graphics and immersive technology, and the availability of inexpensive, transportable and high fidelity VR headsets and computer software, are now establishing VR use as an experience that will 'blur the boundary between reality and its representations' (Ijsselstein, 2004, p. 2). Current virtual environments are capable through the convergence of multi-sensory stimulations, immersion and real-time interactivity to create a strong sense of presence for a user (Ijsselstein, 2004; Spiegel, 2018).

This powerful blurring of illusion and reality in VR, the mind-bending capability of computer-generated images to fool our brains into thinking we are somewhere else, this 'hijacking' of the brain, the auditory, visual, and proprioceptive senses, is considered central to VR's mechanism of action in the area of pain attenuation. VR offers an immersive distraction that inhibits the brain's ability to process pain (Spiegel, 2018). The concepts of presence and immersion are considered fundamental in explaining VR's efficacy in pain attenuation. VR is now being used in a variety of healthcare settings focusing on anxiety, distress and pain attenuation for both paediatric and adult patients undergoing painful medical procedures such as burn wound care, physical therapy, procedural pain, chemotherapy, dental procedures and routine procedures such as venipuncture and intravenous placement (Aminabadi et al., 2012; Carrougner et al., 2009; Gold et al., 2006; Hoffman et al., 2011; Piskorz & Czub, 2017; Schneider et al., 2011; Tashjian et al., 2017). This

proliferation of VR into everyday healthcare settings internationally has led to the creation of a new discipline called therapeutic VR, and the term VR analgesia.

5.3 Virtual Reality as pain attenuation

5.3.1 Virtual Reality and burn-wound pain

Virtual reality is effective in the attenuation of acute pain in both experimental and clinical settings. Virtual reality was first used in 1998 in a series of case studies with paediatric and adolescent burn patients. Patients received treatment for burn pain while using VR as an adjunct to standard opioid treatment. The three patients reported statistically significant reduced pain scores, intensity, and unpleasantness of pain, when using VR, 50%, 43%, and 58% respectively (Hoffman et al., 1998). A further study with burn patients used specifically designed software for pain control. It featured an interactive game, called 'SnowWorld', in which patients interacted with snowmen, igloos, penguins, woolly mammoths, and flying fish by throwing snowballs (Hoffman et al., 2011). The most widely researched use of VR technology has been on patients with burn injuries requiring painful wound procedures, debridement of dead tissue, and physical therapy to increase range of movement (Carrougher et al., 2009; Hoffman et al., 2000; Hoffman et al., 2008). Severely burn-injured patients endure repeated painful procedures and the conventional management with opioid analgesics is often ineffective at maximum doses (Cherny et al., 2001; Shang & Gan, 2003). The severity of their pain routinely requires escalating doses of opioids with corresponding side effects such as nausea, excessive sedation, cognitive dysfunction, respiratory depression, and constipation (Cherny et al., 2001).

These early experimental studies in clinical settings tested the effectiveness of VR as an adjunct to pharmacological treatment for both adult and paediatric burn

injury patients enduring wound dressing changes and physical therapy. Burn injury patients report 31-50% reduction in pain while undergoing procedures with VR (i.e. standard medications plus VR), as opposed to usual treatment (standard medications alone) (Carrougher et al., 2009; Hoffman et al., 2000; 2004b; 2008; Schmitt et al., 2010; Van Twillert et al., 2007). The two earlier studies by Hoffman and et al. (2000; 2004b) have methodological limitations as they are case studies of one or two participants. Larger, controlled study designs, such as within-subjects designs or randomised controlled designs, produce data that is more robust. The three studies meeting these criteria were a within-subjects study design with 19 participants; a prospective randomised controlled study of 39 patients; and a within-subjects randomised controlled study, of 54 subjects (Hoffman et al., 2008; Schmitt et al., 2010; Van Twillert et al., 2007).

These studies have shown significant and clinically meaningful pain reductions when using VR. While previous studies examining VR as analgesia have included a range of burn injury patients in terms of their pain intensity, Hoffman and et al. (2008) specifically selected a subgroup of burn injury patients all experiencing severe pain intensity to study the analgesic effects of VR. Virtual reality was effective for this subgroup undergoing burn wound debridement in a hydrotherapy tank. In one regional burns centre, 11 patients had one of their wounds debrided with or without VR distraction for an equivalent time period as a within-subject condition and order randomised study. Results showed a statistically significant and clinically meaningful pain reduction when using VR. There was a 41% reduction in pain intensity with VR use in patients who reported the highest pain intensity without VR: these patients used a graphic rating pain scale, and their pain levels reduced from 'worst pain' to 'moderate'.

This study has important clinical implications in the area of pain research. Theories previously postulated by pain researchers argue ‘that distraction will be less effective at reducing severe pain intensity levels compared with reducing mild to moderate pain intensities’ (Hoffman et al., 2011, p. 185). McCaul and Mallot (1984) propose that the intensity of the stimulus determines whether and when distraction will occur. They argue that the stimulus will eventually become too intense to ignore, and the distraction will become ineffective. Crombez and et al. (1998) studied high pain catastrophisers who find it impossible not to focus their attention on pain. They hypothesised that distraction is ineffectual if the perception of pain is highly threatening and the affective dimension of pain is amplified. Logically, these researchers would argue the effectiveness of distraction would be reduced when levels of pain were high and severe. McCaul and Mallot, and others ‘predict that distraction will fail exactly when an effective treatment is needed the most’ (Hoffman et al., 2011, p. 185).

5.3.2 Virtual reality and general acute and procedural pain

Much of the earlier research into the effectiveness of VR as analgesia has used non-randomised, within-subject or case study designs with small sample sizes. Sample size in research is one of the factors used to determine statistical power in a test, and the power of a statistical test is the probability that it will produce a statistically significant result. In research, the larger the sample size, the greater the reliability of the results of the data analysis and the greater probability the phenomenon under investigation will manifest (Cohen, 1988).

The need for larger, higher quality studies into the effectiveness of VR as analgesia and to explore VR’s potential in a variety of pain conditions resulted in

Tashjian et al.'s (2017) non-randomised controlled trial of hospitalised patients with a diverse range of somatic and visceral conditions in the acute care setting. This comparative cohort study had a sample size of 100 subjects, with 50 in the intervention cohort viewing a 3D VR experience and the control group viewing a high definition, 2D nature video. Compared to 40% of the control group, a reduction in pain was achieved by 65% of patients in the VR cohort. The effect of VR was found to be independent of the reason for hospitalisation or the principal cause of pain. It was concluded that VR was beneficial in reducing pain levels across a range of pain conditions (Tashjian et al., 2017).

A prospective, randomised, comparative effectiveness trial in hospitalised patients experiencing general acute pain who had mean pain scores of ≥ 3 out of 10 was conducted by Spiegel and et al. (2019). There were 120 participants comprising 61 in the VR group and 59 in the control group. Analysis (T-test) of the average within-subject differences pre- and post- intervention was in favour of VR. Results focusing on a subgroup of participants with the most severe baseline pain (N = 54) found that the effect of VR was greater. These differences remained significant after adjustment for gender and type of pain.

Several studies with children requiring cancer treatment (accessing subcutaneous venous port devices to receive chemotherapy), dental treatment and intravenous line placement have found reductions in pain (Aminabadi et al., 2012; Gold et al., 2006; Wolitzky et al., 2005). Wolitzky et al. (2005) demonstrated the effectiveness of VR distraction in 20 children with cancer experiencing the invasive procedure of subcutaneous port access. A Visual Analogue Scale (VAS) was used to rate pain on a 0-100 scale by the children, their parents, and nurses. Of the 66 correlations computed among raters and ratings, 77% were statistically significant. A

controlled crossover trial, conducted by Aminabadi et al. (2012), included 120 children randomised so that each participant either used or did not use VR distraction during their two dental procedures. Pain severity was assessed using a Faces Pain Rating Scale (FPS). Statistically significant reductions in pain scores were reported for dental procedures conducted with VR distraction, compared to no VR distraction.

A study by Gold et al. (2006) examined the effectiveness of VR during IV placement. A cohort of 20 children in the intervention group used VR for 5 minutes prior to IV placement, during IV placement and 5 minutes after IV placement. Children in the control group could use VR for 3 minutes after IV placement only. Using the FPS instrument, children undergoing IV placement without VR distraction reported a fourfold increase in affective pain compared to children using VR.

Limitations of available literature are due to variations in control groups, frequently small sample sizes and statistical heterogeneity, however, the scientific evidence overall suggests that VR is an effective clinical intervention, either as a standard or adjunct treatment for pain management in acute pain (Eijlers et al., 2019; Mallori et al., 2019; Morris et al., 2009; Scapin et al., 2018; Shahrbanian, 2009; Sharar et al., 2007).

A meta-analysis by Chan et al. (2018) of 20 eligible studies reported that VR had favourable effects with a standardised mean difference pain score reduction of -0.49 (95%CI-0.83 to -0.14, $p = 0.006$). However, post-hoc subgroup analysis found there was no effect of VR on minor surgical procedures or burns wound care, whereas there was a positive effect for VR on needle procedure pain and in burns physical therapy. This review acknowledges the lack of comprehensive, high quality systematic reviews specifically assessing the efficacy of VR in the clinical area of

acute pain procedures. To validate findings, there is the need for further high-quality studies and these authors recommended that clinical trials should be prospectively registered, with data reporting that adheres to Consolidated Standards of Reporting Trials (CONSORT) guidelines, which minimises bias.

5.3.3 Virtual Reality and experimental pain

One of the earliest studies into VR and pain attenuation used video glasses developed for VR purposes. The glasses had the capability of showing 3D and traditional 2D movies. Sound and video were able to be transmitted simultaneously. Results from this study found that participants exposed to the experimental cold pressor pain condition who used the video glasses in both 3D and 2D reported reduced perceived pain and/or unpleasantness, compared to participants in the control group (no video glasses) (Bentsen et al., 1999).

Experimental ¹² pain provides the strongest evidence into the effectiveness of VR as distraction. This is identified in a systematic review by Malloy and Milling (2010) that reports on a range of pain studies. Virtual reality distraction reduced pain for adults experiencing thermal pain (Hoffman et al., 2006a; Patterson et al., 2006) and children experiencing cold pressor pain (Dahlquist et al., 2007). All three studies achieved effect sizes greater than 0.8, being in the large range. Cohen (1988) classifies effect sizes of 0.2 as small, 0.5 as medium and 0.8 as large. A large effect is an effect which is significant enough and/or produces consistent results so that it can be seen 'with the naked eye'. A large effect size is one which is very substantial (Cohen, 1988). The likely reasons for statistically significant results are due to the

¹² Experimental pain refers to deliberately applied pain to participants, usually in the form of cold or pressure (e.g. a tourniquet applied to the arm).

relatively mild nature of experimental pain, that it is time-limited and not associated with disease or compromised health status. Malloy and Milling (2010) comment that they are unsure whether results from experimental pain studies can be generalised to the clinical setting.

A research focus on experimental pain and VR in healthy participants has recognised advantages (Li et al., 2011). This is because it is possible in research situations to separate and/or deconstruct the parameters that are critical in the clinical efficacy of VR, without potentially confounding factors such as pathology of disease, chronic long-term pain, adjunctive medication, and the hospital environment. This research paradigm allows the novel characteristics that have a role in VR distraction to be manipulated in a controlled environment.

5.3.4 Virtual Reality analgesia in labour

The natural progression of the use of VR in the area of acute pain is to use it in labour and childbirth. Many women want a natural and non-pharmacological birth and are motivated to try a range of relaxation techniques which incorporate features of VR such as guided imagery, visualisation, music therapy, controlled breathing training and hypnosis (Wright & Geraghty, 2017). Four quantitative studies to date have published results examining the effect of VR on labour pain in women. Pratiw and et al. (2017) conducted a randomised controlled trial of 60 primiparous parturient women labouring in five Indonesian public health centres. The women were randomly allocated to two groups (30 in each group) with the intervention group using VR and the control group not using VR. This study used a VR sequence environment of river, beach, waterfall and lake, developed by Festivo®, where users glided through the environment. It was a 360 degrees video on a smartphone

Lenovo K4 Note VR series. The intervention of VR was given for 10 minutes at each stage of labour, which was determined by cervical dilatation (latent phase of 1-3cm dilatation, and the three active phases at 4-5cm, 7-8cm, and 10cm dilatation). During each stage, pain scores were measured using the FPS (0-10) by the women and the (NVPS (0-5) was filled in by observers (midwife/researchers).

Results from this study found statistically significant lower pain scores in the intervention group, compared to the control group, using both the FPS and the NVPS. These results are clinically significant in that the women in the intervention group reported decreased pain intensity compared to the women in the control group throughout the progress of their labour, at all four stages of dilatation, with progressively increasing levels of pain intensity.

Frey et al.'s (2018) more recent pilot randomised controlled crossover trial used a within-subjects design to investigate the use of VR in 27 labouring women. The women were observed during unmedicated contractions in the first stage of labour, with and without using VR for equivalent time periods. Statistically significant decreases in sensory pain, affective pain, cognitive pain, and anxiety were observed during VR. The study found that 82% of women reported enjoying using VR during labour and 70% were interested in new VR developments specifically for childbirth.

These authors suggest further VR applications should focus on ease of use, custom-tailored virtual environments, and emotionally engaging content for extended periods (labour can last for hours) that appeal to labouring women, and the use of VR environments that are proven effective in reducing acute pain and anxiety (Frey et al., 2018). However, this study was unable to determine the features of VR environments that may appeal to labouring women, or that may be effective in reducing acute pain and anxiety, as the quantitative study only examined pain

dimensions. The study was not designed to allow insight into features and content of future VR environments. To date there are no published articles which address the incorporation of VR design into clinical practice in the maternity area.

Cowles et al.'s (2019), recent pilot randomised controlled trial sought to determine whether periodic use of VR during labour decreased pain and analgesic use. A cohort of 20 women was randomised to two arms (VR and no VR). Pain scores were assessed by labour and birth nurses every four hours during latent labour, and every hour during active labour. Women in either group were allowed access to all usual forms of analgesia throughout labour. Results from this study showed no statistically significant difference in pain scores between the two groups. Only two women in the VR group used IV pain medicine, compared to four women in the no VR group. Despite the lack of statistically significant results, subjective comments from women revealed that 77% using VR during labour reported that it helped them experience less pain during labour, 33% reported that VR was helpful early in labour, and 77% would want to use VR again in labour.

The most recent study is available as an abstract only and is an open label, randomised controlled trial of nulliparous, term women in labour. Participants were randomised to up to 30 minutes use of either VR or no intervention (control). Of the 40 women who completed the study, 19 were randomised to the control group, and 21 to the VR intervention. Results from the study demonstrated a statistically significant decrease in pain of -0.52 ($p = 0.03$) in the group receiving VR compared to +0.58 in the control group. Maternal heart rate was lower in the group using VR (76.3, $p = 0.01$) compared to 86.8 in the control group (Wong et al., 2020).

5.4 How does VR work as analgesia?

The effectiveness of VR to attenuate pain, as evidenced in subjective reductions in pain ratings, is corroborated by data undertaken by functional MRI (fMRI) imaging. Using experimental thermal pain stimulation, Hoffman et al. (2007) measured activity in brain regions of healthy volunteers when VR was used, compared with the effects of opioids (hydromorphone injection). There was a significant decrease in pain-related brain activity due to opioids and VR in the insula and thalamus only, but not in other areas of the pain matrix. Figure 6 illustrates these results.

Figure 6. *fMRI brain activity.* Copyright Hoffman, H. Reprinted with permission.

Areas of the brain which have been consistently identified as main activation sites when acute pain is experienced, are the anterior cingulate cortex (ACC), the insula, the thalamus, and the primary and secondary somatosensory cortices (SS1, SS2) (Hoffman et al., 2007).

An earlier study by Hoffman et al. (2006b) gave a group of healthy participants a thermal pain stimulation both with and without immersive VR distraction. Consistent with other reports of fMRI during experimental pain, subjects

in the no VR group showed significant pain-related activity in all five areas of the pain matrix (ACC, insula, thalamus, SS1 and SS2). As predicted by the study's authors, there were significant reductions in observable pain-related brain activity in all five areas of the pain matrix. These reductions in pain-related brain activity with VR were supported by reductions in participants' experience of pain across all three dimensions: sensory, cognitive and affective pain (Hoffman et al., 2006b). Both these studies however, focused on game-playing in VR, using the game "Snow-World" (mentioned previously) an interactive game created initially for use with patients with burn injuries, rather than non-interactive VR.

To summarise, VR is able to divert attention from the unpleasant symptoms involved with invasive medical procedures, immersing the participant in a virtual environment and having a profound effect on perception of pain in a variety of clinical settings (Gold et al., 2007). The mechanism of VR analgesia can be explained in the context of a gate-control mechanism as per Melzack and Wall's (1965) GCT where pain demands attention; however, VR diverts attention away from the experience of pain to a computer-generated virtual world.

5.4.1 The neurobiology of virtual reality and pain

The effect of VR through pain attenuation can be explained in terms of simple distraction. Theories, however, have developed which seek to understand the complex neurobiological mechanisms fundamental to the clinical efficacy of VR and influences on perceived pain. Central to understanding the enigmatic actions of VR as pain attenuation, is an understanding of the neurobiology of pain and analgesia.

Gold et al. (2007) define analgesia as 'the attenuation of painful sensations during consciousness' (p. 539), and analgesic development occurs when the ability

to detect pain is interrupted. The process of analgesic development has targeted the deactivation of C fibre transmission by, for example, nonsteroidal anti-inflammatory drugs (NSAIDs) which inhibit prostaglandin production (Vane, 1971) which has a role in C fibre excitation and pain (Heppelmann et al., 1990). A range of pain treatments (e.g. capsaicin cream, used to relieve pain from some arthritic conditions), applied topically, are also associated with C fibre deactivation. However, it is unlikely that VR analgesia is produced as a consequence of direct effects on C fibre pain signaling (Gold et al., 2007).

Additionally, another mechanism of pain attenuation occurs in the brain to produce analgesia. This is attributed to effective interventions such as deep brain stimulation, analgesic medication, for example, opiates and hypnosis. Virtual reality also acts within the brain, possibly with distinct mechanisms of action from other recognised analgesic interventions (Gold et al., 2007). It is thought that by both direct and indirect pathways, VR stimulates pain perception and signaling through a range of cognitive mechanisms that include attention, memory, concentration and emotion and the tactile, auditory, and visual senses. Through this complex network, VR is likely able to transform the pain modulation system, effectively modifying the perception of pain (Gold et al., 2007).

When distraction techniques (music, cognitive tasks) have been used, active cortical regions associated with the process of attention and the modulation of pain have been identified using fMRI, while pain perception regions are less active. fMRI studies monitoring brain activity during distraction have specifically identified increased activation during pain in the PAG, perigenual ACC and orbitofrontal cortex (Valet et al., 2004). In contrast, areas of the pain matrix (thalamus, insular cortex, and midcingulate ACC) demonstrate decreased activation during a cognitive

distraction task. From these observations, it can be concluded that an inhibitory mechanism is involved in pain distraction, associated with the descending pain-modulation pathways (Gold et al., 2007).

5.4.2 The role of the anterior cingulate cortex in virtual reality pain attenuation

Debates that seek to understand the mediation of pain perception by VR focus on the ACC as an area of prime importance. The ACC, a cortical structure of complex nature, sits around the rostrum of the corpus callosum, and is distinctly divided structurally and functionally into two areas (Devinsky et al., 1995). During cognitive tasks that require high levels of attention, the midcingulate ACC is activated. In contrast, the perigenual ACC moderates attentional processes and emotional reactions to pain (Bantick et al., 2002). A study by Bantick et al. (2002) demonstrated the complexity of the ACC in attention, emotion, and pain perception by increasing activity in the perigenual cingulate during a pain distraction task with a related reduction in activity of the midcingulate cortex. It is thought that these changes in relative activity, which resulted in a decreased sensation of pain, implicate a reciprocally inhibited effect from the two regions.

Further evidence from fMRI imaging by De Charms et al. (2005) demonstrated that stimulation of the perigenual cingulate produced analgesia. Based on this knowledge of the neurobiology of pain, (Gold et al., 2007) it is hypothesised that by transporting the user to a highly immersive virtual environment, VR stimulates the perigenual ACC. As part of the descending pain modulation pathway, the perigenual ACC activates the periaqueductal gray (PAG) area of the midbrain, which in turn activates a cascade of signaling functions, providing additional effect by activating the pain modulation pathway and generating analgesia.

5.5 Cognitive analgesic effects

The theory of VR acting through the ACC to shift attention away from pain and generate analgesia is highly plausible, although VR is still considered an enigma in terms of the exact underlying neurobiological mechanisms of pain attenuation. While distraction paradigms focus on attentional processes, other studies have further demonstrated cognitive analgesic effects to cognitive task loading (Seminowicz & Davis, 2007), mood (Villemure & Bushnell, 2009), expectancy (Keltner et al., 2006) and perceived controllability (Salomons et al., 2004).

Seminowicz and Davis (2007), acknowledging that humans engage in cognitive tasks while in pain, sought to determine how the brain balances different cognitive loads due to pain intensity. Their results showed that research participants were able to engage in a task without their performance being affected by mild or moderate intensity pain, and cognitive-related activity was minimally affected. In contrast, pain-related brain activity is reduced when engaged with the cognitive task, but this reduction was small and independent of task difficulty. These authors concluded that the brain can support multi-tasking across perceptual and cognitive loads (Seminowicz & Davis, 2007).

Villemure and Bushnell (2009) successfully manipulated independent emotional and attentional states and found a reduction in pain unpleasantness and decreased activity in pain activated brain areas. This effect was due to the ability of pleasant odours to elicit positive mood changes, separately from attention. Results from this study indicated that distinct neuro-modulatory pathways are fundamental to the emotional and attentional modulation of pain.

The perceived ability to control a painful stimulus affects pain tolerance, suggesting a possible association with neural pathways that process pain. Keltner et al.'s (2006) experimental study found that expectation for a higher intensity noxious stimulus, increases subjective experienced pain intensity. Increased brain activation areas identified the action partly responsible for this as being through the descending pathway that facilitates nociceptive transmission at the contralateral nucleus cuneiformis (nCF). Salomon et al. (2004) manipulated participants' beliefs that they were able to control a painful stimulus. Using fMRI, a nociceptive stimulus that was perceived to be controllable activated three areas in the brain commonly linked with the processing of pain: the anterior cingulate, insular, and secondary somatosensory cortices.

5.6 Virtual reality modulation of pain, more than just distraction?

The prevailing belief in research into the mechanisms of action of VR in pain attenuation is distraction. A number of studies identify effects that are able to be manipulated to maximise this treatment effect (Gutiérrez-Martínez et al., 2010; Hoffman et al., 2004a; 2006a; Johnson & Coxon, 2016; Triberti et al., 2014). However, researchers are interested in other possible novel mechanisms by which VR is effective in the treatment of pain. In a recent systematic review, Gupta and et al. (2018) identified several studies that examined other mechanisms and additional factors relevant to the pain experience, such as self-efficacy and catastrophising.

In a randomised controlled trial by Loreto-Quijada et al. (2014), 77 psychology students compared two VR environments. One intervention group looked at distraction and the other studied active participation in VR as a means of improving perceived control over pain. A third group was a non VR control. The VR distraction

group were engaged in an interactive (VRE) (surreal world). The second group, known as the VR Control Enhancement Condition (VRC) were able to manipulate an irregularly shaped and pointed polygon (representing pain) into a sphere (representing calmness, pain-free). In addition to the shape, sounds were also able to be changed, , beginning with an unpleasant sound that could be manipulated into a pleasant one. Values measured in this study included pain threshold, tolerance to pain, pain sensitivity range, pain intensity, time estimation, pain catastrophising and pain self-efficacy (a person's belief in their ability to tolerate and decrease pain). Results from the study demonstrated, for the VR distraction group, no significant decrease in pain intensity and no significant differences in the cognitive variables (pain catastrophising and self-efficacy). The VRC, however, showed significant results for increased tolerance to pain, an increase in sensitivity to pain, and a decrease in time estimation. In terms of the cognitive variables, there were significant results found for increased pain self-efficacy tolerance and decreased feelings of helplessness. These results demonstrate that the use of VR can be effective in decreasing pain by mechanisms other than distraction (Gupta et al., 2018).

Further evidence into the ability of VR to be effective in the treatment of pain by mechanisms distinct from distraction are demonstrated in a study by Shiri and et al. (2013). This prospective, single-armed, open-label pilot study recruited 10 children to test the feasibility of a system combining VR and biofeedback as a potential treatment option for chronic headaches, migraines and tension headaches. Rather than using shapes and sounds as in Loreto-Quijado et al.'s (2014) study, pictures of each patient were created with a range of emotional moods, from agony to happiness. Using the Galvanic Skin Response (GSR) readings to combine the

facial expressions observed in VR, participants were requested to view the screen and attempt to relax. Once the GSR hit a pre-set cutoff point, the facial expression on the screen would change and theoretically invoke a more relaxed mood in the patient. A post-study survey reported that the majority of participants were able to relax when experiencing a headache, to such a degree that pain eased. There was a significant improvement in the extent to which the headaches impacted daily function at periods of one and three months. In terms of long-term effects, quality of life also significantly increased while undergoing treatment, and post treatment at one and three months. Despite limitations in terms of the small sample size and non-randomisation the study demonstrated the potential use of VR with biofeedback in the area of chronic headache pain, utilising a distinct mechanism to distraction (Gupta et al., 2018).

A further study in the systematic review was conducted by Garcia-Palacios et al. (2015). This study utilised a single-blinded randomised trial of patients with fibromyalgia and made comparisons with standard care (via rheumatology medications) to cognitive behavioural therapy (CBT) treatment in combination with VR. Results from the trial demonstrated a significant decrease in the impact of fibromyalgia as measured by the Fibromyalgia Impact Questionnaire for the treatment group. There were also significant increases in perceived quality of life as reported by the participants, however no significant decreases were found in pain intensity. The limitations of this study were that the control group did not use CBT without VR. However, the study's stated intention was to demonstrate the feasibility and efficacy of VR as an adjunct to CBT in fibromyalgia treatment. Studies in the area of fibromyalgia have indicated that VR is beneficial in assisting people living

with their chronic pain (Garcia-Palacios et al., 2015; Herrero et al., 2014; Morris et al., 2015).

The systematic review by Gupta et al. (2018) identified studies into VR and pain treatment that focused on patients' abilities to change their behaviour, primarily in the area of chronic pain. Studies looked at the incorporation of biofeedback mechanisms and VR in order to promote an awareness and somatic reaction to pain (Shiri et al., 2013). Research into VR and the neurobiological mechanisms of pain attenuation continues to extend beyond distraction, across all pain conditions. Research seeks to measure whether benefits continue once beyond the immediate treatment period, after the VR device is removed (Spiegel, 2018).

5.7 Uniqueness of presence in virtual reality

Discussions on the possible mechanisms of action of VR suggest that the Virtual Environment (VE)¹³ can manipulate a more intricate array of cognitive and emotional conditions than typical cognitive tasks. Li and et al. (2011) propose that VR's analgesic quality lies in the 'interplay of these cognitive mechanisms or from something beyond' (p. 8), unique to VR. Unique to VR is what is known as 'transported presence' which is the ability of VR, through immersion, to take the user to a VE, beyond any cognitive tasks performed at the same time (Li et al., 2011).

The International Society of Presence Research (ISPR, 2000, as cited in Riva, 2009), defines 'presence' (an abbreviated version of the word 'telepresence') as a:

¹³ VR is also referred to as Virtual Environment (VE). Ellis (1991) argues that the concept of an environment is the more appropriate metaphor for a head-mounted, multi-sensory experience in a three-dimensional space. However, in this thesis, the terms are considered synonymous.

Psychological state in which even though part or all of an individual's current experience is generated by and/or filtered through human made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience.

People who experience the virtual world as a more engaging reality than the physical world are considered to be 'highly present' (Slater & Wilbur, 1997, p. 606).

While the design of Virtual Reality technology has brought the theoretical issue of Presence to the fore, few theories argue that the experience of Presence suddenly emerged with the arrival of VR. (Biocca, 1991, p. 14)

Presence is broadly defined as a basic state of consciousness where the participant has experiences determined by mediated technology, and they have 'a perceptual illusion of non-mediation' (hybrid of Barfield, Zeltzer, Sheridan and Slater 1995 and Lombard & Ditton's definition, 1997 as cited in Freeman et al., 2004, p. 67). Various authors propose that the concept of presence in VR is multidimensional. There are three aspects: spatial presence, social presence and co-presence (Ijsselstein, 2004; Lombard & Ditton, 1997). The definition of spatial presence is the sense of being physically located in the VE rather than the real world environment (Schubert et al., 2001; Witmer & Singer, 1998). Social presence is defined as the feeling of socially interacting with other beings, that is, you are interacting with a synthetic partner or avatar (Heeter, 1992; Ijsselstein, 2004; Lombard & Ditton, 1997). Co-presence refers to the feeling of being connected with other people in a computer-generated world in the same moment, despite people being in different places (Ling et al., 2014).

Further to this discussion, Slater (2009) argues that there are two statistically independent components that help people respond realistically in VEs: place illusion

(PI) and plausibility illusion (Psi). Similar to the concept of spatial presence, PI is defined as the feeling of existing in the VE. Place illusion is the type of presence referred to as 'being there'. Slater (2009) prefers to use this term to avoid uncertainty, to ensure that reference is only made to the powerful illusion of being in a place, as opposed to the myriad of meanings that have been attributed to presence.

Plausibility illusion (Psi) is the illusion that experiences that occur in the virtual world are real, despite knowing that it is a mediated environment or a mediated technology (Slater, 2009). A mediated environment, according to Steuer (1993), is a description of a form of communication technology in which 'interaction is not transmitted from sender to receiver; rather mediated environments are created and then experienced' (p. 7).

5.7.1 The study of presence

The concept of presence is a widely studied and analysed topic. Recent debates by prominent presence scholars have developed a theoretical model that creates a framework to describe the psychological process by which presence is experienced, incorporating concepts such as attention and involvement (Wirth et al., 2007). The idea of a two-step process is fundamental to understanding the formation of presence. In the first instance a user must respond to spatial cues to recognise the mediated environment as a plausible place. The second step of the process sees the user experiencing themselves as being situated within that perceived space. Spatial presence is only achievable with the completion of these steps. Wirth et al. (2007) define presence as 'a binary experience, during which perceived self-location and, in most cases, perceived action possibilities are connected to a mediated

environment instead of reality' (p. 497). As defined by the model, presence is a two-dimensional construct, made up of a sense of self-location and perceived possibilities to act (Wirth et al., 2007).

It is generally accepted that presence is a multi-component construct distinguished by two broad groups of variables, namely media characteristics and user characteristics. Media characteristics are separated into media form and media content variables. Media form comprises the technological properties of the display medium. Media content is the plot, narrative, actors and events depicted by the medium, and lastly the characteristics of the user refer to variables unique to individuals, such as age, gender, culture, previous experience with virtual or augmented realities and characteristics such as the user's imaginative abilities or 'willingness to suspend disbelief' (Baños et al., 2004, p. 734). The ability of VEs to create presence is due largely to immersive qualities, indeed presence can be conceptualised as the experiential or psychological equivalent of immersion (Slater et al., 1996; Wirth et al., 2007). In comparison to exocentric desktop computer displays, immersive Virtual Environments (IVEs) have the ability to create a strong sense of presence. This is what distinguishes VR, and ensures its place in the technological future.

5.8 Media Form Characteristics

5.8.1 Immersion

Immersion is a description of technology and 'describes the extent to which computer displays are capable of delivering an inclusive, extensive, surrounding, and vivid illusion of reality to the senses of a human participant' (Slater & Wilbur, 1997, p.

605). In this context, 'inclusive' refers to the extent to which the reality of the physical world is excluded; 'extensive' is defined as the range of sensory modalities contained within the system; 'surrounding' is a reference to the degree to which the VR system is panoramic as opposed to confined to a narrow field of vision, and 'vivid' describes the pixel resolution and quality of the screen display, for example, the richness of colour (Slater & Wilbur, 1997).

A system technologically capable of achieving high degrees of immersion is necessary to experience presence in VR. Immersion depends on the objective, quantifiable features of a VR system and the ability of the virtual system to achieve a 'realistic' environment for the user (Sanchez-Vives & Slater, 2005; Slater & Wilbur, 1997). A range of technological features or spatial cues can be manipulated to increase presence: inclusive, vividness, proprioceptive matching, extensiveness, and interactivity.

5.8.2 Inclusive

Increased presence requires the design of the VR device to be as unobtrusive as possible, that displays be free from signals that let the user know the very existence of the device. Physical embodiments of the system include information display systems, slow screen update rates, and the weight of the device and cables. In an ideal world, such a device would be weightless. Slater and Usoh's (1992) first experimental study on levels of presence asked the question, 'were there any circumstances that especially *decreased* your sense of being 'really there'?' (p. 15) Of the 17 participants, four mentioned outside events which included the voice of the experimenter, and six participants identified poor screen updates, low resolution and high lag time. An interesting finding in this study was that when a deliberate outside

interference (making a loud noise) occurred, participants who reported the highest level of presence, in fact *incorporated* this noise into their VR experience. That is, the noise was experienced and interpreted as being part of the VE, rather than the real world. Slater and Wilbur (1997) interpret this phenomenon in light of Freud's perceptions in the *Interpretation of Dreams*, 'that dreamers weave outside events into the fabric of their dreams' (p. 6). Reference is made to Maury's famous dream about being guillotined as a result of the sensation of something falling on his neck while sleeping (Slater & Wilbur, 1997).

