PARENTS, PROFESSIONALS, AND A PANDEMIC: AN EXPLORATION OF THE INFLUENCE OF ANTENATAL IMAGING ON PRENATAL BONDING

(Attachment in Fetal Imaging study)

Thesis submitted for the degree of Doctor of Philosophy

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Statement of co-authors of joint publications

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Title of research thesis: Parents, professionals, and a pandemic: An exploration of the influence of antenatal imaging on prenatal bonding

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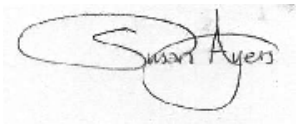
Title of publications:

1. Skelton, E., Webb, R., Malamateniou, C., Rutherford, M. and Ayers, S. (2024). The impact of antenatal imaging on parent experience and prenatal attachment: A systematic review. *Journal of Reproductive and Infant Psychology,* 42(1), 22-44. DOI: 10.1080/0264838.2022.2088710
2. Skelton, E., Harrison, G., Rutherford, M., Ayers, S. and Malamateniou, C. (2022). UK obstetric sonographers' experiences of the COVID-19 pandemic: Burnout, role satisfaction and impact on clinical practice. *Ultrasound,* 31(1), 12-22. DOI: 10.1177/1742271X221091716
3. Skelton, E., Smith., A., Harrison, G., Rutherford, M., Ayers, S. and Malamateniou, C. (2023). "It has been the most difficult time in my career": A qualitative exploration of UK obstetric sonographers' experiences during the COVID-19 pandemic. *Radiography,* 29(3), 582-589. DOI: 10.1016/j.radi.2023.03.007
4. Skelton, E., Smith., A., Harrison, G., Rutherford, M., Ayers, S. and Malamateniou, C. (2023). The effect of the COVID-19 pandemic on UK parent experiences of pregnancy ultrasound scans and parent-fetal bonding: A mixed methods analysis. *PLOS ONE,* 18(6), e0286578. DOI: 10.17371/journal.pone.0286578
5. Skelton, E., Cromb, D., Smith., A., Harrison, G., Rutherford, M., Malamateniou, C. and Ayers, S. (2024). The influence of antenatal imaging on prenatal bonding in uncomplicated pregnancies: A mixed methods analysis. *BMC Pregnancy and Childbirth,* 24, 265. DOI: 10.1186/s12884-024-06469-0
6. Skelton, E., Cromb, D., Smith., A., van Poppel, M.P.M., Morland, C., Harrison, G., Rutherford, M., Malamateniou, C. and Ayers, S. (2024). "It's not just the medical aspects that are important": A qualitative exploration of first-time parents' experiences of antenatal imaging and their influence on parent-fetal bonding. *Radiography,* 30(1), 288-295. DOI: 10.1016/j.radi.2023.11.019

We, the undersigned, co-authors of the above publications, confirm that the above publications have not been submitted as evidence for which a degree or other qualification has already been awarded.

We, the undersigned, further indicate the candidate's contribution to the publications as stated in the declaration below.

Signature: 

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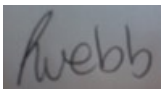
Signature: 

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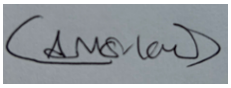
Signature: 

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Declaration

Chapters 3-8 of this thesis are distinct articles written for publication in peer-reviewed journals. All of the papers in this thesis have been accepted for publication in peer-reviewed journals and presented here as the final published article (see Appendices 10-15 for copies of the published articles). The articles are my own work, with guidance from my PhD supervisors and co-authors. I conducted all data collection and analytical processes, and wrote the first draft of each article. I led on all subsequent revisions, including those suggested following submission and peer review. Full references are given below.

Chapter 3 is published in the *Journal of Reproductive and Infant Psychology* as:

Skelton, E., Webb, R., Malamateniou, C., Rutherford, M. and Ayers, S. (2024). The impact of antenatal imaging on parent experience and prenatal attachment: A systematic review. *Journal of Reproductive and Infant Psychology,* 42(1), 22-44. DOI: 10.1080/0264838.2022.2088710

The author contributions are as follows: Emily Skelton, Christina Malamateniou and Susan Ayers developed the review protocol. Emily Skelton registered the review protocol, undertook the literature searches, article screening, data analysis, and interpretation of results, and drafted the manuscript. Rebecca Webb reviewed references for inclusion. Christina Malamateniou and Susan Ayers provided feedback on each draft of the manuscript. Rebecca Webb and Mary Rutherford provided feedback on the final draft of the manuscript.

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The author contributions are as follows: The study design was developed by Emily Skelton, Mary Rutherford, Christina Malamateniou, and Susan Ayers. Daniel Cromb and Alison Smith supported participant recruitment. Emily Skelton analysed the data and drafted the manuscript. Daniel Cromb provided validation on the qualitative data analysis. Christina Malamateniou and Susan Ayers provided feedback on each draft of the manuscript. Daniel Cromb, Alison Smith, Gill Harrison, and Mary Rutherford provided feedback on the final draft of the manuscript.

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I hereby declare that this thesis has not been, and will not be, submitted in whole or in part to another University for the award of any other degree.

Emily Skelton

February 2024

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PARENTS, PROFESSIONALS, AND A PANDEMIC: AN EXPLORATION OF THE INFLUENCE OF ANTENATAL IMAGING ON PRENATAL BONDING

Abstract

Background: Positive parental experiences of antenatal imaging are associated with enhanced prenatal bonding. However, this association is not well understood, particularly for expectant fathers, when advanced imaging techniques such as fetal magnetic resonance imaging (MRI) are utilised, or when there is a suspected prenatal fetal diagnosis.

Aim: This thesis aimed to gain a comparative insight into expectant parents' experiences of imaging during pregnancy and how these experiences may help to enhance parent-fetal bonding. Additional aims were to understand the effect of the COVID-19 pandemic in the United Kingdom on obstetric sonographers (e.g., evaluating occupational burnout) and new and expectant parents (e.g., evaluating prenatal bonding and exploring imaging experiences).

Methods: A convergent, mixed-methods design was used. In addition to a systematic review of literature, three research studies were conducted; two studies utilised online questionnaires to capture data during the COVID-19 pandemic from: 1) UK obstetric sonographers (n=138); and 2) new and expectant parents (n=714). The third study used online questionnaires (n=76) and semi-structured telephone interviews (n=28) with first-time expectant parents who had imaging at a London hospital during pregnancy (including ultrasound and fetal MRI), and were following a routine antenatal care pathway, or receiving specialist care because of a diagnosed fetal condition.

Results and discussion: The systematic review (Article 1) suggested that interactive and parent-centred scan experiences may help to enhance parent-fetal bonding. The study of obstetric sonographers found that over 90% of respondents met thresholds for occupational burnout during the pandemic, which had potential implications for care provision and parental experiences of antenatal imaging (Article 2). Sonographer burnout during the pandemic was explained by experiences of moral injury and ineffective leadership (Article 3). The second study showed that bonding in fathers was significantly lower compared to mothers, which may be attributed to changes in the delivery of obstetric ultrasound services during the pandemic (Article 4). The final study found no differences in bonding between mothers and fathers, but significantly higher bonding in parents having fetal MRI compared to ultrasound (Article 5). Expectant parents valued experiences where HCPs balanced the medical and psychosocial aspects of fetal imaging, particularly when a fetal condition was present (Article 6).

Conclusion: This thesis highlights the integral role of HCPs in facilitating parent-centred experiences of care during fetal imaging to support parent-fetal bonding. However, tensions are identified due to HCP burnout, organisational culture, and the lack of a clear definition of parent-centred care in antenatal imaging.

Summary of thesis chapters

This thesis consists of nine chapters, six of which are research articles that have been prepared for publication in peer-reviewed journals. These articles report the results of the studies conducted in this thesis (one systematic literature review and three empirical research studies). This section briefly outlines each chapter to assist with navigation through the thesis.

Chapter 1 – Background

The first chapter introduces the three main foci of this thesis (prenatal bonding, antenatal imaging, and person-centred healthcare), and considers current literature in the research field.

Chapter 2 - Methodology overview

This chapter presents an overview of the mixed-methods research design utilised in this thesis, and details the participants, measures, procedures, and ethical approvals for each of the three empirical research studies conducted.

Chapter 3 - Article 1 (systematic review of literature)

A systematic review of the literature related to the influence of antenatal imaging on parent-fetal bonding was conducted to gain an understanding of the current knowledge base, identify research gaps, and inform the empirical research studies in this thesis. This article reports the findings from an integrative synthesis of 23 included studies.

Chapter 4 – Article 2 (quantitative findings from thesis research study 1)

The COVID-19 pandemic had a profound impact on the delivery of obstetric ultrasound imaging services. This chapter reports the quantitative findings of thesis research study 1, which used an online questionnaire to measure occupational burnout in UK obstetric sonographers during the COVID-19 pandemic. The effect of the pandemic on role satisfaction and provision of care during ultrasound scans was considered.

Chapter 5 – Article 3 (qualitative findings from thesis research study 1)

Chapter 4 reported high levels of occupational burnout in UK obstetric sonographers during the COVID-19 pandemic. Chapter 5 extends this work by providing additional qualitative context to the quantitative findings of occupational burnout in the workforce. Thematic analysis of free-text responses collected as part of thesis research study 1 was conducted, and suggestions for workforce recovery in the aftermath of the COVID-19 pandemic are discussed.

Chapter 6 – Article 4 (mixed-methods findings from thesis research study 2)

Expectant parents' experiences of pregnancy ultrasound scans during the COVID-19 pandemic were affected by guidance which was introduced to minimise transmission of the virus and keep staff and service users safe. Most notably, this included the temporary restriction of partners and supporting persons at scans. This chapter reports the findings of thesis research study 2, which used an online questionnaire to gain insight into parental experiences of pregnancy ultrasound scans during the COVID-19 pandemic. Prenatal bonding and psychological distress in expectant parents were also measured. An integrated, mixed-methods analysis is presented, providing insight into parental experiences of obstetric ultrasound during the COVID-19 pandemic, and evaluating the effect of the pandemic on parent-fetal bonding.

Chapter 7 – Article 5 (mixed-methods findings from thesis research study 3)

Antenatal imaging is often associated with enhanced parent-fetal bonding, however there is limited understanding of this association in expectant fathers as research studies commonly focus on the maternal-fetal bond. In addition, the increasing use of fetal MRI as an adjunct to ultrasound necessitates the need for dedicated evaluation of the effect of new imaging technologies on the parent-fetal bond. This chapter reports findings from thesis research study 3, which used an online questionnaire to measure prenatal bonding in first-time expectant parents before and after having ultrasound or fetal MRI scans. Multivariate linear regression analyses were used to identify variables associated with increased bonding scores after imaging. The online questionnaire also captured free-text responses related to parental experiences of fetal imaging which were analysed using qualitative content analysis, and used to explain the results of the regression analyses.

Chapter 8 – Article 6 (qualitative findings from thesis research study 3)

Chapter 8 builds on the findings of increased parent-fetal bonding scores after imaging which were reported in Chapter 7. To gain a deeper insight into expectant parents' experiences of antenatal imaging and how these may influence prenatal bonding, independent, semi-structured telephone interviews were also conducted as part of thesis research study 3. First-time parents of differing backgrounds were interviewed (e.g., mothers and fathers, parents having ultrasound or fetal MRI, and parents receiving routine antenatal care or specialist care for a fetal cardiac condition). Thematic analysis was used to analyse the interview transcripts and explore the research question, how does antenatal imaging influence prenatal bonding in first-time expectant parents?

Chapter 9 - Discussion

The final chapter discusses the key findings of the research conducted for this thesis, and considers the strengths, limitations, and implications of the work. Future directions for this work and preliminary recommendations for the provision of parent-centred care in antenatal imaging are proposed.

References for all chapters can be found at the end of the thesis.

1 Background

1.1 Introduction

Prenatal bonding is a complex construct. Broadly, this term refers to the emotional connection or relationship which expectant parents develop to their unborn child during pregnancy (Muller & Mercer, 1993). Poor maternal and paternal-fetal bonding can contribute to negative behaviours during pregnancy and beyond (e.g., neglect, substance abuse, domestic violence), and is associated with parental mental health issues including stress, anxiety, and depression (Göbel et al., 2018). These can affect fetal brain development, and infant cognitive and emotional development (Lindgren, 2001) which may have substantial socioeconomic implications for the child in later life (Ramchandani et al., 2013).

Antenatal imaging, conventionally in the form of 2-dimensional ultrasound, provides an opportunity to acquire knowledge related to fetal development, and is routinely offered to expectant parents in the United Kingdom (UK) as part of their pregnancy care provision in line with the National Health Service Fetal Anomaly Screening Programme (NHS FASP). Fetal imaging examinations are usually performed by healthcare professionals (HCPs) who are specially trained in medical imaging, known as radiographers or sonographers.

Government documentation acknowledges that positive parental experiences of antenatal imaging, which include visualisation of an unborn baby in the womb, can help reduce parental anxiety and promote parental-fetal bonding (All Party Parliamentary Group, 2019). Antenatal imaging also provides an opportunity for parents to discuss fetal well-being with HCPs, which can impact on bonding, particularly for fathers (Ayers & Pickering, 1997; Boukydis et al., 2006; Nabhan & Aflaifel, 2015). An interactive, and parent-centred imaging experience facilitated by the imaging professional is thought to positively support the developing parent-fetal bond as well as reduce maternal anxiety (Boukydis et al., 2006).

The rationale for antenatal imaging is to identify complications in pregnancy and acquire information to support parent and clinician decisions related to postnatal outcome (National Institute for Health and Care Excellence, 2019). In a small number of pregnancies (approximately 2%), imaging may detect the presence of a congenital physical condition in the fetus (Public Health England, 2021). The sole use of 2-dimensional ultrasound may be limited in some clinical contexts, and additional imaging may be performed to further inform on-going care and management of the pregnancy. Advanced antenatal imaging techniques such as 3-dimensional/4-dimensional (3D/4D) ultrasound and fetal magnetic resonance imaging (MRI) are now available, producing highly detailed images and videos which may improve visualisation of the fetus and prenatal diagnosis (Sedgmen et al., 2006; Lloyd et al., 2016).

Despite the frequent use of fetal imaging techniques in clinical practice, it is not clear how they impact on prenatal bonding. Specifically, there is a paucity of published research which uses a rigorous, prospective study design (Righetti et al., 2005). There is also limited understanding of how expectant parents experience imaging processes, particularly fetal MRI, in the context of fetal condition (Lie et al., 2019). It has been suggested that fetal MRI may have a potentially negative psychological effect on expectant mothers because of increased acoustic noise, long duration of the scan, and discomfort of being in a confined scanner (Garel, 2008). Experiences of antenatal imaging may also be negatively affected if a congenital physical condition is suspected or diagnosed in the fetus. For some parents, visualising the condition may aid in their understanding of the diagnosis (Gonçalves et al., 2005; Leung et al., 2006; Sreejith et al., 2018), although for some it may increase distress, especially when faced with a decision about whether to continue with the pregnancy (Mitchell, 2004).

In addition, the paternal perspective of antenatal care, and fetal imaging specifically, is under-represented in existing literature, particularly in relation to the effect on paternal-fetal bonding (Righetti et al., 2005; Pretorius et al., 2006). Current literature focuses primarily on the

maternal perspective, even though it is recognised that antenatal imaging provides an opportunity for expectant fathers to engage with the pregnancy, and may positively influence on-going paternal involvement (Walsh et al., 2017).

The primary aim of this thesis was to explore both maternal and paternal experiences of pregnancy imaging (including advanced imaging techniques, and in the context of a prenatal fetal diagnosis) and evaluate the potential influence of the antenatal imaging experience on prenatal bonding. However, less than six weeks after the commencement of this research project, the UK was placed under a national lockdown in response to the global coronavirus (COVID-19) pandemic (Institute for Government, 2021). Healthcare services were required to rapidly adapt to new recommendations which aimed to reduce virus transmission and protect the health and wellbeing of clinical staff and service users. In antenatal imaging, temporary restrictions on the attendance of partners and supporting persons at antenatal appointments (including imaging) were introduced (Royal College of Obstetricians and Gynaecologists, 2020b), a decision which received substantial criticism from media outlets and parent advocacy groups for its negative impact on expectant parents' experiences of ultrasound scans during pregnancy (BBC News, 2020). This presented a unique opportunity within this research project to observe the effect of the partner restrictions on parent-fetal bonding and parental experiences, and to introduce the perspectives of HCPs performing pregnancy ultrasound scans during this time. Thus, additional aims for this thesis were to gain insight into sonographer and parental experiences of obstetric ultrasound during the COVID-19 pandemic.

This background chapter contains an overview of existing literature and knowledge related to the two key foci of this research: parent-fetal bonding and antenatal imaging. It is organised into four sections:

i. The first section introduces the concept of the parent-fetal relationship, identifying four main definitions currently used in research literature. Three common measures

of parent-fetal bonding are reviewed to identify their individual strengths and limitations, as well as acknowledge important considerations relevant to this work.

ii. The second section considers the role of imaging during pregnancy, providing a short history of the development and implementation of the two featured modalities: ultrasound and fetal MRI. The expectant parent's experience of these imaging processes is explored, and existing models of health and person-centred care are critically evaluated within the context of antenatal imaging.

iii. The third section presents the thesis aims, research questions, and objectives. The impact of the COVID-19 pandemic on the original study design is also considered, which resulted in the development of additional research questions to be addressed in this body of work. This section also contains a summary of the six articles included in this thesis, and maps the aims, objectives, and research questions for each.

1.1.1 Use of additive language in the thesis

This body of work fully acknowledges that variations in the family unit exist from traditional representations. For this reason, additive language (e.g., pregnant women and people, fathers and partners) is utilised where possible and appropriate throughout the writing. However, on occasions where literature explicitly reports findings for mothers or fathers, gendered terminology is used to reflect the specific population studied. This also applies to the reporting and discussion of the thesis research studies as all participants self-identified as mothers or fathers.

1.2 The parent-fetal relationship

This section introduces the concept of the parent-fetal relationship, and acknowledges the associations with attachment theory, in which most of the early conceptualisations of parent-fetal bonding are grounded. Consideration of this work is important to provide historical context and

capture how the field has evolved over time. First, the pivotal work of Bowlby and Ainsworth on the development of attachment theory is discussed before Rubin's early theoretical construct of prenatal attachment is introduced. Rubin's construct provided an important foundation for the influential works of Cranley, Condon, and Muller, who have each offered separate definitions of the parent-fetal relationship and developed tools to evaluate the construct. The final part of this section considers more recent perspectives on prenatal bonding, specifically the application of terminology in the present setting.

1.2.1 An overview of attachment theory

Attachment theory was first proposed in the late 1960s by psychologist John Bowlby (Bowlby, 1969). Bowlby's work arose from his interest in intergenerational transmission of mental health and behavioural problems (O'Shaughnessy, 2023). He hypothesised that negative experiences of care in early childhood can create social and emotional difficulties in later life (Ng & Smith, 2006). Attachment theory is diverse, and draws on ideas from many research domains including evolutionary biology, cognitive neuroscience and psychoanalysis (O'Shaughnessy, 2023). The theory identifies a specific relationship (attachment) between a care-seeking individual (e.g., infant) and a caregiver (e.g., parent or guardian attachment figure) which develops instinctively in response to the infant's need for comfort, safety, and protection to support survival (Bretherton, 2000). The attachment is considered reciprocal when the attachment figure demonstrates commitment to the attachment by responding to care-seeking behaviours such as crying or reaching out to achieve closeness with the caregiver. In cases where the caregiver is not responsive to the behaviours (i.e., the infant experiences separation from the attachment figure), the infant may become physically and/or emotionally unregulated as the attachment system becomes disrupted and overwhelmed (O'Shaughnessy, 2023). This reaction may be characteristic of an insecure attachment style.

Different types of attachment have been identified, initially through observation in an experimental environment known as the Strange Situation Procedure (SSP) developed by Mary Ainsworth (Ainsworth & Wittig, 1969), in which an infant's behaviour was observed during separation and reunion with their caregiver, as well as interaction with a stranger. In this study, most children (65%) demonstrated a secure attachment whereby they showed distress at being separated from their caregiver (mother) but could be quickly calmed on her return. This style was associated with maternal sensitivity in responding to their infant's care-seeking behaviours. Insecure attachment styles were determined when the infant did not respond to the separation or reunion (insecure-avoidant), took time to soothe on being reunited with their mother (insecure-ambivalent), or demonstrated behaviours that could not be classified into any other group (disorganised) (O'Shaughnessy, 2023).

The seminal work of Bowlby and Ainsworth provided the theoretical framework for attachment theory which is still central to contemporary research. Indeed, adult attachment styles are frequently associated with infant experiences of parental caregiving, although limitations in many studies using retrospective reports of childhood experiences have been raised (Fraley & Roisman, 2019). However, much of the literature pertaining to attachment theory is primarily focused on the parent-to-infant and infant-to-parent relationship (Condon, 1993), and far less looks at the parent-to-fetal relationship.

1.2.2 Developing a formal theory of prenatal attachment

The concept of parent-fetal bonding arose from the observation of mothers' affective responses during pregnancy (Deutch, 1945 cited in Brandon et al., 2009). Whilst attachment theory is concerned with the relationship from birth, Deutch posited that grief observed after perinatal loss provided evidence that there is an emotional connection that develops between expectant mothers

and their unborn baby during pregnancy. Thus the "prenatal attachment" became a focus for research.

Building on Deutch's observations, Rubin's early bonding theory (proposed in the mid-1970s) attempted to provide a foundation for the theoretical construct of prenatal attachment (Brandon et al., 2009). Rubin proposed that maternal behaviours exhibited in the post-partum period occurred as a consequence of four prenatal processes: 1) ensuring safe passage of the fetus (e.g., throughout pregnancy and birth); 2) ensuring the baby is accepted (e.g., building a social support network); 3) incorporating the idea of the child into one's conceptualisation of self (referred to as "binding in"), and 4) giving of oneself (e.g., demonstrating investment in, and commitment to the unborn baby). Her theory acknowledged that these processes occurred over the course of the pregnancy, cumulating in a progressive representation of the fetus as more human over time (Rubin, 1976). Growing recognition of the fetus as an independent object is important for the development of the emotional connection as expectant parents can project feelings of love towards the individual being (Lumley, 1990). However, since the concept of the prenatal relationship was originally suggested, alternative definitions grounded within the domains of both developmental and social psychology have now been proposed in the research literature. These are further explored in the following section.

1.2.2.1 Early definitions of prenatal attachment

The idea that pregnancy is a time of considerable change for expectant mothers is widely accepted in literature. Change is not only recognised with regards to the physicality of pregnancy and on-going fetal development, but also in relation to the psychological adjustment that must occur to accommodate a new parenting identity and relationship with the unborn baby (Mercer, 1986). This notion is captured in the works of Cranley, Condon, and Muller; three independent scholars, who have made notable contributions to early definitions and understanding of prenatal attachment.

Although now considered to be historical, these works are further discussed in this section to provide background and contextualise more current work.

Cranley conceptualised the maternal-fetal relationship as multi-dimensional, and identified six aspects of its construct: 1) differentiation of self from the fetus; 2) interaction with the fetus; 3) attributing characteristics and intentions to the fetus; 4) giving of self; 5) role taking; and 6) nesting (later removed because of low reliability) (Cranley, 1981). This prenatal model of attachment uses the following definition: "the extent to which women engage in behaviours that represent an affiliation and interaction with their unborn child" (Cranley, 1981 p. 282), and considers that the maternal relationship is reflected in a pregnant woman's attitudes to pregnancy and motherhood. However, this approach was criticised for the emphasis placed on the behavioural aspects which was thought to neglect important cognitive and emotional aspects of the parent-fetal relationship (Brandon et al., 2009). Furthermore, it was argued that this definition of prenatal attachment was not theoretically well-informed (Muller & Mercer, 1993).

Condon was also critical of Cranley's antenatal attachment model, claiming that her approach was not theoretically sound given that behaviours towards the fetus are limited in pregnancy. Instead, he defined the parent-fetal relationship as an "emotional tie or psychological bond to a specific object" (Condon, 1993 p. 167). In this instance, mental representations of the fetus are considered the specific object. Condon's hierarchical model captured the emotional expression of attachment. The model postulates that adult attachment behaviours are mediated by certain emotional dispositions derived from a core attachment experience, conceptualised as "love" at its pinnacle (reproduced from Condon, 1993 in Figure 1.1).

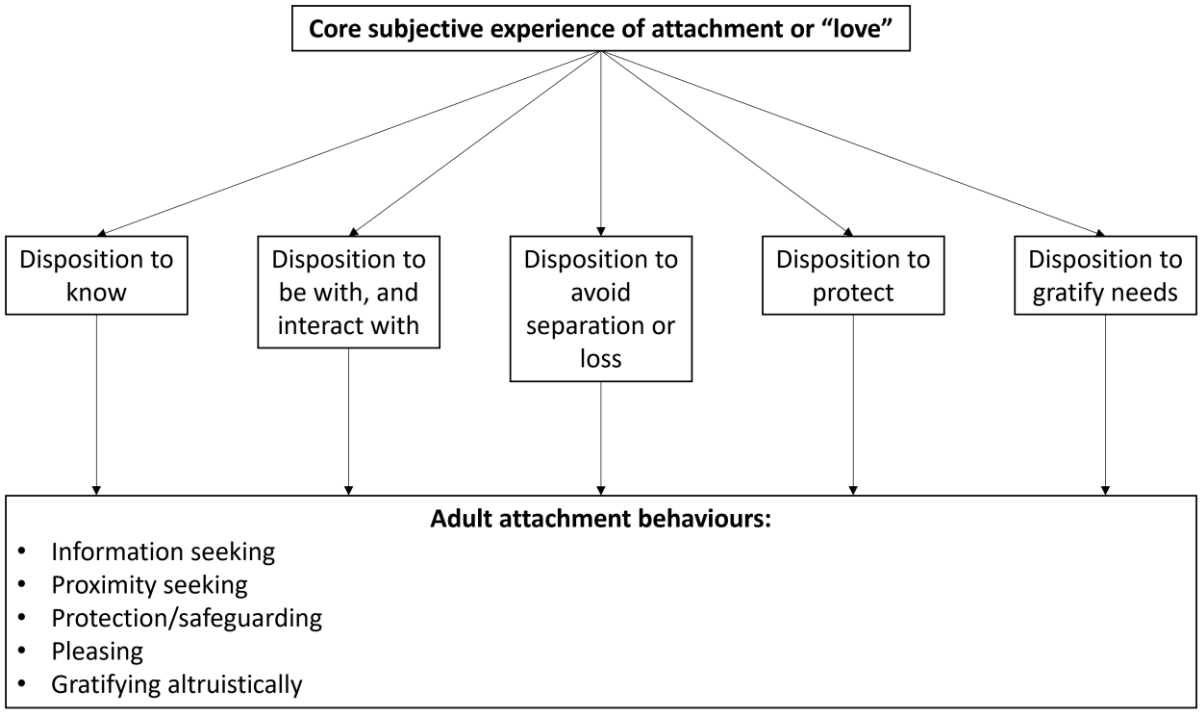

Figure 1.1 Model of adult attachment (Condon, 1993)

The emotional dispositions included within Condon's model are thought to indicate the presence of the parental-fetal relationship, for example, parental curiosity to know more about their unborn baby, experiencing grief at the thought or reality of being separated from their baby, and feeling a strong desire to protect their unborn baby from harm. This model of attachment was also deemed to be applicable to adult relationships (Condon, 1993). Despite the differing theoretical approach, Condon's model shared a similar perspective to Cranley's on the construct of the parent-fetal relationship, also believing it to be multi-dimensional.

In her doctoral thesis, Muller focused on the cognitive domain to define maternal-fetal bonding as "the unique, affectionate relationship that develops between a woman and her fetus" (Muller, 1990 p. 11 cited in Muller and Mercer, 1993). Her attachment model proposes that attachments formed by expectant mothers to their unborn children are influenced by internal representations shaped by early experiences with their own mothers (Muller & Mercer, 1993). The model also considered the associations of other important attachments on the maternal-fetal

relationship, predicting the direct influence of partner attachment. This model is reproduced in Figure 1.2.

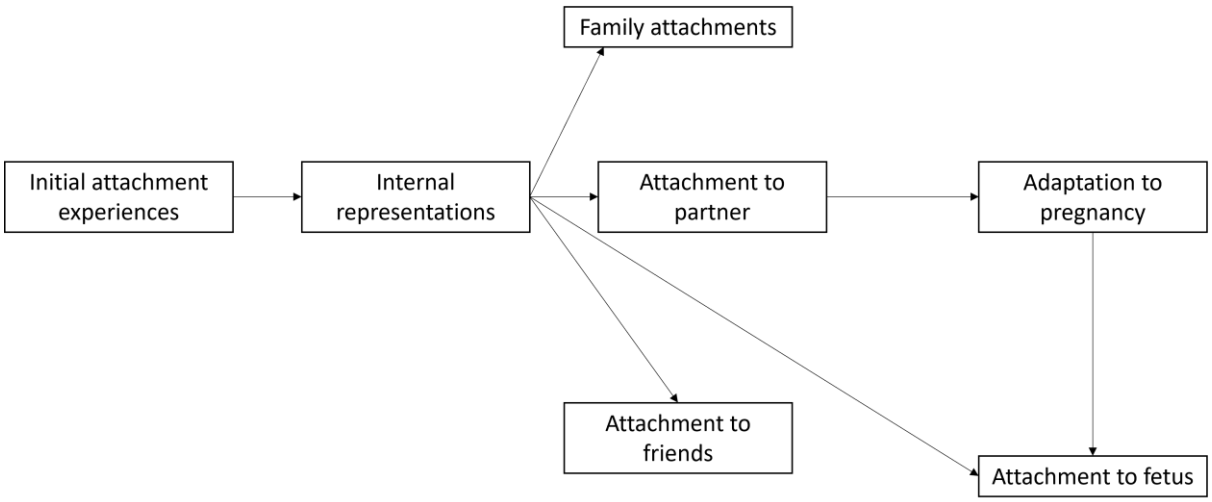

Figure 1.2 Model of attachment (Muller, 1993)

Unlike Cranley and Condon's definitions, Muller considered prenatal attachment to be a unidimensional construct (Muller & Mercer, 1993). However, the knowledge base regarding the maternal-fetal relationship was lacking at that time, and thus required additional investigation to further define the concept, and explore the possible influence of other factors on the developing bond (Doan & Zimerman, 2003a).

More recently, an attempt has been made to unite these varying models and explicitly capture the behavioural, emotional, and cognitive elements of the parent-fetal relationship into a single model (Brandon et al., 2009). To achieve this, Doan and Zimerman identified three key findings through the synthesis of related literature. These highlighted the developmental progression of the parent-fetal relationship, acknowledged the moderating influence of situational factors on the relationship, and supported earlier claims made by Cranley and Condon of the multidimensional nature of antenatal attachment (Doan & Zimerman, 2008). Their model describes antenatal attachment from three aspects: 1) the commencement of the attachment; 2) the level of the

attachment; and 3) the way that it is expressed (e.g., cognitive, emotional, behavioural or through practices of self-care), and hypothesises that cognitive and emotional skills and strategies observed in earlier childhood provide the foundation on which the prenatal attachment can subsequently be built (Doan & Zimerman, 2008). An overarching definition representing their conceptualisation of prenatal bonding has been published as, "the affiliative relationship between a parent and fetus, which is potentially present before pregnancy, is related to cognitive and emotional abilities to conceptualise another human being, and develops within an ecological system" (Doan and Zimerman, 2003 p. 110), thus highlighting the need to also consider the social context and subsequent influence on the parent-fetal relationship (Darvill, Skirton & Farrand, 2010). Indeed, the uniqueness of the bond is further highlighted not just in the variety of definitions proposed by researchers, but also by its differing conceptualisations for individual parents (Borg Cunen et al., 2022).

1.2.2.2 Prenatal attachment or bonding… or other?

As evidenced by the literature presented here, the lack of an accepted definition of the parent-fetal relationship demonstrates the complexity of this phenomenon, and the variability in theories of the construct. Although the term "attachment" is frequently used when referring to the parent-fetal relationship, the accuracy of this has been questioned (Walsh, 2010). Bowlby's original theory conceptualises the attachment system as an infant's instinctive care-seeking behaviours and the caregiver's response to them (e.g., parental sensitivity). Therefore, it is argued that what occurs during the prenatal period cannot truly be considered attachment as the parental care-giving behaviours are initiated in the absence of care-seeking cues from the fetus (Redshaw & Martin, 2013). The unidirectional nature of the prenatal relationship thus necessitates more specific terminology to adequately reflect how the concept is different to attachment. However, this requires consensus on a definition which has yet to be achieved, and may even be unattainable given that

individual differences in parental conceptualisations of their emotional connection to their unborn child are recognised (Alhusen, 2008). Thus, several terms may be utilised in published literature with regard to the construct of parent-fetal bonding including “relationship” and “tie” (Borg Cunen, Jomeen & Borg Xuereb, 2022). Whilst these may be consciously selected by authors to reflect distinct aspects of the parent-fetal relationship (van den Bergh & Simons, 2009), some authors use the terms interchangeably, which may suggest ambiguity in the application of a theoretical or conceptual framework (Darwin & Walsh, 2017).

“Bonding” is the preferred term used in this thesis, although issues associated with this term are also acknowledged as it may still imply a dyadic interaction (Walsh, 2010). It should be noted that “attachment” was used in Article 1 (Chapter 3) at the request of the journal editors and reviewers.

1.2.3 Paternal-fetal bonding

Historically, research around prenatal bonding has been focused on the maternal-fetal relationship (Habib & Lancaster, 2010). However, the development and evolution of the paternal-fetal bond during pregnancy is now fully recognised (Vreeswijk et al., 2014). Although the number of studies with expectant fathers has substantially increased since the early 2000s, the paucity of literature in this field is still acknowledged (Lagarto & Duaso, 2022). There is growing recognition of the importance of the paternal-fetal bond for maternal support and well-being (Lindgren, 2001), as well as for infant cognitive and socio-economic development in later life (Ramchandani et al., 2013). The importance of the early paternal-infant bond is further highlighted by economic analyses of the costs of antisocial behaviour. For example, one study suggested the societal cost to support individuals who did not have a quality parental attachment with their fathers (£13,978) was significantly higher ($p<0.001$) than those who were insecurely attached to their mothers (£10,199) compared to well-adjusted peers (Bachmann et al., 2019).

Societal norms regarding the role of the father have evolved considerably in the last 40 years to move away from traditional expectations of "provider" and incorporate greater emphasis on "caregiver" (Genesoni & Tallandini, 2009). Compared to previous generations, fathers are more involved in pregnancy and parenthood, with the vast majority in the UK now attending antenatal appointments, being present at their child's birth (Redshaw & Henderson, 2013), and contributing to household chores and childcare activities (Chin, Hall & Daiches, 2011). Whilst early ideas around the paternal-fetal bond inferred similarities to the maternal-fetal bond (Condon, 1985), later work recognises pregnancy as an intense and stressful period of psychological transition for expectant fathers (Condon, 2006). In studies comparing the maternal and paternal-fetal relationship, lower bonding scores are observed in expectant fathers compared to expectant mothers. There are various possible explanations for this, including men's lack of physical cues and perceived embodied knowledge of the pregnancy and fetus (Harpel & Barras, 2018). However, the psychological process required of expectant fathers to reconceptualise their identity in the transition to parenthood may also be an explanatory factor for the difference between maternal and paternal bonding. Identity theories have been utilised to hypothesise that paternal-fetal bonding reflects how closely men place their father status in relation to their "self" (McCall and Simmons, 1978, cited in Habib & Lancaster, 2006); a study of 108 Australian, first-time fathers reported a significant positive correlation between prominence of the father status and bonding (Habib & Lancaster, 2006). However, this status was observed alongside several others including husband, worker, and friend which suggests the potential for conflict in balancing these different identities during pregnancy and beyond (Genesoni & Tallandini, 2009).

Separate to his attachment model, Condon (2006) proposed four psychological tasks that expectant fathers need to complete during pregnancy as part of their adjustment to parenthood. These tasks demonstrate the complexity of the transitional process for fathers, whereby establishing an emotional connection to the fetus is only one of these tasks. In addition to the previously described process of conceptualising the self, expectant fathers must also adjust to their relationship

with their partner expanding to include a third party which may cause tension and evoke a sense of rivalry with the fetus if they feel they are competing for their partner's attention (Condon, 2006). Furthermore, expectant fathers may use the pregnancy period to decide the type of father they wish to become. As this is often modelled on their experiences with their own father, it can be problematic if their childhood relationship was suboptimal and lead to feelings of inadequacy and anxiety about embarking on their own parenting role (Chin, Hall & Daiches, 2011). Strauss & Goldberg suggest that fathers' construction of a positive self-image during pregnancy is associated with greater involvement with the infant after birth (Strauss & Goldberg, 1999). For this reason, many researchers and clinicians emphasise the importance of fathers' early engagement in pregnancy to support the transitional period and subsequent involvement with the infant (Hodgson et al., 2021).

Evidence suggests that expectant father's transition to parenthood may be further complicated by their experiences of antenatal care (Finnbogadottir, Svalenius & Persson, 2003). Whilst many fathers want to be involved, many encounter barriers in doing so. For example, expectant fathers have described feeling excluded during antenatal care appointments when HCPs directed conversation solely to the mother (Widarsson et al., 2015). It has been suggested that paternal feelings of exclusion from antenatal care interactions may be associated with inadequate training and awareness of HCPs in expectant fathers' needs for care (Yogman & Garfield, 2016). In addition, a lack of dedicated information and support services presents a further challenge for expectant fathers in navigating antenatal care (Hodgson et al., 2021). Development of the paternal identity is dependent on a complex process of reorganising ideas about "self" (Habib & Lancaster, 2006), thus it may be important to avoid any additional confusion experienced by expectant fathers about their role through unsupportive antenatal care encounters.

Paternal-fetal bonding is thought to initiate when an expectant father receives sufficient information and reassurance of the reality of the pregnancy (Lagarto & Duaso, 2022). It has been suggested that fetal imaging may offer one of the earliest and most powerful opportunities for

expectant fathers to engage with the pregnancy (Walsh et al., 2017), and experience a "trigger moment" for bonding as fetal viability is confirmed. Imaging also provides a unique moment during pregnancy where both parents gain new information about their unborn baby at the same time (Harpel & Barras, 2018). In the absence of physical cues (e.g., until fetal movements can be felt by the expectant father), the visual stimulus afforded by antenatal imaging becomes the method for them to learn about their unborn baby (Draper, 2002). Similar to expectant mothers, it is believed that fathers' emotional connection to the fetus develops progressively throughout the duration of the pregnancy (Habib & Lancaster, 2010), but research also suggests that participation in antenatal care (including imaging) may have a positive influence on the bond, particularly for expectant fathers (Walsh et al., 2021). Indeed, a study of 124 expectant fathers found that whilst paternal-fetal bonding increased over time in all participants, those who responded more strongly to ultrasound demonstrated a larger increase (Tolman et al., 2021). The importance of antenatal imaging in supporting early paternal-fetal bonding, and the potential implications for the future family unit are therefore recognised (Suzuki et al., 2022).

1.2.4 Moderators, mediators, and bonding interventions

Doan and Zimerman's model acknowledges an "ecological system" within which the prenatal bond develops (Doan & Zimerman, 2003a). Researchers have attempted to evaluate various psychosocial factors and determine their mediating or moderating influences on the developing parent-fetal bond, (Bouchard, 2011). Mediating variables are defined as those which may be used to explain an association between two other variables, and moderators are defined as factors which may be used to explain the strength of an association between two other variables (MacKinnon, 2011). Examples of parental characteristics which have recently been studied in relation to their influence on the parent-fetal bond include personality traits (Zolfaghari et al., 2019), anxiety (Göbel et al., 2018), romantic relationship quality (Luz et al., 2017), and attachment to own parents (Gioia et al., 2023). However, findings have been largely inconsistent across the published literature

(Bouchard, 2011). For instance, a review found that maternal-partner relationship quality was positively correlated with bonding (Alhusen, 2008), however, a later study of 161 couples suggested that this relationship was only associated with prenatal bonding in mothers with low levels of neuroticism (Bouchard, 2011). Furthermore, a systematic review of 31 articles concluded that maternal anxiety was detrimental to the developing bond through decreasing quality of emotional proximity to the fetus (Göbel et al., 2018), yet a meta-analysis of 72 studies found that the effect size was low (Yarcheski et al., 2009). Despite these discrepancies, mental well-being during pregnancy is still considered to be a key factor for the developing parent-fetal bond (McNamara, Townsend & Herbert, 2019; Trautmann-Villalba et al., 2023). In addition, the differing influences of psychosocial factors on mothers and fathers have also been observed, with depression being identified as the strongest determinant of maternal bonding, and declaration of attendance at the child's birth reported as the strongest determinant of paternal bonding (Fijałkowska & Bielawska-Batorowicz, 2020).

Another factor which may be associated with prenatal bonding is parity. Parity has recently been defined as "the number of pregnancies reaching a viable gestation, regardless of the outcome" (i.e., including live and stillbirths) (Maraj & Kumari, 2021), and it may be posited that if prenatal bonding is dependent on an individuals' ability to form a mental representation of the unborn baby (Doan & Zimerman, 2003a), primiparous women may have greater capacity to invest time and energy into developing an emotional connection to their unborn child than mothers experiencing competing demands for their attention from other children. Indeed, in a study of 186 expectant parents (93 couples), parity was found to have a significant, medium-sized, negative association with bonding intensity in both mothers and fathers (Göbel et al., 2019). Conversely, Cranley's early work failed to identify any association between bonding and parity (Cranley, 1981). Similarly, a systematic review also published in 2019 reported that fewer than half (5/11) of the included studies reported higher bonding scores in primiparous mothers compared to multiparous mothers, although it must be noted that these studies also assessed maternal mental health and this may be a further influence

on bonding scores (McNamara, Townsend & Herbert, 2019). Ultimately, the varied results in published literature suggest that at present, the association between prenatal bonding and parity is unclear (van Bakel et al., 2013).