5.8.3 Vividness

Participants reported significantly different levels of presence when shown two examples of pictorial realism. A higher level of reported presence was obtained when viewing the more realistic scene (Welch et al., 1996). Research has identified stereoscopy¹⁴ (Hendrix & Barfield, 1996a), as a binocular spatial cue and a wider geometric field of view, identified as a static monocular cue (Cummings & Bailenson, 2016) as positively associated with a presence score (Hendrix & Barfield, 1996a; Lin et al., 2002).

In contrast, a study by Bänos et al. (2008) compared two experimental conditions (stereoscopy versus no stereoscopy) to one of two emotional VEs (relaxation or joy). Results from this study failed to find a difference between stereoscopic and monoscopic VE presentations, either by a participant's subjective sense of presence or their emotional reaction to the scene. This study did not

¹⁴ Stereoscopy (also called stereoscopies, or stereo imaging) is a technique for creating or enhancing the illusion of depth in an image by means of stereopsis for binocular vision. Most stereoscopic methods present two off-set images separated to the left and right eye of the viewer.

replicate previous findings (Freeman et al., 1999; 2000; Ijsselstein et al., 1998) that showed that subjective feelings of presence are increased by the quality of stereoscopy. The reasons for this failure, Bănos et al. (2008) argue, is due to differences in the VE content. Virtual reality content in this study was designed with the sole purpose of inducing positive moods. In contrast, the previous studies used VEs with a neutral content. In practical terms, technological factors are arguably more critical for non-emotional environments than for emotional ones and, “even when technology is involved, it is the experience itself (the mediated experience) and not technology alone that engages the subjective experience of presence” (Heeter, 2003, p. 8).

5.8.4 Proprioceptive matching

Dynamic monocular spatial cues (motion parallax) (Cummings & Bailenson, 2016) or matching, refers to the lag between motor actions and the parallel response of the system (e.g. a turn of the head should result in a corresponding change to the visual display) (Slater & Wilbur, 1997). Ideally, there should be minimal lag, and matching of motor actions require body tracking, or minimally head tracking. In an experimental study, Hendrix and Barfield (1996a) found that head tracking led to significantly higher levels of reported presence and participants became more animated with their bodies: they stood on a chair, bent down, moved forwards and backwards and turned around. It is proposed that ideally a participant in a virtual world should walk by really walking. Participants experienced a higher sense of presence when they walked through their VE using a ‘walking in place’ technique, compared to participants who used just a pointer device to navigate their environment.

5.8.5 Extensiveness

In the health context, specifically motor rehabilitation, the capacity for VR to motivate and engage is essential, and instantly brings to mind the importance of sound (Garner, 2018). Arguably, when correctly implemented, the combination of audio and visual design in computer gaming is able to significantly and substantially increase arousal and engagement (Wolfson & Case, 2000). In the area of psychology, it is suggested that the effect of sound is partly attributed to the changes in a person's level of arousal; that is the degree to which areas of the body under autonomic nervous system control are activated. Elevated heart rate, electrocortical activity, tension in muscles, increased respiratory rate and blood pressure, changes in skin conductivity and the release of adrenaline, all indicate arousal (Garner, 2018).

In the area of VR distraction for pain attenuation, there are clear benefits in the utilisation of sound design in VR, particularly techniques to increase presence. There are two types of sound: spatial¹⁵ and non-spatial¹⁶. Hendrix and Barfield (1996b) discovered that participants reported higher feelings of presence with spatial sound than with no sound or non-spatial sound. Techniques such as immersive soundscapes, the use of novel or hyper-real sounds may have the ability to improve user engagement, and to increase presence, which would have obvious implications for the use of VR in the area of pain attenuation (Garner, 2018).

There is limited research into the effect of sound on VR pain attenuation. A study by Johnson and Coxon (2016) sought to determine whether sound can add to

¹⁵ Spatial sound is an enhanced immersive audio experience where sounds can flow around you, including overhead, in three-dimensional virtual space.

¹⁶ Non-spatial sound is two-dimensional sound, not occupying virtual space.

VRs analgesic effect on acute experimentally induced pain. A group of 27 participants experienced cold-pressor pain to their hand, some while playing a VR game, some while listening to sound, and some combining both the game and sound. A significant interaction of the VR game combined with sound was found. This demonstrated that the pain tolerance differences between the conditions were statistically different. The statistical test for covariance (i.e. interaction) was used to report this result. As predicted, the VR game with sound was more demanding of the user's attention, and increased pain tolerance was greater than the VR game and sound when used separately. The study demonstrated the additional benefits of including sound to any VE and recommended that future research should explore whether specific sounds were more effective as distraction than others (e.g. sounds associated with games, or other distinctive non-game playing sounds).

5.8.6 Interactivity

The manipulation of immersion is also possible due to the ability of a participant to interact with the virtual world or the concept of interactivity. Wender et al. (2009) studied the effects of interactivity with a group of 21 participants undergoing thermal induced experimental pain. The interactive group in the immersive VR system glided through a virtual world and could target and shoot virtual objects by the movement of a trackball. Participants in the non-interactive group had an identical VR system and virtual world but could not use the trackball to target/shoot virtual targets. Results from this study showed a greater reduction in pain during interactive VR, compared to non-interactive VR with a 32% greater reduction in time spent thinking about pain, 75% greater reduction in pain unpleasantness, 74% greater reduction in worst pain and 47% increase in fun

experienced during interactive VR. The study's authors concluded that participant interaction with the VE maximised the benefit of VR analgesia, confirming an attentional mechanism in VR analgesia (Wender et al., 2009).

According to Ijsselstein (2002), interactivity is possibly more important than immersion, and interactive, non-realistic displays are capable of producing significant levels of presence. In general discussions about interactive media, the appeal lies in the ability to provide the user with a strong experience of self-efficacy and mastery. Participants are able to control to some degree the events unfolding in the story, and can see and evaluate their impact on the story through the immediacy of their actions.

In the area of presence, interactivity can intensify the spatial component of the presence experience, increasing the motivation to use the media and heightening the sense of pleasure (Klimmt & Vorderer, 2003; Schubert et al., 1999.; Steuer, 1993). Arguably, as long as interactivity allows the user to experience this control, mastery, and self-efficacy, the pleasure of using the product will increase, and consequently the desire to experience a strong feeling of presence (Klimmt & Vorderer, 2003).

Hoffman et al. (2006a) studied the effect of VR immersive qualities such as goggle size, field of view and peripheral vision on pain reduction and found higher quality VR systems achieved a greater reduction in pain intensity. Participants were randomly assigned to a low-technology VR helmet group, high-technology helmet group or to a no VR group. In the high-technology VR helmet group, 65 participants reported a clinically meaningful pain intensity reduction, in comparison to only 29% in the low-technology helmet group. Importantly, these results show that the quality of the helmet (i.e. goggle size/field of view, amount of peripheral vision when in VR) is

significant in achieving the greatest reduction in pain intensity, and the study-design reduced the possibility that VR analgesia is due to an artefact such as demand characteristics (Hoffman et al., 2006a). Demand characteristics refer to a participant's perception of the behaviour expected of them in an experimental situation, based on the instruction given to them by the experimenter, as well as more subtle cues and hints in the context of the experiment (Ijsselstein, 2004). Therefore, immersion can be manipulated by design features to increase presence and influence the effectiveness of VR analgesia.

5.9 Media content: plot, narrative, and user characteristics

While the role of media form characteristics is significant to the level of presence felt by a user and the impact of immersion, interactivity and perceptual realism cannot be underemphasised: the characteristics of media content and user characteristics must be acknowledged (Baños et al., 2004). Several VR studies have asserted, for example, that users have a sense of presence despite an impoverished environment that some VR provides (Ijsselstein, 2002; Riva et al., 2003). An analysis of a VR ride at Walt Disney World by Pausch et al. (1996) demonstrated that content, background stories and goals, together with the 'physics fidelity' (motion) of the rides had more impact than aspects of the immersive interface, such as displays, graphics and quality of control devices. Conclusions from the study by Ijsselstein (2002) emphasised the importance of presence as a "user experience, the feeling of 'being there' is not intrinsically bound to any specific type of technology; it is a product of the mind" (p. 246).

In order to enhance our understanding of VR it is necessary to understand psychology. Baños et al. (2004) argue that the idea of 'being there' in the virtual

world which can be interpreted as to 'do there' (Ijsselstein, 2002, p. 251) and should, based on their study's findings more correctly be 'feeling there'. Arguably, 'I can do here, therefore I am here', can be reimagined as, 'I feel here, therefore I am here' (Baños et al., 2004, p. 740). The degree to which a user is capable of 'feeling there' (e.g. based on the personality traits of the user, a willingness to experience presence, their creative imagination and susceptibility to remove themselves from the real world to the virtual one, and suspend disbelief) are reliable predictors of presence (Baños et al., 2004; Sas & O'Hare, 2005).

Intrinsic to engagement in all forms of media is the idea of entering new worlds and being involved in exciting activities and interactions outside of everyday life. In the area of media psychology, the psychological theory of play is central to the creation of engaging content that is appealing to users. This theory is particularly useful in explaining the fascinating nature of interactive media environments (Klimmt & Vorderer, 2003).

One of the components of the experience of play involves living vicariously to experience new life experiences. It is closely linked to the concept of presence in VR and the ability to transport users into inaccessible or distant environments (Klimmt & Vorderer, 2003). This attraction of journeying to new environments, social settings and activities appeals not only to children but adults too, who desire to be diverted from daily life experiences. In the field of communication research, this concept is termed 'escapism' (Henning & Vorderer, 2001; Katz & Foulkes, 1962). If media products portray extraordinary environments, rather than simulated every day scenes, this may help users feel a sense of presence because it is fun to "be there" (Klimmt & Vorderer, 2003).

5.10 Emotions and virtual experience

Important to the study of presence and VEs are the role emotions have on the virtual experience. As Huang and Alessi (1999) contend in their study, emotions are essential to the way people experience and interpret the world, and traditional definitions of presence which rely on cognitive and environmental aspects should be challenged to include more emotional aspects of presence. Emotional response to a VE can be achieved by the use of **narrative**, **drama** and **plot** and these aspects have been recognised as fundamental to a sense of presence (Kelso et al., 1993; Klimmt & Vorderer, 2003).

While technical details such as immersion, resolution of the VR system have an influence on the quality of the virtual experience, Sherman and Craig (2003) assert that the main driver of the virtual experience is the user who navigates the direction of the narrative flow by their own emotional and cognitive response to the experience. Narratives have the ability to create mental immersion, allowing the user to become deeply engaged and fully involved in the virtual experience (Waterworth et al., 2002). If narratives or media content are incapable of providing strong sensory input to the user, thus decreasing their potential for mental immersion, a compensatory mechanism exists (Klimmt & Vorderer, 2003). Literature in the field of media psychology refer to Oatley's (1994, 1999) Simulation Theory (ST); the concept of reconstructing the world of the story by accessing individual memories. Oatley (1994, p.53) uses the term **memory emotions** to describe the mechanism by which an affective response is elicited by literature.

Hypnosis and self-hypnosis are based on this concept of retrieval of memories, free floating attention and ego receptivity to internal stimuli (Fromm et al., 1981). The concept of ego receptivity in terms of self-hypnosis relates to the patient's

heightened ability to let unconscious thoughts, emotions or imagery come into awareness. Hypnosis has been described as an altered state of consciousness (Brown & Fromm, 2009). Once this deep trance state is reached, moods (sad, happy or angry) can be induced by requesting the subjects to recall a relevant emotional experience from their lives and replaying this memory in their imagination (Martin, 1990).

In the area of VR and presence research emotional states can be activated by internal simulation, 'by inspiring their audience to activate and retrieve related information from their memories' (Klimmt & Vorderer, 2003, p.353). The idea of internal simulation or mental imagery created from memories is not a new idea in presence research. Biocca (1997), one of VR's early pioneers, referred to daydreaming as a form of presence, and that dreams and to a lesser extent hallucinations were another place we could be present in the imagined environment aside from the physical world. He described dreams as a mental generator, creating images not based on incoming sensory stimulation as in VR, but from a person's memory.

5.11 Emotions and presence

A relationship exists between emotions and presence, however it is inconsistent, controversial, not linear, but rather a circular interaction. It is thought that presence is a necessary pre-requisite for an emotion to occur at all in VE (Felinhofer et al., 2015), at the same time the ability of a VE to invoke an emotional response from a user is key to the effective functioning of a VE (Riva et al., 2007). There is a strong association between the level of presence and pictorial realism with

emotional engagement in VR and type of emotion (Baños et al., 2004; Bouchard et al., 2008; Riva et al., 2007).

Riva et al. (2007) were able to induce two specific emotions in their investigation with sixty-one psychology students; anxiety and relaxation. Similarly Baños et al. (2004; 2008) invoked sadness, joy and relaxation and determined that a bi-directional relationship between presence and emotion exists. Baños et al.'s (2004) study showed that participants found the emotional environment more engaging, natural, believable and real than the neutral environment. Interesting results related to the interaction effects between emotional content and the immersive systems. Together immersion and affective content had an impact on presence, however immersion was more relevant for a neutral environment than for an emotional one. There is uncertainty from this data why there was no immersion effect on presence in the emotional conditions as there was no reporting of the strength of the actual emotions the participants experienced (Diemer et al., 2015).

Baños et al. (2012) used a non-immersive VR system to study the emotions of joy and relaxation but could not find any significant correlation between emotion and presence, despite study results showing high presence ratings. In contrast, a study by Freeman and et al. (2005) used relaxation paradigms with a range of immersion levels, manipulating presence through variations in media form. Only one significant correlation was found between happiness and level of presence. This study reported no relationship between presence and emotion for arousal reducing stimuli, a finding that stands in contrast to other studies demonstrating that presence and emotion are related. The authors theorised therefore that presence and emotion are related only for arousing stimuli in VR.

The effect of information or narrative on emotion has been studied by several authors with some intriguing results. Gorini et al. (2011) in their study, sent participants off to search for a blood container in a VR hospital with participant's receiving information either that it was urgently needed to save a child's life, or being excluded from this information. In the study by Bouchard et al. (2008), patients with snake phobia were told that there were snakes in the VE and actually no snakes were shown. Results from both studies demonstrated that emotionally contextual background information increased the feeling of presence, thus pointing to a causal influence of emotions on presence (Diemer et al., 2015).

While Felnhöfer et al. (2015) were able to induce the intended emotions of joy, anger, boredom and anxiety in their study, they did not find a connection between presence levels and type of emotional state. Their study found that presence levels were equal across all five emotional conditions, joy, sadness, boredom, anger and anxiety. This gave support to a previous theoretical assumption by Slater, (2004) that presence levels are not affected by the type of emotion and that a scene that is dull and boring is expected to elicit the same degree of presence as a scene that is exciting, or anxiety inducing.

5.12 Virtual reality and mood induction

There is an abundance of literature on the role of VE on mood induction. Mood induction procedures (MIPs) exist in the realm of psychology and are used in laboratory settings to examine the influence of emotional states on cognition and behaviour (Martin, 1990). Mood induction procedures, as defined by Baños et al. (2004), are designed to evoke a transitory emotional state in a person in a controlled way and in an artificial experimental environment. There is a difference between

mood and emotions, primarily mood is seen as a long-term, low intensity state with no defining cause, on the other hand emotions are considered to be short-term, intense in nature and caused by specific events (Gray & Watson, 2001).

Furthermore, emotions are characterised by an observable facial expression, an activity that is achieved via the autonomic-nervous system and a subjective feeling (Izard, 1992).

The ability of a VE to elicit a specific emotional response and more importantly the ability to manipulate the content of a VE to invoke the emotional response is important for therapeutic purposes. Research in this area also contributes in the area of design; to our understanding of the design features essential for the elicitation of specific emotional responses in a VE (Felnhofer et al., 2015).

Studies on MIPs have targeted emotional states such as relaxation, joy, sadness, anxiety, anger and boredom (Baños et al., 2004, 2008, 2012; Felnhofer et al., 2015; Riva et al., 2007; Serrano et al., 2013, 2016). These studies have modified virtual experiences to induce specific emotional states by manipulating particular features of media such as sound and music, shadows, lights and textures to change weather conditions, time of day of environments. For example, Felnhofer et al. (2015), Riva et al. (2007), Rohrmann and Bishop (2002) and Toet et al. (2009) used a calm, quiet sunny daytime scene with birdsong to induce a relaxed, happy mood. A study by Freeman et al. (2004) involved twenty participants experiencing Relaxation Island¹⁷, a VE accompanied by a narrative which presented the environment (ocean, waves, sun, breeze, golden sand) and a range of breathing instructions. Participants

¹⁷ Relaxation Island is a VE that has been developed with the EMMA (Engaging Media for Mental Health Applications) Project (<http://www.emma.upv.es/>) specifically to induce a relaxed mood/state (Waterworth et al (2004).

were asked to only notice their breathing, they were asked to describe the act of inhaling and exhaling and were instructed not to alter their breathing. An independent (between) groups design with two levels of one factor was used. Presentation or not of an audio-visual VE to accompany a therapeutic narrative. Another group of participants listened to the audio only with no VE. The narrative combined with the VE produced significantly greater increases in relaxation and decreased negative emotion ratings in comparison to the narrative alone.

5.13 Virtual reality and relaxation/anxiety

The ability of a VE to induce relaxation and reduce anxiety clearly has benefits in a range of clinical settings, particularly related to management of both acute and chronic pain. The premise that environmental factors can influence pain is increasingly recognised within the health sector (Malenbaum et al., 2008). However, despite this growing awareness, healthcare environments continue to be places where distracting stimuli is notably absent, indeed patients' pain conditions may well be exacerbated by the visual and sensory settings they find themselves in (Malenbaum et al., 2008).

Designing healing environments, and healthcare environments that have a positive effect on health and wellbeing is comprehensively explored in the literature. Healing environments are considered beneficial to patients in terms of a range of health outcomes, such as anxiety, blood pressure, recovery postoperatively, analgesic use and length of hospital stay (Ulrich et al., 1991; Ulrich, 1984). Engaging in activities in the outdoors, viewing natural scenes either through a window, or by viewing it via video has been confirmed as being beneficial to people in terms of health and wellbeing (Diette et al., 2003; Frumkin, 2001; Groenewegen et al., 2006;

Ulrich, 1984). Wellbeing is defined as an all-encompassing term which includes experiences of positive emotional states and also generally a satisfaction with life (Cervinka et al., 2011).

The human propensity to connect with nature is considered to have an evolutionary basis and forms the foundation for what is termed the 'biophilia hypothesis'. Coined by entomologist, Edward Wilson, in 1984, it proposes that humans have a genetic predisposition or innate tendency to focus on life and lifelike processes associated with natural features and landscapes. It is inconceivable that the natural environment has not sculpted humans emotional and cognitive processes and that our affiliation with nature has enhanced and ensured the health and survival of our ancestors (Gullone, 2000).

This idea of connectedness with nature (CN) has been studied in the field of environmental health and there are obvious associations with human health (Cervinka et al., 2011). An early study has shown the benefits of nature on the psychological-physiological aspects of stress reduction (Ulrich et al., 1991) and hospital environments that included views from windows of natural scenes or video of natural scenes produced results whereby these patients had shorter postoperative hospital stays, required less narcotic analgesia and reported higher threshold and tolerance to pain (Tse et al., 2002a; Ulrich, 1984). A study by Diette and et al. (2003) placed nature scene murals beside patient's beds and played recordings of nature sounds to patients who were undergoing a painful bronchoscopy procedure. Results using multivariate analysis showed a significant pain reduction for patients undergoing this procedure due to the distraction technique with natural scenes and sounds. The odds of better pain control were greater in the intervention patients (N=41) than in the control group (N=39) (odds ratio (OR), 4.76, an odds ratio >1

indicates a better association with pain control; 95% confidence interval (CI), 1.35 to 16.7).

The viewing of nature scenes is associated with pain reductions by inducing positive emotions and decreasing stress. In a case report by Herrero et al. (2014), VR was used to elicit positive emotions for a patient who had fibromyalgia, a chronic musculoskeletal pain condition, that is characterised by widespread pain and muscle tenderness. The VE the patient viewed was a beach with the images, sounds and narratives selected from the IAPS (Lang et al., 1997). These images were chosen to induce positive emotion, and to encourage behaviour change and self-efficacy. The pictures met the criteria; defined as contributing to a positive valence or pleasant affective experience and high arousal or ability to elicit an emotion. This case report included other images that were based on three dimensions: colour, brightness and saturation. Previous research on the induction of emotions in the treatment of fibromyalgia has established that images with bright and high saturated colours, with a prevalence of green and blue are more effective at evoking positive emotions. The induction of positive emotions promoted motivation in meaningful activities and self-efficacy for these patients (Herrero et al., 2014). A combination of these factors; light and nature in VR environments are likely to produce a synergistic effect on pain reduction.

5.14 Virtual reality analgesia: psychological variables: presence, fun, and anxiety

Virtual reality-based analgesia can be understood in the context of both physiological and psychological variables. Further psychological explanations for VRs analgesic effect lie in our understanding that the descending pain-control

system is significantly affected by emotion. Positive emotions are hypothesised to inhibit a portion of the brain (amygdala) that promotes pain, leading to analgesia (Gold et al., 2007). Being exposed to pleasant images, such as nature scenes, sunny beaches, subjectively lessens the pain experience in comparison to those who experience neutral or unpleasant images (Rhudy et al., 2006). To consolidate our understanding of how VR works as an analgesic and to contribute to improving the efficacy of VR as analgesia the role of psychological variables needs to be recognised as important and independent from physiological variables. Triberti et al. (2014) conducted the first systematic review to identify specific psychological factors instrumental in the efficacy of VR analgesia. Three psychological factors, **presence**, **fun**, and **anxiety** were identified as influential in the efficacy of VR analgesia. Presence was identified as being capable of improving the efficacy of VR as analgesia and is probably the most important psychological factor that is **directly linked** to the experience of VR. It was identified that there was a positive association between a high sense of presence and desirable analgesia effects. This review analysed 11 publications that met the criteria, and 10 out of the 11 studies evaluated presence (Triberti et al., 2014).

5.14.1 Presence: measures

Presence is a measurement that is crucial in determining the effective functioning of a VE and in any VR based intervention research it is essential that it be measured in some way (Triberti et al., 2014). There are, however, no universally accepted means of measuring presence due to its complicated, multi-factorial nature and the varied physiological and psychological manifestations that it displays in people (Nichols et al., 2000). The concept of presence can be described both

subjectively and objectively in terms of a person's relationship to their environment. A person's evaluation of their sense of 'being there' in the virtual world is a subjective measurement and objective measurement is a behaviour that is observed by others. That is, how much do individuals in a VE behave as if they were in the same real-world environment? Riva (2003, as cited in Riva, 2009, p.159) describes the 'core of presence research as being the comparison of human perceptions and responses in the concept of technology with human perceptions and responses in contexts that do not involve technology.'

Many studies use physiological indices of presence in the quest for a more objective, measure of presence, for example, heart rate changes, blood pressure, respiration rate, skin temperature and conductance tests and changes in blood or saliva compositions (Meehan et al., 2005; Wiederhold et al., 2001). However, a recognised confounder, particularly in anxiety-inducing VEs and connected with increases in heart rate or skin conductance is anxiety, often confused for presence. Significantly then, these changed physiological parameters cannot be specifically associated with presence. Garau et al. (2008) used qualitative interviews and breaks in presence to alternate between the real world and the virtual world to assess presence.

The most common tool to measure presence are questionnaires which ask users to self-report their presence level on a scale. There are a range of validated questionnaires (Lessiter et al., 2001; Witmer & Singer, 1998). Generally, there are recognised limitations of using questionnaires to measure presence due to presence being a subjective phenomenon and difficulties in understanding the meaning of items in several questionnaires (Ijsselstein et al., 2001).

In a recent systematic review of questionnaire measures and physiological correlates of presence, Grassini and Laumann, (2020), while acknowledging that questionnaires have advantages in terms of being cheap and easy to administer, outlined several disadvantages. There are several questionnaires measuring presence, a range of constructs explored and a distinct lack of a standard definition for presence as a psychological construct. Consequently, results from studies using different questionnaires and constructs make comparisons difficult. Also, of note by these authors, is that questionnaires assessing the degree of presence are susceptible to response bias. Questionnaires that ask participants about presence directly or indirectly have the potential to influence an answer that they would not have thought about in other conditions (Grassini & Lauman, 2020).

5.14.2 Neuronal mechanisms of presence

The need to understand the neuronal mechanisms underlying the phenomenon of presence has led to the use of EEG in interactive VR. Kober et al. (2012) sought to compare the subjective feelings of presence and its underlying cortical correlates in two distinct immersive VR systems, one highly immersive and the other less so. Previous neurophysiological studies have identified two brain areas which have been identified as paramount to the experience of presence in VR: the parietal lobe and the dorsolateral prefrontal cortex (DLPFC) (Baumgartner et al., 2008). Results from Kober and colleague's (2012) study demonstrated that an increased feeling of presence in the more immersive system was associated with increased parietal brain activation in comparison to the less immersive system. Interestingly, the more immersive VR system increased activity at the parietal brain areas in contrast to the frontal brain areas, however the less immersive system

displayed no such topographical differences. Participants who experienced the less immersive VR system reported less presence ratings and brain activity showed an increased coherence between frontal and parietal brain regions. In contrast participants using the more immersive VR system showed a decreased coherence between these brain regions. The significant conclusions from this study were: that two-different immersive VR systems had different effects on the experience of presence for the participants and led to different cortical activation patterns. The experience of presence, either in a non-interactive (passive viewing) or interactive (where subjects can move freely through VR) VR environment is related to increased activity of a frontal-parietal network, which is modulated by DLPFC. That is likely to regulate activation in parietal brain regions and, resulting from this activation, the experience of presence (Kober et al., 2012 p. 373)

5.15 Design of virtual reality environments

The systematic review by Triberti et al. (2014, p.341) identified that 10 of the 11 studies evaluated presence, and of these, all except two used a single question, such as: 'To what extent did you feel like you 'went into' the virtual world.' There is extensive debate and research around the concept of presence and there are likely multiple factors influential to presence. Thus, a single question is unlikely to be sufficient to capture the complexities of presence as a construct, as 'being there' is dependent on a range of elements experienced by the user. Another issue that this review identified was the measurement of presence as only a one-condition control variable. While this was appropriate in the context of these studies as they compared VR with non-VR or with other distraction methods that were not

immersive, the advancement of knowledge into the efficacy of VR analgesia requires the comparison and analysis of different VEs (Triberti et al., 2014).

For the benefits of VR as an analgesia technology to be capitalised upon, the argument exists for instruction and guidance on the design of VEs that are able to provide optimum pain management. Triberti and colleague's (2014) review provides questions for future research into design of VEs for pain management. Is there a preference for one VR device or another, whether narrative or cinematic VR is more engaging than simple exploratory design and whether gender or age influence the responses to VR media content? Added to this last question could be the influence of culture or ethnicity on a user's response to the content of a VE.

Spiegel, (2018) in his work into VR and chronic pain, discusses the personalisation of VR environments for each individual. He suggests that if VR is to be truly regarded as a therapy then a VR pharmacy needs to be developed. He offers a picture of 'virtualists' who, like doctors prescribing the right dose of medicine, will be prescribing the right VR experience at the right time for the right patient. Finally, he gives us an image of a syringe, and that a VR headset is similar in that 'both are merely devices that deliver a therapy. The device itself is unimportant, it is what passes through the device that matters' (Spiegel, 2018, p.3).

5.15.1 Fun

Fun is the second psychological variable identified in the systematic review by Triberti et al. (2014) as having a positive effect of the effectiveness of VR analgesia. Usability experts designing user experiences propose that we go beyond the concept of usability and consider the concept of 'fun' in user experience studies (Carroll, 2004; MacFarlane et al., 2005; Shneiderman, 2004). Some usability experts describe

their work as ‘funology’ (Blythe et al., 2004). Similar to the idea of looking at pleasant images, a VE needs to be emotionally engaging to the user in order to elicit presence and to be effective as distraction (Baños et al., 2004; Bouchard et al., 2008; Riva et al., 2007). In two studies by Hoffman et al. (2004a; 2008), fun ratings were positively correlated with presence ratings and pain reduction. A number of studies found that participants in the VR condition obtained significantly higher fun ratings compared with participants who participated in the non-VR condition (Maani et al., 2011; Schmitt et al., 2010; Sharar et al., 2007; Wender et al., 2009). These results validate the theory that experiencing fun in a VE is crucial to the effectiveness of VR as analgesia.

5.15.2 Anxiety

If fun is perceived as a positive emotion inhibiting pain, then anxiety is a negative emotion with the opposite effect that facilitates pain. High anticipatory anxiety before labour in pregnant women and patients who regularly require painful medical procedures is a recognised problem and known modifier of pain perception. Women who are anxious and fearful about their impending birth, experience higher pain intensity (Saisto et al., 2001) requiring epidural analgesia (Waldenström et al., 2004). All three dimensions of the pain experience (pain threshold, pain discrimination and pain intensity) are heightened by anxiety and high anticipatory anxiety modified the experience of pain and influenced the capability of all systems of VR to be effective as analgesia (Triberti et al., 2014).

Many studies in Triberti and colleague’s (2014) review that tested VR interventions on reducing pain also reported on anxiety as an outcome measure. However, these authors argue, none of the studies regarded anxiety as a mediator of

VR effectiveness. Anxiety is an important psychological factor to consider as low anxiety was associated with increased responsiveness to VR based analgesia. Several authors examined both anticipatory anxiety and anxiety during treatment in a within-subjects design as an outcome measure in adult and children prior to oncology treatment, intravenous line placement, burn pain and experimentally induced pain (Chan et al., 2007; Gershon et al., 2004; Gold et al., 2006; Gold & Mahrer, 2018; Hoffman et al., 2000; Tse et al., 2002b; Van Twillert et al., 2007). Six out of the eight studies reported significant reductions in anxiety while using VR, and three of these reported significant reductions in anticipatory anxiety. Participants in Tse and colleague's (2002b) study who reported having a lower level of anxiety had improvements in pain threshold and tolerance. There was a significant increase in pain threshold ($t = 5.647$; $df = 71$; $p < 0.001$), mean tourniquet time increased from 123 sec to 187 sec and pain tolerance ($t = 7.088$; $df = 71$; $p < 0.001$), with mean tourniquet time increased from 271 to 380 sec for those participants watching the visual stimulation. The anxiety level was negatively correlated with improvements in pain threshold. Gold et al's (2006) study analysed affective pain (i.e. worry about the pain) and results demonstrated that affective pain increased in the control condition with no VR and was also significantly correlated with intensity of pain. Results from a RCT which evaluated the efficacy of VR compared with standard of care (SOC) for reducing pain and anxiety demonstrated significantly less procedural anxiety (as measured by the anxiety VAS). Patients with high anxiety sensitivity were also found to benefit more from the VR intervention (Gold & Mahrer, 2018).

5.16 Anxiety and pain and perception of time

Patients undergoing painful experiences or procedures, who are distressed and anxious have a perception of time passing very slowly (Somov, 2000; Wittmann et al., 2006; 2007). Patients who experience cancer treatments, such as chemotherapy, identify occupation of treatment time and time perception as an important concern related to this process (Verdura et al., 2005). Accuracy about the passage of time is influenced by a person's emotional state (Droit-Volet & Meck, 2007), for example passage of time appears to vary depending on whether the context is pleasant or unpleasant (Droit-Volet & Gil, 2009).

Studies using the IAPS (Lang et al., 2005) have identified a differential effect on participant's judgements of time as a result of their affective valence. In situations of high-arousal, participants overestimated the amount of time that had passed when viewing unpleasant pictures (mutilated bodies) and underestimated when pleasant pictures (erotic scenes) were shown. In opposition, in low-arousal conditions, unpleasant pictures caused the passage of time to be underestimated and pleasant pictures overestimated. This inverse directional effect of valence suggests two separate actions are activated by arousal: firstly, low arousal is driven by an attention mechanism, and secondly an emotion-driven mechanism for high arousal. Thus, attention and emotion both have an effect on time perception. Distraction interventions, which divert attention away from the passage of time to enjoyable cognitive tasks have an influence on the processing of time, causing a person to subjectively experience time to be shorter than it actually is (Droit-Volet & Gil, 2009; Schneider et al., 2011).

The limited literature on the concept of time perception while immersed in VR proposes that time appears to pass more quickly, this phenomenon is referred to as

the elapsed time compression effect (Schneider et al., 2011). In two studies on healthy adults (Magora et al., 2006) and children (Dahlquist et al., 2009), experimentally induced ischaemic pain was shown to be tolerated for significantly longer periods of time while immersed in VR. Further, in a trial using VR distraction therapy on a group of adult chemotherapy patients, statistically significant results demonstrated that time seemed to pass more quickly (Schneider et al., 2011). The study examined the difference between the actual time elapsed during chemotherapy immersed in VR and their respective estimates of elapsed time. In regressions of the time difference variable (actual minus estimated elapsed time during chemotherapy in VR) F values for all models were significant at $p < 0.001$. The results indicated that they underestimated the duration of an approximately one-hour session by 28%. Most patients underestimated time spent in their chemotherapy session while using VR. However, interesting findings from this study found that variations in cancer diagnosis were associated with the magnitude of differences between actual time elapsed and estimated time elapsed. The greatest change in perception of treatment time as passing quicker was in breast cancer patients. The authors suggest that the reason for cancer diagnosis being an indicator for effect of time estimation may be due to the difference in severity of physical and psychological symptoms among cancers (Schneider et al., 2011). The clinical significance of this study is the development of a 'tool-box' of interventions which can reduce treatment related distress, improve health outcomes for patients in terms of reduced risk of noncompliance, delay, or disruption of life-saving treatments.