Nonetheless, research suggests that the parent-fetal bond may have important implications for fetal and infant brain development (Glover, 2014), and parental mental health and emotional well-being (Göbel et al., 2018). Parent-fetal bonding has also been associated with the practice of healthy behaviours during pregnancy (Lindgren, 2001). Furthermore, the prenatal parent-fetal bond is thought to predict parent-infant attachment in the postnatal period (Trombetta et al., 2021). In light of the reported benefits of prenatal bonding for infant outcomes and parental well-being, it has been suggested that it may be beneficial to identify expectant parents who may require additional support to develop their emotional connection with their unborn child (Darwin & Walsh, 2017). Several interventions to support parent-fetal bonding have been proposed and evaluated by research; these interventions aim to improve fetal awareness and support parental well-being, and have included encouraging expectant parents to count fetal movements (Salehi, Salehi & Shaali, 2017), prenatal yoga (Muzik et al., 2012), antenatal educational programs for expectant mothers with anxiety and depression (Thomas, Komiti & Judd, 2014), and other care-based interventions such as psychotherapy (Flykt et al., 2012). Whilst the reported effects for these interventions have been largely inconsistent (Borg Cunen et al., 2017), establishing the true effect of any intervention proposed in literature is complicated by the heterogeneity between study designs (including the interventions themselves) and variation in the measurement of parent-fetal bonding (Borg Cunen et al., 2017). The influence of antenatal imaging on parent-fetal bonding has also been observed in a small number of studies, in helping parents to develop mental representations of the fetus (Georgsson Öhman & Waldenström, 2010; Sedgmen et al., 2006).

Furthermore, this approach to identifying expectant parents deemed to be “at-risk” of bonding difficulties and offering personalised interventions to support their emotional connection to

the unborn baby makes three assumptions. Firstly, it considers that there is an optimum standard of bonding which must be achieved during pregnancy. Secondly, it assumes that the interventions offered are appropriate and acceptable to the individual parent and their needs. Finally, it places dependency on the existence of a reliable method of evaluating and measuring parent-fetal bonding (Borg Cunen et al., 2017). The next section of this thesis presents a critical evaluation of the three most-used tools in research literature for measuring the prenatal bond.

1.2.5 Evaluating and measuring parent-fetal bonding

Attempts to measure the construct of parent-fetal bonding often take the form of self-report questionnaires. This is because they can provide a fast, reproducible, quantitative measure of bonding which can be used to further understand expectant parents' psychological reactions during the perinatal period (Condon, 1993). Variations in the conceptualisation of the parent-fetal bond have resulted in the development of several commonly used tools for its evaluation; these are the Maternal Fetal Attachment Scale (MFAS), the Antenatal Attachment Scale (AAS), and the Prenatal Attachment Inventory (PAI). All three questionnaires use a Likert response scale and require the expectant parent to respond to a series of statements relating to their behaviours, attitudes, and feelings towards their unborn baby and the pregnancy (Cranley, 1981; Condon, 1993; Muller & Mercer, 1993). However, these tools are often criticised for their simple construction, which may not fully reflect the complexity of the parent-fetal relationship, nor adequately capture and subsequently facilitate exploration of individuals' internalised models (van den Bergh & Simons, 2009). Furthermore, they may not be fully accessible to individuals with reading challenges, as they are often self-administered. The risk of responses being influenced though social desirability bias is also high (Lee, Schoppe-Sullivan & Kamp Dush, 2012). In addition, more general issues related to the use of questionnaires as a tool for measurement must also be acknowledged. For example, the scale or response format used will determine the way in which data can be analysed, the order that

questionnaire items are presented can determine the way in which a participant may respond, and the language used in the question may pose challenges for participant interpretation (Rattray & Jones, 2007).

The MFAS, AAS and PAI are further discussed in the following section, and their applicability for use in this thesis is critically considered.

1.2.5.1 Maternal fetal attachment scale (MFAS)

The MFAS was developed to measure engagement in behaviours which were believed to reflect maternal affiliation towards the unborn baby (Doan & Zimerman, 2003b). The original tool included 37-items which had been suggested by an expert consultation group consisting of clinicians and specialist infant development (Lamaze) practitioners based on their observations of expressions frequently used by expectant mothers (Cranley, 1981). The statements were categorised into sub-scales and reviewed by maternity nurses and maternal volunteers for acceptability before being presented to a study group of 71 participants between 35-40 weeks of pregnancy, most of whom were of white ethnicity and married. The participants' Likert responses (most of the time, frequently, sometimes, rarely, never) were analysed for internal consistency and external validity. Thirteen items were subsequently removed as they were considered to represent physical preparation for the baby's arrival (categorised under "nesting" sub-scale) rather than attitudes towards the pregnancy or fetus. The final scale consisted of 24 items across five sub-scales with high overall internal consistency suggested ($\alpha = 0.85$). An attempt to evaluate validity of the sub-scales was made through the use of correlational analyses as the small sample size was not conducive to factor analysis (Cranley, 1981). This approach was subsequently criticised for resulting in the validation of sub-scales which were later found to inadequately reflect Cranley's conceptualisation of the parent-fetal relationship (Muller & Ferketich, 1993), as between two and four factors have since been reported in various factor analyses (van den Bergh & Simons, 2009).

Despite this, the MFAS was adopted by researchers for use in empirical studies, and widespread demand for the tool has now seen it reproduced in multiple languages (Cranley, 1992). In addition, the removal of items concerning pregnancy events at later gestations (e.g., fetal movements) has resulted in a modified version being used in early pregnancy (Heidrich & Cranley, 1989). Two years after its publication, an adapted version (PFAS) for use in expectant fathers was developed, whereby female-gendered items were rephrased to reflect paternal experiences (Weaver & Cranley, 1983). Although 40 years later the MFAS/PFAS remain one of the most commonly used tools for measuring the parent-fetal bond, the inherent conceptual weaknesses associated with the tool, and the more contemporaneous need to update some of the items to better reflect modern society and technological advances are still acknowledged (Doan & Zimerman, 2003b).

A major limitation of the MFAS was that Cranley's inclusion of items which did not directly relate to the unborn baby may affect the accuracy of the overall score (Condon, 1985). For example, it was found that an expectant mothers' negative attitude toward pregnancy could be present alongside a strong emotional connection (Condon, 1985).

1.2.5.2 Antenatal attachment scale (AAS)

The AAS was designed to address some of the criticism of the MFAS. Versions for expectant mothers (MAAS) and fathers (PAAS) were developed and published simultaneously (Condon, 1993).

The items in the AAS were devised from relevant literature and the findings from unstructured interviews with 15 expectant couples. Following piloting with 54 couples, the MAAS contained 27 items and the PAAS contained 25 items (two items in the PAAS were omitted due to not being appropriate for fathers). A 5-point Likert-scale was used to address to the statements, although wording of the response options varied depending on the item. Completed questionnaires received from 112 couples in different stages of their pregnancy (up to 38 weeks gestational age) were used to develop the scales, which demonstrated high internal consistency (MAAS $\alpha = 0.81$, PAAS $\alpha = 0.81$)

after additional items were eliminated. This resulted in a final total of 19 items in the MAAS and 16 in the PAAS (Condon, 1993). Although Condon's model of attachment was based on five dispositions, factor analysis only identified two factors (quality of the attachment and intensity of preoccupation with the fetus), neither of which reflect the dispositions originally proposed.

As previously described, Condon's definition of the parent-fetal relationship was developed from the construct of adult attachment, and places prior experiences of care and love at its centre. However, it may be argued that this does not fully align with the prenatal bond, which is considered to exist without context and contamination from earlier experiences (Borg Cunen et al., 2017). In addition, the MAAS subscales have also been criticised because they do not fully represent the experiences of multiparous parents. For example, those with children already may score low on the "disposition to know" factor because they have prior knowledge and experience of pregnancy and therefore do not exhibit strong information-seeking behaviours compared to first-time parents (Sandbrook & Adamson-Macedo, 2004). Later work by Condon also suggested the phrasing of some items may make them susceptible to social desirability bias, thus raising concerns over the validity of the MAAS (Condon & Corkindale, 1998). Muller's analyses of the MFAS concluded that due to inconsistencies in the results generated, alternative tools to measure the prenatal bond were needed (Muller & Mercer, 1993).

1.2.5.3 Prenatal attachment inventory (PAI)

The PAI (Muller & Mercer, 1993) was therefore designed provide a more robust measurement by building on Cranley's tool and evaluating the affiliative relationship alongside maternal behaviours.

Items included in the PAI were generated from relevant literature and evaluated for content validity by an expert panel of researchers, nurses, and expectant mothers. Of the 48 items which were originally proposed, 19 were eliminated. The 29 item PAI was validated in a sample of 336

expectant mothers (α = 0.81) and demonstrated a strong correlation (*r* = 0.72) with the MFAS to infer construct validity. Factor analysis identified a single factor which explained 50% of the variance and encompassed four themes of preparedness, fantasising, affection, and interaction. Muller argued that the presence of multiple themes adequately representing the prenatal bond within the same factor reflected the unidimensional nature of the parent-fetal relationship (Muller & Mercer, 1993). The factor analysis also led to the elimination of a further two items which did not load on the factor. Thus, the final PAI contained 27 items, although further revisions have now reduced the PAI to 21 items (Pallant et al., 2014). However, the factor structure of the PAI is inconsistent, and subsequent research has questioned the finding of a single factor. Instead, five-factor solutions including; attributing traits, interaction, fantasy, sharing, and affection have been reported (Siddiqui, Hägglöf & Eisemann, 1999; Bielawska-Batorowicz & Siddiqui, 2008). However, other analyses confirmed Muller's initial single factor, accounting for 79% of the variance in the dataset (Gau & Lee, 2003).

When the total score is utilised (as opposed to the distinct sub-scales), many agree that the PAI is a reliable tool for measurement of the prenatal bond (Gau & Lee, 2003; Busonera et al., 2017), and further validation has been achieved in the pregnant population across different cultural contexts (Foley et al., 2021). In addition, the tool has been modified for use in expectant fathers by amending gender-specific items (Armstrong, 2004).

However, it is evident that there is still no optimal tool for quantifying the parent-fetal relationship. Whilst newer methods such as the Pictorial Representation of Attachment Measure (PRAM) offer an alternative to the questionnaire-based format of traditional tools (van Bakel et al., 2013), it may be argued that limitations in existing tools may reflect persistent ambiguity in the definition of the prenatal bond.

1.3 The role of imaging in pregnancy

The following section provides an overview of the use of imaging in pregnancy to contextualise it within this body of work. The development and implementation of ultrasound technology as the fundamental obstetrical imaging modality is first discussed, before introducing fetal MRI as an emerging technique to complement conventional ultrasound methods. Parental experiences of antenatal imaging are also considered, along with the social and psychological aspects of fetal imaging and their influence on the developing parent-fetal relationship. Finally, different models of care are presented in the context of the obstetric setting.

1.3.1 A brief introduction to antenatal imaging

More than 60 years after the first sonographic fetal images were published, ultrasound remains the most frequently used imaging technique during pregnancy (Bulas & Egloff, 2013). Originally developed from technology using high frequency sound waves to identify material defects in component parts of military and engineering equipment, the physical principles of these pulse-echo industrial "flaw detectors" were applied to human tissues, and the potential diagnostic uses were explored within the medical context (Campbell, 2013). To create an ultrasound image, a pulse of high-frequency sound is directed from a transducer through the body. When the soundwave reaches a tissue interface, part of it may be reflected back to the transducer. The intensity of the returning soundwave (echo) is converted into an electrical signal, which is then used to create pixel data and form the resultant image (Powles et al., 2018). The Scottish obstetrician, Ian Donald, is often credited with the introduction of ultrasound to obstetric practice and it is said that his curiosity to "look behind the iron curtain of the maternal abdominal wall" was the impetus for his pioneering work in the development of obstetric ultrasound which began in the late 1950s (Merz et al., 2023 p. 176).

Historically, the technology was only available for use in pregnancies deemed to be at "high-risk" for complications, that would benefit from medical interventions informed by additional knowledge, such as in cases of placenta praevia (i.e., offering caesarean section birth) and multiple pregnancy (Campbell, 2013). However, it is evident that further development and integration of this technology was largely driven from the clinical motivation, which raises questions of psychological effects and acceptability from the expectant parents' perspective that were not considered until the 1980s (Campbell et al., 1982). Concerns around the ethics of ultrasound use in pregnancy have also been highlighted because of the potential ambiguity it creates around the moral status of the fetus, which may be regarded as separate to that of the mother (Howe, 2014). Although important within feminist literature, these considerations are beyond the scope of this thesis.

As demand for the technology increased, ultrasound machines became more readily available for use within the wider pregnant population (Campbell, 2013). Acquisition of ultrasound data enabled the publication of reference charts for embryological dating in early pregnancy and fetal biometry at later gestational ages, many of which are still used in current clinical practice (Ioannou et al., 2012). The first routine obstetric ultrasound screening programme was introduced in Germany in 1979, and consisted of two scans during pregnancy; earlier scans were used to confirm fetal viability and gestational age, and scans later in the pregnancy aimed to detect fetal growth discrepancies that may indicate placental insufficiency (Merz et al., 2023). However, as technology evolved and image resolution improved, scan protocols have now become more complex to include detailed assessment of fetal anatomy and the fetal circulation using Doppler applications to facilitate the detection of congenital physical conditions in the fetus, and enable timely identification of other pregnancy complications (Salomon et al., 2022).

The practice of ultrasound scanning is not limited to clinicians, and the majority of screening examinations are currently undertaken by specialist trained HCPs, known as sonographers. Although alternative options for entry are being explored to support required expansion in the sonographic

workforce, the most common route for ultrasound training is a postgraduate qualification awarded by an accredited teaching programme. Student sonographers are predominantly from a radiography background, although clinical nurse specialists and other allied health professionals with a relevant first degree are also eligible to train (Society of Radiographers, 2014).

The current fetal anomaly screening programme offered in the UK (NHS Fetal Anomaly Screening Programme, 2021) focuses on the identification of 11 fetal conditions including heart conditions (e.g., atrio-ventricular septal defect, transposition of the great arteries), neural tube defects (e.g., anencephaly, spina bifida), skeletal dysplasias (e.g., achondroplasia, osteogenesis imperfecta) and chromosomal syndromes (e.g., Down, Edwards', Patau's). Antenatal detection of these conditions is made possible because of their structural manifestations in the fetus, and prenatal diagnosis is indicated for parental counselling and informed decision making related to options for clinical management in-utero or immediately after birth, or continuation of the pregnancy (National Institute for Health and Care Excellence, 2019).

In 2022, there were 605,479 livebirths recorded in England and Wales (Office for National Statistics, 2023) and each pregnancy is eligible for ultrasound screening (NHS Fetal Anomaly Screening Programme, 2021). The most recent report published by Public Health England (2021) suggests that around 2% of pregnancies will be affected by a congenital condition however, these figures are often limited by inadequate reporting from clinical departments, and geographical variation in detection rates (Public Health England, 2021). In addition, target detection rates also vary by physical condition (Public Health England, 2018). For example, large discrepancies are observed between detection of anencephaly (98%) and major congenital heart disease (50%). At this point, it is important to acknowledge that most obstetric ultrasound examinations are performed for screening purposes (e.g., a medical procedure conducted within a low-risk population) rather than diagnostic (e.g., confirming the presence of a condition). Thus, as an imaging modality, it is not feasible to suggest that ultrasound provides a perfect result, and this should be highlighted to expectant parents

through information and counselling to support their choices when considering accepting fetal screening (National Institute for Health and Clinical Excellence, 2021).

In the obstetric setting, the quality of ultrasound images can be affected by inherent limitations associated with ultrasound technology and operator dependency in the acquisition and interpretation of standard imaging planes (Wataganara et al., 2016). Human error is often used to explain non-detection of a fetal condition, and clinical negligence in maternity care is thought to cost the NHS £4.2 billion in litigation annually (Royal College of Obstetricians and Gynaecologists & The Royal College of Midwives, 2021), and can be distressing for both parents and the sonographer involved. Ultrasound image quality may also be limited by artefacts, maternal body habitus, challenging fetal lie and the presence of other pelvic structures such as fibroids which can make visualisation difficult (Wataganara et al., 2016). Additionally, due to the design of the ultrasound transducer, the narrow footprint can restrict the field-of-view, particularly at later gestational ages (Bulas & Egloff, 2013). Other reasons for non-detection of fetal conditions may be due to the gestational onset and nature in which the conditions manifest during pregnancy, particularly for congenital heart disease (van Nisselrooij et al., 2020). The routine fetal anomaly screening ultrasound examination is offered between 18^{+0}-20^{+6} weeks of pregnancy as this is considered to be the optimum time to visualise the presence of a condition whilst providing adequate time for expectant parents to consider their options in continuing a pregnancy before the UK legal gestational age limit for termination of 24 weeks (although termination for medical reasons can be performed at any point during pregnancy) (British Medical Association, 2023).

Current clinical opinion suggests that ultrasound assessment alone is adequate in most pregnancies (Wataganara et al., 2016). However, fetal MRI is becoming more frequently used in clinical practice as an adjunct to conventional ultrasound to overcome some of the previously described limitations. Rather than soundwaves, MRI uses a strong magnetic field to induce the movement of protons contained within hydrogen atoms in the body. Positioning of a radiofrequency

(RF) receiver coil over the area of interest enables the pattern of proton movement in a particular anatomical structure to be captured as a signal, which is then converted into pixel image data (Currie et al., 2013). The first fetal MRI scan was performed in 1983 to confirm a diagnosis of placenta accreta (a serious obstetric condition in which the placenta infiltrates the uterine wall) (Smith, Adam & Phillips, 1983 cited in Wataganara et al., 2016). However, early attempts to acquire high quality images of the fetus were challenging because of long scan sequence times and the inability to control for the detrimental effects on the images of fetal and maternal movement artefact without the use of sedation, which resulted in low uptake of services (Bulas & Egloff, 2013). In addition, few centres could offer fetal MRI due to increased costs and lack of clinical specialists trained in image interpretation compared to ultrasound. Thus, it was not until the technology advanced sufficiently to facilitate shorter scan sequences and multi-planar reconstruction software had been developed to correct movement artefact that the use of MRI in the pregnant population became clinically more useful (Roy et al., 2019). It is now recognised for its diagnostic value in evaluating the fetal central nervous system (Tanacan et al., 2020), thoracic cavity including congenital heart disease (Lloyd et al., 2019), and tumours involving the head and neck (Davidson et al., 2021), and it has enabled in-depth, structural, and functional evaluation of the placenta (Cromb et al., 2023) through dedicated clinical research studies.

1.3.2 Parental experiences of antenatal imaging

Whilst both modalities are considered safe to use in pregnancy as they are non-invasive and do not utilise ionising radiation (Wataganara et al., 2016), the method to acquire fetal images using ultrasound is vastly different to that of MRI. As a routine component of antenatal care, most expectant parents are familiar with the ultrasound imaging process in which an ultrasound practitioner (sonographer) moves a transducer across the maternal abdomen to acquire images in real-time, enabling dynamic assessment of fetal and maternal pelvic structures. Scans usually do not

take longer than 30minutes, during which time the pregnant individual will lie on an examination couch, often with their partner or a supporting person sat adjacent to them to share in the scanning experience and provide companionship (Thomson et al., 2022). The examination room is usually dark and quiet, which provides optimal conditions for viewing images and sonographer concentration, and the scan process is generally well tolerated (only becoming uncomfortable if the examination requires a full bladder, or excessive pressure is applied through the transducer).

It is common practice for expectant parents to view the scan images as they are acquired, with most sonographers providing a narrative to assist with parents' understanding (Masroor, Ahmed & Ajmal, 2008). In addition, static images (standard anatomical planes) of the fetus are captured and stored as a record of the imaging examination. In the UK, these images are simultaneously interpreted by the sonographer, and a written report is generated to record the findings of the scan (Gibbs, Edwards & Harrison, 2017). Expectant parents are usually informed of the results before leaving the examination room or scan department, even in the case of an unexpected finding such as a fetal condition or pregnancy complication (Johnson et al., 2019). Unlike other areas of healthcare which may require the delivery of difficult or sensitive news to service users, sonographers have very little time to prepare themselves or expectant parents to receive difficult news, and this process has been associated with distress in the parent, and emotional exhaustion and occupational burnout in the sonographer (Johnson et al., 2020).

The use of strong magnets in fetal MRI necessitates strict requirements to keep service users and staff safe. This usually means that apart from the individual being scanned, no additional persons are permitted in the room for the duration of the examination. The expectant mother is positioned on a table which moves in and out of a narrow, circular gantry containing the magnets, as multiple scan sequences are initiated by a radiographer (an allied health professional specifically trained to use specialist equipment to acquire medical images). When certain parts of the MRI machine are exposed to rapidly changing electromagnetic currents, they vibrate causing loud banging and

knocking noises which may be heard even when wearing MR-compatible headphones to listen to music and communicate with the radiographer in the MRI control room (McNulty & McNulty, 2009). This can be distressing, and may make it difficult for the individual to speak with the radiographer during the examination (McJury, 2022). Fetal MRI scans also require the individual to lay still with the RF receiver coil placed over their abdomen for extended periods of time as the imaging sequences are acquired, which may be uncomfortable during pregnancy, especially at later gestations (Dütemeyer et al., 2023). It may take up to an hour to complete the scan and the images may require post-processing prior to being reviewed by a specialist clinician, thus expectant parents do not receive a finalised report for the examination immediately.

Whilst ultrasound has no known clinical contraindications, some exist for MRI, namely the presence of a non-removable metallic device or implant (Dütemeyer et al., 2023). Claustrophobia (fear of confined spaces) is also often cited as a reason for non-acceptance or failure to complete an MRI scan (Eshed et al., 2007), and although it can be alleviated in some individuals by changing their position during the scan or keeping their head out of the machine, these approaches may be limited for pregnant women and people (Dütemeyer et al., 2023). However, the rate of decline or failure of MRI scanning in the pregnant population is relatively low with studies reporting figures of between 0.3-4.5% (Li et al., 2011; Sanz Cortes et al., 2017). Factors affecting the rates are reported to include claustrophobia as well as general malaise, noise intolerance, physical discomfort, and concerns regarding fetal safety and the potential for an unexpected finding (Dütemeyer et al., 2023). The rationale for the scan may also influence expectant parents' motivation to have fetal MRI, with higher reported rates of acceptance of scans for clinical indications such as a fetal condition or other pregnancy complications (43/44, 98%) compared with research studies (34/104, 33%) (van Der Knoop et al., 2018). The authors of this study suggested that when parents believe the fetal MRI scan may provide additional and valuable information regarding the pregnancy, this may be sufficient motivation to overcome feelings of claustrophobia (van Der Knoop et al., 2018). Indeed, in a study of 830 pregnancies being examined by fetal MRI because of developmental fetal brain conditions, only

four expectant mothers of the 16 who reported feelings of claustrophobia were unable to complete the scan (Griffiths et al., 2019). Other studies suggest that receiving adequate information (Leithner et al., 2009) and being accompanied in the scan room (Derntl et al., 2015) may help to improve the scan experience and support completion of the examination. Additionally, MRI is more commonly used in pregnancies where a fetal physical condition is suspected or has been diagnosed, therefore, it has been suggested that parents may feel more anxious about the examination which may affect their overall imaging experience (Leithner et al., 2008).

Furthermore, the fetal MRI image is markedly different from ultrasound, providing a wider view of the whole fetus and maternal abdomen. Reconstructed images can demonstrate intricate and precise anatomical detailing, for instance in the fetal brain or heart, that may not be visualised with ultrasound. However, relatively little published literature exploring expectant parents' reactions to these images exists (Lie et al., 2019).

It is important to understand expectant parents' experiences of, and reactions to antenatal imaging for two main reasons. Firstly, a deeper appreciation of the service users' perspective facilitates the provision of high-quality care (Bombard et al., 2018). Secondly, knowledge of parents' expectations and experiences of scans in pregnancy may be used to inform and develop fetal imaging services (Ekelin, Svalenius & Dykes, 2008). Much like the paucity of literature pertaining to paternal-fetal bonding, there are even fewer studies reporting the father's experience of antenatal imaging (Walsh et al., 2014). An additional reason to study parental experiences is provided in the context of fetal MRI. As a relatively new imaging modality within the antenatal care pathway, most of the literature is focused on the clinical and technical aspects of the technology. In comparison, parent acceptability, experience, and psychological reactions to MRI scanning in pregnancy have not received as much attention (Leithner et al., 2013).

However, methods of quantitatively evaluating the parental experience of fetal imaging are largely non-existent. This may be attributed to difficulties in objectively measuring an individual's

experience (Larson et al., 2019), but variation in care provided within and across different imaging services could also be acknowledged as an influencing factor. The Parental Expectations, Experiences and Reactions to Ultrasound (PEER-U) tool was developed to address the lack of a validated measure for prenatal imaging (Ekelin, Svalenius & Dykes, 2008). This 24 item questionnaire was constructed from the findings of a grounded theory study (Ekelin, Crang-Svalenius & Dykes, 2004), and is completed in two parts; before and after the ultrasound examination. Internal consistency of the tool is reported to be high (pre-scan $\alpha = 0.77$, post-scan $\alpha = 0.75$) and factor analysis confirmed dimensions which aligned with the earlier qualitative study (Ekelin, Svalenius & Dykes, 2008). However, whilst this tool may be suitable for both mothers and fathers, it is specifically designed for use in the setting of obstetric ultrasound and in the second trimester of pregnancy (e.g., 13-27 weeks gestation), which limits its applicability to this thesis for two reasons. Firstly, parents of pregnancies of gestational ages beyond the second trimester were eligible to participate in the studies conducted for this thesis. Secondly, parents included in the thesis research studies were having ultrasound or fetal MRI in pregnancy. In addition, the PEER-U tool does not directly evaluate the parent-fetal bond, which is a key focus of this thesis.

1.3.2.1 The influence of antenatal imaging on prenatal bonding

Fetal images may be used by clinicians and expectant parents to provide evidence of life (Stephenson, McLeod & Mills, 2016). Clinicians also use fetal images to inform prospective parents regarding prenatal diagnoses and facilitate fetal surveillance to determine whether there is a need for medical intervention. This emphasises the superiority of vision as the sense used to best understand the human world (Favaretto, Vears & Borry, 2020). However, an additional level of meaning is historically noted to exist within the image, representing one of fantasy (Petchesky, 1987) prompting parents to engage in cognitive processes and imagine their unborn baby.

The first studies demonstrating an association between ultrasound imaging and enhanced bonding were published in the early 1980s (Kohn, Nelson & Weiner, 1980; Campbell et al., 1982). Theories of prenatal bonding posit expectant parents' emotional connection begins to form when they recognise the fetus as an independent being (Cranley, 1981), and ultrasound imaging may help to do this by capturing a depiction of the unborn baby within the uterine cavity. Image optimisation settings are used to magnify the fetus, and surrounding maternal and placental tissue can be cropped from the final image.

Fetal images may not be fully accessible to expectant parents, who may rely on commentary and guidance provided by the imaging professional to guide their interpretation (Walsh, 2020). In other words, expectant parents create meaning through their interaction with the image, which is facilitated by the HCP. Thus, it could be argued that the epistemic status of the image may be ambiguous because the parent's understanding may be heavily influenced by what the HCP considers important to highlight (Kroløkke, 2010). This approach may be considered reductionist as it may be seen to override maternal embodied knowledge. For example, an expectant mother who believes she is starting to feel fetal movement may be informed by the HCP that it is unlikely given the anterior location of the placental site which would mask the physical sensation.

It may be argued that the introduction of 3D and 4D ultrasound imaging may alleviate some of the challenges expectant parents may encounter when viewing B-mode ultrasound images. This advanced ultrasound technology enables expectant parents to visualise a surface-rendered representation of the fetal face as a static image (3D) or in real-time (4D), which is believed to be more recognisable to parents and thus easier to interpret without specialist knowledge (Pretorius et al., 2006). Private ultrasound services often market 3D/4D fetal imaging packages as a positive experience for expectant parents and their wider family, promoting benefits for bonding and reassurance (Roberts, 2012). However, published research questions the measured effect of this technology, with several studies not reporting any significant difference in bonding between

conventional 2D ultrasound and 3D/4D images (Righetti et al., 2005; Rustico et al., 2005; Sedgmen et al., 2006; de Jong-Pleij et al., 2013). Although it must be acknowledged that many of these studies were published in excess of 20 years ago and therefore cannot be fully generalised in the context of later technological improvements, these research findings suggest that the imaging modality does not have an influence on the parent-fetal relationship. Rather, they serve to support an earlier hypothesis which acknowledged the importance of the care interaction with HCPs during the imaging experience in facilitating the developing bond (Lumley, 1990).

The increasing accessibility of fetal ultrasound imaging outside of the clinical environment raises important clinical issues such as scans being performed by inadequately qualified or regulated operators and the potential for inaccurate or undetected diagnoses (Howard, 2020). However, appeals to fully medicalise fetal imaging highlight conflicting ethical considerations. If the sole justification for fetal imaging is the purpose of identifying fetal conditions, this has significant implications for approaches to care provision and on the experience of the expectant parent. "Scanxiety" is a colloquial term used to capture an individual's worry prior to an imaging examination of what might be identified (Bui et al., 2021). Although initially applied within the oncological context, literature suggests that expectant parents' feelings of anxiety around imaging in pregnancy peak immediately before an examination and decline rapidly after receiving reassurance from the scan (Businelli et al., 2021). Due to the nature of fetal screening, expectant parents may be counselled that results cannot be relied on for total accuracy, however, this ambiguity may be seen as in conflict with the aforementioned positivist conceptualisation of fetal images, and may serve to create further anxiety in expectant parents and confusion in interpreting the screening outcome (Pilnick & Zayts, 2014). Anxiety in expectant mothers has been previously associated with increased resistance in the uterine arteries which may be detrimental to fetal growth (Teixeira, Fisk & Glover, 1999), thus it is important to be aware of this parental reaction and its potential physiological implications.

A further ethical consideration is related to the concept of fetal screening itself. It has been suggested that expectant parents attend fetal imaging appointments for two main reasons: 1) curiosity and desire to see their unborn baby, and 2) need for confirmation of fetal development to reassure emotional investment in the pregnancy (Thomas, Roberts & Griffiths, 2017). Fetal imaging provides information about the developing pregnancy that is acquired independently of an individual's own temporal or spatial awareness (Favaretto, Vears & Borry, 2020), effectively opening up the "black box" of the womb for medical and psychosocial purposes. Recent studies investigating structural and functional changes in the maternal brain during pregnancy suggest that these enable key adaptive processes to prepare the expectant mother for her new caregiving role (Hoekzema et al., 2022). However, the process of screening for expected fetal development is ethically challenging. Deviation from the societal "norm" may be considered problematic from a medical perspective and clinical management or intervention may be offered in response. Medical terminology has previously adopted phrases such as "defect", "abnormality", and "anomaly" which are now considered to be inappropriate because of their inherent judgement of a social standard of normality (Antenatal Results and Choices, n.d.). The acceptance of fetal screening may be recognised as the first act of responsible parenting in finding out whether an unborn baby has a physical condition, and an individual may feel socially and morally pressured to consent (Brauer, 2016). However, offering parents the option of termination of pregnancy for medical reasons is sometimes complicated by wider ethical and societal beliefs (Thomas & Rothman, 2016). Comprehensive discussion of these issues is far beyond the scope of this thesis, however it is important to be aware of the wider considerations when exploring antenatal imaging.

In pregnancies where a physical fetal condition is suspected or diagnosed, clinicians may refer to scan images when counselling expectant parents (Lalor, Devane & Begley, 2007). Existing literature has explored the effect of visualising a fetal condition on the developing parent-fetal bond, demonstrating variable results depending on the severity of the diagnosis (Tesson et al., 2022). However, it may be considered that visualisation may be beneficial for expectant parents to build a

mental representation of the diagnosis to better understand it (Lalor, Devane & Begley, 2007). In cases of externally visible conditions such as facial clefts, prenatal imaging (especially 3D/4D ultrasound) may help to prepare expectant parents for how the infant may look at birth (Cadogan, Marsh & Winter, 2009). It has also been reported that in comparison to the imaging findings, parental preconceptions of a diagnosis are usually more severe (Lie et al., 2019), which suggests important implications for prenatal counselling.

In addition, that the way expectant parents respond to, and process news about a fetal condition is dependent on the way the HCPs deliver the news (Kratovil & Julion, 2017). This algins with previously reported findings to further highlight the importance of the parent-HCP partnership as a moderating factor for expectant parents' emotional connection to the fetus, and suggests that a substantial contribution to the process is the care interaction that occurs during the imaging appointment (Walsh, 2020). Studies exploring the effect of high-feedback ultrasound imaging (whereby the expectant parent receives in-depth information during the scan or in a consultation immediately after the examination) have been associated with enhanced bonding and increased parental satisfaction of the care experience (Masroor, Ahmed & Ajmal, 2008; Pulliainen et al., 2019). In their cohort study of 60 participants, Masroor, Ahmed and Ajmal found that levels of maternal-fetal bonding (evaluated using the MFAS) significantly increased, and feelings of anxiety significantly decreased in the 30 expectant mothers assigned to receive a short consultation prior to the scan. This consultation aimed to increase maternal awareness of the fetal form and usefulness of ultrasound, and is thought to have enhanced maternal engagement with the fetus during the scan (Masroor, Ahmed & Ajmal, 2008). A study conducted by Pulliainen et al. (2019) utilised an interactive 3D/4D ultrasound examination as an intervention in a cohort of expectant mothers at high-risk for pre-term birth. The examination followed a pre-determined protocol which aimed to promote joint observation of the fetus, guided by the mother and two HCPs present during the scan (a maternal-fetal medicine clinician and a specialist in perinatal and infant mental health). Expectant mothers reported feeling more actively involved and subsequently more satisfied with the examination using

this maternal-centred, collaborative approach, and that their mental image of the unborn baby was strengthened as a result (Pulliainen et al., 2019).

However, it is evident from qualitative studies, particularly those focused on fathers' experiences of antenatal services, that effective feedback and communication is not always provided by the HCP (Widarsson et al., 2015). This may be partly because complex ultrasound imaging protocols require more intense concentration from the sonographer and the demand to multi-task is cognitively overwhelming, or in the case of fetal MRI where the radiographer is located in a different room or communication is affected by acoustic noise during the scan, opportunities for interaction are further limited (McJury, 2022).

The sonographer workforce is currently recognised as an "at-risk" shortage occupation with vacancy rates currently estimated to be at 12.6% (The Society and College of Radiographers, 2019). Coupled with increasing demand for imaging services that reflect the growing population, clinical workflows are currently under extraordinary pressure (Sparks & Nixon, 2022). A lack of resources to support provision of imaging services has previously resulted in high observed levels of occupational burnout in the workforce (Johnson et al., 2019), whereby individuals may avoid interaction in an attempt to preserve limited emotional resources (Salyers et al., 2017). These findings of occupational burnout may help to explain why expectant parents experience unsatisfactory interactions in the scan room, which do not align with their individual needs and expectations for care. In addition, early literature identifies tensions arising between parents and HCPs from the paradox created during co-construction of fetal images. For example, there is a paradigmatic conflict between viewing the fetal image through the objective medical gaze and utilising images to support cognitive tasks of fantasy and imagination (Petchesky, 1987). However, more recent studies have argued that taking a balanced approach to fetal imaging which unites the objective information acquired by the HCP with the expectant parents' subjective knowledge of the pregnancy is achievable and may result in a more parent-centred imaging experience (Rentmeester & Hogan, 2020).

Research suggests that expectations and experiences of antenatal care may be associated with social (e.g., class, race, ethnicity) or biological factors (e.g., age, obstetric history) (Tocchioni et al., 2018). O'Leary also highlights the impact of previous pregnancy loss or trauma on subsequent pregnancies, emphasising the variation in individual needs across differing obstetric scenarios (O'Leary, 2005). The influence of personality traits on care needs has also been reported; individuals who exhibit a higher tendency for neuroticism may have increased requirements for information provision (Weston & Jackson, 2016). The complexity of these biopsychosocial factors renders the generalised approach to antenatal care (including fetal imaging) not just ineffective, but inadequate as well. These findings suggest that an individualised or parent-centred approach may be much better aligned to meet parental needs for care.

1.3.3 Person-centred imaging

The following section builds on the earlier considerations related to parents' individual care experiences during antenatal imaging appointments. First, popular models of generalised healthcare delivery are critically evaluated and explored within the domains of diagnostic radiography and antenatal imaging. The wider challenges for implementation of person-centred care approaches are also discussed and applied to the obstetric setting.

1.3.3.1 Models of healthcare delivery

The traditional biomedical model, which is primarily focused on the diagnosis and treatment of disease, is widely criticised for being reductionist in its failure to recognise the individual behind the physiological or pathological condition (Farre & Rapley, 2017). However, whilst most would agree it is outdated in the current clinical context, it does have a continued presence within the health system, largely because departments are often funded through a "payment by results" approach to care which prioritises service productivity over individuals or outcomes (Farrar et al., 2009).

Nonetheless, other frameworks for healthcare provision have since been proposed to offer an alternative; these include biopsychosocial and person-centred models of care.

George Engel is credited with the development of the biopsychosocial model of healthcare, arguing that the traditional medical model only focused on the physiological aspects of disease and therefore did not accommodate the broader social, psychological, and behavioural dimensions associated with the concept of "illness" (Engel, 1977). This approach aimed to mitigate the reductionist approach of the biomedical model and acknowledge the importance of considering the other domains when making medical decisions. Engel's model distinguishes the biological, psychological, and social domains as distinct systems which require skilful integration to inform and understand illness and patient experiences of care (Engel, 1981).

However, the success of this integration is reliant on effective communication between HCPs and service users, and has been criticised in its application to healthcare because no clear or reproducible method is defined for HCPs in acquiring relevant information to support the individual application of the biopsychosocial model in practice (Ghaemi, 2009). Attempts to address this limitation have proposed the use of a more structured, "patient-centred" interview to obtain the required information with which to personalise the biopsychosocial model, that is led by the service user rather than the clinician (Smith et al., 2013). More recently, attempts to extend the biopsychosocial model have focused on specific clinical applications (e.g., pain and diabetes), as well as considered additional factors such as culture (Hilty, 2015), technology (Card, 2023), and religion and spirituality (Sulmasy, 2002). However, even the later versions have received criticism for continuing to reduce the individual at the heart of the model to the simple sum of the included domains (Haslam et al., 2021). Thus, the need to take a more holistic approach when considering the central role of the individual in their care is highlighted.

Patient-centred healthcare was first introduced as a concept in 1969, and in its simplest terms, can be described in the medical context as "understanding the patient as a unique human

being" (Balint, 1969). However, this early definition has been challenged as it uses the term "patient" which has a strong association with disease and illness, and is therefore not fully recognitive of the differentiation between the individual and their medical condition (Håkansson Eklund et al., 2019). For this reason, subsequent literature in this field frequently utilises the alternative term "person" to mark this philosophical distinction, although it is still noted that many use the terms interchangeably (Santana et al., 2018). One of the frameworks for person-centred care identifies four core principles related to dignity and compassion, co-ordinated care, personalised care, and supporting individuals in their independent lives (The Health Foundation, 2016). This approach conceptualises person-centred care as the collaborative working partnership between health and social care professionals and those who use services, and features in the Person-Centred Approaches Framework (PCAF) (NHS Health Education England, 2017).

The PCAF identifies requirements for knowledge (e.g., supportive technology, accessible information, awareness, and regulation and governance) and activities (e.g., shared-decision making, advocacy, working in partnership, and measuring impact at individual and service level) for person-centred care (NHS Health Education England, 2017). At the heart of this framework, core standards of communication and values-based practice unite the knowledge and activity requirements to facilitate personalised approaches to care. These are also reflected in the eight key principles of person-centred care defined by the Picker Institute, which include: 1) fast access to reliable healthcare advice; 2) effective treatment delivered by trusted professionals; 3) continuity of care and smooth transitions; 4) involvement and support for family and carers; 5) clear information, communication, and support for self-care; 6) involvement in decisions and respect for preferences; 7) emotional support, empathy and respect, and 8) attention to physical and environmental needs (Picker Institute, n.d.). Given these principles, the integral role of the HCP in facilitating and supporting personalised care must also be further acknowledged. Indeed, an umbrella review of published reviews reported that establishing a meaningful, collaborative partnership between HCPs and service users was the most important component of person-centred care (Sharma, Bamford &

Dodman, 2015). An earlier review within the nursing context also highlighted additional considerations such as professional competence and the HCP's commitment to being person-centred (McCormack et al., 2010). However, the concept of person-centred care has received criticism for being too focused on the individual's immediate circumstance, and thus neglecting the wider context (Nolan et al., 2004).

Benefits of adopting a person-centred approach to care have been reported for health outcomes, service user and HCP experience, and clinical resourcing (McMillan et al., 2013). It is therefore not surprising that international organisations such as the World Health Organization (WHO) fully endorse person-centredness within healthcare services, and recognise the associated values and attributes as key competencies for HCPs (World Health Organization, 2007). Although the basic principles for care are noticeably similar, the number of differing frameworks reported in published literature suggest that truly effective person-centred approaches may require contextualisation across medical, nursing, and allied health professional domains of care (Sharma, Bamford & Dodman, 2015).

1.3.3.2 Person-centred care in medical imaging

Biopsychosocial and person-centred models offer a more humanistic view of healthcare than that of the traditional biomedical approach. However, advances in medical technology (particularly diagnostic imaging) may pose a threat to their philosophical approaches as they can inadvertently promote objectification of the body, separating the physical human from the psychological mind (Stahl, 2013). Furthermore, business directives such as "payment by results" seemingly promote increased technological application to support workflow efficiency, which may be associated with poor care quality from overdiagnosis, and an overly medicalised healthcare system (Kühlein et al., 2023). Thus, a balance must be achieved between the technical and caring aspects of imaging professionals' roles to support quality, humanistic care provision. Good progress is being made to

develop person-centred imaging recommendations for different user groups, and literature has been published recently on autism-friendly MRI (Stogiannos et al., 2022), the use of artificial intelligence in breast imaging (Champendal et al., 2023), and care of individuals with dementia accessing imaging services (Higgins, Spacey & Innes, 2023).