Virtual reality interventions have potential as anxiety management tools in the clinical area of pain management. Relaxation techniques can be useful for patients who experience anxiety and fear prior to treatment, and aid in compliance with future

care (Arane et al., 2017). Virtual reality is considered to have an advantage over traditional relaxation techniques which need time to be mastered and require an active imagination. Facilitation of the relaxation process can be expediated by presenting a virtual calm scene 'making the experience more vivid and real than the one that most patients can create using their own imagination and memory' (Gorini & Riva, 2008, p.2).

5.17 Virtual reality hypnosis

The use of hypnosis in pain management has a history stretching back several decades (Elkins, 2014; Montgomery et al., 2000; Patterson & Jensen, 2003), is one of the most reputable in the area of non-pharmacological pain management options and is well documented in the literature (Jensen & Patterson, 2006; Montgomery et al., 2000; Patterson & Jensen, 2003). A systematic review by Kendrick et al. (2016) evaluated the scientific evidence for the effectiveness of hypnosis as an adjunct therapy in the area of acute pain management. Twenty-nine randomised controlled trials evaluating the efficacy of hypnosis during treatments such as bone marrow aspiration, lumbar puncture, burn care, surgical procedures and procedural pain during radiological procedures, abortion and venipuncture were identified. Results identified beneficial results for all these procedures, particularly during surgical procedures where hypnosis was most effective. Seventy-five percent of measures in this area demonstrated significant beneficial results (Kendrick et al., 2016).

There are a range of clinical conditions testing the effectiveness of hypnosis as analgesia including chronic pain conditions for children with cancer (Tomé-Pires, 2012), postoperative pain (Lew et al., 2011), chronic back pain (Elkins et al., 2007;

Tan et al., 2009), and the reduction of labour pain and anxiety (Abbasi et al., 2009; Downe et al., 2015). Studies examining the effectiveness of hypnosis as an intervention consider use in childbirth an area where it is most effective and rewarding (Cyna et al., 2006; Smith et al., 2006).

The combination of immersive VR with hypnosis has been hypothesised as having the potential to increase the effectiveness of hypnosis as an intervention in pain relief and anxiety associated with pain. The ability of VR to expedite the visualisation process for patients in clinical settings using it as a relaxation tool has been appropriated to aid hypnotic inductions. Virtual reality hypnosis (VRH) uses immersive VR as a means of facilitating a hypnotic induction, using similar steps to assist patients as those used in clinician-to-patient hypnotic inductions (Enea & Dafinoiu, 2014; Patterson et al., 2004). The traditional hypnotic induction techniques rely on a person's imaginative ability, their skill at self-absorption. It is hypothesised that VR is capable of inducing hypnosis using the same process, however VR has the advantage in that it can replicate much of the creative stimuli that individuals are required to imagine (Patterson et al., 2004). Individuals must intensely imagine scenarios used in conventional hypnotic inductions, and the objects are cued by clinical hypnotists. The accessibility and efficacy of hypnosis as an intervention will also be increased for individuals with low hypnotisability by using VRH (Patterson et al., 2004; Thompson et al., 2011).

Clinical studies in the area of acute and chronic pain management have explored the use of VHR (Oneal et al., 2008; Patterson et al, 2004; 2006; 2010). In a case report (Patterson et al., 2004) and subsequent case series, Patterson et al. (2006) examined the use of VRH in burn-injured patients before undergoing wound care treatment. Results from the 13-case series reported a mean reduction of 20%

worst pain scores from baseline to post-intervention scores and a 29% decrease in anxiety scores. Clinically significant was a 50% reduction in the quantity of opioids administered prior, during and immediately post wound care treatment (Patterson et al., 2006). There are weaknesses with this case study however, as there was no control group and no randomisation process, therefore the result must be seen as tentative.

Patterson et al. (2010) conducted a randomised controlled trial to determine the effectiveness of VRH in 21 hospitalised patients with physical trauma (i.e. internal injuries, long bone fractures and gunshot wounds). There were three treatment groups; VRH combined with standard care, VR distraction and standard care (VR only, no hypnotic induction) and standard care only. The researchers sought to examine the effects of these interventions upon background pain. Trauma patients experience background pain while they are at rest, this pain is predominantly constant and related to the trauma itself. Patients with chronic pain related to their injuries that received VRH and analgesia had a decrease in subjective pain at 1hr and 8hrs post VRH compared to VR only and standard care and standard care only. Limitations of this study were the small sample size, which meant there was no statistical power to detect significant differences. However, there were still statistically significant differences between VRH and the control groups, so that a study with a larger sample size may well have substantial results.

5.18 Summary

Virtual reality is used in a variety of clinical pain settings in both adults and children. The evidence exists in both clinical trials and systematic reviews that it is effective in the reduction of pain intensity either as an adjunct therapy or alone. It has

also demonstrated its efficacy in the reduction of anxiety in a range of patients, for procedural pain and in oncology. The use of VR in labour and birth is an emerging field, three of the four studies to date have demonstrated statistically significant results in reducing sensory pain perception.

This thesis sought to build on the results of these previous quantitative trials by conducting a mixed method study. By using quantitative and qualitative methods in one group of participants, this study sought to confirm the observations of the previous trials in terms of whether VR had an effect on sensory pain perception. It used pain scores and physiological observations of maternal heart rate (MHR) and blood pressure (BP). Furthermore, this thesis aims to contribute original knowledge and to fill a gap in the available literature by conducting a qualitative study focusing on women's experiences of using VR in the antenatal period and during labour.

This literature review identified several ideal characteristics or criteria increasing the level of presence experienced in VR. Overall a higher level of presence experienced by a user increases the analgesic qualities of VR and the following criteria are appropriate when choosing a VR environment for use in managing pain and reducing anxiety for women in labour. These are:

- Realism
- Interactive
- Narrative
- Fun
- Emotionally arousing

For the purposes of this research project a selection of VEs based as closely as possible on these criteria were chosen for the women to evaluate antenatally and trial in labour. The qualitative phase of this study in the antenatal period will be the

first to identify features of VR that induce an emotional response in the participants and what they wish to experience in their labour.

Labour pain, like pain of any other kind, is not purely sensory but is a complex experience strongly affected by emotions, environment, memory and motivation. However, most studies undertaken by pain researchers to measure the effect of VR on pain intensity and the four studies measuring the effect of VR on labour pain intensity, are dominated by quantitative methodologies relying on numerical scales. The assessment of labour pain in research should reflect its complexity and multidimensional nature, thus a qualitative approach is an appropriate design. In the next chapter, an overview of the methodological approach, that of a mixed methods design, used in this thesis is discussed.

CHAPTER 6: METHODOLOGY

This chapter includes several sections which relate to the research process used in this study. It includes a rationale for the theoretical and conceptual approach to the research process and a description of the research processes used. The preceding chapters have provided a background and theoretical basis to the study's aims. For this study it was considered that a pragmatic mixed methods research design was best suited to answer the research questions and achieve the research aims.

There are a variety of designs in mixed methods research and several combinations such as concurrent, iterative, or sequential. This study used a sequential exploratory design to structure the research. This design allows a degree of flexibility and can accommodate a relative independence between qualitative and quantitative phases of the study, allowing separate data collection and analysis.

The aim of this three-phase, sequential exploratory mixed methods study was to explore the experiences of women using VR in their labour. The first phase was a qualitative exploration of women's initial experience using VR in the antenatal period. In the second quantitative phase, a quasi-experimental study was conducted to determine the effect of VR on labour pain intensity. Finally, in the third qualitative phase an exploration of women's experiences of using VR in labour was conducted. This allowed women to describe, through their narratives, how they used the VR in their labour, in what way (if any) VR benefited them and the challenges that VR presented to them.

6.1 Philosophical underpinnings

Underlying research methodology is the researcher's worldview or paradigm. A paradigm is a way of looking at the world and "is composed of certain philosophical assumptions that guide and direct thinking and action" (Mertens, 2005, p. 7). Paradigms are also recognised as epistemological stances, predominantly positivism/post-positivism and constructivism/interpretivism as distinct shared belief systems that impact the nature of knowledge sought and what research questions are asked (Morgan, 2007). These two distinct paradigms have been dominant in the area of research inquiry and individuals who maintain that paradigms and methods should not be mixed have been labelled as 'purists' (Cameron, 2011; Rossman & Wilson, 1985).

6.2 Quantitative paradigm

Quantitative purists or supporters of positivism/post-positivism believe in the objectivity of social science inquiry, that social observations should be regarded as entities much like physical entities (Johnson & Onwuegbuzie, 2004). Quantitative research relies on a deductive approach where theories can be tested and validated to reach specific conclusions based on general premises. It strives for generalisability by conducting research in a controlled value-free (or value-neutral) or context-free environment (Wheeldon & Mauri, 2011). Post-positivism relies on numeric information, sample size and statistics and the researcher sees herself as not being part of the study (Ansari et al., 2016) and believes in a social world reality that can be determined "independent of social actors" (Bryman & Bell, 2011, p.21).

6.3 Qualitative paradigm

Qualitative purists or constructivists and interpretivists in contrast reject positivism and advocate the superiority of constructivism, idealism, realism, humanism, hermeneutics and, at times, postmodernism (Guba & Lincoln, 1989; Lincoln & Guba, 2000). Their belief is in multiple-constructed realities and the impossibility and undesirability of time and context-free generalisations. Qualitative research focuses on an inductive approach where meaning is generated from the data and logic moves from specific premises to general conclusions (Johnson & Onwuegbuzie, 2004). Qualitative research seeks meaning of the world we live in by studying individual experiences and perceptions (Creswell & Plano Clark, 2018). The qualitative researcher seeks interaction with participants as they are part of the social world (Ansari et al., 2016).

Both quantitative and qualitative approaches have inherent limitations when used in isolation. A quantitative approach is unable to provide an in-depth understanding of social phenomena as it relies on simple data sets and data analysis using numbers to examine an association between predetermined variables (Ansari et al., 2016). A qualitative approach on the other hand, cannot generalise its findings (Dörnyei, 2007). However, the purpose of qualitative research is not to provide generalisable findings, qualitative research focuses on discovery and often uses an iterative approach (Wu et al., 2016). The use of multiple methods in one study can counteract some of the biases and limitations of the methods when used alone and a combination of paradigms in a single study can often strength a given study (Greene & Caracelli, 1997).

6.4 Mixed method research

The idea of combining paradigms in a single study lead to the creation of mixed methods research; referred to as the third methodological movement (Teddlie & Tashakkori, 2003) or the third research paradigm (Johnson & Onwuegbuzie, 2004). It has risen rapidly in popularity in the last 10 years and is a burgeoning area of methodological choice amongst academics in a range of disciplines (Cameron, 2011).

Creswell and Plano Clark (2018) have refined a definition of mixed methods to emphasise one that incorporates core characteristics of mixed methods, as a combination of methods, research design and philosophy. In mixed methods a researcher collects both quantitative and qualitative data in a rigorous process in order to answer a research question and hypothesis. The data is analysed and the two kinds of data and data results are mixed. These methods are systematically arranged into specific research designs that provide the rationale for conducting the study and positions these practices within theory and philosophy.

Practitioners of mixed method research design reject the 'either-or' choices at all levels of the research process (Teddlie & Tashakkori, 2010) and acknowledge the 'paradigm wars' which forces a dichotomy between the postpositivist and the interpretivist positions (Teddlie & Tashakkori, 2003). Purists such as Guba and Lincoln (1989) and Smith (1983) have argued that it is neither possible nor sensible to mix different research inquiry paradigms within a single study. The nature of this debate has become known historically as the incompatibility thesis, the idea that the fundamental differences in the paradigms underlying qualitative and quantitative methods make it inappropriate to mix them (Guba, 1987; Sale et al., 2002; Smith & Heshusius, 1986; Smith, 1983).

6.5 Pragmatism

In contrast to the purist stance the philosophical pragmatic position associated with mixed method research design argued against a false dichotomy between quantitative and qualitative research paradigms and propose an organised use of both approaches (Cameron, 2011). Pragmatism, a derivative of the Greek word 'pragma' meaning action, was founded in the late 19th century as a philosophical movement by American philosopher Charles Sanders Peirce (1839-1914) (Pansiri, 2005). For Peirce, pragmatism was fundamentally a philosophy of meaning, that meaning given to any concept that has real world application lies in the association between the experience and observable results (Ormerod, 2006).

While Peirce is acknowledged for his work in consolidating pragmatism as a philosophical doctrine it was the work of William James who put it on the intellectual map in 1907 with his book, **Pragmatism: A New Name for Some Old Ways of Thinking** (James, 1907). James's definition of pragmatism rejected principles, 'categories', supposed necessities towards facts, action and consequences (Ormerod, 2006).

Finally, in terms of succession, John Dewey, continued the development of pragmatism and its use practically in the field of education and politics in the USA up until the Second World War. Dewey, a professional philosopher, spent much of his career promoting pragmatism as a reorientation of philosophy away from abstract issues and instead moving towards a focus on human experience (Dewey, 1920/2008; 1925a/2008 as cited in Morgan, 2007). Integral to Dewey's philosophy of knowledge was a concept of inquiry in which knowing cannot be separated from doing. For Dewey, the knower and the known couldn't be separated, they were

linked in an inquiry process, which simultaneously depended on both beliefs and action (Morgan, 2007).

These philosophers and innumerable other academics and non-academics in the last century were in consensus regarding the rejection of traditional assumptions about the nature of knowledge and inquiry. There was a challenge by these early pragmatists of the idea that the 'real world' could only be accessed by a singular scientific method (Maxey, 2003). Rather they believed that key to acquiring meaningful knowledge was ordinary experience and a desire for a better world (Wolfe, 1999).

6.6 Foundations of research

All research needs a foundation and this foundation, be it explicit or not is identified in the researcher's chosen 'worldview' or theoretical framework (Creswell & Plano Clark, 2018). Crotty (1998, p.9), in his discussion about worldviews, proposes that these differing stances are not 'watertight compartments', but rather worldviews can guide the general direction of the research and can be used in combination or individually (Creswell & Plano Clark, 2018).

Crotty's (1998, p.5) table, **Common Elements of Worldviews and Implications for Practice** provides a clear account of the controversy relating to pragmatism within social science inquiry, known as the 'paradigm wars' (Teddlie & Tashakkori, 2003, p.5). In terms of key worldview elements pragmatism uniquely stands alone. Distinct from other theoretical frameworks pragmatism as a worldview puts the consequences of the research at the front, emphasises the importance of the research question over research methods used and unashamedly uses multiple data collection methods to inform the study (Creswell & Plano Clark, 2018).

Ontology is the study of being and is concerned with what actually exists in the world for people to know about and how humans can acquire knowledge. A relativist ontological perspective is supported in this research. It supports the belief that reality is constructed within the human mind. This reality is relative for each individual who may experience it differently according to their time and place. There is no one true reality (Moon and Blackman, 2014). In terms of ontology and axiology, a mixed methods researcher may claim an intermediate position, acknowledging the fact that both objective and subjective views of a reality are valuable and that both biased and unbiased perspectives can be included in the research inquiry (Ansari et al., 2016; Creswell & Plano Clark, 2018). Epistemology or the study of knowledge is interested in how people create knowledge and the realms of what is possible to know in the world. A constructionist epistemology is supported in this research. That is that meaning or truth or the construction of knowledge comes about as people engage with and interpret their world (Moon and Blackman, 2014; Crotty, 1998). Epistemologically, central to pragmatism is practicality. Data is collected by the researcher according to 'what works' when answering the research question (Creswell & Plano Clark, 2018). Methodologically, both quantitative and qualitative data are collected, mixed and analysed separately (Creswell & Plano Clark, 2018).

This mixing of methods, it is argued, can strengthen a study, by triangulation, where different methods (either qualitative or quantitative) are used to assess the same phenomena and results from each method converge thus increasing validity (Caracelli & Greene, 1997). It allows us to understand phenomena more fully, to gain in-depth and broader insights due to the wider range of views and perspectives presented (Greene & Caracelli, 1997). A mixed method study that integrates both

interpretivist and postpositivist traditions would seek knowledge based on the lives of the participants and yet also be generalisable to other people and situations:

Enhance understanding of both the unusual and the typical case, that isolate factors of particular significance while also integrating the whole, that are full of emic meaning at the same time as they offer causal connections of broad significance (Greene & Caracelli, 1997, p.13).

Mixing methods in research is not without its challenges and controversy both within and outside the mixed method research community. Mixed method researchers have been accused of methodological eclecticism, and the use of methodological choices that are incongruent and not sufficiently justified (Bryman, 2008). However, Rossman and Wilson (1994, p.778) argue that mixed methods research (MMR) should be 'shamelessly eclectic and the future of the field should feature increasingly interesting mixtures of methods.'

6.7 Rationale for mixed method research design

For this study it was determined that a mixed methods research design was best suited to answer the research question and to meet the research aims. This study aimed to explore the experiences of women using VR in labour. Labour pain, like other kinds of pain, in studies undertaken by pain researchers is commonly quantified using numeric or semantic scales which aim to capture the intensity of pain experienced at that timepoint. However, labour and labour pain are complex, multi-dimensional phenomena.

To fully explore and understand the phenomenon of women's labour and birth experience using VR as a non-pharmacological intervention and to determine a

possible effect on labour pain of VR, a mixed methods approach was chosen as the most appropriate methodological approach. To best capture the experiences of women using VR in labour a qualitative phase within the study was considered most appropriate. A qualitative approach would allow rich description of the phenomenon being studied and allow a better understanding of the phenomenon which would lead to a greater contribution of knowledge in the area.

A further aim of this study was to determine if there was an effect on labour pain intensity for women using VR in their labour. A quantitative approach using a quasi-experimental method was considered most appropriate to answer this question and meet this aim and was included as the second phase of the study. Experimental studies attempt to determine causality between variables of interest. The mixture of qualitative and quantitative phases in this study was considered necessary as each method by itself was not appropriate to answer the research question or to meet all the objectives of the study. The combination of qualitative and quantitative methods in this study on complex phenomena of labour and labour pain would complement each other and strengthen the study.

6.8 Characteristics of mixed method research

In determining the type of mixed method design to use for a research study, scholars in the field refer to such concepts as: dimension of paradigm emphasis, time ordering of the phases and the degree of mixture of methods and where mixture will occur. Morse (2010, p.351) advocates five checks to be undertaken by the researcher.

1. Theoretical drive – inductive or deductive
2. Core component – qualitative or quantitative

3. Supplemental component(s) – qualitative or quantitative
4. Pacing: Simultaneous or sequential
5. Point of interface: Analytic or results narrative.

Creswell (2009) discusses three components when designing a mixed method study that must be addressed by the researcher. These include the timing of the qualitative and quantitative phases within the single study, either concurrently or sequential and the weight whether it is dominantly qualitative or quantitative.

Creswell (2009) advises the researcher to assign equal or unequal weight to the different types of data collected and identify whether analysis favours qualitative or quantitative assumptions about meaning. Mixing of the data refers to where in the study the qualitative and quantitative data are integrated, for example, in the data analysis or narrative findings.

For this study a sequential exploratory mixed model design was selected as the best fit. There were three phases in this study, qualitative, quantitative, and qualitative. These were carried out sequentially, with each phase being completed prior to the next one beginning. Exploratory describes the emphasis of the study which was qualitative, or as Morse (2010) refers to it, the core component with the supplemental component being quantitative. In terms of mixing, preliminary data analysis of the first qualitative phase of the study informed some aspects of the second quantitative phase (Phase 2), mainly in terms of the type of VEs offered to the women when they were in labour based on their self-selected preferences antenatally. The main integration between qualitative and quantitative data is in the results narrative, or the simultaneous discussion of qualitative and quantitative results.

QUAL	→	quan	→	QUAL
QUAL Data Collection		quan Data Collection		QUAL Data Collection
↓		↓		↓
QUAL Data Analysis		quan Data Analysis		QUAL Data Analysis
Data Results Compared				

Table 1. *Sequential exploratory design in mixed methods research* (Creswell, 2009)

6.9 Methods

6.9.1 Phase One - Qualitative

This first phase of the study sought to determine the acceptability of using the intervention of VR in labour. Participants recruited to the study were pregnant women who were introduced to the VR headset and shown the four commercial VEs in their own home. The four VEs were chosen based on criteria identified in the literature.

Figure 7. *Oculus Go VR headset.* Image reprinted with permission

These criteria identified certain elements as being conducive to producing a positive mood state which may include relaxation, happiness, or contentment. Scenes that included elements of nature were chosen to induce a positive mood state. This idea of a positive mood state was chosen in preference to the idea of fun identified in the literature as an important criterion for VEs used in pain management. It was considered that a woman in labour would prefer a positive, relaxing scene rather than an interactive game. Other elements in the VEs were chosen due to their potential to be distracting, they had a narrative component. While ideally more realistic scenes would have been preferred for the

underwater environment and the beach environment, natural environments of this type were found to have groups of people doing activities or talking in the environment which was not considered conducive to relaxation.

The four scenes included an animated underwater scene with dolphins, accompanied by a classical music piece. This VR scene was part of a VR experience titled “Ocean Rift”™.

Ocean Rift is manufactured by Picselica Ltd. Ocean Rift was used in a recent international research study on VR in labour (Frey et al., 2018).

The second scene was also animated, it was a beach scene, accompanied by music and natural sounds such as waves crashing. This was part of Nature Treks VR, manufactured by Greenergames.

The third scene was a scene used for meditation and consisted of brightly coloured moving shapes accompanied by a type of Zen chanting music. It was titled Shape Space VR – Zen Parade and was manufactured by Mack Art Productions.

Figure 8. *Ocean Rift*. Printed with permission by Ocean Rift. Picselica LTD.

Figure 9. *Tropical Island*. Photo by Yang Wewe on Unsplash. Reprinted with permission

Figure 10. *Zen Parade*. Reprinted with permission.

The final scene was a documentary type scene of real shots of space, including the Hubble telescope accompanied by music and a voiceover. This was called Birth of a Star and was part of VeeR and manufactured by Velicious Technologies. A total of 10 VEs were assessed and compared before choosing these final four.

Figure 11. Space scene. Photo New York Public Library on Unsplash. Reprinted with permission.

A semi-structured interview with each participant was conducted. After each VE was viewed a series of open-ended questions were asked about that VE. These questions were to determine if an emotional response was induced after the VE and what this was. Further questions related to questions about the VE and its features, what was enjoyable, not enjoyable, or neutral. After the final VE was shown a series of open-ended questions relating to the concept of presence was asked. The participants were asked how they envisaged using the VR in their labour and their ideal scene. The purpose of this was to determine whether VR was considered useful for distraction, or relaxation by women in labour. Identifying features in their ideal VE would help the participants when choosing VEs to view in labour and would inform future design of VEs for use in labour. See Appendix (A) for a copy of the questions approved by VUW HEW and Appendix (B) are the questions asked of the participants (after transcription of the interviews) which are represented in the antenatal themes.

After the first six participants had used the VR in their labour a modification was made to the study to allow the participant to use the VR headset at their leisure in early labour. At the antenatal interview the participant was shown the basics of

how to use the VR headset, how to charge it and to load up different scenes. The headset was then left at their home, and they could use it whenever and for how long they wanted to in early labour and then bring it into the hospital with them if they were having a hospital birth. This modification was made so that the researcher did not have to be on call 24 hours a day/7 day a week to drop the headset off when the woman thought that her labour had commenced.

6.9.2 Phase two – quantitative

For the subjective measurement of labour pain intensity the Numerical Reporting Scale (NRS) (Appendix C) was used by the researcher. The NRS is a validated instrument recommended for assessment of pain intensity (Hjermstad et al., 2011). This instrument is a numerical scale from 0 (no pain) to 10 (maximum pain). Participants were asked to verbally report their pain score during the intervention when they were wearing the VR headset. The NRS has the advantage of being quick, simple and requires no equipment. The assessment of pain was assessed and recorded for the participants in two-time periods in labour:

1. Pre-intervention (baseline data gathered before they used intervention at the end of a 10 minute period);
2. During the intervention (at the end of the 10 minute period).

Each condition, pre-intervention and during intervention were measured as a 10 minute period to replicate the study by Frey et al. (2018) and previously studied maximum exposure times of VR for acute pain (Hoffman et al., 2011).

At the request of committee members of the Health and Disability Ethics Committee (HDEC) ¹⁸ a randomisation process was included in the research design. Participants were randomly assigned to receive VR, followed by the opposite condition after a 10 minute washout period. This crossover design allowed each participant to serve as her own control to decrease the variability between separate participant's labour experiences. Participants were observed for equivalent times during unmedicated contractions (also without alternative therapies) in both the VR and non-VR conditions. The participants were blind to the randomisation.

The objective or physiological outcome measurements recorded were maternal heart rate and blood pressure pre-intervention or post-intervention and during intervention. The autonomic response to stress is intensified by pain (Miller & O'Callaghan, 2002), as evidenced by a rise in circulating stress hormones in response to pain (Greisen et al, 2001). If we assume that pain changes the autonomic nervous system our assessment tools need to observe the parameters of the cardiovascular system (blood pressure and heart rate responses) (Cowen et al., 2015). However it needs to be acknowledged that the use of physiological measures is controversial on two levels: firstly it is reported that there may only be weak or moderate correlations between physiological changes and pain (Walco et al., 2005) and, secondly the potential confounding nature from other variables such as fear, anxiety and exertion (Van Cleve et al., 1996; Von Baeyer & Spagrud, 2007). However, when conducting clinical pain trials it is still recommended to

¹⁸ The Health & Disability Ethics Committee (HDEC) is a ministerial committee whose function is to secure the benefits of health and disability research by checking that it meets or exceeds established ethical standards. HDEC approval is required when research involves an intervention and human participants. At the same time ethics approval is required by the University conducting the research; Victoria University Human Ethics Committee (HEC).

include these objective physiological outcome measures to ensure a comprehensive approach (McGrath et al., 2008; Von Baeyer & Spagrud, 2007).

Measurements were taken at the end of the two time periods in two stages of labour (early labour – when pain score is <3 or when the woman has 2 contractions in 10 minutes, lasting approximately 30-45 seconds and active labour – when pain score is >8 or when the woman has 3 contractions in 10 minutes lasting approximately 60-90 seconds (Bennett & Brown, 1993).

The assessment of early and active labour was achieved by a number of means, firstly the participant self-reported her contraction strength, frequency and pain score. Her LMC midwife assessed the participant's contraction strength and frequency and asked her pain score. The stage of labour was confirmed on several occasions by a vaginal examination to determine progress by the participant's LMC. The participant, her partner and the LMC were requested to contact the researcher when it was determined the woman was in early labour and active labour either at home or in the hospital.

The majority of measurements were undertaken by myself to ensure consistency, however there were two occasions when this differed. Firstly on one occasion, the participant's partner (who is a Registered Nurse) took the measurements and on the second occasion the participant preferred that her LMC take the measurements. This was completed while I was in the room. The measurements taken in early labour were a combination of a manual sphygmomanometer and manual heart rate measurement and electronic dynamap. The measurements taken in active labour (which are used in the data analysis and discussion) were all (except one) taken by an electronic dynamap. The use of the same instrument for pre-test and post-test measures addresses a potential threat to

internal validity, that of instrumentation, when the instrument changes between pre-test and post-test, which can potentially impact on the scores of the outcome measured (Creswell, 2009).

6.9.3 Phase three – qualitative

This final phase in the study aimed to explore the experiences of the participants who used VR in their labour. These participants were interviewed in their home in the postnatal period; day 7-10. It was difficult to conduct the interviews earlier due to women being tired with a new-born, establishing breast-feeding and often recovering from caesarean section surgery. A semi-structured interview was conducted (see Appendix D for questions).

6.9.4 Interviews

Preparation for both qualitative interviews in phase one and three of the study involved reviewing the literature as to content of the question schedule. It was also necessary to consider my role as a midwife and having prior knowledge and beliefs in terms of labour and birth. I used journals to reflect on this duality of roles, as midwife and researcher and discussed it with midwifery colleagues and my supervisors. This prior knowledge and beliefs that I held could help with the use of prompts in interviews that were stalling and could be useful in building rapport with participants. It was important, however, to put my midwifery hat to one side and to fully engage as a researcher. Berg (2009, p.1010) gives a description of an interview as simply 'a conversation with a purpose.' Thus the questions that need to be asked by the researcher should centre on the aims of the research and ideally

should be short, simple, open and self-explanatory (Patton, 2002; Tolich & Davidson, 2003).

In the design of interview questions, the interviewer should seek to ask open-ended questions and allow the opportunity for the interviewee to consider their response. Open-ended questions also allow the researcher to gather rich data, as opposed to questions that can be answered with just a 'yes' or 'no' (Tolich & Davidson, 2003). Patton (2002) suggests that if greater detail is needed in regards to the responses a series of prompts can be used. In general, it is advisable that leading questions that suggest the favoured response are avoided, correspondingly questions that begin with 'why' should be excluded as the implication exists that the respondent is able to assign cause (Patton, 2002).

While the skill and experience of the researcher is central to the quality of the data and the success of the interview, Tolich and Davison (2003) identify several issues that can affect the process. These are: the social situation, the chosen setting of the interview and power dynamics between interviewer and interviewee. Particularly the last of the three points, power issues, has the potential to make the interviewee give the response they think the interviewer wants to hear or that presents them in the most favourable light. Researchers need to be aware that people have a natural tendency to want to give the 'right answer' to questions or the socially desirable answer, in order to preserve their self-image (Tolich & Davidson, 2003, p.141). While the design of questions is constructed in order to elicit a logical response, social behaviour is invariably founded on emotional or illogical factors (Rees, 1997).

In order to mitigate some of these problems, the researcher is encouraged to use different approaches or change roles to optimise the interview performance

(Berg, 2009). Such strategies can include the use of role play or questions based on scenarios, where the participant is asked to imagine a scene or set of circumstances and explains it to the researcher (Patton, 2002). While Berg (2009) encourages us to view interviews as similar to the everyday conversations we have with people, their intent is diametrically opposed. Where an interaction in a normal interchange may be discontinued due to a level of discomfort between the parties, a skilful interviewer should at this point extend out the interesting dialogue by the use of prompts (Berg, 2009). In a similar vein the researcher conducting the interview often wishes to move the conversation from one topic to another. A useful way of achieving this is by summarising the preceding conversation and by indicating the new topic of interest. It is ideally managed by giving the interviewee the opportunity to add any final comments before the conversation moves on (Patton, 2002).

Another important consideration in the interview process is the potential for the recollection of emotional or upsetting events by the participant (Patton, 2002; Rees, 1997). If this occurs and the participant becomes upset it may be prudent for the interview to either be paused, postponed or abandoned in some cases. However it is argued, in some instances these emotional upheavals can be cathartic, giving participants a voice and an opportunity to resolve personal issues (Patton, 2002; Rees, 1997).

This study interviewed participants antenatally in phase one and many participants shared their previous labour and birth experience with myself. Phase three of the study interviewed participants about their current labour and birth experience. Labour and birth is a life changing momentous experience which leaves many women emotional and vulnerable. I am a midwife and aware of this and

participants were advised in the information sheet and in person that the interview would be paused, or discontinued if any recollections caused distress.

6.10 Recruitment of participants

The core component of this mixed method study was qualitative. The number of participants is generally small in qualitative research as its purpose is to gain an in-depth understanding of the phenomena being studied (Burns & Grove, 2001). A purposeful non-random sampling method was used to recruit participants. This method was chosen as it would capture information rich cases to study in-depth. It is acknowledged that qualitative data, rather than being interested in empirical generalisation (Patton, 2002) has as its purpose to contribute to understanding and knowledge by describing phenomena within a certain group of people or population (Wu et al., 2016).

Sample size in qualitative research is also dependent on practicalities of time related to the research and the concept of saturation of information. This concept of saturation is best explained as being at the point when no new information from interviews is forthcoming. This can result in trying to recruit additional participants if saturation hasn't been reached or reduction of the sample size if saturation has been reached. Therefore, the research design should remain flexible and emergent in regard to sample size numbers (Patton, 2002).

Response to recruitment for this study was very encouraging, occurring almost immediately after recruitment flyers went out and continued over the recruitment period of six months. Participants volunteered to take part in this study after meeting the following inclusion criteria:

- Nulliparous or multiparous
- > 35 weeks pregnant and over at time of recruitment
- 18 years of age and over

Participants were excluded from the study if they met the following criteria:

- History of seizures
- History of vision or hearing deficits
- History of psychiatric disturbances
- History of severe nausea
- History of predisposition to motion sickness
- English as second language and as a result requiring use of an interpreter

Participants for this study were recruited by a variety of means. Firstly, information about the study was sent via email to LMCs, midwives and obstetricians in the community. This initial information was in the form of a recruitment flyer with basic details about the study and my contact phone number and email (see Appendix E). Information about the study was also distributed via the locality hospital's community midwifery team via email and face-to-face information sessions. This included distributing copies of the recruitment flyer. I also visited group practices of LMC midwives and obstetricians and gave details of the study and left recruitment flyers. I attended several antenatal classes in the community informing the attendees of the study and handing out recruitment flyers. At all the face-to-face meetings there was an opportunity to experience the VR environments that the participants would be shown.

Women interested in participating in the study contacted myself either by email or phone and I then sent a copy of the information sheet and consent form (which included inclusion and exclusion criteria) via email (see appendix F). There were

three phases to the study and there was an information sheet specifically for the first phase and third phase separately (see appendix G and H) and another information sheet and consent form which included consent for all three phases (appendix F). All the participants except one indicated at first contact that they wanted to be in all three phases of the study. Two participants didn't want to do the first antenatal phase, just the labour phase and postnatal phase. The information sheet sent out to all except one gave information about all three phases and consent was given for the three phases. An appointment was made with the participants for the first phase of the study, and I went through the information sheet with the participant, identifying inclusion and exclusion criteria. Any questions about the study were answered. Participants signed the consent form and retained a copy of the information sheet and consent form. Participants received a koha for participating in this study.

6.11 Data analysis – qualitative

Qualitative analysis allows for the data to be extracted from texts, observations and interview scripts and this results in the 'thick, rich description' of the phenomena being studied, of people's lived experiences (Creswell & Miller, 2000; Denzin, 1989; Krippendorff, 2004; Geertz as cited in Patton, 2002). Interviews were recorded by me, using a Sony digital voice recorder and an iPhone, and downloaded to a laptop for transcription. Each voice file was transcribed verbatim by me. Patton (2002) describes verbatim transcriptions as the essential raw data for qualitative analysis. Thematic analysis (TA) based on Braun and Clarke's writings (2012) was used to encode the qualitative information derived from the semi-structured interviews. Braun and Clarke (2019) have updated their thematic analysis approach. They prefer to use the term reflexive TA, which, they argue, needs to be

implemented with theoretical insight and transparency. It is necessary for the researcher to be fully aware of the philosophical and theoretical assumptions underpinning their use of TA (Braun and Clarke, 2019).

The 'systematic' and 'sophisticated' development of TA by Braun and Clark (2012) was incorporated into their research in the field of psychology. Braun and Clarke (2012) argue that the strength of TA lies in the fact that it is not an approach to conducting qualitative research, but just a method to analyse data. This allows TA to be flexible and to be used across three main continua within which qualitative data is situated. These are: an inductive or a deductive approach to coding and data analysis, an experiential versus a critical attitude to data and an essentialist or a constructivist theoretical perspective (Braun & Clarke, 2012).

Inductive TA is usually experiential in orientation and positions itself within an essentialist theoretical framework, that is it gives meaning to lived experiences in the world as expressed in the data. Deductive TA is associated with a critical orientation to the data and is constructionist in its theoretical framework. It is interested in how the world is constructed and the beliefs and presumptions that informs the data (Braun & Clarke, 2012). For my research project I followed an inductive thematic analysis framework.

The qualitative strands in this study suited a TA method to data analysis. Part of the research question was experimental and exploratory and so an inductive approach dominated, in which codes were driven by the data content on the basis of participants' experiences. This study used the six phases of the TA process as identified by Braun and Clarke (2012).

Firstly, and common to all qualitative approaches to data analysis I familiarised myself thoroughly with the data by listening to the audio recordings of

the interviews as I transcribed them and simultaneously any words or phrases that resonated with me in relation to the research question were noted down in a journal. I read and re-read the transcripts. As I read the transcripts, I made notes on the data in the following ways: by annotating transcripts, underlining portions of the data to highlight items of interest.

The second phase of the TA approach is the beginning of the systematic analysis of the data by coding which is the building block of analysis. I worked through the text in the interview transcripts by identifying the code name on the hard-copy data and highlighting the text. I then transferred the relevant text under the code name into a notebook. While some parts of text came under several codes, I did not worry about that overlap at this stage preferring to ensure that the coding was inclusive, thorough, and systematic.

Figures 12 and 13. Development of codes and themes.

Phase 3 is where the data analysis begins to take shape, it is the generation of themes from codes. A theme, according to Braun and Clarke, 'captures something important about the data in relation to the research question and represents some level of **patterned** response or meaning within the data set' (2012, p.82). The coded

data was searched for similarity and overlap, and I organised it into broad topics or themes. Once themes were identified, I collated all the data extracts relevant to each theme.

The fourth phase of the data analysis involved reviewing the potential themes. I checked the themes and subthemes that were generated from the data against the collated data extracts in order to see whether that theme captured the data. I reviewed the themes in relation to the entire data set and reread all the data to ensure that my themes captured the data in a meaningful way.

The fifth phase in the thematic analysis process refers to the defining and naming of themes. I named the themes and wrote several sentences about each theme, what is unique and specific to each theme. They state that each theme should have a singular focus, related but not overlapping and should directly address the research question.

In the final sixth phase the report is written. I selected extracts that would provide a vivid, compelling example of the themes I had chosen, why those extracts were interesting and how they related to the research question. The extracts were interpreted in relation to the theme and the research question. These were part of my results chapter. The analysis and discussion of the findings of the qualitative data in relation to background literature was included in separate discussion chapters.

6.12 Rigor in qualitative research

Rigor and trustworthiness of qualitative data can be addressed using the following criteria: credibility, transferability, and dependability. In terms of credibility: triangulation of research methods and data, continuous checking of data (coding, themes) by validating data with key informants, transferability: extensive participant

quotes, dependability and the maintenance of an audit trail including memos, coding entries and concept maps (Creswell & Plano Clark, 2011; Miles & Huberman, 1994; A. Teddlie & Tashakkori, 2009).

For this research study, after the recordings were transcribed they were sent out to each of the research participants to check for accuracy and any other feedback was sought. In terms of transferability there are extensive participant quotes included in the results section of this thesis. Finally, dependability, a comprehensive data file was established and maintained throughout the research process for each participant. This included details of the participant in each phase of the study, transcripts, field notes after each interview and records after each step in the data analysis process including coding notes and the development of initial themes and how these developed into final themes and subthemes.

6.13 Rigor in quantitative data

The term rigor in quantitative research is usually described as validity and reliability. There are threats to internal and external validity in conducting experimental research (Teddlie & Tashakkori, 2009). Internal threats discussed in the context of this research study are mortality or participant drop-out rate and instrumentation. Only one participant dropped out of this research study. Threats to internal validity in relation to instrumentation refer to if the instrument changes between a pre-test and post-test measurement as this can affect the participant scores (Creswell, 2009). The same instrument, that is, the numeric verbal reporting scale and the same manual blood pressure machine or dynamap (electronic blood pressure machine) was used pre-test and post-test in this study to ensure validity.

External validity refers to statistical conclusion validity when the researcher draws inaccurate inferences from the data due to inadequate statistical power (Creswell, 2009). It is acknowledged as above that the subjective pain scores were underpowered with a sample size of 14.

6.13 Data analysis – quantitative

Quantitative data analysis is the analysis of numerical data, the determining of whether a relationship exists between variables. To determine whether a relationship existed between VR (the independent variable) and labour pain intensity (the dependent variable) a data analysis method which tested a hypothesis was necessary. Such a data analysis method is classified as an **inferential statistical** method and an example used in this study is the t-test, used to test for significance of differences between the means of two groups (Teddlie & Tashakkori, 2009). This study compared objective physiological measures and subjective measures of labour pain intensity during intervention and post-intervention, and pre-intervention and during intervention. To determine the sample size required for the study I made some assumptions (regarding MHR, BP in labour) as there was little quantitative research in the literature measuring variables in labour to assist in determining statistical power. I have assumed that the MHR, maternal systolic and diastolic blood pressure and mean arterial pressure will each have a standard deviation of 5 units.

The programme G-Power was used to calculate the sample size by assuming that with a sample size of 10 women in active labour the research study had enough statistical power (at least 80%) to detect a 5 unit decrease in maternal heart rate, maternal systolic and diastolic blood pressure, testing at the 5% significance level using a one-sided paired sample t-test to compare the physiological measures

during intervention and post-intervention and pre-intervention and during intervention. The sample size for this study was 14 participants in active labour.

It was determined that a sample size of 14 was feasible, so 14 participants used the intervention in this study. The sample size was limited due to unforeseen difficulties accessing the participants that included the LMC or the participant or the participant's partner not contacting me when the participant was in labour.

The data was analysed using SPSS software. Note: It is acknowledged that the standard deviation may be larger which will reduce power.

In terms of the subjective measurement of pain scores using the Numeric Reporting Scale (NRS) the same approach was used (utilising one-sided paired samples t-tests), however it was estimated that a sample size of 16 was needed (or as large as 27 depending on the standard deviation). Any analyses using pain scores was therefore going to be underpowered with a sample size of 14 but may still be useful for planning future quantitative studies in this area as it would provide an estimate of the effect size. Another approach that was taken with the subjective measurement of pain scores using the NRS was to report the number of 14 participants (as a percentage) that reported a decrease in pain. This would be useful to determine statistical power and required sample size in future studies and would contribute to future research in this area.

6.14 Ethics

All research needs to be conducted in an ethically sound manner. Obtaining ethical consent for this study involved several processes and organisations. This was a three- phase mixed method study. Each phase was separate, however each phase needed to be conducted in order. Phase one of the study obtained ethical approval

from Victoria University of Wellington Human Ethics Committee (VUWHEC 0000026410) on 5th April 2019. Phase two was an intervention study and ethical approval was obtained through the Health Disability Ethics Committee (HDEC 19/NTB/30) on 4th April 2019. Part of HDEC's requirement was an information sheet and consent form that included all three phases of the study. This was used to consent all the participants as they all agreed to participate in more than the first phase of the study. This part of the study was also registered as a Clinical Trial with the Australian and New Zealand Clinical Trial Registry on 30th March 2019 as it was an intervention (Clinical Trials Registry number: ACTRN12618001776291P). Phase three of the study obtained ethical approval from Victoria University of Wellington Human Ethics Committee (VUWHEC 0000027393) on 30th May 2019.

As the phase two intervention part of the study involved gathering data from participants in a hospital setting, two District Health Boards, were contacted via their research committees to provide locality approval to conduct research. This locality approval was obtained on 2nd April 2019 and permission to conduct research in a tertiary and secondary birthing unit at a satellite hospital and a stand-alone birthing unit was given. As part of the locality approval, consultation was also undertaken with Research Advisory Group – Māori (RAG-M) on 5th April 2019.

6.15 Informed consent and privacy of participants

In addressing the ethical requirements of informed consent for participation in this study, all participants were provided with a plain-language information sheet (see Appendix E) describing the study and its processes. I was present when the participant read the information sheet and was available to answer any questions

that arose. The participant signed the consent form and was given a copy of both the information sheet and the consent form.

The participant's identities are confidential in the dissertation and the names used are pseudonyms. The data is kept in a secure place and the recordings and transcripts are only available to myself and my supervisors. All participants were offered a copy of their transcript prior to the dissertation being completed and to check for accuracy and were informed of their pseudonym. All information on computers are held on password-protected files to ensure confidentiality. Data will be held for 5 years after the completion of the thesis and then destroyed.

6.16 Protection from harm

When the participants were in labour verbal consent was always obtained prior to the measurement of the research variables. The participants were also informed that they could take the VR headset off at any time if they felt nauseous or suffered from motion sickness. This advice was given in the first phase of the research in the antenatal period and the second phase of the study when the participants were in labour. The participants were informed in the information sheet of the possible side effects of VR.

The final phase of the research in the postnatal period explored women's experiences of using VR in their labour and birth. The postnatal period is a particularly emotional and exhausting time for women as they recover from a long labour and surgery such as caesarean section or instrumental deliveries. While previous research recommends interviews on day 2 or 3 for optimum memory recall, this was not practical or possible for the participants involved in this study. Many participants were in hospital until Day 5 after a caesarean section birth and many

participants stated when they were first recruited that they did not want to be interviewed so soon after birth. It was important to respect this wish and day 7-10 became the best time to conduct the interviews. It was important when visiting participants in their home with a newborn baby to conduct the interviews as quickly as possible. Reflecting on labour and birth can be emotionally upsetting for many women and participants were able to stop or pause the interview at any time.

6.17 Cultural issues and the Treaty of Waitangi (Te Tiriti o Waitangi)

There is the potential for cultural harm to occur whenever research is undertaken, particularly in situations where the researcher and research participants are from disparate cultural and ethnic backgrounds (Mertens, 2003). Researchers in Aotearoa New Zealand need to understand the cultural diversity that exists and the need to acknowledge this diversity when undertaking research. This includes an awareness of differences in historical focus and cultural symbols among different ethnicities. Also, of significance is the cultural difference between the researcher and the researched (Spoonley, 2003).

In Aotearoa New Zealand ethical and Treaty of Waitangi obligations require transparent and accountable consultation with the *tāngata whenua* in the area of conduct of research, recruitment of participants and the dissemination of research findings. Given the importance of the Treaty of Waitangi in Aotearoa it is appropriate that any research explicitly considers the principles of the Treaty of Waitangi, Partnership, Participation and Protection at all stages of the research journey.

Spoonley (2003) suggests that research is a partnership that needed to be negotiated at every stage of the research journey. Researchers need to be accountable to the community and to take responsibility for their own actions when

conducting research. Finally, the outcomes of the research, for example, new knowledge, skills and any publications need to be shared with the community of interest.

For this study an attempt was made to recruit Māori participants through LMC midwives who had significant numbers of Māori clients, recruitment flyers were distributed and face-to-face meetings with the LMCs were held. Consultation prior to the research study commencing was undertaken with Research Advisory Group Māori (RAG-M) and further consultation was sought in a teleconference meeting of the Health Disability Ethics Committee. Advice from the Māori representative on HDEC was to acknowledge when recruiting Māori research participants that the head is tāpu and that asking someone to wear a headset may be an issue.

6.17 Summary

A research project must demonstrate trustworthiness, the ability to show the cohesion and relationship between the aims and objectives of the research and the features of the research design. Integral to this process are descriptions of how the research is undertaken, how recruitment of participants is carried out and an overview of cultural and ethical issues addressed. This concept of trustworthiness also depends on the meticulous analysis of data and accurate presentation of research findings. This chapter has considered and acknowledged these areas in relation to the three data strands of this mixed methods research project. The following chapter presents, interprets and discusses the findings from the first phase of this mixed method research project; the qualitative data from the semi-structured interviews with women in the antenatal period of their pregnancy after they experienced the VR and four specific VEs.

CHAPTER 7: PHASE ONE ANTENATAL QUALITATIVE FINDINGS

This and the following two chapters present the findings from the three phases of the sequential exploratory mixed method study carried out to answer the research questions posed at the beginning of this thesis and to achieve the aims of the research. The research questions posed were: what are the experiences of women using VR antenatally, what is the effect of VR on labour pain intensity and what are the experiences of women using VR in labour? The aims of the research were to determine the acceptability of VR as an intervention in labour and to measure variables of labour pain intensity to determine whether VR had an effect on labour pain intensity and to explore women's experiences of using VR in labour. In this first chapter the findings from the qualitative interviews with women in the antenatal period after they had experienced the four VEs are presented and discussed. In Chapter 8 the results from the quasi-experiment are presented and discussed. In Chapter 9 findings from the interviews held postnatally with participants are presented and discussed.

The chapter commences with an overview of the participant sample who were interviewed. It then presents each of the three themes and their connected subthemes that were constructed from the analysis.

7.1 Participants

Demographic data was obtained from the 25 pregnant women who expressed interest in the project, and of these 23 consented to all three phases of the study. Two participants consented to participate in phase two and three only. One participant withdrew after phase one of the study. Of the 24 potential participants, 23

completed phase one of the study, 14 completed phases one and two, and 19 participants completed phase one, two and three. Two participants completed phase two and three of the study only. Four of the participants who consented to all three phases were unable to participate in phase two or phase three due to expeditious births, and two participants who consented to all three phases could not participate in phase two or three due to early epidural use and not using VR at all in labour.

Figure 14 summarises participation in all three phases of the study.

Figure 14. Flow chart showing phases of recruitment of participants

Demographic characteristics of the 25 women are summarised in Table 2.

Table 2 shows that most (64%) participants were aged between 25 and 34 years, and approximately two thirds (68%) were having their first baby. Participants actual ages ranged from 28 to 42 years. Most participants identified as New Zealand European (60%). No Māori or Pasifika women participated in the research, however six participants identified as Asian (2 Filipino, 1 Korean, 1 Cambodian and 2 Indian). Ninety six percent of the participants had received a tertiary education. Only two participants had previous experience with VR.

Table 2. *Demographic characteristics of participants*

Characteristic	n (%) of total sample N = 25
Age (years)	
25-34 years	16 (64)
Over 34	9 (36)
Ethnicity	
New Zealand European	15 (60)
Other European	4 (16)
Asian	6 (24)
Educational Qualifications	
Secondary School 3-4 years	1 (4)
Tertiary	24 (96)
Primiparous	17 (68)
Multiparous	8 (32)

7.2 Antenatal findings

This phase of the research was designed to determine whether the participants, after viewing the VEs, would agree to use VR during their labour. Twenty-four participants agreed to using it in their labour from the outset of the study, and the 25th participant agreed to using VR in her labour after the antenatal

interview. As described in Chapter 6, all the participants viewed all four VEs. The VEs were all consumer ready products that are downloadable on the Oculus Go website, either free or for a fee (\$2-\$10). There was no cost to women. The VEs were shown in the same order to all the participants. The order was as follows:

1. “Ocean Rift” featured an underwater environment with dolphins (https://www.oculus.com/experiences/nft/1253785157981619/?locale=en_US), referred hereon after as the Dolphins VE.
2. An animated beach environment from “Nature Treks VR” (<https://naturetreksvr.com>), referred hereon after as the Beach VE.
3. An abstract-like art environment of coloured moving ‘blobs’, accompanied by a type of Zen chanting music. The VE was titled Shape Space VR – Zen Parade (<https://www.ShapeSpaceVR.com>), referred hereon after as the Blob VE.
4. A documentary type environment of real shots of space, including the Hubble telescope accompanied by music and a voiceover. This VE was titled Birth of a Star (<https://veer.tv>), referred hereon after as the Space VE.

Each VE was viewed by the participants in the order above. Headsets were removed after each VE, and questions were asked about the VE and then again after all four VEs were viewed. Each VE was viewed only once by every participant. The viewing lasted 7-10 minutes. This meant in total that the participants were engaged in VR for approximately 40 minutes.

The focus of the interviews was on the participant’s experience of using VR in this introductory antenatal session. In presenting the findings selected quotes from the transcripts of the interviews are interspersed within the text. To maintain confidentiality pseudonyms are used to identify the source of the quote. Minor grammatical and syntactical changes have been made to the quoted excerpts to assist the reader. Three full stops “...” are inserted where words have been removed from a comment. This is reserved for passages that are overly long and tautological.

When presenting the themes and subthemes, I often refer to the specific VE that the participants were discussing at the time, to provide context to what the participants said. I provide more than one quote in places, to capture variability of responses and to demonstrate responses to the different VEs.

7.3 Overview of themes

There were three major themes that emerged from the analysis (Table 3). The first theme, **virtual reality as an emotional experience**, describes the participants' impression of the VEs in terms of an emotional experience. These experiences varied greatly amongst participants with some reacting positively and others negatively to each VE. The first subtheme to this theme is the *participants' responses to the four VEs*. The second subtheme is the experience of VR as a *memorable and imaginative experience*. Participant's emotional experience was enhanced by the recollection of a personal memory and, a participant's ability to engage with the VR on an emotional level was enhanced by using creative imagination. The second theme, **presence - 'being in the virtual world'** describes the concept of presence, the feelings described by the participants that they were in the virtual world as opposed to the physical world while they were viewing the VEs. There were specific features which enhanced this sense of presence, and they were constructed as subthemes: *relating to the story in virtual reality, immersing oneself virtually, and movement and narration influence being present*. The third theme **envisaging using virtual reality in labour** describes the various ways the participants envisaged using the VR in their labour. The two subthemes for this third theme were *VR's potential in different stages of labour* and *the ideal virtual reality environment*.

Table 3. *Themes from antenatal qualitative interviews*

Major Themes	Sub-Themes
Virtual reality as an emotional experience	<ul style="list-style-type: none"> • Responses to the four virtual environments • Memorable and imaginative experience
Presence - 'being in the virtual world'	<ul style="list-style-type: none"> • Relating to the story in virtual reality • Immersing oneself virtually • Movement and narration influence being present
Envisaging using virtual reality in labour	<ul style="list-style-type: none"> • Virtual reality's potential in different stages of labour • The ideal virtual reality environment

7.4 Virtual reality as an emotional experience

There was a range of emotional experiences after each of the VEs were viewed and these were described in the participant's narratives. The participants described how watching and listening to each VE evoked emotional responses. These responses were both positive and negative. All the participants were able to recall a particular emotional state and participants used a variety of emotion words to describe their experience. All four VEs induced at least one emotion for each of the participants.

7.4.1 Responses to the four VEs

Common responses to each of the VEs are described next. In presenting these, the response to each VE is presented separately.

The underwater dolphin environment: calm, relaxed and serene

Most commonly, when the women described the dolphin VE they reported feeling 'relaxed', an emotional state of low tension, 'calmness or happiness.' Other descriptions when referring to this VE were 'immersive', 'encompassing', 'pleasant', 'engaging', 'serene', 'safe', 'excited' and 'interesting.' The dolphin VE has an animated environment which is underwater and consists of a group of dolphins swimming around. This movement is accompanied by bubbles, seeming to appear and disappear when the user breathes in and out. There is a discrete sound of bubbles and water. Several participants described their engagement with the underwater dolphin VE as engaging, calming and serene.

It was fantastic, very calming but not sleepy, engaging. I loved the dolphins, they were playful...calm, sweet, and curious. (Lisa)

For other participants a sense of calmness experienced in the VE was related to serenity and feeling soothed.

The beach environment: A little bit boring, with not a lot happening

The beach VE was described very similarly to the dolphin VE. Common descriptions were that it was 'relaxing', 'calming', and 'soothing'. Some participants however considered it as 'boring'. The beach VE is set in a tropical looking island with a sandy beach, turquoise blue water with waves gently rolling. There is a palm tree gently swaying, clouds slowly moving overhead. Within the scene there are various objects, a rowing boat and some animals, birds in the sky and turtles moving across

the beach. As well as the sounds of the waves it has some soft music playing in the background. Hannah found the discrete sound of the bubbles relaxing; *“It was really peaceful and relaxing everything was slow moving...so it just made you feel calm and relaxed”*.

Several participants identified that the beach environment provided moments when there was less stimulation through less action and, while this may be relaxing, it meant the VR for some was not interesting.

I liked the dolphins better; this was a little bit boring...being at the beach I wanted somebody to be there with me and there's not a lot happening.
(Cara)

The blob environment: Engaging, scary, disconcerting

The third VE, the blob VE, evoked strong emotive words and diverse descriptions by some such as: ‘creepy’, ‘disturbed’, ‘confused’, ‘scary’, ‘weird’, ‘strange’, ‘uneasy’, ‘unusual’, ‘uncomfortable’, ‘disconcerting’. Many others did not share these disconcerting experiences and had a positive response to the blob VE. These positive descriptions included the VE was ‘beautiful’, ‘creative’, ‘intriguing’, ‘captivating’, ‘engaging’, ‘interesting’, ‘meditative’, ‘entrancing’, ‘absorbing’, ‘hypnotic’, ‘unique’, ‘calming’ and ‘soothing.’

This VE consisted only of some animated shapes which looked like blobs of multi-coloured paint moving through the environment. The blobs move constantly and come towards the viewer. Accompanying this scene is some music that sounds almost like chanting. This environment produced a divisive reaction amongst the participants. Some were positive, finding it engaging and distracting, for others it produced a very negative response of confusion, anxiety, and fear.

Like nothing I've ever experienced before, it was almost quite scary...very distracting, bordering on unpleasant because it was just a little bit scary.
(Katie)

I was thinking, what the hell am I looking at?...it made me feel quite anxious...and it's all a bit trippy...it was uncomfortable rather than distracting so I wasn't enjoying being in the experience, so I took the goggles off a lot quicker than I did on the others. (Jane)

The level of disturbance and confusion was such that this VR was reported by some participants as not having any calming or relaxing effect. The weirdness of the environment was not unpleasant for all the participants, Gina for example found it distracting, and enjoyed the constant change of the environment. She commented that it was “*really intriguing, really captivating, really different and I could probably be quite engaged in that for a long time just because of the constant change, it was so weird.*”

The space environment: engaging, creepy, cool

The final VE, the space VE evoked emotive words and descriptions such as: ‘curiosity’, ‘engaged’, ‘safe’, ‘interesting’, ‘nice’, ‘relaxing’, ‘calming’, ‘ethereal’, ‘awesome’, ‘intense’, ‘informative’, ‘boring’ and ‘lovely’, while also being ‘creepy.’ This VE was the only one utilised that is not animated. It consists of real footage of space and the Hubble, resembled a documentary in that it provides an informative commentary of what is going on in the environment. A narrator provides the voice over and accompanying this is classical type music. Some of the participants described this VE in terms of engagement and curiosity. For other participants this

VE produced negative reactions. They described it as being creepy and not relaxing at all.

Curiosity...definitely fully engaged, I'm like, what, this is cool, what's going on and then when you fly into this telescope, and it shows you all the colours and you look around. (Jackie)

Reason's participants gave for this VR not being relaxing varied. For Hannah it was because *"It made me want to concentrate...it made me more alert or aware."* In contrast for Janet, it was mainly because of its content; *"It was interesting, still a bit creepy...I can't imagine it's relaxing, but it's engaging."*

7.4.2 Memorable and imaginative experience

The ability of the VE to induce an emotion or to be appealing was often due to the participants retrieving a pleasant memory that they associated with the scene. Many of the participants recalled memories that they had of a specific place, for example when viewing the tropical island, some participants recalled overseas holidays to tropical destinations, such as Bali. While others were reminded of places closer to home, such as Kapiti Island in the North Island, despite Kapiti Island not looking particularly tropical. These memories appeared related to their positive experience of a place rather than how similar a place looks in relation to the VE.

It does stimulate the memories, like those beaches are fantastic, like, wow it does look like Koh Samui, and it takes you back to all those happy beach times that you've had. (Jackie)

Is that Kapiti Island or the time we were in the Philippines?, it took me back to different memories, or definitely somewhere I'd like to go, you

can imagine yourself on the beach with your towel and sunscreen...it took me to my own story to a time when we were on a beach...perhaps because I could imagine myself or it made me think about memories of my own...it just made me start daydreaming. I definitely found it a lot more relaxing the scenes that I could picture myself in, that took me to a memory or took me to another place. (Hannah)

For Lisa, it was not a place, but the association with a special memory of her mother, and her love of space that induced a positive emotion.

I love outer space and my Mum loved outer space and she passed away seven years ago and any time I watch anything to do with space, I always think of her...if I was using this space scene in my labour and birth it would be cool to bring her back in a really positive way and just to remember that she is still with me, in that moment...(Lisa)

Many of the participants expressed an ability to create imaginative stories connected to the VEs. This creative ability enhanced their enjoyment of the VE and induced a strong emotional response. There was a noticeable difference amongst the participants and their imaginative responses after viewing the VEs. Some participants were literally buzzing with excitement after a VE and described in detail what they imagined happening or saw in the VE. Other participants described the VEs only in a few words with little detail. They appeared to find it difficult to imagine or create a story within the VE. Narratives of the participants identified the importance of using their imagination or their ability to suspend disbelief to enhance their VR experience. Each participant had their own unique VR experience, and this could be different for each participant. This was reflected in what they shared about their ability or desire to suspend belief while being in the VE.

I was trying to make a new idea of where I could be right now, so this is a new beach and maybe I've kayaked there right now but you find yourself quite lost in the scene, which is good...I could be sitting there by myself; I could be shipwrecked...You could go into lots of different thoughts. It didn't remind me of anywhere that I could have been, but it made me think about where I could be. (Katie)

7.5 Presence – 'being in the virtual world'

Presence is often described as the feeling of "being there" in the VE more than in the physical environment. This concept was introduced to the participants in the interviews. It was a concept that was unfamiliar to them. However, when they described their experiences in VR, they used terms that indicated that they were experiencing this concept of presence. They used phrases such as: "*I was really in it*" (Cara), "*it was like I was instantly there...it didn't feel fake, it felt quite real which added to it*" (Jackie), and "*bubbles that came from me, that was sort of me, and it felt quite real*" (Joan). The expression of such phrases demonstrated a feeling of disorientation, and of disconnect at times, of being between the virtual and the physical world. Presence is a subjective feeling and was experienced individually and to different degrees by the participants who used the VR. Participants spoke of scenes in the VEs that evoked a sense of presence.

The dolphins...seemed to be attacking my goggles and the space thing...I didn't expect that, it was really cool, it felt like I was there. (Rebecca)

Participants who viewed the Dolphin VE were observed reaching out their hands as if to touch the dolphins. Fiona describes her experience of the Dolphin VE: "*it was good, sometimes you felt like you wanted to go and touch them...it was as if*

you were there. Do you get people kind of [makes swimming gestures with hands], swimming around?" The Blob VE and Beach VE also evoked a feeling of presence for some participants.

Maybe the weird one [Blob VE] ...I felt like I was more in it than looking...with the dolphins it was probably having the air bubbles coming out continuously and just the very natural sounds...the way things were interacting in a close way with me. (Cara)

I remember the kayaks sitting there, just the feeling that you can really put yourself just lying there, the heat of the sand, you can almost feel it but you're not there. (Helen)

The ability of the VE to enable the participants to feel a sense of presence or being there and to be distracted was influenced by the extent that participants could relate to the VR story, images, and sound, immerse themselves in the VE, and by the movement and narration features of the VEs.

7.5.1 Relating to the story in virtual reality

The concept of relatability was described by the participants in many of the narratives. For the VE to feel real, to be believable and to be effective as distraction it needed to be an environment that they could relate to or imagine that they could be part of. The quality of the VR also had an impact. As demonstrated in the quotes, viewing a scene that was indicative of their own world experience was enjoyable, reassuring, and relaxing.

I liked the underwater scene the best which I'm a little surprised about because I'm not a water lover...but actually, I found that, and then the

beach scene being the two that I enjoyed...for it to be relatable makes it easier for my mind to switch off. (Liz)

Probably the beach one, because that's where I felt most relaxed. I could just be there, whereas with the others I was aware that this is such a weird and wacky scene that I would never be in...I've never been to outer space, I've never been in a world with random paint blobs, and I've never swum with dolphins...it's just my ability to put myself in the scene. (Helen)

Some, but not all participants, shared that they did not relate to the Blob and Space VEs as these environments were too outside of their everyday experience or did not exist in their reality. For some participants, these scenes created a sense of discomfort and unease. For one participant (Gina), however, the Blob VE was so different and outside of her sense of reality that she found it appealing and found it helpful as distraction. She found aspects of this VE, the constant change and peculiarity of it, very engaging.

For a VE to be relatable the realism of what was being watched and heard was a crucial feature identified by the participants. The technical quality of the images, the digital fidelity, such as pixilation, use of colour and depth images (e.g., perspective, and shadows), or natural movements enhanced the experience of VR. Poor technical quality in the Beach VE was found to be distracting in an uncomfortable way and caused several participants to complain of eye strain. The realism of the VE in terms of the content and storyline was also a factor. For this study only the Space VE had both a narrator and a storyline so there was no ability to compare. In the three animated VEs the level of realism surprised the participants.

It's [Dolphins VE] quite realistic and I was probably expecting something less realistic, but it looks pretty good, the association with dolphins and water is very nice...if there was anything, it felt slightly blurry but that was the only thing...In the beach scene you can see its animation. (Rebecca)

It [Beach VE] seemed a bit more pixelated than the [Dolphin VE] ...It was a bit harder on your eyes and a distraction from the good parts of the scene...and I think some of the quality issues meant that I was quite aware that it was a video...I don't know if it needs to be real...the actual quality of the images is important, the music and the sound is important. (Donna)

The animation for some deterred the ability of the VE to distract them.

They put down this circle and the dolphins go through it and then it exploded and...it just made me stop thinking about relaxing and I thought, this is computer-animated or something, rather than a natural scene...the turtle, the waves and the sand didn't look that realistic either, if it looked like more realistic [like the] waves crashing on the beach I probably would have quite liked that...but I just felt a bit bored. (Cara)

Blurriness and pixel issues were not the only quality issues encountered.

Although many participants persevered with watching the Beach VE that had these issues, others did not, and considered such issues would not be tolerable in labour.

The beach scene and what made me stop that one early was that there was a black flickering light around the bottom-half of the screen...but I don't think I could have managed with that flickering light...if you are already a bit irritable, which you are in labour...anything can be irritating so that even a little flicker could be, just no, I can't deal with it. (Katie)

7.5.2 Immersing oneself virtually

Wearing a VR headset gives the user an all-encompassing view of the environment they are watching. There is a sense of dimension that is experienced requiring the head to be turned, raised, or lowered and this creates realism through a fidelity that draws attention and results in the immersion of the experience. The images can be seen by the person moving their head 360 degrees. A person can see the VE in their peripheral vision also. The intent of this immersive experience is to block out the physical world as much as possible. Immersion in VR is also experienced by sound that appears to be all around them. This combination of visual and auditory sensory stimulation enhances the VR experience. The Dolphin VE was considered very immersive. For some participants being immersed was about being involved.