Guidance for medical imaging published by professional organisations recommends the practice of person-centred care (The Society and College of Radiographers, 2018). However, as much of the evidence-base used to inform these publications arises from the medical and nursing professions, its generalisability to the medical imaging context may be limited (Hebblethwaite, 2013). A recent body of work conducted by Hyde and Hardy explored person-centred care within the domain of diagnostic radiography (Hyde, 2024). Using a two-stage, multi-method approach, data relating to individuals' attitudes, experiences, and perceptions of person-centred care in medical imaging settings were collected from different participant groups including service users, trainee radiographers, qualified radiographers, and clinical managers. The analysis resulted in the development of a formal conceptual framework which identified three key domains of care as: 1) event interaction (e.g., related to the imaging task); 2) perception of care (e.g., service user perception of the care experience); and 3) control over environment (e.g., departmental signage, waiting areas). Key moments for care were highlighted before, during, and after the imaging examination through questions directed at HCPs across domains of patient knowledge and understanding, attire (if required to change clothing for the examination), user needs and wellbeing, safety and security, and the scan room environment. The framework is presented in the style of a Venn diagram, and the central concept shared by the three domains is captured as "care communication" (Hyde & Hardy, 2021b).

As highlighted earlier in the PCAF, quality communication during the care experience is of paramount importance to person-centred care (NHS Health Education England, 2017). If this is ineffective, the interaction is likely to break down and lead to feelings of dissatisfaction, which may

have implications for experiences or even attendance at subsequent appointments (Pollard et al., 2019). However, it must be acknowledged that communication does not simply relate to verbal dialogue or non-verbal cues, but there must also be an underlying appreciation, respect, and attempt to understand the other individual in order to build a trusting and collaborative partnership (Flickinger et al., 2016). This approach is conceptualised within radiographic literature as compassionate communication (Taylor, Bleiker & Hodgson, 2021).

One potential challenge to achieving compassionate communication, and subsequent quality person-centred care in medical imaging is the fast-paced and highly demanding clinical environment which can make it seem as if HCPs simply do not have the time to engage in conversation beyond directive instruction for the examination (Hyde & Hardy, 2021a). However, further difficulties may arise when considering how different individuals involved in the care interaction prioritise different aspects. For example, research has shown that radiography service users prioritise human interaction, and perceive the receipt of psychological as well as physical care to be of greater importance during a medical imaging appointment than clinical radiographers or radiography managers, who both rank service efficiency higher (Hyde, 2024). This observable discrepancy in the perceptions of person-centredness between service users and HCPs suggests that despite the development of guidance and recommendations to support personalised care in imaging departments (Hyde & Hardy, 2021b), challenges exist for its integration within practice.

1.3.3.3 Challenges for integrating person-centred care within clinical departments

Measuring and evaluating person-centred care

Quality in healthcare is often evaluated through measures of service user experience, in particular, satisfaction with the experience of care may be utilised as a measure of person-centredness within a service (Browne et al., 2010). Attempts to measure experiences of care often take the form of a survey with varying results reported in published literature, explained by the use

of multiple tools (sometimes of questionable reliability and validity), and the difficulties associated with quantitatively evaluating what is effectively a subjective concept (Beattie et al., 2015). For this reason, service user experience surveys may focus on more objective items such as task performance, although it has been previously suggested that quality interaction with HCPs is a better indicator of person-centred care (Hyde, 2024). Indeed, factors related to an individuals' positive experience of care have been reported to include effective communication, feeling respected by HCPs, and HCP responsiveness to individual needs and preferences for care (Sharma, Bamford & Dodman, 2015). Additionally, tools may not be fit for purpose if they do not incorporate a clear definition of person-centredness within the clinical context and have not been developed in conjunction with service users. This may mean that any included items do not fully and accurately reflect values and priorities for care (Lord & Gale, 2014), which can lead to unsuccessful efforts in service improvement. Collecting and analysing data on service user experience and satisfaction can also be resource intensive, and there may be issues of accessibility in the tools which must also be considered (Beattie et al., 2015). However, these criticisms should not dissuade HCPs from conducting experience and satisfaction surveys but highlight the important of utilising the most appropriate approach for the clinical context.

Organisational culture and vision

Clinical departments often cite time-pressures and under-resourcing as barriers to person-centred care (Moore et al., 2017). Whilst these inevitably pose a threat to quality care provision, successful integration of person-centred approaches to care into clinical services also requires a clear definition of person-centredness in the specific context, effective leadership, and buy-in and commitment from the team (Hebblethwaite, 2013).

As previously discussed, the use of differing paradigms to underpin healthcare within a clinical department may also create confusion for the delivery of quality healthcare (Hebblethwaite,

2013). However, this could be mitigated by effective, person-centred leadership which promotes organisational change, and models a shared vision of care (Wood, 2021). Person-centred leadership may be defined as "leadership supporting, creating and securing person-centred values and practices" (Eide and Cardiff, 2017, p. 95), and has been associated with positive changes in workplace culture, including greater staff engagement, less resistance to change, and improved working environments in nursing research (Cardiff, McCormack & McCance, 2018). Having a shared vision for care provides clear direction within a clinical team, helping to focus individual efforts into transforming practice (Lukas et al., 2007). All members of the team who will be delivering the vision should be involved in its development to ensure it is realistic and achievable, and to provide individuals with a sense of ownership to support their future motivation (Martin et al., 2014). In addition, care provision is noted to be strengthened in departments that conduct person-centred research, further highlighting how values and principles for care can be embedded across all aspects of clinical practice (Moore et al., 2017). However, research into person-centred leadership is currently lacking and therefore, full adoption of this approach may be limited until there is further evidence to support and validate the person-centred care framework (Eide & Cardiff, 2017).

Integration of person-centred care requires buy-in and commitment from clinical staff, thus successful implementation may also be challenged by negative perceptions from clinical staff (Hebblethwaite, 2013). This could be unintentional in some HCPs who may habitually revert to traditional biomedical models of care delivery (Moore et al., 2017). However, it has been argued that conceptualisations of person-centred healthcare may be detrimental to staff because, if focusing solely on the individual service user during the care interaction, the personhood of the HCP themselves may be overlooked, thus undermining the importance of reciprocity in the working relationship (Buetow, 2011). In the context of obstetric sonographers, the line between technical mastery and being considered an extension of the ultrasound machine can be blurred (Rentmeester & Hogan, 2020). This depersonalisation of HCPs may cause them to feel unappreciated as individual practitioners by senior colleagues and managers, as well as those they care for (Holmes et al., 2017).

Feeling valued at work is associated with job satisfaction and role retention in HCPs (Bimpong et al., 2020). In contrast, not feeling valued may contribute to occupational burnout (Salyers et al., 2017). Burnout is defined as an individuals' prolonged response to work-related stressors (Maslach, Schaufeli & Leiter, 2001), which can occur when the demands of an occupational role chronically exceed the resources available to support it (Demerouti et al., 2001). It has been linked with poor safety outcomes and individuals' psychological wellbeing (Hall et al., 2016). In addition, occupational burnout may negatively affect an individual's capacity to provide high quality care (Salyers et al., 2017) as they must feel they have their needs met before they can care for others (Beardsmore & McSherry, 2017). Thus, it is understandable that HCP buy-in to person-centred care initiatives may be limited without effective support and leadership (Hebblethwaite, 2013).

Organisational challenges for implementation

Dedicated training for HCPs focused on raising awareness of an individual's values of care (e.g., values-based practice), and enhancing communication techniques is required to support the provision of high-quality person-centred healthcare (Moore et al., 2017). Literature highlights the importance of embedding person-centredness across all levels of clinical education (Santana et al., 2018). Training may be delivered by expert facilitators in the first instance, and further supported through organisational leadership and mentorship programmes in order to maintain a positive, person-centred departmental culture (Pelzang, 2010). However, there may be financial and time implications associated with training in clinical departments (Moore et al., 2017), and where training is offered, it may require adaptation to meet the needs of the HCPs or the services users whom they are working with (Bhattacharyya et al., 2018). Whilst many clinical educational programmes do include communication training to support person-centred care, it has previously been suggested that continued emphasis on task-based competencies in the curriculum fails to appropriately

highlight its importance, thus creating a barrier for integration in future clinical practice (Pelzang, 2010).

1.3.3.4 The concept of parent-centred care in fetal imaging

Benefits for person-centred care in the antenatal setting are reported for improved safety and parental satisfaction (Severinsson et al., 2017). The need to support and educate HCPs in the delivery of person-centred care is evidenced by the formation of organisations such as the Picker Institute (www.picker.org) and Personalised Care Institute (www.personalisedcareinstitue.org.uk). However, there is currently no agreed or universally accepted model or framework of care specific to obstetrics, although recent work has identified commonalities with the broader principles of person-centred approaches such as respect and dignity, effective communication and therapeutic relationship (Dong, Jameel & Gagliardi, 2022). An integrative review of empirical literature identified three key themes in its conceptualisation of women-centred care within antenatal services as: 1) clinical practice (e.g., incorporating women-centred approaches for care); 2) maternity service provision (e.g., models of care and service delivery); and 3) education (e.g., raising awareness of care practices during training and into roles post-qualification) (Brady et al., 2019). However, this review is limited outside of the labour and birthing context, and only considers the immediate, caring partnership between the pregnant individual and their named midwife which may be seen to overlook other important relationships during pregnancy, such as those between expectant parents. However, references to the development of models of antenatal care which may be inclusive of the expectant father have also been criticised for inappropriately medicalising the paternal transition to parenthood, placing additional pressure on HCPs to care for another individual in the clinical setting, and potentially compromising expectant mothers' choices for care (Draper & Ives, 2013), further highlighting challenges in the development of a more specific model of care. In addition, previously described models related to diagnostic radiography (Hyde, 2024) do not fully encompass aspects

unique to antenatal imaging such as the immediacy of results, and the fact that the examination generally occurs in the absence of any clinical symptoms of illness or disease. Recommendations for person-centred care in diagnostic radiography are largely focused on improving the service user's experience of imaging tasks (Hyde & Hardy, 2021b), and do not fully reflect the specialist psychological care needs of expectant parents as they navigate their changing identities and transition to parenthood (Mercer, 1986). With no clear definition of parent-centred care, it is therefore understandable that departments may take a task-focused, objective, and generalised approach to care which can predominantly focus on the fetus as the patient or recipient of care (Williams, Alderson & Farsides, 2001), and is thus reductive of expectant parents.

The importance of parental engagement in healthcare practices for supporting infant outcomes is acknowledged, and as such, family-centred care practices are becoming increasingly implemented in neonatal and paediatric settings (Franck & O'Brien, 2019). The underlying philosophy of the family-centred approach emphasises the provision of healthcare in the context of the needs of an individual, their family, and their community (Committee on Hospital Care & Institute for Patient and Family Centered Care, 2012), promoting the involvement of the individual and those important to them in their care, and in partnership with HCPs (Park et al., 2018). Principles of respect, support, collaboration and empowerment are associated with family-centred models of care (Franck & O'Brien, 2019), again highlighting similarities with person-centred approaches. The concept of family-centred obstetric sonography was considered in 1986 through a collection of correspondences from practicing HCPs in which the involvement of additional family members (including partners), and sharing of scan information with expectant parents was discussed (Craig, 1986). However, despite their openness to recognise and support of the new family unit, their general consensus on care delivery still heavily emphasised a traditional biomedical approach with the HCP firmly "in charge" of the examination (Craig, 1986, p. 99). Nearly 40 years later, it could be argued that the situation in clinical departments is largely unchanged.

An alternative approach to inform ideas about parent-centred care proposed by Rentmeester and Hogan (2020) strives to achieve balance between the medical and psychosocial domains of antenatal imaging (Rentmeester & Hogan, 2020). This aims to address paradigmatic conflict in the construction of fetal images (e.g., medical/objective vs. experience/subjective) and the associated tension related to authority of knowledge. For example, when HCPs prioritise medical objectivity as "truth", this can be dismissive of expectant parents' lived experience which can lead to feelings of alienation (Young, 2005). Similarly, it could be considered that when an expectant parent questions the HCP's interpretation, they too may feel undermined in the interaction. Drawing on Gadamer's theory of philosophical hermeneutics which understands communication as a "fusion of horizons" between two parties (Risser, 2019), Rentmeester and Hogan highlight how the care interaction may be better supported when both parties acknowledge and agree that truth exists within the differing perspectives they bring to the situation. They conclude that "sonographers who cultivate technical mastery, build patient rapport, explain the process and the significance of the ultrasound, and understand the patient's world are able to provide excellent patient care" (Rentmeester and Hogan, 2020, p. 1). Whilst this work provides a promising development in the conceptualisation of parent-centred obstetric ultrasound, the lack of a similar consideration related to fetal MRI is also evident.

As considered above, the absence of a formal model or framework presents several challenges for the provision of care. Firstly, adopting a standardised approach assumes that all parents have the same needs (Buetow, 2011). Secondly, it assumes that HCPs have an adequate understanding of what those care needs are and are best placed to support them, which may be inadvertently associated with a paternalistic approach to care (Chervenak & Mccullough, 2014). Finally, it makes it difficult to inform initiatives to improve care through education and training of HCPs.

Although this lack of an agreed conceptualisation of person-centred care may be considered a limitation for developing frameworks and recommendations for practice (McCormack et al., 2010),

ironically, it could be argued that reaching an agreed consensus may actually undermine the ethos of truly individualised, person-centred care by encouraging standardised practice (Buetow, 2011). Furthermore, person-centred care practices must also recognise the HCPs as an individual in the care experience to encourage reciprocity in the interaction and mitigate against role disengagement that may lead to subsequent occupational burnout (Schaufeli, Dierendonck & Gorp, 1996). However, what does seem to be universally accepted within person-centred care literature is its shared mission to achieve improved satisfaction and experiences of care for both service users and HCPs, and positively contribute to health outcomes overall (Sharma, Bamford & Dodman, 2015). Thus, research is required to gain a deep understanding of parental experiences of fetal imaging, with particular focus on parental type (e.g., mothers and fathers), imaging modality (e.g., ultrasound or fetal MRI), and the presence of a fetal condition to help provide evidence to inform future models and recommendations for care that are truly parent-centred and supportive of all individuals involved in the care interaction.

1.4 COVID-19 impact on antenatal imaging and thesis research

In March 2020, the UK was placed under a national lockdown in response to the COVID-19 pandemic (Institute for Government, 2021). During this time, one aim of healthcare services was to minimise the risk of transmission of the virus in clinical settings. Face to face contact between patients and HCPs was avoided where possible, leading to the rapid development of telehealth as an alternative platform to allow continuity of care (Park et al., 2020). However, virtual appointments were not a viable option for certain antenatal services, including birth and ultrasound scanning. For obstetric sonographers and ultrasound practitioners performing pregnancy scans (up to 30minutes in duration) in close contact with expectant parents in small, enclosed scan rooms, adhering to physical distancing guidelines was not possible (The Society and College of Radiographers, 2020). In addition, difficulties in procurement of PPE meant that many scans were performed by HCPs who were not

adequately protected from potential virus transmission. As a result, many NHS Trusts took the decision to place temporary restrictions on persons accompanying pregnant women and people to antenatal care appointments. For some, this meant fathers and partners missing out on milestone pregnancy moments like scans, and pregnant women and people receiving unexpected or difficult news by themselves (BBC News, 2020). Although many were understanding of the measures taken to prevent virus transmission, tensions related to the restrictions around partner attendance at pregnancy ultrasound scans were highlighted in the media and by parent advocacy groups including campaigns from Pregnant Then Screwed (www.pregnantthenscrewed.com/but-not-maternity/) and Birthrights (www.birthrights.org.uk/campaigns-research/coronavirus/). The restrictions were also distressing for sonographers/ultrasound practitioners who were often required to communicate unexpected scan findings to unsupported pregnant women and people from behind the physical barrier of a mask (Dyer & Hammett, 2020).

In December 2020, guidance published by NHS England stated that pregnant women and people "should have access to support from a person of their choosing at all stages of the maternity journey, and that all Trusts should facilitate this as quickly as possible" (NHS England, 2020). This guidance replaced a framework originally published in September 2020 by the Royal College of Obstetricians and Gynaecologists, Royal College of Midwives and the Society and College of Radiographers in partnership with NHS England and NHS Improvement (Royal College of Obstetricians and Gynaecologists, 2020b). However, England's third COVID-19 lockdown (which began on 5th January 2021) saw many NHS Trusts revert back to restricting partner attendance at scans, with many parents becoming distressed after experiencing a lack of adherence to professional guidelines (The Guardian, 2021).

Naturally, changes to the provision of pregnancy ultrasound services during the COVID-19 pandemic generated new avenues for research relevant to this thesis, particularly in understanding: 1) how parents' and sonographers' experiences of obstetric scans had been altered because of the

pandemic and, 2) the psychological and emotional impact of the pandemic on parents and sonographers. For expectant parents specifically, the potential influence of altered scan experiences on prenatal bonding warranted research investigation. For sonographers, it was important to explore the implications of the pandemic for occupational burnout within the ultrasound workforce, the impact of the pandemic on clinical working practices, and consider how changes to services may affect the provision of parent-centred care. The addition of these new perspectives to this thesis are further considered in the next section.

1.5 Thesis overview

Overall, this thesis intends to present a unique insight into maternal and paternal experiences of pregnancy imaging (including advanced fetal MRI techniques), and to examine the potential influence of the imaging experience on parent-fetal bonding.

1.5.1 Aims, research questions, and objectives

This thesis research had three overarching aims. These were to:

1) Provide a comprehensive perspective into expectant parents' experiences of antenatal imaging in pregnancy following a routine care pathway and/or those in which a congenital physical condition is suspected or has been diagnosed in the fetus,
2) Examine the impact of antenatal imaging on parent-fetal bonding in mothers and fathers of pregnancies following a routine antenatal care pathway,
3) Explore how parent-centred care is manifested in the antenatal setting to further improve the fetal imaging experience for expectant parents.

To achieve these aims, the following research questions and their individual objectives were created:

a) What is the expectant parent's experience of antenatal imaging?

i. Explore expectant mothers' and fathers' experiences of fetal ultrasound and MRI examinations:
    i. Whether being scanned (mothers) or attending the scan (fathers),
    ii. In uncomplicated pregnancies and those with a suspected or diagnosed congenital physical condition in the fetus.

b) How does antenatal imaging affect self-reported parent-fetal bonding scores?
    i. Comparison of mothers and fathers,
    ii. Comparison of fetal ultrasound and MRI examinations.

c) How can antenatal imaging service provision be further improved to be truly parent-centred?
    i. Provide empirical evidence regarding parental bonding scores and lived experiences of fetal imaging to guide the development of best practice recommendations for professional organisations and service providers, and to inform future training,
    ii. Explore the collaborative parent-HCP partnership in antenatal imaging.

1.5.2 COVID-19 impact on the thesis research

As a result of nationwide restrictions around new research studies commencing at clinical sites, data collection for this project was delayed by 6 months. However, given the pregnancy scan experience for expectant parents and sonographers/ultrasound practitioners was markedly altered because of the COVID-19 pandemic, this delay provided a unique opportunity to develop an additional research study dedicated to understanding the implications of the changes to antenatal imaging service provision on the developing parent-fetal bond and the ultrasound workforce. Further aims and objectives were developed to extend the original scope of the thesis and gain additional insight from HCPs providing antenatal imaging services during this time. This enabled representation of both parents and HCPs in the thesis research.

1.5.3 Additional COVID-19 aims, research questions, and objectives

Two further aims were included to reflect the impact of the COVID-19 pandemic and its impact on antenatal imaging services during this research project. These were to:

4) Explore obstetric sonographer experiences of performing pregnancy ultrasound scans during the COVID-19 pandemic and evaluate how this may impact the parental experience of antenatal imaging,
5) Explore the pregnancy ultrasound scanning experiences of mothers and fathers during the COVID-19 pandemic to evaluate the effect on parent-fetal bonding.

To achieve these aims, the following research questions and their individual objectives were also created:

d) What is the obstetric sonographer/ultrasound practitioner's experience of performing pregnancy ultrasound scans in the UK during the COVID-19 pandemic?
    i. Evaluate and explore psychological distress in the ultrasound workforce,
    ii. Evaluate and explore occupational burnout in the ultrasound workforce,
    iii. Evaluate change of practice and clinical workflow during the COVID-19 pandemic,
    iv. Evaluate the impact of COVID-19 related practice changes on obstetric sonographers/ultrasound practitioners.
e) How did expectant parents experience pregnancy ultrasound scans in the UK during the COVID-19 pandemic?
    i. Determine the effect of the COVID-19 pandemic on parental experiences,
    ii. Compare the experiences of mothers and fathers/partners,
    iii. Compare expectations of pregnancy ultrasound scans with actual experiences during the COVID-19 pandemic,
    iv. Evaluate the effect of the COVID-19 pandemic on the parent-fetal bond.

1.5.4 Overview of the thesis research and articles

To achieve these aims, one literature review and three research studies were conducted. These were:

1. A systematic review of the literature on the influence of fetal imaging on parent-fetal bonding,
2. An online survey of UK obstetric sonographers performing pregnancy ultrasound scans during the COVID-19 pandemic (thesis research study 1),
3. An online survey of new and expectant parents having pregnancy ultrasound scans in the UK during the COVID-19 pandemic (thesis research study 2),
4. A mixed-methods study of expectant parents which collected data through an online survey and individual, semi-structured interviews (thesis research study 3).

Results are reported in six papers, presented in Chapters 3 to 8 of this thesis. Table 1.1 provides an overview of the articles included in this thesis, their research question(s), and how each map to the thesis aims, research questions and objectives.

Table 1.1 Overview of articles included in this thesis

Article	Chapter	Article objectives	Thesis aims addressed	Thesis research questions/ objectives addressed
1 – The impact of antenatal imaging on parent experience and prenatal attachment: A systematic review	3	- Enhance current understanding of the impact of antenatal imaging on the parent-fetal bonding - Identify factors of the imaging experience which may affect bonding	1, 2, 3	a)i, a)i)i, a)i)ii b)i, b)ii c)i, c)ii
2 – UK obstetric sonographers' experiences of the COVID-19 pandemic: Burnout, role satisfaction and impact on clinical practice	4	- Understand the impact of the COVID-19 pandemic on sonographer burnout and psychological distress - Consider implications of the COVID-19 pandemic on the ultrasound workforce	3, 4	c)ii d)i, d)ii, d)iii, d)iv
3 – "It has been the most difficult time in my career": A qualitative exploration of UK obstetric sonographers' experiences during the COVID-19 pandemic	5	- Provide additional psychosocial context to findings of occupational burnout in the ultrasound workforce - Consider how the findings may be used to underpin workforce recovery strategies	3, 4	c)ii d)i, d)ii, d)iii, d)iv
4 – The effect of the COVID-19 pandemic on UK parent experiences of pregnancy ultrasound scans and parent-fetal bonding: A mixed methods analysis	6	- Evaluate parent-fetal bonding during the COVID-19 pandemic - Explore ultrasound experiences of mothers and fathers/partners	3, 5	a)i, a)i)ii b)i c)i, c)ii e)i, e)ii, e)iii, e)iv
5 – The influence of antenatal imaging on parent-fetal bonding in uncomplicated pregnancies: A mixed methods analysis	7	- Identify parental and scan variables which may be associated with enhanced parent-fetal bonding after ultrasound or fetal MRI - Explore how identified variables may facilitate bonding	1, 2, 3	a)i, a)i)I, a)i)ii b)i, b)ii c)i, c)ii
6 – "It's not just the medical aspects that are important": A qualitative analysis of first-time parents' experiences of antenatal imaging and parent-fetal bonding	8	- Provide a deeper insight into the role of antenatal imaging in influencing parent-fetal bonding - Further understand how this influence may change with different parental circumstances and pregnancy outcomes	1, 2, 3	a)i, a)i)i, a)i)ii b)i, b)ii c)i, c)ii

2 Methodology overview

2.1 Overview of chapter

To inform the aims and objectives of the research studies presented in this thesis (Chapters 4-8), a systematic review of published literature was first undertaken (Chapter 3). This section provides a broad overview of the methodological approaches utilised in the subsequent research studies. Specific details for each study are reported in Chapters 4-8 (Articles 2-6).

2.1.1 Design

A convergent, mixed-methods study design was used for this thesis whereby quantitative and qualitative data were collected concurrently and analysed separately. Where appropriate to the research question, the findings were then merged during a later interpretation phase (Creswell, 2015; Guetterman, Fetters & Creswell, 2015). Mixed-methods approaches have become increasingly popular within the health and social sciences, however this does not simply involve the collection of different types of data, rather the strength of the methodology arises from the integration and interpretation of the combined data (McCrudden, Marchand & Schutz, 2021). The rationale for using a mixed-methods design is dependent on the research question, but may include mixing data for the purposes of triangulation (e.g., corroborating findings), expansion (e.g., building on initial findings) or illustration (e.g., explaining findings using complimentary data) (Doyle, Brady & Byrne, 2016). This approach was chosen as most appropriate to fully explore the research questions using an integrated combination of statistical trends from bonding-questionnaire data and personal experiences captured through free-text survey responses and during interviews. Mixed-methods approaches can be utilised to moderate the inherent limitations associated with one approach by harnessing the strengths of another (Creswell, 2015). For example, quantitative methods are often criticised for minimising the participant's voice, however, in a mixed-methods approach this can be mitigated

using qualitative approaches to provide an additional narrative (McCrudden, Marchand & Schutz, 2021). All three research studies conducted for this thesis collected quantitative and qualitative data; online questionnaires were utilised in studies 1 and 2, and research study 3 used an online questionnaire and individual, semi-structured interviews. In addition to reporting separate quantitative (Chapter 4, Article 2) and qualitative findings (Chapters 5 and 8, Articles, 3 and 6) from the research studies, fully integrated mixed-method findings are also presented (Chapters 3, 6 and 7, Articles 1, 5 and 6).

2.1.2 Philosophical approach and researcher positionality

According to Creswell (2015), definitions of mixed-methods research can vary by investigator. For example, a mixed-methods study may be designed around core philosophical assumptions, or grounded in existing theory for the purpose of perspective transformation (Creswell, 2015). This thesis utilises mixed-methods as a research process which aims to achieve superior exploration or understanding of a phenomenon by combining quantitative and qualitative data (Tashakkori & Creswell, 2007). However, tensions are acknowledged in relation to the integration of data which exist within distinct paradigms (Maarouf, 2019). Quantitative data is traditionally associated with the scientific/positivist perspective which assumes a single objective reality and identifies the researcher as separate to the phenomenon under investigation. In contrast, qualitative or interpretivist paradigms acknowledge multiple realities and the influential role of the researcher on the construction of knowledge (Bleiker et al., 2019). Thus, in relation to mixed-methods research, an alternative paradigm is required to inform and support the methodological and integrative processes of mixed-methods research.

Whilst literature suggests several alternative paradigms to support mixed-methods research such as critical realism and dialectics, pragmatism is the one which is most frequently associated with the approach (Shannon-Baker, 2016). Pragmatism acknowledges some fundamental commonalities

between quantitative and qualitative paradigms in that they both seek to understand the world, and believe in the value of knowledge for making practical differences (Kekeya, 2019). Unlike quantitative and qualitative approaches which emphasise type of knowledge (epistemology) or understanding of reality (ontology) as the basis for research inquiry, this philosophy centralises the phenomenon of interest so that research is conducted in the most appropriate way to address the research question (Yardley & Bishop, 2015). The investigator is therefore free of inherent restraints to draw on quantitative and qualitative methods, choosing the one which will best serve their research purpose. However, this does not mean that the pragmatic approach is completely devoid of philosophy. Rather, it enables the researcher to successfully combine quantitative and qualitative assumptions by appreciating ontological intersubjectivity (e.g., accepting existence of a single reality, of which individuals may differ in their interpretations) and taking an epistemological stance which is informed by ontological intersubjectivity (e.g., knowledge may be observable and unobservable depending on the individual's belief of reality) (Maarouf, 2019).

These assumptions also require reflexivity of the investigator, in recognising the influence their prior experiences, knowledge, and judgements may have on the research findings and outcomes, which may be useful for others in understanding their interpretations of data (Jamieson, Govaart & Pownall, 2023). Whilst it is questioned whether use of reflexivity statements in research literature may threaten research integrity if the work is judged by the authors' positionality rather than the content (Savolainen et al., 2023), it is a required practice of reflexive thematic analysis (Braun & Clarke, 2022) which was utilised in this thesis, and therefore a brief statement of positionality is included here and in articles 3, 4 and 6. The researcher is a white, cis-female in her mid-30s who does not have children of her own and has no personal experience of pregnancy or medical imaging, but has been a practising obstetric sonographer since 2011.

2.1.3 Participants

Data were collected from a total of 936 unique participants across the three research studies. Of these, n=138 were obstetric ultrasound sonographers (Chapters 4 and 5) and n=798 were parents (Chapters 6-8). Snowball sampling was used to optimise timely recruitment of sonographers and parents to the two online studies conducted during the COVID-19 pandemic. In-person, convenience sampling was used to support recruitment of expectant parents to the final mixed-methods study.

2.1.3.1 Thesis research study 1- Obstetric ultrasound sonographers during the COVID-19 pandemic

Obstetric ultrasound sonographers (or ultrasound practitioners) were invited to share their lived experiences of working during the COVID-19 pandemic. Inclusion criteria required participants to have been performing pregnancy ultrasound scans since March 2020 (i.e., since enhanced measures to protect against COVID-19 were announced in the UK), be aged 21 years old or over (minimum age to have completed an ultrasound training qualification in the UK), and consent to taking part in the online study. Trainee sonographers, or sonographers practising outside of the UK were not eligible to participate to keep the research question focused on a single population. On 9th March 2021, the study was launched across social media platforms (Twitter, LinkedIn and Facebook), and distributed amongst professional networks.

To optimise recruitment through snowball sampling methods, participants were encouraged to share the weblink for the online questionnaire with their colleagues. From the initial launch, two further invitations for participants were circulated prior to the study being closed on 6th May 2021. Most sonographers completing the online questionnaire were white (86.5%), female (96.6%), aged

51-60 years old and working in the South East region of the UK (22.5%). Completion rate of the questionnaire was 81.0%. The findings from this questionnaire are reported in Chapters 4 and 5.

2.1.3.2 Thesis research study 2- New and expectant parents during the COVID-19 pandemic

Snowball sampling via social media platforms was also used to support recruitment of new and expectant parents for the online study presented in Chapter 6. These parents were invited to share their experiences of pregnancy ultrasound scans during the COVID-19 pandemic. Parents were eligible to take part in this study if they were aged 18 years old or over, waiting for an ultrasound scan in their pregnancy or had experience of one during the COVID-19 pandemic (i.e., since March 2020), had a good understanding of the English language, and provided their consent to participate. Exclusion criteria were new and expectant parents under the age of 18, or those who had not received antenatal care in the UK during the COVID-19 pandemic. No exclusions related to parity were applied to capture a breadth of parental experience. The online parent questionnaire was launched on 9th March 2021 which coincided with the 3rd national lockdown in the UK (Institute for Government, 2021). Following the launch, two further invitations to participate were circulated on social media with a specific call for fathers and partners to take part before recruitment closed on 25th April 2021.

A total of 714 parents (mothers and fathers) responded to the online questionnaire, with an average completion rate of 79.8%. The pregnancy was on-going in fewer than half of the parents answering the questionnaire (47.4%).

2.1.3.3 Thesis research study 3 - Prenatal bonding in first-time expectant parents

For the final study, convenience sampling was used to recruit first-time expectant parents. This approach was selected over other methods like purposive sampling to mitigate the disruption to

fetal imaging services at the clinical site because of COVID-19, and facilitate timely data collection according to the project timeline. The clinical site was acknowledged as a participant identification centre (PIC), thus prospective participants were first introduced to the study by clinical or research staff involved with their care around existing fetal imaging examinations. Posters were also displayed in clinical waiting areas so that interested parents could self-select to take part in the study if they had not been approached by staff.

Expectant parents were eligible to take part in the study if they were "first-time" parents. This was defined in this context as expectant parents with no living children and no prior experience of pregnancy imaging beyond the first trimester. Although any association between parity and prenatal bonding is unconfirmed in literature, only "first-time" parents were included in this research study to mitigate the potential effect of any prior imaging experiences which may have influenced their experiences of imaging during the study period. However, based on this definition, it is acknowledged that expectant parents who had experienced early pregnancy loss were still eligible to participate. Further eligibility criteria included participant age of 18 years old over, commitment to the ongoing pregnancy, and having either a fetal ultrasound or MRI scan during the pregnancy. The gestational age of the pregnancy was required to be between 18-36 weeks. This was selected to align with the gestational age at which most fetal imaging would take place at the clinical site, and was also suited for use of the PAI to evaluate prenatal bonding (Muller & Mercer, 1993). Parents were required to have a confident understanding of the English language to support the informed consent process and because it was acknowledged that those who do not speak fluent English may have a different experience of the fetal imaging appointment because of variation in interpreting services offered by the clinical site. Four groups of expectant parents were recruited during this phase of the project, including: 1) parents having routine clinical ultrasound scans; 2) parents having research fetal MRI scans as a "healthy volunteer" (e.g., following a routine antenatal care pathway); 3) parents

having clinical ultrasound scans because of a known or suspected fetal cardiac condition; and 4) parents having research fetal MRI scans because of a known or suspected fetal cardiac condition.

All recruitment and data collection procedures for this study took place remotely. To support the informed consent process, a participant information video was produced alongside a written information sheet. This was accessed via a private YouTube link (www.youtube.com) and provided prospective participants with an alternative method of receiving information about the study, as well as an opportunity to "see" the researcher and promote the human-centric approach to the research despite the remote methods used. A dedicated webpage was also created to provide a further source of information about the project (www.blogs.city.ac.uk/afi-study).

Data collected from expectant parents were analysed and reported in two articles (Chapters 7 and 8). A total of 76 expectant parents following a routine antenatal care pathway (58 mothers, 18 fathers) completed the online questionnaire for this study (Chapter 7). Of these, 64 parents had ultrasound and 12 had fetal MRI scans. The parental age range in this sample was 23-41, and most parents were of white ethnicity (75.0%), educated to postgraduate degree level (51.3%), and working in full-time employment (84.2%).

Individual, semi-structured interviews were conducted with n=28 expectant parents (18 mothers, 10 fathers) having ultrasound (n=20) or fetal MRI (n=8) scans during their pregnancies (Chapter 8). Of these, eight were parents of pregnancies with a prenatal diagnosis of a fetal cardiac condition. The average parental age in this sample was 32 years old, and again, most parents were of white ethnicity (78.6%), educated to degree level (75.0%), and all were working in full-time employment (100.0%).

2.1.4 Measures

Three tools were used throughout the studies to measure different self-reported variables. These were selected because they were validated for use in the defined populations, and/or would facilitate direct comparisons with published literature and within the thesis. The Oldenburg Burnout Inventory (Demerouti et al., 2003) was used in the first research study to measure occupational burnout in obstetric sonographers during the COVID-19 pandemic (Chapter 4, Article 2). The CORE-10 tool (Barkham et al., 2013) was used in Chapters 4, 6 and 7 (Articles 2, 4 and 5) to measure psychological distress in obstetric sonographers and parent participants. Finally, a modified version of the Prenatal Attachment Inventory (PAI) (Muller & Mercer, 1993) was used in Chapters 6 and 7 (Articles 4 and 5) to measure prenatal bonding in expectant parents. The original version of the PAI contains 21 items, some of which are gendered. In Chapters 6 and 7 (Articles 4 and 5), gendered items of the PAI were either reworded to be neutral and applicable for both parents (e.g., "I tell others what the baby does inside me" became "I tell others what the baby does inside the womb") or removed entirely (e.g., "I let other people put their hands on my tummy to feel the baby move"). Cronbach's alpha analyses were conducted and reported in each article to determine validity of the modified 16 item PAI.

2.1.5 Procedures

The section below presents a brief overview of the informed consent and data collection procedures for the research studies in this thesis. Further details are reported in the specific chapters.

2.1.5.1 Electronic informed consent

Electronic informed consent completed via a secure, online survey platform (Qualtrics, 2020) was obtained from all research participants prior to data collection. This process and the subsequent development of the consent forms used for each of the studies were informed by a narrative literature review published in addition to the work presented in this thesis (Skelton et al., 2020a). The methodological contribution of this paper is further discussed in Chapter 9.

2.1.5.2 Thesis research studies 1 and 2 - COVID-19 studies

Processes of informed consent and data collection for the COVID-19 studies (Chapters 4-6) were conducted through Qualtrics (Qualtrics, 2020). Following confirmation of consent, obstetric sonographer and parental participants were then able to access the relevant questionnaire for their profile.

Obstetric sonographers were asked to complete a single questionnaire, which composed of questions relating to their experiences of performing pregnancy ultrasound scans during the COVID-19 pandemic. Occupational burnout and psychological distress were also measured using the OLBI and CORE-10 tools respectively. The findings from the study of obstetric sonographers are reported in Chapters 4 and 5 (Articles 2 and 3).

Parental participants were also asked to complete a single questionnaire, although the content of this differed depending on whether the pregnancy was on-going at the time of providing their responses. For expectant parents only, the modified PAI was used to evaluate prenatal bonding. Otherwise, both parent groups were asked about their experiences of pregnancy ultrasound scans during the COVID-19 pandemic and psychological distress was measured during the CORE-10 tool. The findings from the study of parents during the COVID-19 pandemic are reported in Chapter 6 (Article 4).

2.1.5.3 Thesis research study 3 - Prenatal bonding in first-time expectant parents

Expectant parents who were following a routine antenatal care pathway were asked to complete an online questionnaire. This was hosted on the secure survey platform, Qualtrics (Qualtrics, 2020). The questionnaire was presented in two parts; part one was completed by parents in the 2-weeks prior to the fetal imaging appointment to capture their expectations for the scan and provide a baseline measure of prenatal bonding (modified PAI) and psychological distress (CORE-10). The second part of the questionnaire asked parents about their experiences of the scan, as well as re-evaluate prenatal bonding (modified PAI) and psychological distress (CORE-10) post-imaging. This was completed by parents up to 4-weeks following the fetal imaging appointment. The results of this questionnaire are reported in Chapter 7 (Article 5).

Following completion of the second part of the questionnaire, parents were invited to take part in a semi-structured telephone interview (Chapter 8, Article 6). Of these, twenty consented to be interviewed. A further eight expectant parents having additional imaging in pregnancies where a fetal cardiac condition was suspected or had been diagnosed were also invited to be interviewed.

No financial incentives were offered to parents for taking part in the study, however, all participants were individually thanked for their contributions to the research in a follow-up email. Although this presented a potential risk to recruitment for the studies, the decision was made not to offer an incentive for participation after discussions with parent project collaborators, who, on review of the study design and objectives, felt that this may influence expectant parents' motivation to take part in the studies and subsequently affect the fidelity of the experiences shared.

2.1.6 Public involvement and engagement

The studies presented in this thesis benefit from the invaluable contributions received from parent and professional volunteers throughout the duration of the thesis research. Parent volunteers

were known to the research and supervisory team and approached to contribute based on their personal interest in the topic and experience of reviewing academic content (n=12). Representatives from two UK-based organisations representing parents were also invited to collaborate on the project. Antenatal Results and Choices (ARC) are a charity who provide non-directive information about antenatal screening and testing, and support for expectant parents who have received a fetal diagnosis during pregnancy. Fathers Reaching Out offer mental health support to parents throughout the perinatal period. Their work is particularly focused on promoting the importance of fathers' mental health for improved family outcomes. A final group of professional volunteers (n=3) were identified through the Society of Radiographers Ultrasound Advisory Group (SoR UAG), all of whom had substantial experience in obstetric ultrasound imaging.

In the earlier stages of the research project, public involvement and engagement activities were focused on study development and design. Project collaborators were approached to provide feedback on the original research proposal, which resulted in changes to the research questions and a reduction in the extent of participant involvement to better align with the broader objectives of the thesis. In addition, all study materials, including the participant information video, electronic informed consent form, online survey platforms, and the interview guide used in thesis research study 3 (Chapter 8, Article 6) were reviewed and piloted by parents and professionals prior to their use. All reported the video to be clear and informative, and the online platform to feel secure and mostly easy to use. However, based on the feedback received, some instructions to participants were rephrased to assist their navigation through the surveys.

A virtual project kick-off meeting was hosted on 16th September 2020. The launch was attended by academic supervisors, representatives from the Society and College of Radiographers, and a parent project collaborator. This event provided an opportunity to meet with and update those in attendance of how their contributions had shaped the design of the project. The event also helped to promote the research as two short news articles were subsequently published online.

Parent and professional collaborators have also been involved with the write-up of the articles presented in this thesis by providing reflective feedback on qualitative study findings (Chapters 5, 6 and 8). In keeping with recommendations for enhancing trustworthiness in qualitative research and avoiding positivist assumptions surrounding quality practices which do not align with reflexive approaches (Varpio et al., 2017), member reflections were utilised to support credibility of the findings and understand the relationship between the findings and participant's experiences (Tracy, 2010).

2.1.7 Ethical approval

For thesis research studies 1 and 2, ethical approval was obtained from the City, University of London School of Health and Psychological Sciences Research Ethics Committee (reference: ETH2021-1240, date of approval: 09 March 2021, Appendix 1). Ethical approval was obtained from the NHS West of Scotland 3 Research Ethics Committee for thesis research study 3 (reference: 20/WS/0132, date of approval: 12 November 2020, Appendix 2). Additional approval for thesis research study 3 was given by the City, University of London School of Health and Psychological Sciences Research Ethics Committee (reference: ETH1920-1680, date of approval: 30 November 2020, Appendix 3).