It was very immersive, it felt like being in the water...seeing the dolphins moving around...so one might be over there moving around...and you can look up at the surface of the water and that seemed quite real...and you immerse yourself in the scenes and that's quite a positive. (Gina)

For other participants, it was being in the audience; *"I found it quite immersive and quite relaxing and quite fun as well, being able to follow the dolphins around"* (Jo).

Most participants spoke of immersion being a positive experience, but for a few participants it was not positive as the nature of the headset meant they could not get away from it.

I suppose claustrophobic might be a word even though it's the big open ocean, you feel quite immersed in it, which is possibly not a positive...I guess it feels quite all encompassing...the fact that you can look in any direction and it's still there, unlike when you look at television...that does feel that it's quite immersive. (Jodie)

Different types of sound in VEs can add or detract from the ambience and mood of a scene and add to the feeling of presence or being in the VE. A variety of sounds can accompany VEs, for example, natural sounds such as waves crashing, bird noise and music. For Joan, the nature of the sound was hypnotic. Sounds that were considered as realistic by participants aided the sense of being present and contributed to participants feeling relaxed.

I really enjoyed it and the music as well was very, it really matched nicely with how the birds were moving and it made me feel quite relaxed in that sense. (Liz)

Soft kind of sounds that made it quite relaxing...just kind of slow, peaceful, quiet, yeah kind of like the one that was on the beach scene, something subtle. (Hannah)

While most of the sounds on the VRs were commented on positively, one sound in the Space VE was not liked by some participants and impacted on their ability to be immersed or to be relaxed.

The underlying music was fine, but it was the noise, the didgeridoo type noise which made it less appealing, it certainly wasn't relaxing, that groaning noise. (Jodie)

Colour was also identified by the participants as an important feature in a VE. It contributed to the feeling of immersion the participants experienced in a particular VE as particular colours helped create an ambience or mood experienced by participants. The use of colour in a VR also made the experience feel more realistic and aided participants to feel that they were present. Colours matched the story of the VE and provided a balance to the pictures on display to the viewer. The colours were sometimes enjoyed, adding to the experience of immersion in VR.

The colours [in Space VE] were amazing and to be surrounded by all that colour and watching the stars go by, it actually made you feel in awe. And when you went into the Hubble telescope, that was cool, it kind of came around and engulfed you, that was probably the coolest part.
(Jane)

I really liked the colour use [in Beach VE], very calming, it made me really feel like I was at the beach, making me want to go on holiday...It took me away from where I was sitting...I liked the pictures and the colours, the deep purples and oranges and those kind of colourings were very, quite sensual, and relaxing and with the contrast of the darkness and the sky. (Liz)

However, the colours were not always pleasant or enjoyable, they could create a sense of discomfort or unease.

The colours [in the Blob VE] are weird, they're not comfortable colours...too black and contrasting with the light blue, they're too contrasting. (Helen)

7.5.3 Movement and narration influence feeling present

The VEs which had more action or movement occurring in them or more objects to observe or try to locate (e.g., Dolphin VE) were more distracting for the participants interviewed. These VEs were often described as “busy”, with a lot going on and were considered as ideal to distract and engage while viewing. There was a sense with the busier environments that you could be more of an active participant, be involved in the VE rather than watching it as a passive participant.

There are nice, simple scenes so there's not too much to distract, I did get a fright with one of the dolphins coming at my peripheral [vision]... [The Blob scene] was quite beautiful, so different, and changeable and there was always something to look at. (Katie)

Researcher: “Did the movement help to draw you in to the scene?”

Absolutely and then once you got close, you could really see the 3D nature, like paint dripping but it was also 3D, there were a lot of things in there, there was a light source, so there were shiny bits or reflections on part of the objects, there was quite a lot of things to think about. (Katie)

The VEs described by participants as “slow” or “boring” (e.g., Beach VE) had little movement in them; they were quite static. Although static, these environments were sometimes described as peaceful and relaxing but once again there was an indication of passivity, so it seems impossible to lose oneself in these environments.

I found the [Beach VE] quite boring, there wasn't much to see, so I didn't feel that distracted...as opposed to the other one where I was, like, oh there's another dolphin, whereas there's

just one lonely little turtle making its way up the beach...not a lot happening, you're thinking, wow that's lovely but it's almost as if there's not enough happening for me to lose myself in. (Jane)

In the [Beach VE] I'd like something a little more to look at on the actual sand...like a shell or something...there wasn't really anything really to look at, it was all up or further away. (Liz)

In the Blob VE, the movement of the shapes coming towards the participants was described as, disconcerting, frantic. Several of the participants reported that this VE made them feel anxious and overwhelmed. Jane found the movement of the shapes towards her creepy and the feeling of being suspended in the sky added to this feeling of anxiety.

First, of, when I put it on, I was thinking, what the hell am I looking at, yeah, it made me feel quite anxious, because I couldn't tell what anything was that I was looking at and then they were getting closer to me, whatever they were and I didn't want them to touch me, it felt a bit creepy. I felt that I was suspended in the sky as well which was quite weird...and maybe, them coming not quite so close to you, so you could see them further away, but some of them were coming very close and for me personally, I was like, no I don't like that. (Jane)

For Liz, it was that the Blob VE was, “very busy...it felt a... little overwhelming...I didn't like the fact that there was a lot coming at me at once...there was a lot going on. Interactivity, connected to movement, contributed to participants in this study experiencing the VE as more realistic and enhanced the enjoyment of the experience. It also contributed to feeling a higher level of presence, the feeling of being part of the VE. They found a VE more distracting when they felt they could be interactive within it. In particular, the Dolphin VE was reported as being very

interactive; the combination of the movement of the dolphins up close and the use of bubbles was enjoyable and appeared to be synchronised to align with and or guide the breathing of the participants.

I found that it was part of the experience [having to move head around], because if you didn't interact with it then it wouldn't feel very real because when you are under-water you are looking around at everything, so I didn't mind that at all. (Jane)

I found it quite immersive and quite relaxing and quite fun as well, being able to follow the dolphins around with the breathing and bubbles. The beach scene I found that quite calming, maybe a little less interactive than the dolphin one. I felt I wanted something to happen, but I'm not sure when I'm in labour, whether that's what I'd want or not (laughing). (Jo)

Well, the positive was I was definitely distracted because I was looking for things, oh there's one and down there, there's another one, it just caught a fish. (Jackie)

This interactivity, however, could also be disconcerting. Both Paula and Jackie shared that the dolphin coming right up to your face impacted on their relaxation and was not necessary in the VE.

In the Space VE, there was a narrator telling the story of the birth of a star. This VE was made with real footage. Participants' descriptions of this VE emphasised the importance of both the narrator and the storyline for both distraction and enjoyment. This VE was compared to a documentary, or a movie experience. It was engaging because it was telling a story that was compelling and needed to be watched until the end. Participants reported that they felt that they had to keep

listening to find out what happened, like a movie. This VE was more likely to be described as distracting and engaging rather than relaxing, possibly due to the inclusion of a narrator and an educational component. The narrator, the music and the storyline all contributed to providing a distracting and engaging experience for many of the participants.

Yes, I liked this one the best...it was more engaging because it moved around, it talked to you, this one was instant distraction and I like documentaries...it made time pass...I felt that this one totally felt safe, instant curiosity, engaged, very colourful and the narrator is talking to you in a very soothing voice. (Jackie)

It required participants to concentrate on what was happening as the facts were narrated.

I was watching a movie and getting informed which made it more immersive because you were being narrated and spoken to. It made it more distracting because I was...really in the scene. I found it more interesting rather than self-directed looking around. I need[ed] to pay attention to what he's talking about, so it distracted me more. (Jodie)

You're completely transported away from what's going on in the room...He was talking about some star formations, you wanted to know where he was going to next, which would make me, engage me more and probably spend longer in VR because there's more coming. (Katie)

The distracting nature of the narrator was seen by some as a potential problem in labour. There was concern expressed that being “talked to” would become annoying and may distract them from focusing on the labour process.

It was very distracting I didn't even notice that you had removed the controller because I was so focused on that. It was really interesting but I don't know how I would feel in labour about all of the talking and I can't imagine I'd be too focused on anything but the whole point is taking you out, but I don't know if I could then focus on something else as well...well, it's a story isn't it, the talking I don't really think it's a negative, it's just I don't know how I'd feel about it in labour, someone talking at me while I'm looking at those things. I could see how you could like it and it's nice, it could just take you completely out. (Helen)

7.6 Envisaging using virtual reality in labour

The participants actively engaged in all four VEs and all the participants wanted to use the VR device in their labour. They found using VR to be an effective distraction, describing it in terms of escape, and helping to remove them from the present reality. Many participants articulated they envisaged that they would use the VR in labour to distract them from the pain of contractions, as a tool to help them relax, and to encourage positive thoughts while labouring. The use of the word escape by the participants was a powerful description of how VR resulted in some participants feeling as if they had removed themselves from the physical environment and yet were present. Participants used words such as “remove”, “drift off”, “being taken away”, “lose yourself”, to convey this sense of escape from the physical world into the virtual world.

It completely removes you and you immerse yourself in the scenes...like you sort of forget that you're in the room...but I would feel a slight bit of guilt about escaping into that other world for a bit. (Gina)

I can see how it would take you away, you're almost not even looking at it, it's just something, and even the music, the music's not very nice to listen

to, but it's enchanting...I can absolutely see how it would take you away from the immediate pain that you were feeling. (Helen)

In discussing VR and managing their labour pain, participants considered that VR could act as an 'anchor' and help them ground themselves, enabling them to feel calm and in control of their pain. They shared they would use it as a visualisation tool to help bring them back to a serene, focused state. As such a tool, one participant said that it would work similarly to meditation. Participants were concerned that when they were in labour, they might lose control. They wanted to avoid negative thoughts and the feeling that they were not coping with labour and the pain. They acknowledged that feeling out of control or catastrophising would affect their ability to cope with the pain of labour.

I think because it's so novel, it's quite a distraction and staying in a curious and positive mindset, I think it would be really helpful for that and that's what I'm looking forward to, yeah. I think that I'd really like to use it in early labour to enjoy the contractions, to not just suffer them but to get through them and to work with them and I think that the visuals and the visual cues will be reminders to stay calm and be relaxed. (Lisa)

Lisa found the Space VE quite inspirational and moving. She imagined using the beautiful environment throughout labour to remind herself, that labour, like life itself is transient and fleeting. She said this VE was empowering, and the images, the sound of the countdown and the operatic music in the scene would help release tension and aid relaxation while in labour. She would use the scene to pace herself between contractions.

It's fleeting [the Space VE] like life is fleeting and that's O.K., it's really positive...The pacing [of the VE] because it was a narrative it felt like it had a beginning and an end and I think that's going to be important, you will get through it [labour]. You have to go through it [labour] and the imagery of going through a star, of going through a cluster, that was wonderful, you have to go through it [labour], there's no way of getting around it (laughing), it doesn't have to be painful or scary, you just go through it...yeah, it was empowering...I liked the music, in the beginning the lyrics were: 5,4,3,2,1 and I use numbers and count downs and it's that time sequencing, I really want to bring that in and I do a relaxation technique where I just count back 5,4,3,2,1 slowly and it's wonderful that the operatic music was going 5,4,3,2,1, (laughing). (Lisa)

Participants perceived the VR as a 'tool' to include in their toolkit of complementary therapies for use in labour. They would not use the VR on its own but would use it alongside and interchangeable with other techniques such as: water immersion, music, hypnobirthing, other visualisation, and meditative techniques. They also envisaged that they would use the VR to help relax them, to calm them and help them focus on their breathing techniques:

If you're getting to a point of being a bit restless or time is just not passing, it could be a good distraction...I also think for pain management, visualisation as well as breathing, to have something to focus on rather than the pain. (Annie)

From what I've learnt about labour in a very theoretical way, if you can be more relaxed, it helps, so I think I would probably use it for actual distraction from pain but also to try and get myself kind of calm and relaxed. (Donna)

7.6.1 Virtual reality's potential in different stages of labour

When the participants imagined how they were going to use the VR in their labour, they identified stages of labour that they thought the VR would be useful, but in this identification, there was some caution as indicated by words such as “*we’ll wait and see*” depends how things “*pan out*”. They each had a clear idea of when in labour they would most likely use it. For some it was early labour and for others it was active labour, and a third group said they would use it in both early and active. Those who envisaged using it in the early stages of labour felt it would help fill the time when you are waiting for things to happen, for the contractions to increase and become regular, for labour to establish. In addition, participants considered that using it early would help keep them calm and help prevent exhaustion.

I think I’ll probably use it in early labour just to get me through that time, set the tone for things to come, but I’ll see how I go, I don’t know how things are going to pan out. (Polly)

We’ll wait and see but I imagine in the early stages of labour it would be good for reducing anxiety and just remaining calm and not getting too exhausted by trying to manage the pain. (Gina)

Some participants considered being taken away from the labour experience may not be a good idea. Helen for example commented that once labour was established and the contractions intensified, she would not want the VR to distract her, she wanted to focus on her contractions.

I think once things get more established, I won’t want anything touching me or I don’t want to focus on anything. I will just want to focus on what I

am trying to do, but I can see that in early labour it would be absolutely something I would use, maybe later it's something that I wouldn't even go to. (Helen)

Jodie elaborated further on the need to be free to engage in labour itself.

I feel that in active labour, its possibly not going to be appealing. I feel like my mind is going to be elsewhere, I'm not going to be interested in looking at dolphins because the end of the birth is in sight, so it might not be something I'm willing to commit my time to when there's lots of other things going on.

Those who considered they would use it in both early and active labour, advised that they would use it for different purposes at these times. In early labour they would use it to aid relaxing, and in active labour as a distraction. These participants choices about when they were using it spoke of it as being one of several strategies they could use. Jackie envisaged using the VR in both early and active labour, arguing however that continued use of it would depend how it first worked.

I definitely would use it in labour, hopefully I get to use it in active labour...I guess I'd be more confident if it worked for me in early labour, then I would have more trust in the VR, if it's taken the edge of the pain, then I would use it in active labour as well. (Jackie)

I think both [relaxation and pain management] ...my plan is to try and have things up my sleeve for active labour when it gets more painful and to be able to relax in early labour as well so I might pull it out [the VR] then as well. (Annie).

7.6.2 The ideal virtual environment for labour

Envisaging how they would use it in labour and after trying out the four VEs, the participants described features and environments that they thought they would enjoy in their labour and that they would find distracting and relaxing. There was a variety of environments mentioned, demonstrating how subjective a VR experience is. Features participants wanted included the natural world, people, particular sounds and colour. For some participants, environments that interested them and were personal to them were important.

It needs to be an environment that the person wearing the goggles finds relaxing, so if someone's afraid of water, they're not going to like the underwater dolphin scene...I'm quite an active person so I like to see scenes where there's things happening to keep my interest. Some people might prefer the beach one...whereas for me if I'm lying on a beach, I can do it for 10 minutes and then I'm like, what are we going to do now? so if I was designing a VR scene it would be an environment that I like, on the water, underwater, or skiing down a mountain and it would be activities and things happening in the scene so every-time I looked in a different direction there's something to pique my interest, something to keep me involved in the experience. (Jane)

The idea of a natural environment was popular amongst the participants:

I quite like rainwater, like walking through bush, and being in that setting, like a rainforest...and the birdlife...that would be something I'd be interested in...I quite like the calming music that goes with some of the VR scenes, but I find that rain is always calming to me. (Liz)

For some, their love of animals was incorporated into their ideal VE, combining nature and animals.

Mine would very much be like lots of animals, so I can imagine something like being in Africa with elephants and lions...there wouldn't be a lot happening but just being able to watch and to see animals moving in their natural environment that would probably be my absolute ideal.
(Annie)

The idea of incorporating people and family members into the VEs was mentioned several times in terms of enjoying the environment. While several participants mentioned they would want to know the people, others considered just having people present who were being natural was sufficient. Participants considered the presence of people would either act as distractor watching people on a beach or at a café or would be a motivator to help with labour.

I would like a natural scene, not very many people, a few kids in there, just to remind you that it's all worth it...you're doing this for your children. Yes, absolutely, my hubby and my daughter, if I could replay the whole Fiji experience in that I was just hoping I'd get with the beach scene...if I could take that scene from Fiji where we went altogether, that was very, very nice. (Polly)

Only one participant (Jane) did not want any people in the VE, she wanted privacy and isolation, imagining herself as the only one present [Beach VE] in the kayak. The ideal VE for labour had to be relaxing, as opposed to being a distraction. These participants talked about preferring environments that had “not much going on”. Movement in the VE would be slow, and repetitive.

Something that's just a little repetitive is probably quite good, so the waves coming in and out, the tree waving gently, that's something that

can lull you, something you can relax your breathing too, something that's nice and slow, nothing moving too fast. (Katie)

The movement would also help with contractions and should be designed to be specific to labour. One participant (Lisa) related the opening of the cervix to a flower.

The opening visuals, your muscles and the different muscles in the uterus contracting up and opening of the cervix. I think that opening visuals could be helpful, you know, flowers opening. (Lisa)

In contrast, other participants described their ideal VE as one that would be the most distracting in labour. They wanted busy VEs with a lot happening in them and VEs that were interactive, that they could move with, rather than just passively watching.

This book that I was reading about, they were using VR, it described a scene which sounded quite cool, where you were on a...device, floating down a river and kind of going past various things that, when you looked over one way you would veer slightly that way. And quite interactive, yeah you can control a little bit. I think having scenes that gradually changed as you floated past would be quite good. (Jo)

One of the two participants who had previously used VR wanted something extremely fast. She considered the idea of a rollercoaster, or an interactive game, something that was fun and so extreme in its ability to be distracting.

The only other times I've used VR was the shark encounter and you were going down in a cage and it was purposefully designed to try and scare you, there were sharks swimming, and you don't know what's

coming and there are things coming up from the deep, it's so real and it's almost like, I would go that way, or a rollercoaster or extreme things...Really intense, really involved, like active participation...but it would just so take you away, you'd be so distracted...and it's so fun!
(Helen)

Narrative was identified as an important component for the VE to be distracting, a combination of a narrator voicing the story and a storyline within the VE. No one topic was identified as particularly important. Topics suggested for narration included a travelling narrative, a museum tour, and different works of art. Participants identified how different features could be used for different purposes, for example, the dolphin VE was described as mainly for relaxation while the space VE that was narrated was more for distraction.

When the narrator talked, that really helped as well or be part of a David Attenborough scene...but if he's talking to you, it's like that's really calming and you get to turn around and look at all the birds and waterfalls. (Jackie)

Colours and images were also features many participants wanted. Participants who were familiar with hypnobirthing apps which commonly feature colour, used their experience of these apps in designing their ideal VE for use in labour. Some participants picked a kaleidoscope of colours, while others focused on only one or two colours.

With the hypnobirthing rainbow relaxation audio...They invite you to experience all the colours of the rainbow [from] indigo...strawberry red and they invite you to be enveloped within that colour...the VR would just

be a swirling mist of colour and just be in that colour and it's very relaxing. (Katie)

I think I'd create very fluid kind of pinky colours...I don't know pink seems really womb like and just nice, calming music, not too many things coming at you in various directions. (Paula)

7.7 Discussion

This section discusses the key findings from the first phase of this pragmatic mixed method study, which aimed to determine the perceived acceptability and feasibility of using VR as an intervention in labour by the participants. Participants who participated in this study each had an emotional response to VR; these were influenced by experiences that were memorable and utilised the women's imagination. They experienced being present in the VR environments and could relate to VR environments. The women provided a variety of perspectives about when they might use VR in labour and what features of VR they would enjoy.

7.7.1 An emotional response to virtual reality

Findings from this phase indicate that all the participants responded emotionally in the antenatal period to watching and listening to the four VEs. These emotional responses and experiences were highly varied and individual to each participant, although commonly the Dolphin VE and the Beach VE were described as 'relaxing', inducing feelings of 'calm' and 'happiness.' A study conducted by Cowen and Keltner (2017) categorised 27 discrete emotions. This range of emotions and more were used by the participants to describe their emotional responses to the VEs. The ability of VR to evoke emotions is not new, it has been identified in the

literature relating to cognitive psychology (Baños et al., 2004; 2008; 2012; Felnhofer et al., 2015; Riva et al., 2007). In cognitive psychology VR has been found to work as a mood induction procedure that can induce common emotional states such as relaxation, joy, sadness, and anxiety.

Similar to the findings by Banos et al. (2012) who researched responses by the elderly to two nature-based VRs, the current study found that natural environments with colour, narration and interactive VEs were engaging to the participants. Baños and colleague's (2012) two nature-based environments were designed to induce positive moods for elderly people and achieved this through VEs that had blue sky with a wide green field, and the participants could walk through leafy plants, bushes, and flowers. Participants in the current study identified several elements of nature that produced emotional responses. Water, walking through bush with the sounds of birdlife were relaxing and calming, these were activities that the participants enjoyed and that they enjoyed in VR. A VE by Felnhofer et al. (2015) showed students virtual parks which used elements of nature to induce joy; the daytime park represented a calm, quiet, sunny environment which had a background of birdsong. The significance of the findings of the current study are that the participants had a favourable response to trialing VR and were open to it as a resource to add to their birthing toolkit.

7.7.2 Memorable and imaginative experience

The participants identified two main features that helped create an emotional experience and enhanced their ability to evoke emotional responses from the VEs. These were their use of memory, recalling a past pleasant experience that was associated with a positive mood and their use of creative imagination. Participants

were reminded of tropical holidays, beach days with their family and, for one participant, a connection with a memory of a loved one through a specific VE. Similarly, in a study on the experiences of women who laboured in an alternate birth room in Denmark, the use of visual and auditory stimuli elicited positive emotions as they were associated with important aspects of the couple's daily lives (Nielson & Overgaard, 2020). The projection of natural landscape scenes on walls of the alternative birth room were positive distractions and just as the participants in the current study recalled holidays and experiences they had had, women in the Danish study described recalling childhood memories from the beach as they watched the projections.

The phrase 'memory emotions' was coined by Oatley (1994) in a discussion on his simulation theory. It refers to a conceptualisation of the process of reading fictional narratives, though the inferences can be applied to all types of media exposure. Similar to what happened in the current study, where the participants engaged in the world of the story, people, according to Oatley's theory re(construct) the world by accessing their own memory, their own individual experiences and thoughts (Oatley, 1994, 1999). In a discussion about the concept of memory emotions as related to VR Klimmt and Vorderer (2003) argue that engagement and enjoyment may be fostered by memory emotions, and consequently influence experiences of presence in VR. Although the term 'episodic memory' is used to describe the process by which an emotion is evoked in a listener to a certain piece of music (Baumgartner, 1992; Davies, 1978), in the current study the emotion was sometimes stimulated by other sounds, most notably the sound of running water.

The ability of VR to have people suspend disbelief is a strong precursor to having an enhanced emotional experience in VR and to perceive the media as

realistic (Baños et al, 2004). Many of the participants in the current study gave a detailed description imagining their time on the tropical island. They imagined how they got to the island, who might be there with them, and what they did on the island. These imaginative narratives indicate that they had found the VE both engaging and enjoyable. In literature related to VR it is argued that imagination is:

The power of imagination can allow us to dwell where we choose, when we choose and with whom we choose. We are limited only by what we can imagine and our ability to communicate. (Sherman & Craig, 2003, p.7)

Creative imagination and engagement, together with a willingness to experience presence in VR are also reliable predictors of an individual's ability to experience presence (Sas & O'Hare, 2005).

7.7.3 Presence – 'being in the virtual world'

The concept of presence was introduced to the participants in this study after they had experienced the VEs, and they were being interviewed. It was often used interchangeably by the participants with the concept of distraction. Many of the participants described the concept of presence, of being there, being part of the scene without referring to the word as it was not a concept they were familiar with. In the German version of the iGroup Presence Questionnaire (Schubert et al., 2001) a question to evaluate presence is a single item *Sense of Being There* and assesses whether the participant sensed their presence in the virtual world. Participant's descriptions in the current study of interacting with the dolphins as if they were real, reference to the beach and feeling the heat of the sand as if they were there and experiencing the blueness of the ocean are evidence that they experienced

presence. The idea of being captivated by the virtual world is also included in the iGroup Presence Questionnaire. Involvement encapsulates the attention a person gives to the VE. Given that the greater attentional resources that a person spends on the VR, the more likely they are to identify with the computer-mediated environment and achieve a greater degree of presence (Slater & Steed, 2000), it was important that the participants in the current study could watch more than one VE. It is possible that the findings regarding presence in the current study were influenced by the participants interest in finding additional tools to add to their birthing tool kit. Women during the antenatal period are encouraged to try different strategies to see what works best for them.

7.7.4 Relatability and meaningfulness

One of the requirements for the VE feeling more real than the physical world or being more distracting for the participants in the current study was the relatability of the scene. The relatability of a scene connects with the concepts of memory and imagination. Many of the participants were able to relate to scenes, like the beach, because of their own experiences being on holiday as opposed to the Zen like environment with the moving blobs or the space environment. The ability to connect their experience in VR to prior experiences allows a person to bring their own knowledge and expectations into play, this creates a more compelling and memorable illusion (Thornson et al., 2009). In their discussion about the VR experience Sherman and Craig (2003) identify a specific confluence of factors which work to persuade the user that the VE is real and exists. The very first of these factors is that the environment needs to be personally meaningful to the participant. Similarly, the participants in the current study wanted to include family members or

friends in the VE, as a way of making the experience personally meaningful. They considered these people would remind them why they were going through the labour and birth. Being able to personalise an experience rather than it being abstract helped the participants in the current study to feel a greater sense of presence, to really feel like they were in the virtual world rather than the physical world.

This is similar to a study which looked at virtual chess for players and non-players. Results from this study demonstrated that personal meaning was one factor which enhanced the sensation of being in the virtual world. The amount of presence experienced by an individual depended on how much the content of the VE was meaningful to them (Hoffman et al., 1998).

The realism of the VE was another feature identified as enhancing the VR experience and the feeling of presence. How realistic the VE was perceived by the participant was influenced by the content of the VE and the technological quality of the VR. Participants in the current study who found the VEs to be of cartoonish quality or with technological glitches indicated they were less engaged, and this affected their ability to relax or enjoy the environment. Participants in the current study also preferred the realism of the VE to an abstract VE and experienced a higher level of presence. Most of the participants enjoyed the Dolphin VE, the Beach VE and the Space VE rather than the Blob VE with its weird, moving shapes, described as being like a Salvador Dali painting. The preference for realism may also be linked to the fact that the participants in the current study were trialing VR for use in their forthcoming birth and labour.

This valuing of realism is similar to findings by Waterworth and Waterworth (2003) that reported that more abstract VEs induce less presence than concrete environments. Sherman and Craig (2003) found that extremely realistic displays that

merge vision and sound in one environment have the greatest impact on the degree of immersion that is experienced by the user. In VR the term verisimilitude is used to refer to the quality of VR having the appearance of truth or its ability to depict realism. There is a realism axis or a continuum starting from “highly verisimilar” to “highly abstract” (Sherman & Craig, 2003).

Although aware that the VEs were animated the participants in the current study were still engaged with the VE as if it was real. Features of the animated VE though cartoonish, such as in the Dolphin VE, where the hoops the dolphins were jumping through exploded, there was still a sense of magical escapism that was experienced. Sherman and Craig (2003) argue that the rendering process which produces a cartoonish quality can create the impression for the user that they are entering a dream world or fantasy state of mind. While the participants in this current study did not talk about entering a fantasy world, they did actively engage with the VR experience. Similarly, a study by psychologists on the use of VR to treat phobias found that a VR world that looked like a cartoon did not prevent engagement in the world (Rothbaum et al., 1996).

Several features of the VE were identified by the participants in the current study as contributing to a feeling of presence. The participants' descriptions of immersion such as having an all-encompassing view when wearing the VR headset enabled them to feel like they were shut out from the physical world. The feeling of immersion was not always perceived as positive, it was sometimes expressed as claustrophobic. Bouchard et al. (2008), also reported that immersion may be anxiety producing which could result in an enhanced feeling of presence. In this current study two methods were used to establish immersion. Firstly, notes were taken of the participant's responses while they were watching the VE. These notes as well as

preset questions were used to ask the participants how deeply they felt they were immersed in the VE. Both the observations and their verbal response to questions about presence provided evidence of the degree of engagement and immersion in the VE.

The finding that movement in the VEs was significant in terms of its ability to be relaxing or distracting is useful. VEs that were slow or had little action were considered by the participants as being suitable for relaxation purposes but not likely to be distracting enough to reduce the intensity of pain of contractions when they went into labour. The implication of this finding is that when midwives discuss VR as an option for use in labour they need to let women know there are multiple different types of VEs and advise women to select so that they can tailor the level of movement they want at any one time. For optimal distraction, participants in the current study commented that the VEs needed to be busy, with a variety of features to be looked at, and a VE that could be explored with more action. There is no comparative literature that has used qualitative interviews to explore how women imagine using VR in labour and no literature that identified features of VR that enhanced relaxation or distraction when people are engaged in a stressful engaging activity such as labour.

It is also significant that the VEs that were interactive were particularly enjoyed by the participants and this enjoyment contributed to the realism and the sense of being in the VE. The sense of interaction experienced by many participants was that the dolphins were coming up to them, they felt so close that they could touch them. Not only was it evident that what they saw and heard brought them enjoyment, the participants also liked that the Dolphin VE helped them control their breathing and could see the potential of this in labour. This finding of interaction

supports the work of Sherman and Craig (2003) who note that the ability to interact with the virtual world is a key component of the virtual experience and increased interactivity leads to feelings of being involved in VE.

Other researchers have found that the level of participant interactivity influences the subjective feeling of presence (Welch et al., 1996). Welch et al. (1996) found that participants who were able to control the car in an automobile driving VR task rather than be purely passengers experienced an increased sense of presence. Controlling one's breathing, which is important in labour, is not unlike driving a car. It provided the ability of the participants to feel emotionally and cognitively engaged in the virtual experience and generated a feeling of presence (Waterworth & Waterworth 2003).

7.7.5 Narratives

Similar to engaging in the plot of a movie (Scholer & Higgins, 2009), many of the participants in the current study found the narrative component of the Space VE, a short documentary concerning a star engaging and an effective distraction. The narrative was a voice-over describing the process and story of the birth of a star in conjunction with classical music and accompanying visuals. Participants described the VE experience as like watching a movie, and wanting to keep watching to see what happened, and how the story evolved. This idea of narratives as stories, that users can view from a first-person perspective, can create a meaningful experience for the person and become emotionally engaging. It is not unique to VR alone, as it is part of media form and content characteristics (Gorini et al., 2011). The fundamental attraction of media still lies in the plot, the content, and the ideas and emotions that it is able to communicate to the user (Ijsselstein, 2002).

Findings from the current study identified that sound was another feature of a VE that contributed to the enjoyment of the VR experience and to the ambience of the experience. The use of sounds varied from verisimilitude natural sounds accompanying the scenes such as waves crashing, birdsong to abstract musical scores. Background sounds are used to create an ambience, to increase the drama of the scene or to assist the participant as they move through the experience. The quality of the sound can also increase the feeling of being immersed in the VE (Sherman & Craig, 2003). The importance of the addition of sound to VEs was recognised in a study by Johnson and Coxon (2016) that found sound can enhance the analgesic effect of VR in participants experiencing experimental pain. Similar to what the participants in this current study shared, findings demonstrated that the inclusion of sound alongside the VR game likely added to the effectiveness of the distraction, it made the game more attentionally demanding, thus shifting attentional resources away from the painful stimuli. The findings from the current study also indicated that not all sounds are acceptable and sounds such as groaning or grinding noises may not be suitable during labour.

The finding that colours in the VEs added to the ambience and the enjoyment (or not) of the experience for the participants in the current study is not new. Literature has identified that colours with intense brightness and saturation levels induce positive emotions and arousal. To evoke positive emotions, researchers have indicated that images with bright and high saturated colours, predominantly green and blue should be used (Herrero et al, 2014). In contrast, a relaxing environment should have warm colours, with low brightness and saturation (Guilford & Smith, 1959 as cited in Baños et al., 2012). The four VEs viewed in this research had different colours, and the intensity of these varied. The deep blue of the sea and the

gold of the sand in the beach scene inspired feelings of relaxation and calm for many women. No research has particularly focused on whether pregnant or labouring women prefer any one colour or colours. Birthing rooms very often have warm colours.

7.7.6 Envisaging using virtual reality in labour

Findings from the current study indicated that all the participants after trialing the four VEs would use VR in their labour and that they considered it an acceptable and feasible intervention. The participants described the VR as enjoyable and novel and they were looking forward to using it either in early and active labour, or both. They identified that the VR could be used in a variety of ways, as distraction or 'escape' and as an 'anchor' or a way of grounding themselves and to avoid negative thoughts or catastrophising. This is the first study that explored women's experience of using VR in the antenatal period with a view to use it in labour. Other research studies have identified a range of pain-coping strategies that women describe they would want to use when they are in labour. Lowe (2002) found that strategies for managing pain include relaxation, distraction, imagery, breathing techniques, control and focusing.

Findings from this current study identified the use of breathing as a relaxation technique when they were experiencing the Dolphin VE. In this experience the participants could synchronise their breathing with the bubbles that were coming out of the virtual diver's mask. The potential of VR's impact on breathing has obvious benefits for women in labour. Women in labour are very focused on their breathing and are coached by support people and midwives on how to breathe through contractions and in between. The use of controlled breathing is a coping strategy

favoured by women and midwives in all stages of labour (Simkin and Bolding, 2004; Thomas and Dhiwar, 2011; Thomson et al., 2019). It is a simple technique which helps to reduce stress and anxiety.

Similar to participants in the current study, other research has identified the role that catastrophising has and how it leads to women thinking increasingly more negative thoughts in pregnancy (Escott, 2004; 2009). Participants in this current study wanted to avoid catastrophising in labour, however the alleviation of anxiety and pain-related fear antenatally can impact both the intrapartum and puerperium period. In a study by Flink et al. (2009) it was found that women who did not catastrophise before labour had a better postnatal recovery. In contrast, women who catastrophise prior to labour reported higher levels of discomfort postnatally (Escott, 2004; McNeil et al, 2010). Currently there are no studies which look at catastrophising in labour.

Envisaging using VR in their labour, the participants described the type of VEs and features of the environments that they would like to view in their labour. For many this concerned a pleasant memory of a place, holiday or with people they cared for. The possibility exists because of this finding to create a VE that is a personal memory and to use it antenatally and while in labour. In this way the playing of a pleasant memory may help induce an emotional response and enhance the emotional experience of the VE.

Views of nature were also identified by many of the participants as their preference in a VE when they were in labour. These natural environments were described as calming and relaxing. The participants described these environments in terms of their own personal preferences, such as a mountain, tropical island, or a rainforest. In order to explain why a focus on nature induces feelings of calm and a

reduction in stress, the biophilia hypothesis was proposed by Harvard entomologist, Edward Wilson in 1984 (Gullone, 2000).

The biophilia hypothesis proposes that because of evolution, human beings have developed an innate tendency to affiliate with the life-giving forces of nature. Research has demonstrated that psychological wellbeing is enhanced when people are exposed to natural elements in the environment. There are features that people have an affinity to, these include water (life-giving), savannah (as opposed to a dense forest, as the savannah has a bounty of food, and the savannah is more conducive to the detection of predators). According to this hypothesis, the natural environment has shaped both our emotional and cognitive brain, and the tendency to biophilia still exists in humans, cross-culturally in symbolic ways (Gullone, 2000).

In contemporary society the creation of parks, and the maintenance of nature reserves is associated with the belief that exposure to nature promotes positive emotions and psychological wellbeing, the reduction of stress related to urbanisation and fosters physical wellbeing. Past studies that seek to examine the human relationship with nature focus on the affective response to natural environments and are typified by the presentation of a variety of landscape scenes to participants in the form of photographs and video (Ulrich, 1993). The study of the ability of natural environments to elicit affective responses has now moved into the area of VR, the media environment of our time.

The use of natural environments, such as leafy parks and beaches, are common in the literature on VR and mood inducing products. In their study which aimed to modify negative thinking and anxious mood states, Freeman et al. (2004) used a VE, 'Relaxation Island', which contained visual representations of imagery and audio associated with relaxation and positive moods (e.g., calming sea waves,

swaying palm trees, sounds of a tropical island). The accompanying narrative set the scene for the relaxing environment (the blue ocean, waves, bright sun, breeze, and golden sand on the shoreline) and their results demonstrated that narrative, plus audio and VR, was associated with mood changes, reducing negative emotion ratings, and increasing relaxation.

7.8 Summary

This first phase of this exploratory sequential mixed model design involved the participants trialing VR by watching four virtual environments and being interviewed about this experience. Findings from the interviews demonstrate that VR is an intervention that the participants were interested in using in their labour and birth. They found it an enjoyable, novel intervention that was able to elicit certain emotional states, such as happiness, relaxation and joy which enhanced their emotional experience of VR and as a distraction technique.

The participant's narratives identified features that helped them to be emotionally engaged in the VE, these were: memory and the use of imagination. For the participants to be distracted and to feel presence or the sense that you feel like you are in the virtual world, several features of VR were identified as important. These were described as the ability to relate to a particular VE over another and for it to be personally meaningful. To have an impact the VEs also had to be immersive which would occur more easily in the VEs where there was movement, and narration. The participants described how they anticipated that they would use the VR in labour. Finally, in the interviews, the participants provided their personal preferences including their rationale for the type of VE they found enjoyable or relaxing and what they would like to use in labour.

At the end of the interviews the participants were given the VR headsets to take home with the aim of becoming more familiar with them and the four VEs in preparation for when they went into labour. They were encouraged to find other VEs on the internet that they might like to use instead of or in addition to those they had trialled. The next chapter presents phase two of this mixed method study; the quantitative results from the quasi-experiment which measured the effect of VR on the sensory experience of labour.

CHAPTER 8: PHASE TWO INTRAPARTUM QUANTITATIVE RESULTS

In this chapter, the quantitative data from the quasi-experiment with the pre-intervention, during intervention and during intervention, post intervention phases is presented, interpreted, and discussed. These results relate to data from the 14 participants who completed the study while in active labour. These participants used the VR headsets during active labour and pain scores, heart rate and blood pressure was recorded from all women while using and not using VR.

The utilisation of a within-subjects crossover design meant each participant served as her own control. Differences were calculated as control (no VR) conditions minus the intervention (VR) condition. Significance was determined by 95% confidence intervals (CIs) that do not include zero. Differences were evaluated by examining mean differences (VR – no VR) in sensory pain, maternal heart rate and mean arterial blood pressure and performing paired *t*-test across the groups. This test compared the average differences between the VR and no VR group.

8.1 Results – pain scores

The results of the reported pain scores are shown in Figure 15.

Figure 15 Graph of pain scores with and without VR in labour

This graph shows the pain score without and with VR during active labour as the mean ($\pm$ SD) and the individual scores for each participant. Of the 14 participants who participated, 12 participants reported lower pain scores while using VR and two reported the same pain scores with and without VR. Five of the participants reported a decrease in their pain score of one and seven reported a decrease in pain scale greater than one and up to three. The mean pain score for participants in active labour (with VR) is 6.14 ± 1.35 , which was lower than for when VR was not used 7.61 ± 1.80 .

A paired samples t-test determined that there was a statistically significant difference between pain scores with and without VR, $t(13) -6.501$, $p = <.001$. The mean difference was -1.464 , 95% CI $(-1.951, -.978)$. This means that the pain score for participants in active labour was 1.464 points lower on average when VR was used.

8.2 Results – Maternal Heart Rate

The results of the maternal heart rate are shown in figure 16.

Figure 16 Graph of maternal heart rate with and without VR in labour

This graph shows the heart rate (HR) without and with VR during active labour as the mean ($\pm$ SD) and the individual HR for each participant. Five of the participants had HRs that were slower by 10 to 24 beats per minute (bpm) while using VR compared to when they were not using VR. The other 9 participants had smaller and variable differences in HR. That is, their HRs with VR were between 6 bpm slower to 4 bpm

faster without VR. The mean HR for participants in active labour (with VR) is 79.86 ± 11.78 which was lower than when VR was not used 85.57 ± 15.79 .

A paired samples t-test determined that there was a statistically significant difference between HRs with and without VR, $t(13) = -2.383$, $p = .033$. The mean difference was -5.71 , 95% CI $(-10.896, -.533)$. This means that HR for participants in active labour was 5.71 points lower on average when VR was used.

8.3 Results – Mean Arterial Pressure

Results of mean arterial blood pressure are shown in figure 17.

Figure 15 Graph of mean arterial blood pressure with and without VR in labour

This graph shows the (MAP)¹⁹ without and with VR during active labour as the mean ($\pm$ SD) and the individual MAP for each participant. Eleven of the participants had MAP that was lower by 2 to 17 mmHg while using VR compared to when they were not using VR. The other 3 participants had either no change or an increase of up to 7 mmHg in MAP when using VR. The mean of the MAP for participants in active labour (with VR) is 88.78 ± 10.51 which is lower than for when VR was not used 92.61 ± 9.90 .

A paired samples t-test determined that there was a statistically significant difference between MAP with and without VR $t(13) -2.591$, $p=.022$. The mean difference was: 3.832, 95% CI (-.636, -7.027). This means that the MAP for participants in active labour was 3.832 points lower on average when VR was used. Table 4 summarises these results.

Table 4 : Mean (SD) of pain scores, MRH and MAP by treatment condition.

	Pain	MHR	MAP
VR	6.14 ($\pm$ 1.35)	79.86 ($\pm$ 11.81)	88.78 $\pm$ 10.51
No VR	7.61 ($\pm$ 1.80)	85.57 ($\pm$ 15.79)	92.61 ($\pm$ 9.90)
Mean Difference	-1.464	-5.71	-3.832
P Value	<.001	.033	.022

8.4 Discussion

The primary outcome for worst pain intensity (sensory pain) score was significantly lower in the VR condition (6.14 compared to 7.61 in the no VR group, 1.46 difference). The labour score reductions observed in this study are similar in

¹⁹ The definition of mean arterial pressure (MAP) is the average arterial pressure throughout one cardiac cycle, systole and diastole.

trend magnitude to those of previous studies in the use of VR in the labour process (Frey et al., 2018; Pratiw et al., 2017). Frey et al., in their (2018) study, reported a mean 0.8 decrease in sensory pain scores as the mean difference between No VR and VR. In Pratiw and colleague's (2017) study, in latent phase and three active labour phases, pain scores were 1.4, 1.2, 1.7 and 1.6 less when women used VR compared to no VR using the Face Pain Scale (FPS) and 0.8, 0.9, 1.2 and 0.8 less when using VR compared to no VR using the Non-Verbal Pain Scale (NVPS).

In the current study physiological variables of sensory pain, maternal heart rate and mean arterial blood pressure were significantly lower in the VR condition. The maternal HR differences in the current study were less than demonstrated in Wong and colleague's (2020) study which were 76.3bpm (using VR) compared to 86.8bpm (no VR), a difference of 10.5 bpm.

Other studies using VR in acute pain settings provide some similarities with this study in terms of pain score differences when using VR and not using VR. In one of Hoffman and colleague's (2008) clinical studies into the use of VR during burn wound debridement, participants reported significantly less pain when distracted with VR (pain ratings decreased from "severe" (7.6) to "moderate" (5.1), a difference of 2.5). Aminabadi and colleague's (2012) study of 120 children (60 VR; 60 control) on VR for pain control in dental pain, there was a reported decrease in pain ratings of 1.11 for those using VR compared to not using VR. Spiegel and colleague's (2019) prospective randomised comparative effectiveness trial of 120 participants (61 VR; 59 control) demonstrated a 1.17-point incremental reduction in pain vs controls ($p=0.048$).

Several studies on the use of VR for invasive oncology procedures have measured physiological variables of pain intensity as an outcome. Similar to the

current study's 5.7-point difference in heart rate, a 6.4 and 7.8-point difference in heart rates was found with children and adolescents undergoing either venipuncture or subcutaneous venous port access. Results compared the group using VR to the no VR group (during VR 90.3bpm, control 96.7bpm, after VR 84.4bpm, control 92.2bpm), however these results did not reach statistical significance (Nilsson et al., 2009). In this study there was less variation with the individual pain scores than with maternal HR and MAP. This could explain the statistical variances between pain and physiological scores.

A study by Wolitzky et al. (2005), on the use of VR on pediatric oncology patients found statistically significant differences in pulse rates during and after the intervention. In this study the difference between intervention and control groups during the medical procedure was 21.80 bpm ($p < 0.05$) and after the procedure a 14.50 bpm difference in pulse rate ($p = 0.12$). This difference in pulse rate is significantly greater than that demonstrated in the current study.

A further study which examined the use of VR distraction for pain control during dental procedures, such as periodontal scaling, on adults, was conducted by Furman et al. (2009). A within-subject design with thirty-eight participants who experienced all three treatment conditions: control (no distraction) and two distraction methods: immersive VR and movie watching was conducted. Results from this study found a similar downtrend trend in pain scores to the current study; a 2.19 difference in visual analogue scale (VAS) pain scores (1.76 ± 1.4) for VR, $2.57 \pm$ for the movie) and 3.95 ± 2.1) for the control. During the VR experience participants also had significantly lower pulse rate (68.3 ± 7.7) compared to 79.0 ± 10.8) of controls and similarly to the current study a lower diastolic blood pressure

during the VR experience; 81.0 ($\pm$ 9.0) versus 86.0 ($\pm$ 8.9) in the no VR group, a 5-point difference.

8.5 Summary

In the second phase of this study the results from the quasi-experiment were presented, interpreted, and discussed. The data from the pre-intervention, during intervention and during intervention, post-intervention components of the intervention study demonstrated statistically significant reductions in sensory pain and certain physiological markers of sensory pain, maternal HR, and MAP. The following chapter is a presentation, interpretation, and discussion of the Phase Three findings of this mixed method research study, the qualitative interviews with participants in the postnatal period.

CHAPTER 9: PHASE THREE POSTNATAL QUALITATIVE FINDINGS

In this chapter the findings from the postnatal interviews with the participants are presented, interpreted, and discussed. The focus is on the participants' experiences of using VR technology as a non-pharmacological method in their labour. Nineteen participants contributed their experience and perspectives of this novel intervention in their labour. The chapter begins with a presentation of the findings. Similar to Chapter 7, attention is given to using quotes from the transcripts to demonstrate the themes. It then discusses the findings in relation to the literature.

9.1 Overview of findings

All the 19 participants used VR in their labour. The amount of time that the participants used the VR was not timed in a formal way. However, several of the participants recalled how long they used the VR outside of the 2 x 10 minute measurement periods of the quantitative experiment. Times ranged from five minutes to two and a half hours of continuous use of VR. While some of the participants viewed some of the VEs they had been introduced to antenatally, many of the participants chose different VEs based on their personal preferences, that were available on the Oculus Go platform. Three major themes emerged from the analysis (Table 5). The first theme; **impact of virtual reality VR on labour** articulates the participant's experiences of VR in labour. These experiences had an impact on their labour in a variety of ways. Two subthemes described how VR impacted their labour: *virtual reality as a form of escapism*, and *the relaxing and enjoyable experience of virtual reality*. The second theme **managing the pain of labour** relates to how VR supported the participants to manage this pain through such methods as helping the participants control their breathing and by giving them a

sense of control while they were in labour. A subtheme of *using virtual reality at different stages of labour* reveals the participants experiences of the timing related to their use of VR. In addition to the specific time in active labour that participants were asked to use VR for the experimental aspect of the research participants also chose to use VR in early labour and in active labour or both. The third theme captures the **challenges and surprises of using virtual reality in labour** and the subtheme of *recommendations for future use of virtual reality in labour* reports on what the participants recommended may be useful modifications for future VEs and VR headsets for use by labouring women.

Table 5. *Themes from postnatal qualitative interviews*

Major Themes	Sub-Themes
Impact of virtual reality on labour	Virtual reality as a form of escapism The relaxing and enjoyable experience of virtual reality
Managing the pain of labour	Using virtual reality in different stages of labour
Challenges and surprises of using virtual reality in labour	Recommendations for future use of virtual reality in labour

9.2 Impact of virtual reality on labour

The participants identified a variety of ways in which VR had an impact on their labour experience. These included the impact of VR as a form of escape from the medicalised hospital environment, from the boredom of a long, slow labour, and as a means of removing themselves from their present reality. Virtual reality also had an impact on their labour experience in terms of bringing enjoyment to the experience, aiding in relaxing the participants and reducing anxiety while they were in labour. Finally, VR had an impact on their perception of their birth as a positive experience, it contributed to satisfaction with their birth.

9.2.1 Virtual reality as a form of escapism

All participants described how using VR was a form of escapism from many aspects of their labour. This included the pain that they were experiencing in labour and from the relentless of time passing slowly while they were in labour. Participants also described how the VR helped them escape from their immediate surroundings, often a medicalised birth room and the VR enabled them to escape their actual reality, they could escape from the present. Participants found the VR was an effective form of distraction and in many of the narratives, used the word 'escape' to convey going to a different place to get away from the pain of labour. Other descriptors of escaping were "a trippy experience", "to space out" and "absorbing". Participants spoke of using the VR as a distraction to shift their attention away from the immediate pain, and to reduce the intensity of the pain.

So, it was nice at the beginning, I remember wearing it in the early stages of labour, I was like, oh my God, I totally forgot about the contractions, it was great...I didn't even think about the pain, it was quite um, quite absorbing...I just forgot about it [labour], I didn't pay attention to it, it distracted me to an extent. (Rebecca)

I found it a relaxing and distracting tool during early labour...I think the VR distracted me to an extent from the pain of contractions, however, when I used it my pain level was not that high. (Angela)

Participants referred to specific elements of the VE which helped to distract them. They identified aspects of the VE which allowed them to focus on something other than the pain, these included images such as watching the dolphins in the

Dolphin VR as well as listening to sounds, such as the waves crashing on the beach and the classical music on the Space VE.

I could focus on what I was seeing and try and distract my mind and then every time the contractions were coming I was just trying to focus on whatever I was watching, like the dolphins and things coming and it really helped me. (Diana)

I was focusing on the views, the different sounds, and animals in the rainforest, I got distracted so I wasn't really focusing on how painful it was. (Joan)

The participants who were experiencing labour for the first time shared they had been prepared for a long and slow labour. Using the VR in labour was one of several strategies' participants said helped them escape the boredom of their long labour and the relentlessness of the contractions. Other strategies referred to included hypnobirthing, water immersion and listening to music. Virtual reality was used in between these other strategies or concurrently.

It was nice and calming and a distraction from, you know, I had been having contractions and the whole day was quite long already and it was just a nice escape. (Gina)

I had my headphones with a meditation track which I listened to on repeat seven times, and I knew every word and I was just, oh, that is a bit boring now, so [the VR] was something to do as well, like the distraction that we talked about, so I think that was the benefit. I don't know what I would have done if I just had to sit in the bath for five hours with nothing going on. (Katie)

The escapism experienced, was such that some participants lost all concept of time and that time passed more quickly. According to Jackie the impact of using the VR was that “*Time wasn’t time...it moved a lot faster*”. Time was impacted not only regarding the overall length of their labour, but also regarding the time between contractions and the perspective of how long contractions lasted.

I found it quite good, I think it distracted me and I think that it seemed to increase the time between my contractions. (Fiona)

When I was having a contraction, I think it just helped to distract me a little bit and it helped the time go quickly, the contractions almost seemed shorter than when I wasn’t wearing the goggles. (Lisa)

As part of the idea of VR as escapism, the participants enjoyed the distraction effect of the VR but also its ability to remove them from ‘the sterile, medical room’. Many of the participants commented on the impersonal nature of the birthing rooms and how they enjoyed that VR brought some colour and beauty into the environment. Immersing oneself in the VE, helped some participants remove themselves figuratively from being in hospital.

It was a whole day I was in that room, and I needed that, kind of escape, change of scenery, so that really helped. (Joan)

Well, it certainly helped when they put the IV line in...it helped the feeling of being at the hospital, I think, which is quite a sterile place, it [the VR] made it more colourful and entertaining...it takes you to a different world, it takes you home, it makes your mind wander, to dream...and I was like: ‘remember when I was in Italy...they say you just need to rest. Well, I can rest here and still be in this world of colour and fun and beauty. (Jackie)

So, it was good for me just to escape...so, distraction and the ability for me to go into my own little world and not have to look around me at the same clock that's going very slowly in the same medical room. (Katie)

Katie, in response to the researcher's statement: "So it helped to change your environment?" shared not only that she could enter her "own space", but she could also enter what was "a pleasant space". Like many participants Katie shared the view that the VR experience did not just involve her, but her partner also. She commented "we did the dolphins at the beginning and then the Savannah which was such a pleasant environment".

For many participants, the process of labour was associated with a need to withdraw or escape from the present and the actual physical environment they were in. They described the juxtaposition that the labouring woman often finds herself in, wanting support people around, yet also needing to go within themselves, to an internal place, which enabled them to cope and manage the intensity of the labour experience.

You can just keep it on but close your eyes and just go into your own little space and then open them and it's still there it's quite good. (Jo)

I really like being present for all of it as well, but it was neat to just go somewhere else for a while. (Lisa)

The labour experience for some participants, gave them a sense that they were on show. They experienced a sense of surveillance, of being watched by support people or the midwife as their labour progressed. This was sometimes an

unsettling feeling, and the VR allowed the participants to escape from this and be alone.

I just thought it was really cool to take a minute, to just be me, because I had so many people around me, which I really wanted and I loved, but it was quite cool to go in, so very internal, to take that time and have the goggles across my eyes and with the audio and the one [scene] that we chose was a really relaxing beach scene and it was really lovely when I wasn't having a contraction. (Lisa)

I just thought that [husband] and the midwife were just sitting around and watching me...I felt like I was the one that was on show, or on display and what I could do with the VR was escape all that and I could put on the VR, and I couldn't see them and because it's got a little bit of audio I could hear them when I needed to hear them...it made me feel I was in my own little world, and I didn't feel so watched...and even if I had my eyes shut I was in my own little world. (Katie)

Although alone, the participants also valued that even though they had a VR headset on, they could still hear their support people and midwife when they needed to.

9.2.2 The relaxing and enjoyable experience of virtual reality

All participants found the VR intervention to be a novel and entertaining experience in their labour. They enjoyed using it and found that it helped them to relax, creating a sense of peace and calmness.

I really loved the scene that I looked at, the beach scene, it was really relaxing...I was just sitting on the floor leaning against the chair and felt calm and relaxed. (Lisa)

I asked my husband to give me the VR, it was really helpful, honestly. Although I can still really feel the pain of the contractions but after each VR rush, I can sense that I am calm and relaxed during the intervals of the contraction...I was only watching the scene with the beach...I can just hear the birds and the waves of the ocean, that's all, it was relaxing.
(Linda)

For one participant (Jackie) using VR was credited with being more effective in reducing anxiety than pain; *"totally reduced anxiety...more so than the pain."* The enjoyment of the VR experience for several participants was accentuated by the ability of the VE to invoke a happy connection or a pleasant memory. Connections were with animals, events, and places.

The period when I was wearing the goggles was a very happy moment in the labour experience and I remember being very relaxed...it helped that the scene which was played on the VR featured manatees which looked remarkably like my dog and that I remember making me feel very happy. (Jane)

Being in an enjoyable space, also helped manage the anxiety of labour, and for some distract the focus on the technology used in the birth.

When we were watching the [Beach VE], I was like, oh my God, this looks like Bali, so it takes you away from right now, or waiting for, oh the monitor moved, is baby O.K., all these worries that you have, it just takes them away. (Jackie)

Many participants felt that using the VR in their labour contributed to them having a positive birth experience and increased the satisfaction with their birth. For

many, this positive birth experience was due to being relaxed and calm in labour. For Paula, she was satisfied with the outcome of her birth as, despite being induced, she was able to have a non-pharmacological birth. The experience of using the VR made for a positive birth experience for many participants simply because it helped with the boredom of the labour and allowed them to try something that was different and proved to be fun.

The memory of wearing the goggles is a very happy memory, so I feel lucky to have a good memory. (Jane)

I am really over the moon about how my birth went considering it was an induction and not the home birth that I wanted. I'm so pleased that it went well and doing the VR part, didn't take away anything from that and I just think the VR adds a little bit of extra. (Paula)

I think so, yeah, just making it a really special experience, very novel, just to have something to do, just going through contractions and sitting there it was nice to have something to focus on. (Lisa)

It was good, it was fun, it was nice. Thinking back, I don't know what I would have done for such a long time, just waiting, and having pain if I didn't have the VR. (Katie)

9.3 Managing the pain of labour

Pain is a multi-dimensional construct and all participants referred to how they focused on managing their pain. The ability of the VR intervention to assist the management of labour pain at different stages of the labour process was articulated by all the participants. They described the VR as aiding their pain management by helping them control their breathing and giving them a sense of control over the

labour. Participants used various VR techniques in conjunction with features of the VEs. In one example, a moving image of the dolphin appearing, and disappearing was used as a reference point for the similar ebb and flow of the contractions.

The bubbles come and make a sound that's really relaxing, make you believe that you are already there...I saw the dolphin was coming and the contraction was coming, I could focus, that is the contraction and then the dolphin was moving and then I was moving with that, so that's the contraction...so focus on your object of reference, so focus on something and then move with that thing and the contractions are going to come and go like the dolphin, so it would appear and then it would go, so I think it was quite nice, very relaxing, I love it. (Diana)

As a way of managing labour pain, several features in the VEs were used by participants to assist in coping and tolerating the pain. For example, Liz synchronised her breathing with the visualisation and sound of the bubbles in the Dolphin VE. The combination of the sound and the image and the immersion of the experience intensified the effectiveness of the distraction.

It kind of has that in line with hypnobirthing without having to do all the hard work for hypnobirthing which is why I was keen to give it a go, being able to physically see an image rather than imagining an image is cool and being able to practice looking at those images...trying to capture all these senses, like the underwater one. I really loved that when you breathed the bubbles were there and so you heard the noise and saw the noise, so it's trying to capture these different senses to try and distract. (Liz)

For Liz, not only was the VR useful, but it was also relatively effortless to use.

Using the VR in labour was a valued asset to help participants to relax, to focus on breathing techniques which in turn helped them to manage the pain of the labour contractions,

It helped with the breathing and the relaxation which then helped with the pain...It was nice to have as an option, it was nice to have my headphones with my meditation there and then the VR. It was like having options, just staying in the right headspace, it was the right thing because then that was what helped with the pain, not getting stressed, not getting overwhelmed. (Katie)

Some participants found features of the VE which enabled them to regulate and synchronise their breathing with their contractions.

Yes, I feel it did [have an effect on relaxation], depending on what the scene was. The natural beach scene [Beach VE] with the sound of the waves coming in and out assisted me to relax possibly by helping my breathing to be more regular. (Paula)

The idea of self-efficacy or a belief in one's ability to manage the pain of contractions was described by the participants. They used aspects of the VEs to help them gain this sense of control, for example, focusing on the dolphins in the Dolphin VR, their movement or using the positivity of the VE, such as elephants wandering by to get them through a contraction. Having a sense that the pain of contractions could be managed gave the participants a feeling of control, a belief in their ability to labour. This belief that they were in control of the process of labour helped them manage the pain.

Oh, yeah, because you feel like because everything [with labour] is so uncertain, so having the chance to be able, so like, I said to you, that I used the dolphins as my reference point, so it gives a little bit of control, that part of labour, because you don't know what's going to happen, but I'm trying to manage my pain right now, I might not be able to in a couple of hours, but right now it's working. (Diana)

One participant (Patricia) described her experience in labour and the impact of the VR as helping to make her feel calm which gave her a sense of being in control; *"I think by feeling calmer, I did feel more relaxed and in control for some of my labour."* For other participants the VR helped by giving them confidence that they could get through labour.

I could finish a contraction thinking I'm not sure whether I could do this and then open my eyes and go, oh, there's an elephant, so it added a bit of positivity. (Katie)

Many participants recalled feeling reductions in pain (sensory pain) and spending less time thinking about pain (cognitive dimension). Reflecting on their experience of labour using the VR, participants felt that the intensity of the labour pain, the sensory dimension of pain, was reduced.

So, using the VR goggles, in the first stage I really felt that it took the edge of the pain away, so I could focus on what I was seeing and try and distract my mind and then every time the contractions were coming, I was just trying to focus on whatever I was watching, like the dolphins and things coming and it really helped me, so that my pain went from 6 to 4...I pretty much remember that part, so I really felt that it helped me. (Diana)

The pain is still there, it wouldn't go away of course, but then when I was using the VR it probably lessened it by one or two times lower than the actual pain itself without the VR, if I'm like getting 9 or 8 without the VR then it was a bit less with the VR, like a 6 or a 7. (Linda)

Although it was considered effective some participants shared the effect was minimal and therefore having the headset on was not warranted at that time.

I think it did reduce my pain and from memory I think I did say my pain score was reduced, but I don't think it was substantial enough for me to continue using it, in conjunction with the other techniques I was using outside of the VR headset. (Liz)

Some participants shared that their partners considered that VR impacted on the experience of sensory pain.

I'm not sure whether the experience diminished the pain intensity I felt or not. The first time that I used them I think my contractions were cooling off for a period of time before ramping up again so perhaps it wasn't the best time to use them from the point of view of research, although I really enjoyed using them. My husband mentioned that I seemed to calm down quite quickly when using them so perhaps they did affect the intensity of pain – hard to tell. (Jane)

My husband mentioned a photograph [he took] of me, wearing the headset, and he said, I was almost asleep, and it appeared to be the biggest break I had from contractions. In this moment, I was asleep, and he observed that the contractions would come but I didn't seem distressed by them, and I was in the bath, and I had the headset on, and I seemed really relaxed, it was before I used the gas. (Katie)

Using the VR in their labour influenced the cognitive dimension of pain for all participants. It helped the participants not only during contractions but also between contractions.

The VR did distract me from thinking about pain. When I felt a contraction starting, I would try to focus more on the scene I was watching. In between the contractions the VR helped prevent me from thinking about what was coming and how much more painful the labour would become...I was able to distance myself from the pain for some contractions, I found the distraction from pain really helpful. (Patricia)

Yeah that was definitely less when I had the goggles on, yeah, and the time of the contractions, I wasn't thinking how long is this one, you know, when is this one going to end, which is helpful to get through them. (Lisa)

9.3.1 Using virtual reality in different stages of labour

Many of the participants chose to use the VR outside of the measurement periods during the labour. For five participants it was in the early stage of labour when they were usually in their home environment, for fourteen other participants they preferred to use it in the active stage of their labour, and seven participants used it in both early and active stages. The effectiveness of VR in a particular stage of labour was very individual for each participant and highlighted the subjective experience of labour pain and the variety of coping strategies that women utilise.

The decision by the five participants who only used the VR in the early stages of labour was influenced by the intensity of the pain the participants were experiencing and because they had other strategies they were using.

I did use it when I was in very early labour, that was more relaxing and fun...I'd gone to sleep and then I woke up, so I thought these are getting strong, so I didn't pull out the VR. I got to that stage [where] I just needed to concentrate hard so I think it was more of a distraction...and I was apparently transitioning so I don't think I could have handled anything.
(Janet)

The 14 participants who used VR in the active stages of labour (seven had also used it in the early stages of labour) considered it was very useful for managing the pain. In this later stage it was often used in conjunction with other tools the participants had in their toolbox such as hypnobirthing, water immersion, massage, and touch.

I found it more effective in the later labour...I think I just needed to space out at that time, I just needed to go away and be as calm as I could and just take things as they came, whereas in the beginning I was very in control, and I needed to have my wits about me a little bit more. I think we did use it a little bit before in the early labour. (Katie)

I think it was active labour, I think soon after that I went into the pool and that's when everything got away from me (laughing), well just after the pool really. I meant to come back to use the headset again, but it was just too much for me. (Donna)

9.4 The challenges and surprises of using virtual reality in labour

Using VR was a relatively new experience for all but two of the participants. All participants had been introduced to it antenatally, and nine participants used it at home. Using VR in labour presented some unexpected challenges because of the hardware of the VR set, and some surprises because of unexpected reactions such

as the impact on the connection with others during labour. Despite these challenges most participants shared something positive about the benefits of using VR in labour.

Many of the participants shared that their plans for managing their labour included using water immersion as a coping strategy. Knowing that the VR headset was not waterproof was therefore a barrier to its effective use. Some participants said they were quite anxious about damaging the equipment and the headset restricted their movements in the water. One participant who used the VR in the birth pool, however found it very stressful, she found the goggles heavy and was constantly worried that she would get the goggles wet.

When I was in the water in the tub I was more concerned that I would get the goggles wet and then because I chose to be on all fours inside the tub, the goggles, the weight in front was dropping my head...they were very heavy...when I tested them outside the water, it worked superfine in the first part. (Diana)

Using the VR in other than a sitting position (which the VR headset is used in most cases) was uncomfortable and awkward. It felt heavy, particularly in the neck area. This heaviness was problematic if a participant used it while they were on all fours, that is while they had both their knees and arms/hands on the floor. This position of being on all fours also proved difficult for the participants when viewing aspects of the VE. Their vision was limited to just what was in front of them, they missed objects meant for distraction.

Because I wanted to be on all fours, when I was having a contraction then I was just looking at sand. (Lisa)

I got a bit frustrated with it, when I was using it in the position I found most comfortable, on my knees up on my elbows in a slightly seated position. It was in the middle of the night, and I hadn't had much sleep, I was already quite tired and I found it quite frustrating...I wanted to focus on the manatees but they were not in my view and so I had to move my head to try and watch them, they kept going out of my vision which became frustrating, it became less enjoyable because of that. (Liz)

Even though participants were keen to try VR, the realities of the experience of managing this as well as labour was not as pleasant and was harder than they had anticipated. For example, it was tiring trying to move their head to look at the images, and it was restrictive when the participants were in active labour.

When I was in labour I enjoyed being quite active and moving around and I found that when I had the headset on I couldn't move around and when the contractions came, I was worried about finding something to hold onto or finding something to sit on rather than thinking about what the VR was doing...I thought it'd be something that I'd really be into, but it wasn't until I was in labour that I realised I wanted to move, and it wasn't as practical for me. (Hannah)

The VEs used were consumer ready products. Some of the VEs the participants chose because they had viewed them antenatally, had disadvantages when used in labour. For example, many of the VEs used were designed for short periods of time of meditation and relaxation. Using these short scenes in labour was annoying for the participants as they needed to be constantly replayed. Participants described just getting into a VE, finding it relaxing and calming, and then it just stopping. The participants had found no VEs that had a running time of more than 10 minutes.