3 The impact of antenatal imaging on parent experience and prenatal attachment: A systematic review (Article 1)

This chapter was published as:

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3.1 Abstract

Introduction

Medical imaging in pregnancy (antenatal imaging) is routine. However, the effect of seeing fetal images on the parent-fetal relationship is not well understood, particularly for fathers or partners, or when using advanced imaging technologies. This review aimed to explore how parent experience and prenatal attachment is impacted by antenatal imaging.

Method

Comprehensive searches of 10 electronic databases, with grey literature and hand searches, were performed between September 2020-April 2021 using a systematic search strategy. Wildcard and Boolean operators were used in combination with key words (e.g., fetal, imaging) to generate search queries. Inclusion criteria were English language primary research studies published since 2000, describing or reporting measures of attachment after antenatal imaging in expectant parents. Studies were evaluated against inclusion criteria by two reviewers and critically appraised. The Pillar Integration Process facilitated integrative synthesis.

Findings

Twenty-three (13 quantitative, 10 qualitative/descriptive) studies were included (2462 participants, including 186 fathers). Six pillar themes were identified: 1) the scan experience begins before the scan appointment; 2) the scan as a pregnancy ritual; 3) feeling actively involved in the scan; 4) parents' priorities for knowledge and understanding of the scan change during pregnancy; 5) the importance of the parent-sonographer partnership during scanning; and 6) scans help to create a social identity for the unborn baby.

Conclusion

Antenatal imaging can enhance prenatal attachment. Parents value working collaboratively with sonographers to be actively involved in the experience. Sonographers can help facilitate attachment by delivering parent-centred care tailored to parents' emotional and knowledge needs.

Keywords: Antenatal; Attachment; Bonding; Experience; Imaging; Parents

3.2 Introduction

Prenatal attachment is described as the emotional connection parents form to their unborn child (Condon, 1993). It is important for healthy infant brain development (Glover, 2014), parental emotional well-being (Göbel et al., 2018) and represents a transformation during pregnancy whereby expectant parents start to reconceptualise their identity from self to care-giver (Walsh, 2010). The concept arose from Bowlby's early definitions of attachment theory (Bowlby, 1969) however, the term "prenatal bonding" is often used interchangeably in literature to describe the parent-fetal relationship (Walsh, 2010). For clarity, the parent-fetal relationship is referred to as "attachment" throughout this review to incorporate all constructs, although bonding is recognised as a synonym in this context and therefore included as a key word to ensure all relevant records were captured during searches.

Routine medical ultrasound imaging during the antenatal period is generally regarded as a positive pregnancy experience which also facilitates the bonding process as it allows expectant parents to create a mental image of their unborn baby (Walsh, 2020). This image can be central to the developing attachment by providing a visual catalyst for parents to construct and fantasise about their "imagined child" (Trombetta et al., 2021), to which they attribute personal characteristics to humanise the fetus and thus experience a deeper emotional tie towards the unborn baby (Condon, 1993). It is thought that prenatal attachment can predict the quality of the parent-child relationship after birth, thus antenatal imaging may provide a unique and early opportunity during pregnancy for parents to establish a positive emotional connection towards the fetus, or for HCPs to provide timely intervention and support to parents if required (della Vedova & Burro, 2017). For most parents, scans are an enjoyable and reassuring experience (Thomas, Roberts & Griffiths, 2017). However, there is evidence to suggest that the experience may also lead to increased anxiety and stress in parents, particularly those who are unable to interpret the image (National Institute for Health and Care Excellence, 2019), which may impact on the developing relationship.

Research in this field is warranted, especially with the increasing use of advanced fetal imaging techniques to complement routine ultrasound imaging, including three-dimensional (3D) and four-dimensional (4D) ultrasound, and fetal magnetic resonance imaging (MRI). These modalities produce highly detailed images and videos of fetuses, yet the effect of seeing these images on the developing parent-fetal relationship is not well studied or reported (van den Bergh & Simons, 2009), especially for pregnancies in which a fetal anomaly is suspected or has been diagnosed. For some parents, visualising the anomaly may aid their understanding of a diagnosis (Gonçalves et al., 2005; Leung et al., 2006; Sreejith et al., 2018), although for some it may increase distress, for example, if faced with a decision to continue the pregnancy (Mitchell, 2004). Furthermore, studies evaluating the effect of imaging on the paternal-fetal relationship are sparse (Walsh et al., 2017), even though quality prenatal attachment is associated with a positive effect on maternal emotional well-being and the maternal-fetal relationship (Lindgren, 2001; Borg Cunen et al., 2017).

This review aimed to explore the research question, 'what is the effect of medical imaging in pregnancy on prenatal attachment?' to enhance current understanding of the impact antenatal imaging may have on the parent-fetal relationship and identify factors of the parent imaging experience that may affect attachment.

3.3 Materials and methods

The protocol for this review was registered on the PROSPERO database (CRD42020197259). No patients were involved in the development or conduct of this review. Funding was received from the College of Radiographers Doctoral Fellowship Award (DF017) and City, University of London.

3.3.1 Search strategy

The PRISMA statement (Page et al., 2021) was used to develop a search strategy from key words identified using the PEO framework (Khan et al., 2003) (Table 3.1). This was reviewed by a university librarian specialising in literature searches and piloted for efficacy. Identified key words and synonyms were combined with Wildcard and Boolean operators to generate search queries (e.g., TI (mother* or maternal or mum*) AND TI (magnetic resonance imaging or mri) OR TI (ultrasound or sonography or sonogram or ultrasonography) AND TI (bonding or attachment or relationship or behaviour or experience)) (Appendix 4). During September 2020-April 2021, searches of 10 electronic databases were performed (MEDLINE, CINAHL, PsychNET, Academic Search Complete (via EBSCOhost), Embase, MIDRIS (via OVID), The Cochrane Library, PubMed, Scopus and Web of Science)) in addition to searches of grey literature (HMIC, OpenGrey, NICE, TRIP) and doctoral dissertations (ProQuest Dissertations, Theses Global).

Table 3.1 PEO framework to identify key words and develop search terms

POPULATION	EXPOSURE (INTERVENTION)	OUTCOMES
mother / maternal	imaging / screening / assessment / modality	attachment / bonding / relationship / behaviour
father / paternal	ultrasound / sonography / US	experience
parent / parental	dimensional / 2D / 3D/ 4D	
fetal / fetus / antenatal / obstetric / pregnancy / prenatal / expectant / prepartum / antepartum	magnetic resonance / magnetic resonance imaging / MRI	
fetal anomaly / abnormality / prenatal diagnosis	scan / examination	

3.3.2 Eligibility criteria

Studies were eligible if they were primary research studies published in English describing or reporting measures of attachment in expectant adult (≥18 years old) parents in the context of medical imaging in pregnancy. To incorporate the impact of fetal imaging advances, studies published before 2000 were excluded. Only studies where the antenatal imaging examination was the research intervention (e.g., 2D/3D/4D ultrasound or fetal MRI) were considered for inclusion. There was no restriction on gestational age or fetal anomaly diagnosis. Studies measuring prenatal attachment after birth were excluded to reduce recall bias.

3.3.3 Selection of papers

References were imported into review management software program, EPPI-Reviewer4 (Thomas, Brunton & Graziosi, 2010). After removing duplicates, titles and abstracts were screened for relevance. Full texts of studies meeting the eligibility criteria were retrieved for further evaluation. Using the same key words as the electronic databases, additional searches were performed on Google Scholar and using web-based literature searching platform, ResearchRabbit Beta3 (www.researchrabbit.ai). Reference lists of included studies were hand-searched for additional

relevant studies. All references were reviewed by ES, with independent double-screening performed by RW on a randomly allocated 10% of the total studies for both title/abstract and full-text screening. Discrepancies were discussed by the reviewers to reach consensus following each level of screening.

3.3.4 Data extraction and quality appraisal

A database was developed for extraction of study characteristics including participant demographics, study design and reported measure of attachment or qualitative insights. Included studies were quality appraised using Joanna Briggs Institute checklists (Lockwood, Munn & Porritt, 2015; Moola et al., 2020a, 2020b; Tufanaru et al., 2020). These assist reviewers in evaluating the rigor and validity of published research, helping to identify flaws in reported study designs and methods through focused questions. Reviewers can respond with “yes”, “no”, “unclear”, or “not applicable”. Whilst a scoring system is not embedded in these checklists, studies with a high proportion of “no” or “unclear” responses are suspected to be of lower quality.

3.3.5 Data synthesis

Owing to the heterogeneity of the studies, a research synthesis (Sandelowski, Voils & Barroso, 2006) was more appropriate than the separate meta-analytical and meta-ethnographic approaches proposed in the protocol (Skelton et al., 2020b). This method is becoming popular in health research as it enables extraction of categories and themes from quantitative and qualitative data pertaining to a research question, facilitates validation or triangulation of findings (Moon, 2019), and creates a more complete understanding of complex phenomena of interest (Stern et al., 2021). The Pillar Integration Process (Johnson, Grove & Clarke, 2019) was used to integrate and synthesise quantitative and qualitative studies in a convergent approach, as it is flexible for use across study designs, yet provides a well-defined methodological approach to the analysis in keeping with the

nature of a systematic review (Flanagan, Dowling & Gethin, 2020). After initial, separate analyses of quantitative and qualitative studies had been completed, the 4-stage (listing, matching, checking, Pillar building) Pillar Integration Process was used to build central, integrated themes. In the first stage, coded categories from quantitative studies and themes for qualitative studies were listed in the respective column on the joint display matrix. The data was then matched to the opposite quantitative or qualitative column and horizontally rearranged to reflect the corresponding content. The rows of matched data were then cross-checked for quality and completeness, before the Pillars were built in the central column to represent the integrated themes from each row (Johnson, Grove & Clarke, 2019).

3.4 Results

Results of the searches are given in Figure 3.1. After removing duplicates, 20,279 references were screened by title and abstract. Of these, 19,952 did not meet the inclusion criteria and were excluded. After detailed review of 327 full-text references, 304 were excluded. Twenty-three studies (13 quantitative and 10 qualitative/descriptive studies) were eligible for inclusion. Agreement between the two reviewers was 98% on title and abstract, and 91% on full-text screening.

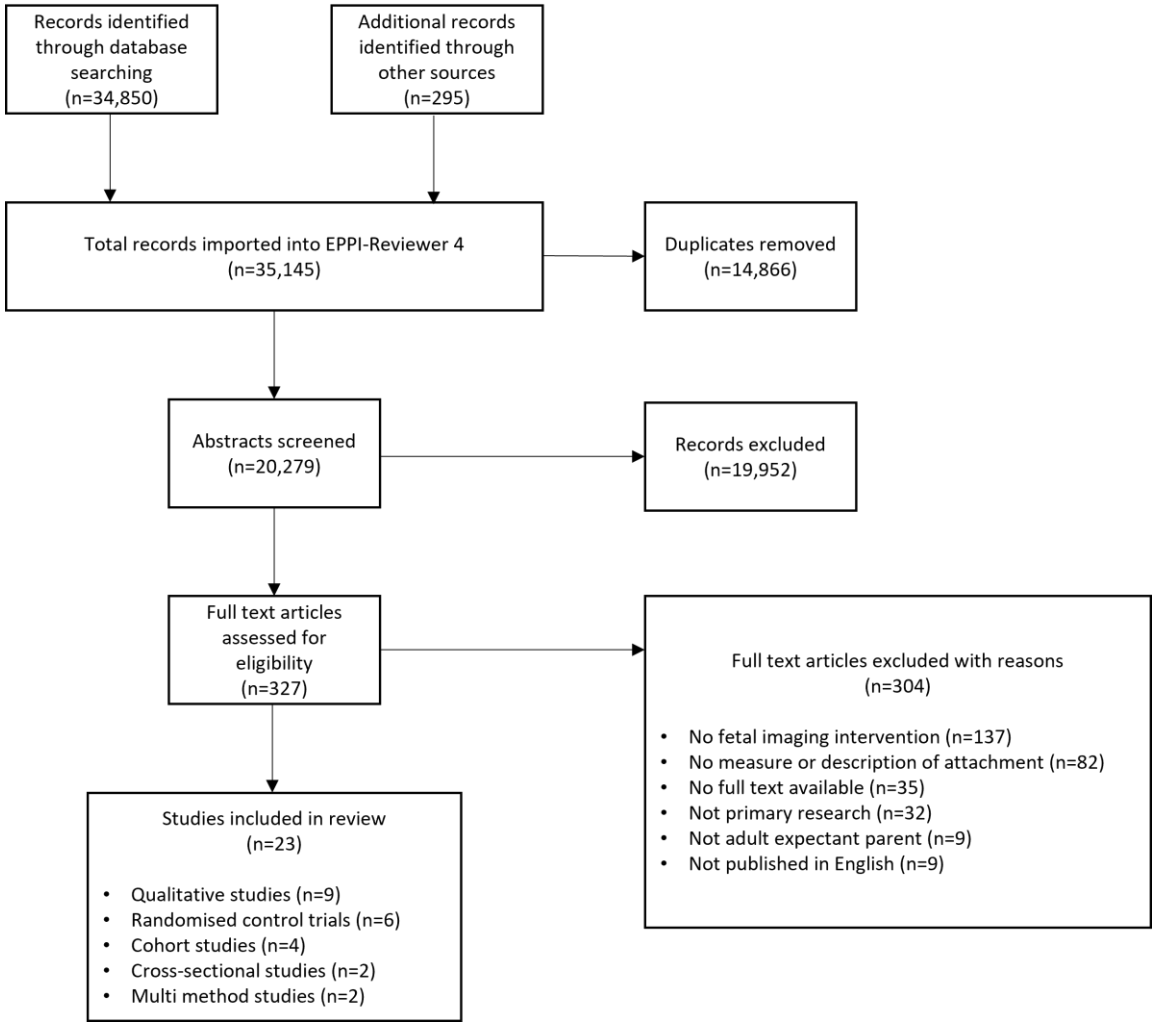

Figure 3.1 PRISMA diagram

3.4.1 Study characteristics

Study characteristics are presented in Tables 3.2 and 3.3. There were nine qualitative studies (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan, Marsh & Winter, 2009; Firth et al., 2011; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019), six RCTs (Righetti et al., 2005; Rustico et al., 2005; Boukydis et al., 2006; Sedgmen et al., 2006; Lapaire et al., 2007; de Jong-Pleij et al., 2013), four cohort studies (Lalor & Devane, 2007; Edwards et al., 2010; Robak-Chołubek, Chołubek & Piróg, 2015; Polizzi et al., 2017), two cross-sectional (Harpel & Barras, 2018; Sidi & Josheu, 2019), and two studies using a multi-method approach (Cristofalo et al., 2006; Murakami et al., 2012).

Most studies (n=13) were conducted in European countries (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Rustico et al., 2005; Righetti et al., 2005; Lalor & Devane, 2007; Lapaire et al., 2007; Cadogan, Marsh & Winter, 2009; de Jong-Pleij et al., 2013; Wadephul, Jomeen & Glover, 2015; Robak-Chołubek, Chołubek & Piróg, 2015; Øyen & Aune, 2016; Polizzi et al., 2017; Westerneng et al., 2019), followed by the USA (n=5) (Freeman, 2000; Boukydis et al., 2006; Cristofalo et al., 2006; Edwards et al., 2010; Harpel & Barras, 2018), Africa (n=2) (Firth et al., 2011; Sidi & Josheu, 2019), Australia (n=2) (Stephenson, McLeod & Mills, 2016; Sedgmen et al., 2006), and Japan (n=1) (Murakami et al., 2012).

Seventeen studies featured maternal participants only (Dykes & Stjernqvist, 2001; Rustico et al., 2005; Boukydis et al., 2006; Cristofalo et al., 2006; Sedgmen et al., 2006; Lalor & Devane, 2007; Edwards et al., 2010; Firth et al., 2011; Murakami et al., 2012; de Jong-Pleij et al., 2013; Wadephul, Jomeen & Glover, 2015; Robak-Chołubek, Chołubek & Piróg, 2015; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Polizzi et al., 2017; Sidi & Josheu, 2019; Westerneng et al., 2019), five included both parents (Ekelin, Crang-Svalenius & Dykes, 2004; Righetti et al., 2005; Lapaire et al., 2007; Cadogan, Marsh & Winter, 2009; Harpel & Barras, 2018), and one study only recruited fathers (Freeman, 2000). Studies with specific research foci included 3D/4D ultrasound (n = 8) (Righetti et al.,

2005; Rustico et al., 2005; Sedgmen et al., 2006; Lapaire et al., 2007; Cadogan, Marsh & Winter, 2009; Edwards et al., 2010; de Jong-Pleij et al., 2013; Wadephul, Jomeen & Glover, 2015), scans in 3rd trimester (n = 5) (Lapaire et al., 2007; Edwards et al., 2010; de Jong-Pleij et al., 2013; Robak-Chołubek, Chołubek & Piróg, 2015; Westerneng et al., 2019), known or high chance of fetal anomaly (n = 3) (Cristofalo et al., 2006; Cadogan, Marsh & Winter, 2009; Polizzi et al., 2017), first-time mothers (n = 2) (Dykes & Stjernqvist, 2001; Sedgmen et al., 2006), and ethnic minorities (n = 2) (Firth et al., 2011; Sidi & Josheu, 2019). No studies reporting fetal MRI as the imaging modality were included.

Increased prenatal attachment was measured or reported after scanning in 16 studies (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Righetti et al., 2005; Rustico et al., 2005; Boukydis et al., 2006; Sedgmen et al., 2006; Lalor & Devane, 2007; Edwards et al., 2010; Firth et al., 2011; Murakami et al., 2012; de Jong-Pleij et al., 2013; Robak-Chołubek, Chołubek & Piróg, 2015; Stephenson, McLeod & Mills, 2016; Øyen & Aune, 2016; Sidi & Josheu, 2019), was unchanged in one study (Westerneng et al., 2019), and temporarily decreased after scanning in one study following diagnosis of fetal anomaly (Cristofalo et al., 2006). Four studies reported no difference in attachment between imaging modalities (Righetti et al., 2005; Rustico et al., 2005; Sedgmen et al., 2006; de Jong-Pleij et al., 2013), however one study found a significant difference in prenatal attachment after 3D/4D compared to 2D ultrasound (Lapaire et al., 2007).