Despite having chosen the VEs that they were going to use, some participants found the content of some VEs did not always work for them when in labour. Many participants expressed a desire to view a VE of natural landscapes, however these were very short, often just consisting of a wave constantly breaking. They also often contained groups of people walking through the VE which some participants found intrusive.

So, the [VR] just ran out just when you're starting to get absorbed in it and you've kind of broken out of that zone when you're trying to find a different scene or if you go into a scene that doesn't work well...And there was one scene which had more people in it and I just didn't like that, I didn't like walking past those random strangers. (Paula)

I was very interested to try the scary blob thing [Blob VE] that we'd talked about, because it was so strange when you introduced me to it and I was just fascinated to see what it would be like in the flesh and I think it was quite good but it was quite short and it kept running out and so it was a little annoying to have to start it each time, so something that's continuous because potentially it's a very long time to keep it on for, so a longer scene. (Katie)

An aspect that some participants mentioned that they did not like about using VRs in labour was due to immersive effect of VR. They shared that all-encompassing aspect of the goggles resulted in them feeling disconnected at times from their partner and from their labour experience.

I probably just wanted to be a little bit more engaged with family...my partner and my midwife...I was going to have family come up briefly as well...it can be a good thing to take you away from your room and your

scene and, I just wanted to make sure my partner was involved as well.
(Paula)

Being taken away from one's partner also concerned Angela who expressed that she felt she was not connecting with them while in VR, and therefore the whole labour experience was not being shared.

Although I also felt it was removing myself from the situation and from my partner who I wanted to be present with. (Angela)

Husbands/partners also shared with their partners that they felt disconnected from what they were experiencing.

My husband mentioned that he felt disconnected from me whilst I had the goggles on and mentioned that if there was a way of sharing the VR experience that may be useful. My husband thought it would be great if there was a screen which showed what the goggles were displaying to him also, so that there would be less of a disconnect. (Jane)

Yet, using VR offered the opportunity for partners to be involved in the labour and birth in a different way. Some partners for example put the VR headset on themselves, viewed some VEs and helped to select the VEs that were watched. For one partner, it reportedly made being supportive in labour easier.

But you know, it's not his favourite place to be and he reluctantly is there, and he feels quite awkward with it, so he probably preferred it when I was using the VR, it takes away his responsibility, he had to be there. He would have probably been into sorting out the scenes if he were more tech savvy, would be into anything that gave him some sort of other thing to do, he'd rather not be there and I'm fine with that too. (Paula)

9.4.1 Recommendations for using virtual reality in labour

Following the experience of using VEs in their labour, some participants identified specific features and VEs that they enjoyed using. Features identified included what was in the VE as well as wanting the VEs to contain considerable movement. If they used VR in labour again they would recommend or view VE's with this content and/or features.

I liked both of the scenes that I watched and I definitely liked the wilderness scenes, it just didn't have enough movement or animals in it for me to actually focus on and the fact that like the underwater scene that I preferred the most [the manatees], it was quite a soothing motion that the animals were doing but they were out of view, so once I moved into their view it was better...it was more the fact that they weren't in my vision so I definitely found what I liked, it's just there wasn't enough in there for me.
(Liz)

For one participant the relaxing water in the Beach VE was an acceptable substitute for not being able to use water in her birth.

It just showed me how the beach scene was so nice, yeah, I'd probably go for the nature ones, maybe a stream or a waterfall, and for me it wouldn't have needed birds coming in, it just would have water and the sound of water because I didn't get to have my water birth, so it was quite nice to have water involved in another way. The scenes were just too short, you were just getting into in, it just disrupts the flow a little bit. (Paula)

9.5 Discussion

This section presents a discussion of the key findings from the third phase of this pragmatic mixed method study, which explores the experiences of participants using VR in their labour. Three key findings are discussed. Firstly, that VR is a useful intervention to assist with managing labour, secondly, that using VR while labouring poses challenges, and thirdly areas that the research raises for further development.

9.5.1 Virtual reality as a useful intervention to manage labour

Phase three of the study identified a variety of ways in which VR had an impact on the experience of labour for the participants. Virtual reality was described as an effective distraction technique by most of the participants, allowing them to shift their focus away from the intensity of the pain during contractions. They were able to absorb themselves in the immersion of the VE and remove their attention away from the pain. The distraction by using the VR provided the participants with a sense of being able to ‘escape.’ People who use VR recreationally commonly wish to experience escapism (Garner, 2018). Tuan (2000) in his discussion on VR and escapism, identifies escape from earth as one experience people value about VR. This idea of escaping from earth is a basic aspect of VR due to the presentation of an alternate world and also, critically, the shutting out of the actual physical world (Garner, 2018). Participants in the current study used terms to describe this shutting out of the physical world while being in labour. They talked about “escapism from the reality of what was going on” and “going somewhere else for a while.”

Participants described how they wanted to escape during the worst of the pain. They used the VR as a coping strategy and part of VR’s impact for the

participants was as a form of escapism. Wanting to escape from labour pain is not a new finding but knowing that VR is a useful tool to aid escaping this pain has not been established previously. A study by Karlsdottir and colleagues (2013) explored women's perceptions of labour pain and the strategies they used to manage and prepare for this pain. Women prepared for and managed the pain of contractions with different strategies, by 'mental pain management' through utilising creative imagination, de-stressing prior to the birth, going to a 'happy place' and using distraction techniques like counting during a contraction. Virtual reality is a useful tool to add to these strategies.

Escott and colleagues (2004) conducted a review of the literature surrounding psychological knowledge in relation to the development of coping strategies for pain management in labour. Similar to participants in the current study, the review identified that women managed their thoughts as a form of distraction, thinking of other things or imagining they were somewhere else, taking their focus away from the pain of contractions. Participants in the current study used the VR to help them imagine they were somewhere else, the VE was another place where their imagination could take them. They created stories around the VEs that they viewed, and this increased the effectiveness of VR as distraction. Escott and colleagues (2004) review found women describe psychological therapies to manage labour and the term "cognitive strategies" was used to describe the manipulation of cognitions through such methods as imagery, coping statements or distraction. The utilisation of imagery involved the woman conjuring up an image that alters aspects of the pain experience. When the technique of distraction was used, the distraction could be either passive or active. Passive distraction is considered as an attention-diversion strategy whereby attention is redirected to another stimulus, such as television.

Active distraction involves techniques such as counting backwards (Escott et al, 2009).

Virtual reality was effective in distracting the participants in this study from the intensity of labour pain and had a positive effect on labour pain intensity. The effectiveness of VR as a distraction technique was both passive and active. It was passive in that participants could just watch and listen but was active in that with immersion participants moved and followed the scenes. The finding that distraction worked has immediate practical implications in the maternity setting. Due to the low cost of many VR headsets, that they are now lighter and wireless, the experience of participants in this research indicates that the use of this technology is a viable option for women to use in their labour. The research findings indicate it is not likely to be the only strategy labouring women would use, rather it is useful in conjunction with and as a complement to other strategies such as water immersion, hypnobirthing, and visualisation.

For many women, particularly primiparas, labour can be long and relentless. Findings from the current study described how participants used the VR and its distraction qualities to escape from the boredom of a long labour and the feeling of 'clock watching.' In a study by Lundgren et al. (2009) that explored women's long-term memories and experiences of birth, details of the birthing room were exaggerated with for example the clock on the wall becoming 'the enemy' (p.123). Time was experienced differently; slowly or not at all, a 'feeling of forever being in this process' (p.123). Similarly, participants in the current study expressed the idea that time was experienced in a different way with VR, particularly in relation to the contractions, increasing the time between the contractions or making the contractions feel shorter. The finding that VR helped participants to experience time

passing more quickly, indicate that VR can be a useful tool for helping women tolerate the pain of labour as it can positively influence the “rest” time between contractions. There are two possible explanations for this benefit. It may have been a response to a psychological phenomenon, the feeling as if the contractions were shorter or it may have concerned the physiological effect of reduced pain intensity and inducing uterine relaxation. These findings regarding time are in line with those of research which examined the time effect of VR on study participants experiencing experimental pain (Dahlquist et al., 2009; Magora et al., 2006) and patients during chemotherapy treatment (Schneider et al., 2011). In all three of these studies, pain was tolerated for significantly longer periods and time was experienced as passing more quickly, known as the elapsed time compression effect.

The immersion of the VR also enabled participants in the current study to escape the environment they were in, described as sterile, medicalised, devoid of colour and comfortable furnishings. This finding is similar to women in a university hospital based study that compared a humanised model of care with a biomedical model of care (Ferrer et al., 2016). Ferrer et al. found that women disliked the clinical and impersonal labour, birth, and postnatal rooms, preferring the more personal, pleasant, and relaxing rooms in the humanised model. For the participants in the current study, VR allowed them to select an environment that was different to the labour room. Many valued that VR took them to an environment that they found relaxing with soothing sounds and colours (one of the VEs chosen was the underwater scene with dolphins). They were able to experience this environment simply by putting the VR headset on and play the VE they enjoyed. This alternate environment was described by the participants as like “going to a different world”, or “like entering a dream”. Their experience of being able to change their environment

by simply putting on a VR headset demonstrates that this technology could be readily adopted in any birth environment, including highly medicalised birth rooms. It has the potential be used to reduce anxiety in operating rooms prior to epidural catheter insertion for caesarean or forceps deliveries.

The final experience of escapism, articulated by participants was the concept of escape, of 'going to their own space' or their 'own little world'. The idea of going within themselves, of withdrawing from the present reality to a private world is a common theme in the literature surrounding birth. Karlsdottir and colleague's (2013) exploration of women's preparation for labour found that women used the phrase "to be in their own world" (p.323) to be 'egocentric' (p.321), to trust one's own body and remind themselves that they could cope with the pain without medication. In an earlier study by Halldorsdottir and Karlsdottir (1996) women indicated that they entered into a private world during their birth experience, despite being surrounded by other people. It was necessary for these women to withdraw into this private world as protection against vulnerability and insecurities. This desire to withdraw into a private world was also evident in the findings in the current study. Participants expressed the need to escape from the feeling of surveillance, of being watched or on display, at the same time acknowledging that they were surrounded by support from their midwife and support people. This feeling of being observed while labouring is a type of neo-cortical stimulation which can inhibit effective contractions in labour and privacy (Odent, 2008).

Discussions in the literature on reducing neo-cortical stimulation describe how labouring women can cut themselves off from the world, by going to another planet (Buckley, 2009). To reduce this neo-cortical stimulation an environment which avoids visual stimulation is advocated, no bright lights and not very loud sounds.

Theoretically, it is possible that the use of VR could increase neo-cortical stimulation, however this was not apparent in this study. Rather it appears that the participants found the VR so effective in terms of distraction that it aided their ability to escape and remove themselves to another world. A possible explanation is that women birthing in current hospital environments with constant interruptions, invasive monitoring and a feeling of surveillance are unable to reduce the neocortical stimulation that is crucial to physiological birth. Virtual reality as evidenced in the findings of this study emerged as a method to paradoxically reduce neocortical stimulation and allow participants to feel removed from their surroundings.

9.5.2 Virtual reality as relaxation and avoidance of catastrophising

The effectiveness of VR in the management of labour pain and as an effective coping strategy during labour for the participants in the current study was partly due to the ability to induce relaxation and a feeling of calm. The participants engaged with the VR to avoid negative thoughts and to reduce anxiety about the birth. Participants found the VR experience novel, enjoyable and fun. They recalled their experiences wearing the VR headset as positive and because of this positive experience and happy memories all but one ($n= 18$, 95%) would consider using the VR in their next pregnancy and would recommend it to pregnant friends. These findings confirmed the acceptability of VR as a distraction technique in labour.

Part of the process of creating a positive calm atmosphere is the avoidance of negative thoughts or catastrophising. The findings indicate that the participants found that the VR helped them to reduce worrying about the progress of labour, whether it was too long and how baby was coping. Catastrophising in labour is described by Escott et al. (2009) as women progressively having more negative thoughts about

the impending birth. In their study, they found that women who catastrophise prior to labour experience greater discomfort. Virtual reality helped participants in the current study to avoid negative thoughts or catastrophising in labour which has the potential to contribute to a positive birth experience and help to tolerate pain. Positive birth experiences have an immediate impact on the woman and her family and has implications for future pregnancies.

Findings from the current study suggest that VR was used in a variety of ways to manage or cope with the physical and psychological challenges of labour. Participants found that VR was effective in managing their labour pain and that it was used as part of a range of coping strategies to help them on their maternal journey. Women use non-pharmacological techniques in labour not purely to inhibit the perception of pain but also to intensify the emotional experience of childbirth, to provide comfort to themselves, to be an active participant in the birth process and to master the pain, thus increasing their confidence and self-belief in themselves (Simkin & Bolding, 2004). Studies have identified that women who use complementary alternative methods (CAM) in pregnancy are highly motivated by a desire for self-determination, active participation and autonomy in their maternal journey (Mitchell & McClean, 2014; Warriner et al., 2014). Participants in the current study strived to be active in their labour and to be autonomous and in control of their birth. Similar to women in other studies, the participants used a variety of coping strategies in their labour from music, acupuncture, massage, heat and cold, hydrotherapy and distraction.

The findings indicate that the participants used the VR in several ways to help them manage their pain in labour. While the VR was used predominantly as a distraction technique, focusing their attention on the VE rather than the pain, some

participants used the VR in novel ways. As an example, the movement of the dolphins in the underwater scene was used to synchronise the ebb and flow of the contractions. Virtual reality was used to manage contraction pain by assisting participants with breathing techniques and help them feel in control of the birth process.

Aspects of VEs assisted the participants with their breathing techniques which helped to relax and prepare them for the contractions that were coming. Breathing techniques are important for women in labour and are the most fundamental of coping strategies for the management of labour pain. Women used breathing techniques most often as a reaction to pain and then used relaxation techniques to feel calm and avoid pain (Spiby et al., 2003). The use of relaxation and breathing techniques in labour is associated with a reduction in anxiety and pain perception and an increase in a woman's ability to tolerate pain (Murray & McKinney, 2013). Women aspire to labour and birth in a calm environment, hoping to maintain this feeling of calmness themselves (Huber & Sandall, 2009).

The ability to manage their labour pain by using such coping strategies as distraction, breathing techniques and relaxation gave the participants a sense of control in the labour process and a confidence in their ability to master the pain. Similarly, other researchers have found that women report a greater sense of personal control when they have a choice in pain management, are active participants in decision making around these choices, and when they use their own personal coping strategies (Hodnett, 2002; McCrea & Wright, 1999). Women who use coping strategies and choose the self-comfort measures that work for them in labour are actively participating in their labour and using her own resources in tandem with her support people. This gives the women a greater sense of

confidence, which allows them to cope better with the labour, enhancing emotional wellbeing. While the pain-relieving capabilities of such methods may only offer modest or short duration of reductions in pain perception their contribution to the psychoemotional, spiritual, social and cultural factors of the birth experience are largely positive (Simkin & Bolding, 2004).

9.5.3 Virtual reality contributes to a positive birth experience

Many of the participants who used VR in labour reported that it contributed to a positive birth experience and increased their satisfaction with their birth experience. They recalled their experience of using the VR as a happy memory, helping time pass quicker, helping to relax them and helping them tolerate the pain of labour. Women in other studies who had used non-pharmacological methods of pain relief rated them highly in terms of satisfaction and had a strong desire to use them in future pregnancies (Simkin & Bolding, 2004). Women are more likely to rate their birth experience as positive if they are satisfied with their performance, take pride in their ability to be in control of their behaviour and body in childbirth and are able to influence their environment (Bryanton et al., 2008; Hardin & Buckner, 2004).

Participants were able to influence their environment, they were able to change the medical room they were in and immerse themselves in their chosen VE. The influence of the birth environment on birth satisfaction and birth outcomes is well documented in the literature (Foureur, 2008; Lundgren et al., 2009). In a UK national survey of 2000 women, nine out of 10 women considered that the physical surroundings influenced how easy or hard it was to give birth. Women who were surveyed emphasised the importance of beauty, nature and ambience in the birth room and identified sensory elements such as aromatherapy, music, and visually

appealing outlooks such as windows that looked out to a nature view with water features, as examples of ways to enhance the birth space (Newburn & Singh, 2003). The portability of the VR headset means these could change any environment that women labour in.

The finding that participants used the VR to create a more positive environment, an environment which took them to tropical beaches, or other natural landscapes aligns with what is understood about birthing environments and labour. In Lepori's (2008) seminal discussion about birth space, she advocates for colours used to cover the walls of birth rooms to be from the body energy system (chakras), that are part of eastern philosophy, medicine, and spirituality. These colours are considered to evoke sensory responses in different parts of the body. Lepori (2008) also emphasises the importance of incorporating elements of nature, views of the sky, water, mountains, flowers or trees through a window or pictorial representations of nature in designing architecture for birth which helps to develop the mind/body/spirit connection.

Ways to change the birth space into a more positive environments have been explored in the literature, in a variety of ways, from the specially designed Snoezelen room in Australia (Hauck et al., 2008) which displays wall patterns with fibre-optic lights that slowly change colours, tanks with colourful tropical fish, relaxation music and aromatherapy to an alternate birthing room in Herning, Denmark, which uses visual and auditory stimuli of natural landscapes on the walls (Nielson & Overgaard, 2020). Both studies reported positive feedback from the women who used the rooms, the rooms provided relaxation and distraction and, for some of the women in the Danish study, the visual and auditory stimuli captured their attention which helped them cope in labour. They described it as feeling like they were inside a

'bubble' and women described the peace in just watching that [the projected images] (Nielson & Overgaard, 2020, p.8).

Virtual reality offers a simple, low-cost option of changing the environment which can be used in any birth setting even the most medicalised. The findings indicate that the participants could control when they want to enter a VE and when they want to return to the physical world. They choose from a range of VEs suited to their personal preferences and what they want to achieve, distraction, relaxation, or enjoyment. Virtual reality allowed the participants in the current study to truly escape and go into another world.

Several dimensions of pain were identified by the participants as being affected when using VR in their labour. The first dimension, sensory pain or the intensity of the labour pain was recalled by the participants as being reduced when they used the VR. Several participants recalled that they gave a reduced pain score when the experimental component of the study was conducted. These findings validate the statistically significant reductions in sensory pain and physiological variables of MHR and MAP measured in the quantitative phase of this study. In terms of cognitive pain or time spent thinking about pain, VR was effective as a distraction technique and had a positive effect on this pain dimension. These results suggest that VR can be used as an analgesic to reduce both sensory and cognitive pain in labour. Virtual reality can be used on its own or as an adjunct to other complementary therapies or pharmacological methods of pain relief. This is the first study which has explored sensory and cognitive pain dimensions in qualitative interviews.

9.5.3 Using virtual reality in different stages of labour

The findings indicate that outside of the planned VR use, participants used the VR to manage their labour pain at different stages of the labour process. Many participants reported that the VR was effective in the early stages of labour, particularly when they were at home. In long labour and particularly in early labour the participants had a range of strategies to utilise which helps the time pass while they wait for active labour. In their home environment they were able to utilise the VR on their own, using it as a self-comfort measure before they felt they needed to wake up their support person or move to the hospital environment. Given that the participants were also able to use the VR outside the measurement periods for the experimental component of the study when in labour means that the findings give more information about the value of VR in labour. This freedom to use VR at any time was a unique feature of this study and allowed the participants to use the VR whenever they wanted in labour and for however long it suited them. It allowed them to manage the VR themselves, or in conjunction with their partner and so worked as a self-managed therapy in labour.

Other participants in the current study found the VR more effective in the active stage of labour and some participants used it in both early and active stages of labour. Participants referred to the labour pain as “ramping up” and “getting away from them”, becoming too intense in the active stages of labour and the VR was not benefiting them as it had in early labour. For one participant the VR was too much of a distraction for her, she was wanting to concentrate on the contractions themselves.

Labour pain is a highly subjective experience for women and women experience each stage of labour in a different way and utilise a range of coping strategies individually. This was evident in the narratives of the participants in the

current study. A meta-analysis which explored the range of coping strategies women chose to utilise in labour identified that women initiated using relaxation and/or massage techniques to make the pain more tolerable but those difficulties arose as the intensity of the pain increased. Women who used these techniques reported that they were less effective than expected (Thomson et al., 2019). Similarly, women in Escott and colleague's (2004) study which investigated the range of coping strategies that women used to manage pain and anxiety prior to and during their first experience of labour. They reported that distractions such as watching television, listening to music, and reading were used more in early labour rather than active labour when the contraction pain intensified. Women describe the process of labour as like a marathon, they start out feeling exhilarated, looking forward confidently to giving birth or "finishing the race." However, over time, the intensity of contractions increases feelings of exhaustion, discouragement and a decrease in confidence overwhelms them (Callister et al., 2003).

9.5.4 Challenging nature of virtual reality for women in labour

Finally, using the VR in their labour was not without its challenges for the participants in the current study. This was the first study to explore qualitatively the experiences of women using VR and in addition to their positive comments the participants articulated aspects of the VR that frustrated and disappointed them. Labour is often long, extending well over several hours. The biggest challenge in using the VR in labour for the participants was the brevity of the available VR environments. Currently there are no specific VEs for labour, those used were consumer ready products available on the VR platform, Oculus Go. Participants found that they were just relaxing into the VE when it finished. They found

themselves watching the same VE over and over on a loop, as they enjoyed the scene, but it was short, perhaps lasting on average 10 minutes. Some of the participants who used it for long periods located a variety of VEs which appealed to them, for example one participant enjoyed animal scenes so found VR content of Savannahs in Africa, another participant enjoyed travel so found scenes of Venice or North Korea. Partners helped navigate the VR menu and located scenes that would appeal to their partners as they laboured. This perhaps provides a novel role and contribution for partners and other support people to make in the area of birth. Many partners and support people feel they have not got a defined role in the birth process or feel uncomfortable in the birth environment.

Some participants who used the VR in the birthing pool had to discontinue as the VR headset were not waterproof, they were disappointed about this. The experience of using the VR headset in the birthing pool was enjoyable for most of the participants as there was minimal movement in the water and they could watch an underwater VE which enhanced the relaxing nature of the water environment. Many other participants would have wanted to use the VR in the birth pool if they had been waterproof and this is something that needs to be considered for the future use of VR in labour.

The finding that being restricted in their movement while using the VR was not limited to the birth pool. It also occurred because of the labouring positions some participants adopt. Despite this limitation participants saw the VR as a useful tool in their toolbox of coping strategies to use in labour and there were times when they wanted to move and times when they just wanted to be still, for example on the birthing ball. There were problems with using the VR in non-traditional positions, for example, while on all fours. It meant that the participants had to move their heads to

see some of the images on the screen and this constant trying to locate the images was very tiring. While the VR headset was found to be mostly comfortable and light for the participants, it was described as bulky and could become heavy if you were in a position other than sitting.

Participants chose VEs which they were interested in and found enjoyable. Many of the participants were drawn to nature type environments which they described as relaxing and calming. There was a range of VEs that were chosen by the participants in their labour.

Finally, the immersion of the VR was described by several of the participants as a problem as it led to a sense of feeling disconnected from their partner or their midwife while they were in labour. They did not feel that they could engage with their support people. Most of the participants did not comment on this as a problem, which was surprising that it was not more of an issue. There is the potential for the partner to wear a headset also and share what the labouring women is experiencing in VR.

9.6 Summary

In the third phase of this study, data from the qualitative interviews with participants in the postnatal period was presented, interpreted, and discussed. The participants described how they used the VR practically in their labour and birth. Virtual reality was part of a selection of coping strategies they instigated throughout different stages of their labour, for some participants it was early or active labour, but some participants used it in both stages. They found it to be effective distraction in labour, it was enjoyable, and it helped to induce relaxation and a feeling of calm. It helped them feel in control and contributed to their perception of a positive birth experience.

The final chapter which follows concludes this thesis and discusses limitations of the research, implications for practice and implications for future research.

CHAPTER 10: CONCLUSION

This research sought to determine whether VR would be an acceptable and feasible intervention for use by women in labour. This thesis further examined whether VR would have an effect on labour pain intensity and explored the experiences of women using VR in their labour. The following questions and aims were formulated:

What are the experiences of women using VR antenatally, what is the effect of VR on labour pain intensity and what are women's experiences of using VR in labour?

The aims of this mixed method study were to determine whether women would use VR in labour, to measure variables of labour pain intensity and to explore women's experiences of using VR in labour.

There are three parts to this aim and as a result, the use of a pragmatic mixed method design with three phases, qualitative, quantitative, and qualitative was appropriate in terms of answering the research question and achieving the aim. In terms of the first part of the aim, this thesis demonstrated in the qualitative interviews with pregnant women antenatally that they wanted to use VR in labour as they saw it as a feasible intervention. The VR used in this thesis was an off-the-shelf VR headset and supported VEs. Based on the findings from this phase where it was found that participants enjoyed their experience of using VR while pregnant, and that it was emotionally arousing, effective as distraction as well as relaxing and fun. Participants were motivated to use the VR in their labour as a complementary

alternative therapy and as another coping strategy to help manage pain, aid relaxation, and to feel in control.

In relation to the second aim, to measure variables of labour pain intensity, the use of VR demonstrated significant reductions in sensory pain using self-reported pain scores as similarly reported in three published research trials. The findings from this research support the use of VR as an effective method of pain management in labour. In addition to the other studies, this research demonstrated decreases in the cardiovascular responses to pain as indicated by the recordings of the maternal heart rate (MHR) and mean arterial pressure (MAP) when using and not using VR. This provides physiological data that is consistent with what is understood of pain perception, response, and cortical control of pain. The neurobiological response to pain is complex and while it is recognised that a painful stimulus elicits certain autonomic responses that can be measured and integrated as physiological markers of nociception, these responses measure presence of pain rather than severity and are affected by stress responses and underlying pathology.

Finally, the third aim explored in postnatal qualitative interviews women's experiences of using VR in labour. This is the first study to explore the phenomenon of VR in labour qualitatively. Participants described their experiences of using VR in their labour, highlighting its effectiveness as distraction from pain intensity, from the boredom of labour, from the birth environment and from their present reality. Participants in this study used VR as a coping strategy in labour that was effective in managing their pain, aiding relaxation, and avoiding negative thoughts. Many of the participants associated their experience of VR and satisfaction with their birth and identified a sense of control as contributing to a positive birth experience and ability to manage pain. These findings align with literature on how women use

complementary alternative therapies and coping strategies in labour and establishes VR as an acceptable and effective nonpharmacological method in labour.

10.1 Triangulation

The individual data from each of the three phases of this study was collected and analysed separately to produce three sets of findings, two qualitative and one quantitative. To integrate the qualitative and quantitative findings a triangulation protocol was used that was originally developed for use for the integration of different qualitative methods (Farmer 2006). In this protocol, it is argued that the primary purpose of triangulation is to explore convergency, complementarity and dissonance within the data sets (Farmer, 2006). Methodological triangulation, used here, relates to the use of several research methods and data collection techniques. Presented within several tables, a unified list of themes from both sets of qualitative data are compared to each other and the quantitative findings to determine convergence or dissonance amongst meaning and prominence of themes derived from the data. Three tables were developed that comprise the key themes related to the research questions. A convergency coding scheme is used based on agreement; full agreement amongst the three sets of findings/results of comparison, partial agreement indicating agreeing on one set of findings but not all, silence, where one set of findings aligns with the theme while the other sets of results/findings are silent and finally dissonance, indicating disagreement amongst the findings/results (Farmer, 2006). Table 6 presents the levels of agreement between the themes that emerged from the antenatal findings the quantitative results and the postnatal findings.

Table 6: Nature of similarities concerning participants' antenatal experiences with VR and the postnatal findings

Theme and agreement across 3 studies	A/N Qualitative	Quantitative	P/N Qualitative
Virtual reality as an emotional experience	Participants were able to evoke a range of emotional responses after viewing each of the four VEs.	Silence	Agreement. Participants described how viewing a VE in labour evoked a range of emotional responses of feeling relaxed, calm, happy
Presence – being in the virtual world	Participants described being present or being in the virtual world when they used the VR.	Silence	Agreement. Women described the VR in their labour as effective distraction and being able to take them away from the physical world.
Envisaging using VR in labour	Participants described using VR as a potential coping strategy in labour. As escape – using the VR as effective distraction from the pain of labour and as anchoring – to avoid catastrophising and negative thoughts in labour.	Silence	Partial agreement. In labour the participants used VR as a form of escapism – it was effective as distraction to escape the pain of contractions, to escape from a long, relentless labour, to escape from the sterile, medicalised room and to escape from the present reality. They also used VR in their labour to avoid negative thoughts and to gain a sense of control.
Subtheme: VR's potential in different stages of labour	Participants identified different stages of labour, early or active where they envisaged using the VR would be useful.	Silence	Partial agreement. Participants who used VR in labour identified different stages that they preferred using it and they found it effective. For some participants it was early, for some it was active. Some used it in both early and active labour.
Subtheme: The ideal VR environment	Participants described what their ideal environment would be for use in labour.	Silence	Partial agreement. Some participants identified features of the VE that they enjoyed while they were in labour. Participants also recommended future VE's for use in labour.

Antenatally, participants clearly identified how they would use the VR as part of a selection of coping strategies to help them in early and active labour. The

participants envisaged using the VR to help them manage their labour pain, to gain a sense of control or to anchor themselves. Table 7 presents the levels of agreement between the quantitative data, the themes that emerged from the antenatal and postnatal findings.

Table 7: Quantitative data related to labour pain intensity compared to themes derived from antenatal and postnatal findings

Theme and agreement across 3 studies	Quantitative	A/N Qualitative	P/N Qualitative
Virtual reality decreased labour pain intensity	Participants reported decreased pain scores while using VR in labour and both heart rate and mean arterial pressure was reduced when using VR.	Silence	Agreement. Participants recalled in their narratives that their labour pain intensity, the sensory dimension of pain was reduced when they had VR on.

Quantitative data demonstrated decreased pain scores and physiological variables of labour pain intensity, MHR, and MAP. Participants recalled in their postnatal interviews that they had reported decreases in pain scores, the sensory dimension of pain and that they spent less time thinking about pain, or the cognitive dimension of pain. Table 8 presents the levels of agreement between the themes that emerged from the postnatal findings, the quantitative results, and the postnatal findings.

Table 8: Nature of similarities concerning participants' postnatal experiences with the use of VR in labour and the antenatal findings

Theme and agreement across 3 studies	P/N Qualitative	Quantitative	A/N Qualitative
Impact of virtual reality on labour Subtheme: Virtual reality as a form of escapism	Participants described using the VR as effective distraction, to escape the pain of labour, a long, relentless labour, the medicalised environment, and their present reality.	Silence	Agreement. Participants when envisaging how they would use VR in their labour described using it as a form of escapism, as effective distraction from the pain of labour.
Subtheme: The relaxing and enjoyable experience of virtual reality	Participants described the positive experience of VR that helped them relax, calm them and was a happy experience.	Silence	Partial agreement. Participants had a range of emotional responses to the four VEs they viewed. Included in these responses was: relaxing, calmness, happiness.
Managing the pain of labour. Subtheme: Using VR in different stages of labour.	Participants identified specific stages of labour when they used the VR, early and active or both early and active.	Silence	Partial agreement. Participants envisaged using the VR in specific stages of labour.
Challenges and surprises of using VR in labour	Participants identified several challenges when using the VR in their labour	Silence	Silence
Subtheme: Recommendations for future use of VR	Participants suggested features that would be useful for future VE's in labour.	Silence	Partial agreement. Participants identified their ideal VE's and features they would like included in them.

Postnatally, VR was described both as potentially, and then experientially, as an effective distraction technique which was both enjoyable and helped the participants relax and induced feelings of calm. In terms of sensory pain, the

participants reported postnatally that VR reduced labour pain intensity, and this was confirmed by the quantitative results in the second phase of this study.

The impact of VR on the experience of labour and the subtheme of escapism described in the participant's narratives postnatally is that VR is effective as distraction, to help avoid negative thoughts, to relax and help calm them and to feel in control of the labour process. In the narratives, the participants described their ideal VE and features of the VE for use in labour and for future labours, and a preference for natural landscapes was articulated.

This study used the findings from both antenatal and postnatal interviews to identify specific VEs or features that were the most popular and to incorporate these in design specifications for future VEs for women in labour. Participants chose the VEs they had watched at home and that were easily accessed in labour. Table 9 presents the design features and user requirements that arose from these phases of the study.

Table 9. Design and User Requirements

Design	User Requirements Addressed
A VE that lasts continuously for 30 minutes to one hour	Virtual environments were too short
A VE that changed over the course of viewing – from a slow relaxing scene to a busier interactive scene	Users wished to use VEs in both early and active labour. In early labour, they wanted a more relaxed scene and in active labour they wanted a scene that was more distracting
A natural landscape scene with water features, rainforest, natural sounds	Users' preferences were for scenes that had natural features, particularly water
A realistic VE	Realism preferred to animation
Easy to navigate through VE	Users wanted easy access when in labour
Virtual environments that could be seen in positions other than sitting or standing	Users changed into unusual positions in labour but still wanted to be able to see all features of the VE
A fully waterproof VR headset or waterproof casing around VR headset	Users wanted to use the VR in the birthing pool

10.2 Limitations

This mixed method research study included two qualitative components that explored participants (pregnant and labouring women) experience of using VR in labour, as such it presents the labour experiences from these participants' perspectives and cannot be generalised to the larger population of birthing women. However, it needs to be acknowledged that it was not the intent of the qualitative phases to generalise findings to individuals outside of the study. As Greene and Caracelli (1997) argue it is up to others to determine the transferability of the findings. This means that people (women, health professionals and others) may relate to these findings and consider that they would be applicable in their context. The value of qualitative research is in the development of themes and descriptions in the particular context for specific individuals and for a specific site (Creswell, 2009).

The first limitation concerns sampling. The initial sample of participants was purposively selected, and the participants who consented were highly motivated to experience the VR technology in their labour. The first phase of the research study was exploratory in nature, thus of necessity it was conducted with relatively small sample sizes, however this does not negate the worthiness of these findings, rather it provided an opportunity to present unique and individual narratives from the participants viewpoints. As this was the core sample for the other phases of the research it is not known how applicable the findings are to pregnant women generally. A further limitation of the sample is the socio-demographic characteristics of the participants. Despite attempts to obtain an ethnically diverse sample, no Māori or Pasifika women were recruited. It is difficult to determine the reasons for this as there was interest amongst both Māori and Pasifika midwives for this research project. Research should include Māori and Pasifika participants to fulfil Treaty of

Waitangi obligations. When I undertook this research, I adhered to the Kaupapa Māori values of whakaute (respect), mānaakitangi (hospitality), kaitiakitanga (guardianship) and rangatira (leadership) and wairua (wellbeing of everyone involved).

A third limitation is that the postnatal interviews relied on recall up to 10 days after the women's birth experiences. However, in a literature review, previous studies have demonstrated that women's recollection of their labour and birth experience is surprisingly accurate years after the event (Niven & Murphy-Black, 2000).

The fourth limitation is one that was highlighted in the methodology section is recapped here. For the subjective measurement of pain scores using the NRS it was estimated that a sample size of 16 was needed (or as large as 27 depending on the standard deviation). Thus, the analysis using pain scores is underpowered with a sample size of 14 and the statistical significance therefore should be accepted with caution.

This research acknowledges my own position within the construct of knowledge developed from this study. My role as a researcher and midwife placed me in a 'interested' position within the research, which is a subjective position. This can be a limitation, but this position can also have its advantages as it brings different strengths and insights to the research. It can influence what I heard from the women and what I considered important conceptually in the research. It is therefore important to acknowledge that my personal positioning and philosophy may have influenced the research findings.

10.3 Implication for practice

The main claims and key contributions to knowledge that emerged from this research are the acceptability of VR for women in labour, both early and active, and the benefits that women may experience when using the VR in labour. The VR was embraced positively when the participants first tried it in the antenatal period, finding it a novel and interesting addition to the range of coping strategies that they envisaged using in their labour. After using the VR, the participants reported it was very effective as a distraction technique, helped them relax during their labour, helped them with their breathing techniques and to avoid negative thoughts. Many of the participants described how it helped them feel a sense of control of the labour process and contributed to satisfaction with the birth experience.

The findings from this thesis have significant practical implications in maternity for a variety of practitioners, midwives, obstetricians, and obstetric anaesthetists. There were statistically significant reductions in sensory pain and physiological variables of pain intensity and the women recalled the reductions in sensory pain postnatally. Therefore, the use of VR can be recommended for use by women at all stages of labour, particularly for use in early labour when they are at home and needing another tool in the box of coping strategies to help manage labour. It could also be potentially used as a therapy antenatally to help with relaxation and to reduce anxiety. During this time women could familiarise themselves with the technology and VR experience and select VEs prior to using it in labour. It is minimally invasive and if any side effects are experienced, these stop immediately once the VR headset is removed.

Midwives can access a VR device relatively cheaply by purchasing on-line for overseas products. Women may also purchase their own device. VR is relatively

easy to use, but having some technological understanding and experience of trialling it themselves would be an advantage. Midwives could offer it to women who are considering using non-pharmacological methods of pain relief. Because VR provides effective distraction, it could potentially be useful for the wider health care team to aid insertion of epidural catheters, in phlebotomy and IV cannulation.

The findings from this thesis also have practical implications in all clinical areas that deal with acute pain. In this thesis, VR was shown to be an effective distraction technique, with benefits in reducing anxiety, aiding relaxation and these positive results can be successfully transferred to other acute pain settings. Furthermore, the findings have application in the area of design of VEs. This thesis reports on user preferences and expectations in the use of VR in the maternity setting. It identified aspects of the VR experience that were acceptable and challenging for use by women in labour, features which may be incorporated into future VE designs. Many features of the VEs were identified as increasing distraction, increasing presence, and evoking particular emotions. Using these findings from the qualitative interviews in the antenatal period some basic design specifications were obtained that could be used in the future for the design of specific VEs for use for women in labour.

10.4 Implication for future research

There are future research opportunities in the area of VR and labour as findings from this thesis support potential benefits in this area. Multi-center randomised controlled trials in clinical settings in New Zealand have the potential to provide high quality results with larger sample sizes and intervention-based research

measuring sensory, cognitive, and affective pain variables together with physiological variables.

Future research should focus on the use of VR in the antenatal period in preparation for relaxation and stress reduction in labour and developing hypnobirthing VR content could be explored. Due to the current popularity of hypnobirthing for pregnant women, the use of VR as a possible hypnotic induction technique is another promising research concept.

Future research should also explore the specific VEs and features that woman would prefer in VR. The research should also target recruitment Māori and Pasifika women so that developments are culturally informed. For example, whether the use of one particular VE is more distracting and useful in active labour, or whether another VE is able to elicit feelings of relaxation in labour and what is specific about that particular VE. The development of cultural VEs for users that align themselves to Māori or Pasifika values should also be considered. This research also recognises the potential for VR as a medical technology and health device.

10.5 Conclusion

This thesis has responded to the knowledge gap that existed in the literature regarding a qualitative exploration of women's experiences using VR in labour, and the findings from this research identified that women were very interested in using VR in their labour, whether it was early, active or both. Women used the VR as part of their coping strategies during labour and found it beneficial as a distraction technique and a relaxation technique. It helped them to remain calm in labour, to reduce anxiety and avoid negative thoughts and provided some women with a sense of feeling in control that contributed to a positive birth experience. This thesis also

provided new knowledge in VR and design of VEs for women in labour. It identified features that induced emotional responses, contributed to enjoyable experiences, increased the sense of presence and levels of distraction. These features influence the effectiveness of VR in the birth setting. This thesis supports the use of VR as a medical technology with benefits for pregnant women in their labour and birth setting. It is a project that integrated innovation, vision, and intuition in the combined areas of health, technology, psychology, and computer science to enhance the birth experience for women.

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APPENDICES

Appendix A

Questions for Usability Study of Virtual Reality Technology and Content for Pregnant Women Ante-Natally

Can you tell me about your overall experience using Immersive Virtual Reality?

- Can you tell me whether you enjoyed your VR experience?
- Can you tell me why you enjoyed the experience?
- If you didn't enjoy the VR experience, can you tell me why?
- What did you enjoy about the VR experiences? Why?
- What VR scenes appealed to you the most? And why?
- What VR scenes didn't appeal to you? And why?
- What features of the VR scenes did you enjoy? And why?
- What features of the VR scenes didn't you enjoy? And why?

In terms of the IVR experiences, was there a particular VR scene where you felt you were 'really there' more than the others?

- What VR scene was it?
- What was it about this VR scene that you felt "really there" compared to others?
- Was there anything that stood out in the experience?
- Was there anything about the experience that surprised you?
- Was there anything about your responses that surprised you?

Did you feel more as if you were in the VR scene or in the room?

- Did this change over time?
- If so, how so?
- How do you think you will remember this experience?
- Was the VR scene something you saw or somewhere you visited?

Can you tell me whether you would use VR in labour?

- Why would you like to use it in labour?
- Can you tell me why you wouldn't want to use it in labour?
- What would you change in terms of the VR experience for labour?
- When in labour do you think you would like to use VR?
- Can you tell me about your comfort level in terms of the headset?
- If you could change the headset how would you do it?
- Can you tell me how you found using the controls during VR?

Can you tell me whether you would use any of these VR scenes in your labour?

- Why would you use these scenes?
- If you wouldn't use any of these scenes, why not?
- Is there another scene you would like to use in labour?

Appendix B
ANTENATAL INTERVIEWS

Questions asked after each Virtual Environment (VE):

Can you tell me your first impressions of that scene?

If you could use a mood word for that scene what would it be, you can use several?

Can you tell me what the positives and negatives were about that scene?

If you could change anything about that scene would you change?

Questions asked after all four VE's were shown:

Was there a VE where you felt you were there more than in the room?

What scene was it and what was it about the VE that you felt more in the environment than in the room?

How do you imagine using the VR in your labour?

If you were a VR developer for labour, what VE would you develop and what features would you include?

Can you comment on the comfort of the headset?

Appendix C

NUMERIC RATING SCALE

Numeric Rating Scale (NRS)

A Numeric Rating Scale of pain intensity (NRS) consists of a range of numbers (usually 0 to 10, but sometimes 0 to 100 or other ranges). For this research I used 0 to 10. Respondents were told that the lowest number represents no pain and that the highest number represents an extreme level of pain (worst pain you can imagine). They were asked to state the single number that best represented their level of pain intensity.

This scale comprises of 0 to 10 numbers:

No pain	0
	1
	2
	3
	4
	5
	6
	7
	8
	9
Worst pain you can imagine	10

(Hjermstad et al, 2011)

Appendix D

QUESTIONS FOR POSTNATAL INTERVIEWS

Opening question: Can you tell me about your experience of using Virtual Reality in your labour and birth as if I am your pregnant friend?

Follow up questions:

Can I ask when you were at home, how much did you use it at home?

What was the main benefit of the VR when you were in labour?

Can you tell me whether you found it useful in reducing pain intensity?

Can you tell me whether you think that the Virtual Reality technology had an effect on the time spent thinking about labour pain?

Can you tell me whether your experience of using VR had an effect on your ability to relax in labour?

Can you comment on whether using VR had an effect on your ability to control or manage labour pain?

Can you tell me whether there are any particular VE's that you enjoyed when you were using it?

Can you tell me what scene you watched when using it at home?

Can you tell me whether it had an effect on staying in control in labour?

Can you tell me whether you think VR helped to relax you in labour?

Can you tell me in terms of birth satisfaction, did the VR contribute at all?

Would you use recommend it to a pregnant friend?

Would you use it in another pregnancy?

Can you tell me whether you would use it differently next time?

And can you tell me how you found the comfort of the headset?

Appendix E

**Try Virtual Reality
Distraction Therapy in
late pregnancy and
labour**

Study Title: A mixed methods study into usability of Virtual Reality Distraction Therapy in late pregnancy and labour

Early studies have shown that Virtual Reality is effective in the reduction of pain intensity and anxiety in labour. My name is **Lorna Massov**. I invite you to take part in this innovative research, as part of my PhD project at the Graduate School of Nursing, Midwifery and Health. My project is looking at the usability of Virtual Reality in labour. It has three parts:

- You are invited to try a range – 4-6 Virtual Reality scenes in late pregnancy (>35 weeks pregnant) using wireless VR goggles (similar to the picture above). You will be interviewed (approx. 1 hour) about these experiences and whether you would use VR in your labour.
- You would be invited to wear the VR goggles in your labour for a short period - 20 minutes in total. You would be asked to score your pain intensity and have your heart rate and blood pressure recorded once while wearing the VR goggles and without them. You are welcome to wear the VR goggles for longer in your labour.
- You would be invited to share your experiences of using Virtual Reality in your labour after the birth of your baby by giving an interview (approx. 1 hour) on Day 2 or 3.

If you are 35 weeks pregnant and over and older than 18 years and would like to take part or receive further information please contact me:

Mobile: 027 2271 492

Email: lorna.massov@vuw.ac.nz

This research project has received ethical approval from: Health & Disability Ethics Committee Ref: 19/NTB/30 and Victoria University Human Ethics Committee Ref: 26410.

Appendix F

Appendix D

Participant Information Sheet

Study Title:	Women's Experiences of Using Virtual Reality in Labour: A Mixed Methods Approach	
Locality:	Wellington	Ethics committee ref.: 19/NTB/30
Lead investigator:	Lorna Massov	Contact phone number: 027 2271 492

You are invited to take part in a project towards a PhD qualification. The project comprises three phases and you are being invited to take part in all three. The project is looking at the usability of Virtual Reality in labour and the effect of Virtual Reality on the experience of labour pain. Whether or not you take part is your choice. If you don't want to take part, you don't have to give a reason, and it won't affect the care you receive. If you do want to take part now, but change your mind later, you can pull out of the study at any time.

This Participant Information Sheet will help you decide if you would like to take part. It sets out why the study is being done, what your participation would involve, what the benefits and risks to you might be, and what would happen after the study ends. The researcher will go through this information with you and answer any questions you may have. You do not have to decide today whether or not you will participate in this study. Before you decide you may want to talk about the study with other people, such as family, whānau, friends, your Lead Maternity Carer or other healthcare providers. Feel free to do this.

If you agree to take part in this study, you will be asked to sign the Consent Form on the last page of this document. You will be given a copy of both the Participant Information Sheet and the Consent Form to keep.

This document is six pages long, including the Consent Form. Please make sure you have read and understood all the pages.

WHAT IS THE PURPOSE OF THE STUDY?

This study is to determine whether pregnant women think it is possible to use Virtual Reality in labour and whether they would want to use it. The next part of the study seeks to determine whether Virtual Reality has an effect on the labour pain experience of women and the final part of the study seeks to explore women's experience of using Virtual Reality in labour and birth. I am doing this research to explore managing pain during labour without drugs as an alternative to other methods. Many women seek out an effective alternative to

pharmacological pain relief in labour and this study seeks to address this need. I intend to use the findings from this research to benefit women who wish to use alternative methods in labour and to add to our knowledge in the maternity setting around new and alternative methods of pain relief in labour.

This project is supported by Victoria University Doctoral Research Scholarship funds.

Any other questions can be answered by Dr Brian Robinson (04 463 6155). This research has been approved by the Health and Disability Ethics Committee and Capital Coast District Health Board Research Committee.

WHAT WILL MY PARTICIPATION IN THE STUDY INVOLVE?

You have been invited to take part in this study because you are over 35 weeks pregnant and meet the inclusion criteria of the study.

The study involves three different phases. The first will be a few weeks before you have your baby, the second is during labour and the final phase is after the birth of your baby. You are invited to participate in all three phases.

Phase 01: Usability of Virtual Reality

If you agree to take part in the usability study your involvement would be to trial four Virtual Reality environments in the antenatal period of your pregnancy. You would be asked to wear the wireless Virtual Reality headset on top of your head, much like goggles (like in the picture). The scenes would be pleasant nature like scenes, such as forests, water, underwater images. Each Virtual Reality scene lasts a maximum of 10 mins. You can take breaks between the scenes. After the Virtual Reality experience, you will be asked to fill in some details about how old you are, how many babies you have had, your ethnic background, education qualifications and use of technology. You will be asked some further questions about your overall experience using the headset, whether you would like to use it in your labour. You will also be asked some questions about the specific Virtual Reality environments shown to you. This will be recorded. This part of the study would take up to 1-2 hours of your time and could be done your home.

Phase 02: Using the Headset During Labour

If you agree to use Virtual Reality in your labour you would be asked to wear the headset for 10 minutes twice during your labour. In early labour, when your pain score is less than 4 on a pain scale and you are contracting 2-3 in 10 minutes, lasting 20-40 seconds. And then in active labour, when your pain score is greater than 6 and you have 3-4 contractions in 10 minutes, lasting 60-90 seconds. At the end of each 10 minute period – not wearing the VR headset (no VR) and wearing the VR headset (VR) you will be asked by the researcher to score your pain intensity using a pain scale. You will also have your heart rate and blood pressure taken and recorded. You can choose to wear the headset at any other time you choose, for how long and how often. You will be helped to put your Virtual Reality headset on

if you wish and for the Virtual Reality scene that you chose to be started. You can choose to stop the Virtual Reality experience at any time by removing the headset or by indicating to the researcher or your Lead Maternity Carer that you wish to stop. The researcher will only be present during your labour to conduct these measurements. You can ask her to leave the room at any stage.

Phase 03: After your birth

If you agree to take part in this phase of the study, I will visit you at your home on the second or third day after the birth of your baby. I would be interested in asking you about your experiences of using Virtual Reality in your labour and birth. This interview would be informal and would take approximately 30-45 minutes of your time. This interview will also be recorded.

WHAT ARE THE POSSIBLE BENEFITS AND RISKS OF THIS STUDY?

There are no specific benefits to you in participating. However, the greatest benefit in participation is likely to be the activity of self-reflection of your birth experience. The researcher and Victoria University of Wellington is likely to gather valuable data and feedback about your experience using Virtual Reality in labour that will benefit future groups of women and will be shared amongst practitioners who care for women in labour.

There is a small risk of women experiencing motion sickness and eye strain when using Virtual Reality, but this will stop once the headset is removed. If at any point you feel motion sickness, you are encouraged to stop immediately and rest. If symptoms continue you will be provided with water and the researcher will remain with you until your symptoms resolve.

There will be mild and temporary discomfort associated with having your heart rate and blood pressure recordings monitored in labour.

You may feel concerned about being identified in the report. You can be reassured that your data results will remain confidential and only be viewed by myself and my academic Supervisors. The study results will be reported using an alias. As the study is using a case report format there is a risk that you could be identified despite the use of alias. You will be given the opportunity to review a summary of the interviews. No dissemination of your data will happen without your explicit permission.

WHO PAYS FOR THE STUDY?

This project is supported by a Victoria of University of Wellington Scholarship. You will not incur any costs by taking part and will not have to travel anywhere. A token of my appreciation (koha) will be offered upon completion of the final interview.

WHAT IF SOMETHING GOES WRONG?

If you were injured in this study, which is unlikely, you would be eligible for compensation

from ACC just as you would be if you were injured in an accident at work or at home. You will have to lodge a claim with ACC which may take some time to assess. If your claim is accepted, you will receive funding to assist in your recovery.

WHAT ARE MY RIGHTS?

You are volunteering to take part. You do not have to take part in this study and you can withdraw at any stage. You can ask questions about the study at any time during participation and remove the Virtual Reality headset at any stage.

You will not be identified in any presentations of the work.

WHAT HAPPENS AFTER THE STUDY OR IF I CHANGE MY MIND?

After you have taken part and changed your mind about being involved, please contact the lead investigator, Lorna Massov, and any data and information associated with your participation will be destroyed.

We will securely store the information and any data you have provided for ten (10) years and it will then be destroyed. We can present the findings of this study at conferences or in books or journals. When the project is concluded you will have the option of receiving a lay summary of the key findings of the dissertation and/or given access to the full dissertation upon request.

WHO DO I CONTACT FOR MORE INFORMATION OR IF I HAVE CONCERNS?

If you have any questions, concerns or complaints about the study at any stage, you can contact:

Lorna Massov, PhD student, Graduate School of Nursing, Midwifery and Health,
University of Wellington
027 2271 492
lorna.massov@vuw.ac.nz

If you want to talk to someone who isn't involved with the study, you can contact an independent health and disability advocate on:

Phone: 0800 555 050
Fax: 0800 2 SUPPORT (0800 2787 7678)
Email: advocacy@hdc.org.nz

For Māori health support please contact:

Cheryl Goodyer
Manager, Capability
Māori Health Development Group
Phone: (04) 806 2370
Email: Cheryl.Goodyer@ccdhub.org.nz

You can also contact the health and disability ethics committee (HDEC) that approved this study on:

Phone: 0800 4 ETHICS
Email: hdec@moh.govt.nz

Consent Form

Please tick to indicate you consent to the following

I have read, and I understand the Participant Information Sheet.	Yes ☐
I have been given sufficient time to consider whether or not to participate in this study.	Yes ☐
I have had the opportunity to use a legal representative, whanau/ family support or a friend to help me ask questions and understand the study.	Yes ☐
I am satisfied with the answers I have been given regarding the study and I have a copy of this consent form and information sheet.	Yes ☐
I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without this affecting my care.	Yes ☐
I consent to the research staff collecting and processing my information.	Yes ☐
I understand that my participation in this study is confidential and that no material which could identify me personally, will be used in any reports on this study.	Yes ☐
I understand the compensation provisions in case of injury during the study.	Yes ☐
I know who to contact if I have any questions about the study in general.	Yes ☐
I understand my responsibilities as a study participant.	Yes ☐
I understand that the information I have provided will be destroyed 10 years after the research is finished	Yes ☐
I agree to take part in all three phases of this study determining the usability of Virtual Reality in labour and the effect on the experience of labour pain.	Yes ☐
I wish to receive a summary of key findings of the study and/or a completed copy of the final dissertation.	Yes ☐ No ☐

Declaration by participant:

I hereby consent to take part in this study.

Participant's name: _____

Signature: _____

Date: _____

Declaration by member of research team:

I have given a verbal explanation of the research project to the participant and have answered the participant's questions about it.

I believe that the participant understands the study and has given informed consent to participate.

Researcher's name: _____

Signature: _____

Date: _____

Appendix G

Appendix E Assessing the Usability of Virtual Reality Technology and Content for Pregnant Women Antenatally

INFORMATION SHEET FOR PARTICIPANTS

You are invited to take part in this research. This research is a PhD project with three phases. You are invited to take part in this first phase and after you would be invited to participate in phase two and three. The project is looking at the usability of Virtual Reality in labour, the effect of Virtual Reality on the experience of labour pain and exploring the experience of using Virtual Reality in labour in the postnatal period. Please read this information before deciding whether or not to take part. If you decide to participate, thank you. If you decide not to participate, thank you for considering this request.

Who am I?

My name is Lorna Massov and I am a Doctoral student in Midwifery at Victoria University of Wellington. This research project is work towards my dissertation.

Are you eligible to participate?

Some people would not be advised to experience Virtual Reality and should not take part in this research. For example, if you have epilepsy or a history of seizures, vision or hearing deficits, severe nausea, predisposition to motion sickness and a history of psychiatric disturbances involving delusions and/or psychosis.

What is the aim of the project?

This project aims to determine whether you would use Virtual Reality antenatally in your labour and if not, why not. The study also seeks your opinion about the usability of Virtual Reality technology and content by asking you to experience four Virtual Reality environments. This research has been approved by the Victoria University of Wellington Human Ethics Committee (0000026410).

How can you help?

You have been invited to participate because you are pregnant – 35 weeks or over. You will be invited to wear a Virtual Reality wireless headset and view 4 Virtual Reality environments chosen by the researcher. These scenes are pleasant scenes that will include natural scenes of beach, water, rainforest or underwater ocean scenes. Each Virtual Reality experience will

last a maximum of 10 mins. You can take a break in between the scenes of however long you wish. After these experiences you will be interviewed. The interview will take approximately 1 hour. If you agree to take part, I will let you experience the Virtual Reality scenes and interview you at a location of your choice, either your home or another location you choose. I will ask you questions about your experience of using the Virtual Reality headset and the content you have viewed. I will audio record the interview with your permission and write it up later. You can choose to not answer any question or stop the interview at any time, without giving a reason. You can withdraw from the study by contacting me at any time before 22 November 2019. If you withdraw, the information you provided will be destroyed or returned to you.

What are the risks to my participating in this study?

If you have a history of intense motion sickness when using VR, simulation motion games and/or 3D movies it is advised that you do not take part in this research. If you do choose to take part in this research, please be aware that some people experience eye strain, mild nausea or motion sickness after experiencing Virtual Reality. If this occurs remove your headset immediately or ask the researcher to do this for you. The discomfort should stop after this and you can choose whether you wish to continue or to discontinue with the VR experiences. If symptoms continue after you have removed the headset the researcher will provide water and encourage you to rest. The researcher will continue to check on your symptoms and will stay with you until your symptoms resolve.

What will happen to the information you give?

This research is confidential. This means that the researchers named below will be aware of your identity, but the research data will be combined, and your identity will not be revealed in any reports, presentations, or public documentation.

Only my supervisors (Dr Brian Robinson, Dr Edgar Rodriguez and Dr Robyn Maude) and I will read the notes or transcript of the interview. The interview transcripts, summaries and any recordings will be kept securely and destroyed on 2 January 2026.

What will the project produce?

The information from my research will be used in PhD dissertation and academic publications and conferences. Your contributions to this study may also lead to a commercialisable product able to be developed in a business context.

If you accept this invitation, what are your rights as a research participant?

You do not have to accept this invitation if you don't want to. If you do decide to participate, you have the right to:

- remove the Virtual Reality headset at any time,
- choose not to answer any question,
- ask for the recorder to be turned off at any time during the interview,
- withdraw from the study before 22 November 2019,
- ask any questions about the study at any time,
- read over and comment on a written summary of your interview,
- be able to read any reports of this research by emailing the researcher to request a copy.

If you have any questions or problems, who can you contact?

If you have any questions, either now or in the future, please feel free to contact me:

Student:

Supervisor:

Name: Lorna Massov

Name: Dr Brian Robinson

Phone: 027 2271 492

School: Graduate School of Nursing, Midwifery and Health Practice.

Email: lorna.massov@vuw.ac.nz

Phone: 04 463 6155

Email: Brian.Robinson@vuw.ac.nz

Human Ethics Committee information

If you have any concerns about the ethical conduct of the research, you may contact the Victoria University HEC Convenor: Dr Judith Loveridge. Email hec@vuw.ac.nz or telephone +64-4-463 6028.

Assessing the Usability of Virtual Reality Technology and Content for Pregnant Women Ante-natally

CONSENT TO INTERVIEW

This consent form will be held for 5 years.

Researcher: Lorna Massov, Graduate School of Nursing, Midwifery and Health, Victoria University of Wellington.

- I have read the Information Sheet and the project has been explained to me. My questions have been answered to my satisfaction. I understand that I can ask further questions at any time.
- I agree to using the Virtual Reality headset and to experience four Virtual Reality scenes.
- I agree to take part in an audio recorded interview.

I understand that:

- I may withdraw from this study at any point before 22 November 2019, and any information that I have provided will be returned to me or destroyed.
- The identifiable information I have provided will be destroyed on 20 December 2026.
- Any information I provide will be kept confidential to the researcher and the supervisor.
- I understand that the results will be used for a PhD dissertation and academic publications and presented to conferences.
- My name will not be used in reports, nor will any information that would identify me: Yes ☐ No ☐
- I would like a summary of my interview: Yes ☐ No ☐
- I would like to receive a copy of the summary of findings and have added my email address below. Yes ☐ No ☐

I agree to being contacted about future phases of this research. Yes ☐ No ☐

Signature of participant: _____

Name of participant: _____

Date: _____

Contact details: _____

Appendix H

Women's Experience of Using Virtual Reality in Labour

INFORMATION SHEET FOR PARTICIPANTS

You are invited to take part in this research. Please read this information before deciding whether or not to take part. If you decide to participate, thank you. If you decide not to participate, thank you for considering this request.

Who am I?

My name is Lorna Massov and I am a Doctoral student in Midwifery at Victoria University of Wellington. This research project is work towards my dissertation.

What is the aim of the project?

This project aims to explore the experiences of women who used Virtual Reality in their labour and birth. Women will be interviewed on Day 2 or 3 postnatally and asked an in-depth, open-ended question about their experience with using Virtual Reality technology in their labour. Additional questions and prompts will evolve from this initial question. This research has been approved by the Victoria University of Wellington Human Ethics Committee (0000027393).

How can you help?

You have been invited to participate because you agreed to use Virtual Reality in your labour and birth. If you agree to take part, I will interview you at a location of your choice, either your home or another location you choose. I will ask you questions about your experience of using the Virtual Reality headset in your labour. The interview will take approximately an hour. I will audio record the interview with your permission and write it up later. You can choose to not answer any question or stop the interview at any time, without giving a reason. You can withdraw from the study by contacting me at any time before 22 November 2019. If you withdraw, the information you provided will be destroyed or returned to you.

What will happen to the information you give?

This research is confidential. This means that the researcher named below will be aware of your identity, but the research data will be combined, and your identity will not be revealed in any reports, presentations, or public documentation.

Only my supervisors and I will read the notes or transcript of the interview. The interview transcripts, summaries and any recordings will be kept securely and destroyed on 20 December 2026.

What will the project produce?

The information from my research will be used in PhD dissertation and academic publications and conferences. Your contributions to this study may also lead to a commercialisable product able to be developed in a business context.

If you accept this invitation, what are your rights as a research participant?

You do not have to accept this invitation if you don't want to. If you do decide to participate, you have the right to:

- choose not to answer any question,
- ask for the recorder to be turned off at any time during the interview,
- withdraw from the study before 22 November 2019,
- ask any questions about the study at any time,
- receive a copy of your interview recording,
- receive a copy of your interview transcript,
- read over and comment on a written summary of your interview,
- be able to read any reports of this research by emailing the researcher to request a copy.

If you have any questions or problems, who can you contact?

If you have any questions, either now or in the future, please feel free to contact me:

Student:

Supervisor:

Name: Lorna Massov

Name: Dr Brian Robinson

Phone: 027 2271 492

School: Graduate School of Nursing, Midwifery and Health

Email: lorna.massov@vuw.ac.nz

Phone: 04 463 6155

Email: Brian.Robinson@vuw.ac.nz

Human Ethics Committee information

If you have any concerns about the ethical conduct of the research, you may contact the Victoria University HEC Convenor: Dr Judith Loveridge. Email hec@vuw.ac.nz or telephone +64-4-463 6028.

Women's Experience of Using Virtual Reality in Labour

CONSENT TO INTERVIEW

This consent form will be held for 5 years.

Researcher: Lorna Massov, Graduate School of Nursing, Midwifery and Health, Victoria University of Wellington.

- I have read the Information Sheet and the project has been explained to me. My questions have been answered to my satisfaction. I understand that I can ask further questions at any time.
- I agree to take part in an audio recorded interview.

I understand that:

- I may withdraw from this study at any point before 22 November 2019, and any information that I have provided will be returned to me or destroyed.
- The identifiable information I have provided will be destroyed on 20 December 2026.
- Any information I provide will be kept confidential to the researcher and the supervisor.
- I understand that the results will be used for a PhD dissertation and academic publications and presented to conferences.
- My name will not be used in reports, nor will any information that would identify me: Yes ☐ No ☐
- I would like a copy of the transcript of my interview: Yes ☐ No ☐
- I would like a summary of my interview: Yes ☐ No ☐
- I would like to receive a copy of the final report and have added my email address below: Yes ☐ No ☐

Signature of participant: _____

Name of participant: _____

Date: _____

Contact details: _____

Health and Disability Ethics Committees
Ministry of Health
133 Molesworth Street
PO Box 5013
Wellington
6011

0800 4 ETHICS
hdec@mh.govt.nz

04 April 2019

Ms Lorna Massov
PO Box 7625 Newtown
Wellington 6242

Dear Ms Massov,

Re:	Ethics ref:	19/NTB/30
	Study title:	Women's experiences of using Virtual Reality in labour: A Mixed methods approach

I am pleased to advise that this application has been approved by the Northern B Health and Disability Ethics Committee. This decision was made through the HDEC-Expedited Review pathway.

Summary of outstanding ethical issues

The main ethical issues considered by the Committee which require addressing by the Researcher are as follows.

- It appears that Phases 1 and 3 of the project have now been brought within the purview of the Committee as they are now clearly part of the informed consent document. The Committee therefore requires a Safety Protocol for home visits (which could be identical to that used by the Researcher in her capacity as a visiting midwife) and, also a brief outline of the type of questions which will be asked in the Phase 1 and Phase 3 interviews. These documents could be submitted as via the expedited Amendment Pathway. This should be done before the study is commenced.
- It is unlikely that participation will affect your health but if it does, you will be contacted immediately. It appears to mean that if new information comes to light about any deleterious effects of VR during or after the study, participants will be informed immediately

The Committee requested the following changes to the Participant Information Sheet and Consent Form:

- The Committee would like you to amend the following sentence in the PISC so that the meaning is clearer.

Phone 0-4-463 6028
Email judith.loveridge@vuw.ac.nz

MEMORANDUM

TO	Lorna Massov
FROM	Dr Judith Loveridge, Convenor, Human Ethics Committee
DATE	5 April 2019
PAGES	1
SUBJECT	Ethics Approval Number: 0000026410 Title: Assessing the usability of Virtual Reality technology and content for pregnant women in the antenatal period

Thank you for your application for ethical approval, which has now been considered by the Human Ethics Committee.

Your application has been approved from the above date and this approval is valid for three years. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with the research.

Kind regards,

Judith Loveridge
Convenor, Victoria University of Wellington Human Ethics Committee

VICTORIA UNIVERSITY OF
WELLINGTON
TE HERENGA WAKA

Phone 0-4-463 6028
Email judith.loveridge@vuw.ac.nz

TO	Lorna Massov
FROM	Associate Professor Judith Loveridge, Convenor, Human Ethics Committee
DATE	30 May 2019
PAGES	1
SUBJECT	Ethics Approval Number: 27393 Title: Women's Experiences of Using Virtual Reality in Labour

Thank you for your application for ethical approval, which has now been considered by the Human Ethics Committee.

Your application has been approved from the above date and this approval is valid for three years. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with the research.

Kind regards,

Judith Loveridge
Convenor, Victoria University of Wellington Human Ethics Committee

Demographic Information Sheet

What is your age? _____

How many babies have you had previously? _____

Ethnicity: Please tick all that apply

NZ European ☐

Māori ☐

Other European ☐

Cook Island Māori ☐

Samoan ☐

Indian ☐

Tongan ☐

Chinese ☐

Other (please specify) _____

What is your highest level of education?

Secondary School 1-2 years ☐

Secondary School 3-5 years ☐

Tertiary ☐