Table 3.2 Extracted characteristics of qualitative/descriptive studies

Study information	Aim	Participants / Inclusion criteria	Setting for data collection	Timing in relation to scan / Fetal GA	Methods	Analysis	Findings / Themes (bonding)
Freeman (2000) The influences of ultrasound stimulated paternal-fetal bonding and gender identification USA No funding source declared Ethical approval not reported	To evaluate the significance of 2nd trimester ultrasound as a visual aid in stimulating the paternal-fetal bonding process	25 men aged 19-43 Male half of an expectant couple in second trimester or later, no knowledge of fetal sex	Private outpatient ultrasound scan clinic	During 2nd trimester scan (specific GA[1] range not specified)	Custom designed questionnaire before and after fetal sex identified, observation and interview during scan. Reactions with partner/other family members and opinion of ultrasound reliability noted by sonographer	A priori: word coding, observations of body language, emotional/verbal responses	92% stated that revealing the gender of the fetus under US had no real effect on their ability to bond with the child. 76% said they already felt an initial bond. Witnessing the scan rather than seeing pictures afterwards escalated the bond to the next level

[1] Gestational age has been abbreviated to GA within the table

Dykes & Stjernqvist (2001) The importance of ultrasound to first-time mothers' thoughts about their unborn child Sweden No funding source declared Ethical approval not reported	To evaluate the importance of ultrasound to women's thoughts about their unborn child	10 women aged 22-33 First-time mothers having first ultrasound in uncomplicated pregnancies, Swedish-born	8 interviews in university department, 2 interviews in women's home	One week before, one week after first scan (GA = 17 weeks)	Semi-structured interview lasting 30-60 minutes, pictorial illustration of imagined fetus	Grounded theory	Greatest impact of ultrasound was realisation of carrying a child. After the scan, women described feeling closer to/taking greater care of the fetus: 1. The existing fetus 2. The coming child 3. The woman's life situation 4. Parenthood 5. Delivery
Ekelin et al (2004) A qualitative study of mothers' and fathers' experiences of	To conceptualise parents' thoughts and feelings around the	22 pregnant women (age 22-39), 22 (male) partners (age 27-41), including 12	Participant's home	2-4 weeks after the scan (GA = 2nd trimester)	Semi-structured interview	Grounded theory	After the scan, parents felt closer to their baby, but also to each other. 1. Confirmation of a new life

routine ultrasound examination in Sweden Sweden Funded by the Vardal Foundation Ethical approval not reported	routine 2nd trimester ultrasound scan	sets of first-time parents Normal 2nd trimester ultrasound examination (first routine screening during pregnancy), proficient in Swedish language, partner present during scan					2. Visualising - the evident option 3. Overwhelming to see life 4. Becoming a family and reassuring

Cristofalo et al (2006) Women's response to fetal choroid plexus cysts (CPC) detected by prenatal ultrasound USA Study sponsored by The Thomas Wilson Sanitarium for the Children of Baltimore City Ethical approval not reported	To determine maternal responses to detection of fetal CPC on ultrasound	35 pregnant women (mean age = 32.2) Women with isolated fetal choroid plexus cyst detected during ultrasound, no additional anomalies, no smoking or substance use	Not stated	GA = 24 weeks	Semi-structured interview with semi-quantitative component	Modified thematic content analysis, statistical analysis including *t*-test, x^2, correlation coefficient, simple linear regression	68% of women experience negative emotions after diagnosis including grief, feeling burdened with anxiety, diminished pleasure in pregnancy and decreased attachment to the baby. 1. Features of the diagnostic situation 2. Accuracy of information recalled after the diagnosis 3. Subsequent information seeking 4. Resultant genetic testing 5. Affective responses
Cadogan et al (2009) Parents' views of 4D ultrasound scans following diagnosis of cleft condition UK	To explore the value of 4D ultrasound for parents after a fetal cleft is detected using 2D ultrasound	Parents of 20 pregnancies: 11 couples and 9 mothers Expectant parents with diagnosis of fetal cleft during routine 20-week ultrasound scan,	Questionnaire completed in clinic, by telephone, during a home visit, at parents' convenience	Pre-scan: completed when parents had decided to have 4D scan Post-scan: as soon as possible after 4D scan	Semi-qualitative questionnaire	Thematic analysis	None of the parents reported feeling that the 4D scan had adversely affected the bonding process with their babies. 1. Opportunity 2. Preparation 3. Seeing the cleft

No funding source declared Ethical approval not reported		having 4D ultrasound around 28-weeks gestation		Post-natal: during cleft clinic			

Firth et al (2011) Pregnant women's beliefs, expectations and experiences of antenatal ultrasound in Northern Tanzania Tanzania/UK No funding source declared Ethical approval reported	To explore women's beliefs, expectations and experiences of BomaNg'ombe ultrasound service	66 mothers (41 questionnaires, 25 interviews) Pregnant women aged 18 or over attending BomaNg'ombe antenatal clinic, literacy proficiency to complete written questionnaires	Questionnaires completed in clinic reception, interviews undertaken during clinic consultation (including scan)	GA at data collection varied (not stated), ultrasound scan between 12-24 weeks	Questionnaire or semi-structured interview	Continuous thematic analysis, descriptive statistics	Participants found that seeing the baby was pleasurable, confirmed life and pregnancy, and brought closeness with their baby. 1. Pregnancy and local beliefs 2. Experience and awareness of ultrasound 3. Perceived benefits, expected outcomes, accuracy and capacity, positive experience 4. Anxieties and fears

Wadephul et al (2015) Women's experiences of commercial three-dimensional ultrasound scans UK No funding source declared Ethical approval reported	To explore women's individual choices to have private 3D/4D scans, their expectations /experiences and impact of scan on maternal-fetal bond	6 women Pregnant women aged 18 or over who were planning to have a 3D/4D scan	Unclear	1) Before scan (GA = 25-30 weeks) 2) After scan (GA not stated) 3) Late pregnancy (GA not stated)	In-person or telephone semi-structured interviews. Validated questionnaire for assessing attitude to pregnancy, bonding, anxiety and depression.	Interpretative phenomenological analysis of interviews. Descriptive analysis of quantitative findings	One participant's post-scan bonding score increased considerably (reflected in the way she talked about the fetus). The scan helped to make the fetus more real. 1. Reasons, expectations and experiences of 3D/4D scan 2. Impact of scan on psychological experience

Oyen & Aune (2016) Viewing the unborn child – pregnant women's expectations, attitudes and experiences regarding fetal ultrasound examination Norway No funding source declared Ethical approval reported	To gain a deeper understanding of pregnant women's expectations, attitudes and experiences of pregnancy ultrasound	8 women, randomly selected from hospital scan list (aged 20-37) Healthy women with uncomplicated pregnancies, proficient in Norwegian language	Hospital	Prior to 18-week ultrasound (6 interviews undertaken 2-3 days before the scan, 2 interviews on the day of the scan)	In-depth interviews	Modified phenomenological analysis	Visualizing the "baby" represented a strong emotional dimension and initiated the bonding process and the planning of a new life. 1. I want to know if everything is fine 2. Viewing the unborn child 3. Holistic care

Stephenson et al (2016) Ambiguous encounters, uncertain foetuses: Women's experiences of obstetric ultrasound Australia Study funded by The Australian Research Council Ethical approval reported	To explore the ontological, aesthetic and epistemological ambiguities of prenatal ultrasound	26 pregnant women (aged 27-48) Not explicitly stated	Private/public hospital clinical for observations, unclear setting for interviews	Within 2 weeks of scan (17 interviews after 1st trimester 12-week scan, 10 interviews after 2nd trimester 18-20 week scan)	Semi-structured interviews, researcher observation in hospital and private scan clinics, audio recording of routine scans	Not described	Scan allows women to connect with baby as an "intimate and uncertain stranger". Connection is partly facilitated by sonographers. 1. Ontological ambiguity 2. Aesthetic ambiguity 3. Epistemic ambiguity 4. Moral pioneering in making decisions 5. Moral pioneering as commitment enabled by ambiguity

Westerneng et al (2019) Experiences of pregnant women with a third trimester routine ultrasound – a qualitative study The Netherlands Study funded by the Academy of Midwifery Amsterdam-Groningen Ethical approval reported	To explore pregnant women's experiences of 3rd trimester routine ultrasound	15 women (including 2 with suspicion of intra-uterine fetal growth restriction on scan) aged 25-42 Women with uncomplicated pregnancies who had received at least one third trimester ultrasound, proficient in Dutch language	Interviews conducted in participant's home (n = 14) or place of work (n = 1)	Scans between 28-30 weeks and 34-36 weeks gestations. Interviews conducted during 3rd trimester (exact GA not stated)	Semi-structured interviews	Thematic content analysis	Pregnant women seem to appreciate a third trimester routine ultrasound, but it does not seem to reduce anxiety or to improve bonding with their baby. 1. The ultrasound as a bonus 2. The ultrasound to get confirmation 3. The ultrasound as part of a normalisation process

Table 3.3 Extracted characteristics of quantitative studies

Study information	Aim	Participants / Inclusion criteria	Setting for data collection	Timing in relation to scan / Fetal GA	Measure of prenatal bonding	Methods	Findings in relation to bonding
Righetti et al (2005) Maternal/paternal antenatal attachment and fourth-dimensional ultrasound technique: A preliminary report Italy No funding source declared Ethical approval not reported	To investigate the role of 4D ultrasound on the developing parent-fetal bond	44 expectant couples (mean female age = 33, mean male age = 35) Italian nationality, presence of partner during scan, uncomplicated pregnancy	Unclear	Time 1 = before 2nd trimester US Time 2 = two weeks after scan (GA[2] = 19-23 weeks)	MAAS/ PAAS[3]	Couples asked to complete MAAS or PAAS questionnaires before the ultrasound scan and 2 weeks later (randomised to 2D = control group, or 4D = experimental group)	Maternal global attachment and quality of attachment was significantly different between the first and the second assessment. No significant difference in attachment in men. No significant difference shown between 2D and 4D ultrasound scanning groups. Attachment not associated with age, years in relationship or education

[2] Gestational age is abbreviated to GA in the table

[3] MAAS and PAAS refer to the Maternal and Paternal Antenatal Attachment Scales respectively

Rustico et al (2005) Two-dimensional vs. two- plus four-dimensional ultrasound in pregnancy and the effect on maternal emotional status: a randomized study Italy Funded by GE Medical Systems, Austria Ethical approval not reported	To assess whether additional 4D ultrasound in pregnancy aids maternal recognition and causes emotional impact	100 women (mean age = 32 years) Pregnant women with a 2nd or 3rd trimester ultrasound scan booked at single site	Unclear	Questionnaires completed after scan (mean GA = 21 weeks)	MAAS	52 women randomly assigned to 2D ultrasound only (Group 1), while 48 women underwent 2D plus 4D ultrasound (Group 2). All the women completed two questionnaires (recognition of fetal anatomy and perception of scan). Sub-set of 46 women completed MAAS	MAAS scores were similar in the two groups, but there were more women with positive attachment changes in 4D scan group. Regardless of scan type, women who had seen all they wanted answered more frequently that the scan had changed for the better their perception of the fetus
Boukydis et al (2006) Women's Responses to	To evaluate the impact of prenatal US consultation	52 women (mean age = 23 years) Pregnant women undergoing	Scan clinic	(GA 16-26 weeks)		Women were randomly assigned to a standard ultrasound screen group (n = 24) or	MFAS increased significantly after scan in consultation group, no significant change for standard group. Significant

Ultrasound Examinations During Routine Screens in an Obstetric Clinic USA Funded by Office for Research, Wayne State University Ethical approval not reported	on maternal-fetal bonding	ultrasound scans at single site			MFAS[4]	an ultrasound consultation group (n = 28). STAI and MFAS completed immediately before and after scan	increase in "attributing characteristic to fetus" sub-scale in consultation group. Post scan questionnaire responses from consultation group suggested increased bonding
Sedgmen et al (2006) The impact of two-dimensional	To explore the impact of timing and type of ultrasound exposure on	68 women Nulliparous expectant women aged 18 years old or over having a	Time 1: in scan clinic Time 2: participant's home	Time 1: immediately before scan	MAAS	Women completed questionnaires and were then randomised to either 2D or 3D ultrasound	Attachment increased after both 2D and 3D ultrasound exposure - women receiving their first ultrasound scan showed the greatest change.

[4] MFAS refers to the Maternal Fetal Attachment Scale

versus three-dimensional ultrasound exposure on maternal–fetal attachment and maternal health behaviour in pregnancy Australia No funding source declared Ethical approval reported	maternal-fetal bonding and health behaviour in pregnancy	routine 12 or 18 week ultrasound scan in an uncomplicated pregnancy		Time 2: 5-7 days after scan (max 3 weeks) GA = 12-14 weeks or 18-22 weeks		examination groups. Repeat questionnaires were completed 1 week after scan	Alcohol consumption was significantly changed after scan (no difference between 2D and 3D). No difference in maternal change in perception of the fetus between 2D and 3D
Lalor and Devane (2007) Information, knowledge and expectations of the routine ultrasound scan	To examine the provision of pre-scan information to women and their knowledge/ expectations of the scan	462 women (aged 17-45) Women attending scan clinic for routine 2nd trimester ultrasound, uncomplicated pregnancies. Antenatal care	Scan clinic	Time 1: immediately before scan Time 2: immediately after scan Mean GA = 19 weeks	Semi-customised	Pre and post scan elf-administered questionnaires exploring women's knowledge and expectations of the examination, and whether their expectations were achieved	Over 80% of participants expected the scan to increase their attachment to the baby. 64% perceived their expectation of increased attachment after the scan was met

Ireland No funding source declared Ethical approval reported		may be private, shared or provided via public hospitals					
Lapaire et al (2007) Two- versus three-dimensional ultrasound in the second and third trimester of pregnancy: impact on recognition and maternal–fetal bonding. A prospective pilot study Switzerland	To assess the impact of 3D vs 2D ultrasound on maternal-fetal bonding	60 women and partners combined German-speaking women, BMI[5] < 35, singleton pregnancy, unremarkable 1st and 2nd trimester scans. Partners included if present at scan	Unclear	After scan (exact timing unclear) GA = 23-34 weeks (mean 27 weeks)	Customised	Participants attending for antenatal care randomised into groups: Group 1 = 2D followed by 3D scan Group 2 = 3D followed by 2D scan. Post-scan questionnaire of parent experiences completed	Maternal recognition was higher with 3D (p = 0.004). Mothers preferred 3D ultrasound but it had no significant impact on post-scan bonding.

[5] BMI refers to Body Mass Index in the table

No funding source declared Ethical approval not reported							
Edwards et al (2010) Maternal reactions to two-dimensional compared to three-dimensional foetal ultrasonography USA No funding source declared Ethical approval reported	To compare maternal reactions viewing 3D ultrasound fetal face vs. 2D ultrasound	112 pregnant women Pregnant women having ultrasound scans for clinical indications, satisfactory 2D and 3D images obtained during scan	Unclear	After scan (exact timing unclear) GA = 24-36 weeks	Customised	Post-scan questionnaire evaluation of participant reaction to scan	3D imaging resulted in significantly more favourable reactions than 2D. 3D imaging was significantly better than 2D regarding feeling closer to the baby

de Jong-Pleij et al (2013) Three-dimensional ultrasound and maternal bonding, a third trimester study and a review The Netherlands No funding source declared Ethical approval not reported	To compare the effect of 3D/4D ultrasound vs. 2D ultrasound on maternal-fetal bonding	133 women Low-risk pregnant women with no previous experience of 3D/4D ultrasound	Participant's home	Time 1: 1-2 weeks before scan Time 2: 1-2 weeks after scan Mean GA at scan = 32 weeks	MAAS	Randomisation of participants to either Group 1 (additional 3D/4D scan) or Group 2 (additional 2D scan). MAAS completed before and after scan	MAAS scores were significantly higher after scan in both groups. No differences in MAAS scores between the US groups. Visibility and recognition were significantly positively related with the increase in MAAS scores in the 3D/4D group

Murakami et al (2012) Japanese women's attitudes towards routine ultrasound screening during pregnancy Japan Funded by Grant-in-Aid for Scientific Grants and Japan Society for the Promotion of Science Ethical approval reported	To investigate Japanese women's views of routine prenatal US screening	261 Japanese women (mean age = 30 years) Singleton pregnancy women aged 18 or over within 2nd trimester of pregnancy with no known complication	Scan clinic or participant's home	Questionnaire completed within 2 weeks of scan Mean GA for completion = 24 weeks	Customised	Self-administered questionnaire following ultrasound scan, content analysis of free text responses	Participants' views of ultrasound scans mostly identified feelings of pleasure (n = 234, 98.3%), and increased attachment to their fetus (n = 232, 97.5%)

Robak-Cholubek et al (2015) Determining fetal sex in pregnancy with reference to pregnant women behaviour in late pregnancy Poland No funding source declared Ethical approval not reported	To evaluate the influence of fetal sex determination during prenatal ultrasound on emotional and practical experience	200 women Pregnant women who found out the sex of their baby through ultrasound between 19-36 weeks GA	Unclear	Mean GA to find out fetal sex = 22 weeks GA at survey completion = 29-41 weeks	Customised	Participants asked to complete a quantitative survey	After discovering fetal sex, 80% of participants felt their emotional bond with the baby increased when the pregnancy was unplanned. For planned pregnancies, this figure was 58%. After the scan, most women started to acquire clothing for their future babies

Polizzi et al (2017) A study on maternal-fetal attachment in pregnant women undergoing fetal echocardiography Italy No funding source declared Ethical approval not reported	To investigate possible effects of fetal echocardiography on prenatal bonding	168 pregnant Italian women (high-risk group mean age = 31, low-risk group mean age = 30 years) Pregnant women high-risk for fetal CHD having echocardiography and low-risk pregnant women having morphological ultrasound scans in 2 centres	Scan clinic	Questionnaire completed immediately before scan, experience of scan reported afterwards GA (echocardiography) = 23 weeks GA (morphological scan) = 21 weeks	PAI[6]	85 women had echocardiography, 83 women had standard morphological scan asked to complete bonding questionnaire and report emotional experience of scan	No statistically significant differences in attachment scores between the two groups

[6] PAI refers to the Prenatal Attachment Inventory in this table

Harpel & Barras (2018) The impact of ultrasound on prenatal attachment among disembodied and embodied knowers USA Funded by the College of Applied and Natural Sciences at Louisiana Tech University Ethical approval not reported	To explore perceived impact of ultrasound technology on prenatal bonding in mothers, fathers and grandmother	73 pregnant women (mean age = 29), 76 fathers (mean age = 29), Caucasian majority 18 years old or over, currently pregnant or expectant father, attended scan or was shown pictures/video from scan of current pregnancy	Online	Unclear	Customised 14 item scale	Online questionnaire completed during pregnancy	No significant differences in attachment between mothers/fathers who both attended the scan. Significant differences in attachment for fathers who did not attend the scan

Sidi & Josheu (2019) The Role of Ultrasound in Enhancing Maternal – Fetal Bonding in Kaduna Metropolis, Nigeria Nigeria No funding source declared Ethical approval reported	To evaluate the role of ultrasound in enhancing maternal-fetal bonding	403 pregnant women Not explicitly stated	Unclear	Unclear	Customised	Convenience sampling, structured questionnaire completed before and after scan	219 participants indicated being closer to their babies after the scan.

3.4.2 Quality appraisal

Critical appraisal indicated a moderate level of quality across the studies (Table 3.4). Quality was considered higher where studies used a pre- and post-scan comparative design (Dykes & Stjernqvist, 2001; Righetti et al., 2005; Boukydis et al., 2006; Sedgmen et al., 2006; Lalor & Devane, 2007; Cadogan, Marsh & Winter, 2009; de Jong-Pleij et al., 2013; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Polizzi et al., 2017), chose a validated questionnaire for quantitative data collection (Righetti et al., 2005; Rustico et al., 2005; Boukydis et al., 2006; Sedgmen et al., 2006; de Jong-Pleij et al., 2013; Polizzi et al., 2017), and fully described the analytical process (Freeman, 2000; Cristofalo et al., 2006; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016).

Elements of qualitative studies that were considered of lower quality were: not disclosing the relationship of the researchers to participants (e.g., to determine whether this relationship could have influenced data collection) (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Wadephul, Jomeen & Glover, 2015; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019), not describing the data collection environment in sufficient detail (Ekelin, Crang-Svalenius & Dykes, 2004; Cristofalo et al., 2006; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016), and not reporting triangulation methods (Dykes & Stjernqvist, 2001; Cristofalo et al., 2006).

Elements of quantitative studies that were considered of lower quality were: using non-validated questionnaires (Lapaire et al., 2007; Lalor & Devane, 2007; Edwards et al., 2010; Robak-Chołubek, Chołubek & Piróg, 2015; Sidi & Josheu, 2019; Murakami et al., 2012), unclear participant recruitment or randomisation procedures (Righetti et al., 2005; Boukydis et al., 2006; de Jong-Pleij et al., 2013), and not providing details for the ultrasound scan protocol (Righetti et al., 2005; Robak-Chołubek, Chołubek & Piróg, 2015; Polizzi et al., 2017; Sidi & Josheu, 2019).

Fourteen studies did not report ethical approval (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Righetti et al., 2005; Rustico et al., 2005; Boukydis et al., 2006; Sedgmen et al., 2006; Cristofalo et al., 2006; Lapaire et al., 2007; Cadogan, Marsh & Winter, 2009; de

Jong-Pleij et al., 2013; Robak-Chołubek, Chołubek & Piróg, 2015; Polizzi et al., 2017; Harpel & Barras, 2018).

Excluding lower-quality studies based on these considerations, however, would severely reduce the quantity of data available for use in this review, therefore it was decided they should still be included.

Table 3.4 Quality appraisal of included studies

Study information and methodology/study design used	Checklist used for quality appraisal	Limitations, confounding factors, and mitigation of bias	JBI score
Qualitative studies			
Freeman (2000) Qualitative, cross-sectional ethnographic	JBI cross-sectional	• Sonographer undertook scan and data collection • Private scan facility • Unsure of parity/demographics • No definitive confirmation of sex/post-partum follow-up • Non-validated questionnaire • Sonographer and self-reported outcomes • Standardised scan: anatomy imaged first • Triangulation of interview, questionnaire and observational data • Pregnant partner blinded to responses	Y = 1 N = 3 U = 4 N/A = 0
Dykes & Stjernqvist (2001) Qualitative	JBI qualitative	• Unsure of scan protocol for standardisation • No discussion of reconciliation process • Researcher influence/position not acknowledged • No member checking/ triangulation described • Interview guide provided • Coding undertaken by two researchers • Representative quotes used to illustrate themes	Y = 7 N = 2 U = 1 N/A = 0
Ekelin et al (2004) Qualitative	JBI qualitative	• Unsure if participants were interviewed separately • Mix of first-time parents and those who already have children • First routine scan during pregnancy • Single researcher who conducted the interviews did not work in the ultrasound department • Researcher's theoretical position not stated • Member checking described for one couple • Analytical process described in full • Analysis undertaken by three researchers	Y = 7 N = 2 U = 1 N/A = 0

		• Representative quotations from first-time parents only	
Cristofalo et al (2006) Semi-qualitative, cross-sectional	JBI cross-sectional	• Self-selection of participants ? diversity of sample and generalisability of findings • Data collection settings not described • Data collection instruments not published • Unclear of data collection instrument development/validation • Methodological rigour and reliability not discussed • Statistical power is uncertain • Two-stage data analysis including independent review and group consensus	Y = 2 N = 2 U = 4 N/A = 0
Cadogan et al (2009) Semi-qualitative	JBI qualitative	• Data collected over 3 year period which may incorporate technical advances • Different settings used for data collection • Non-uniform approach to questionnaire delivery by clinical research team • Questionnaire development/validation not described • Analytical process not described fully • Participant characteristics not stated • Incomplete data sets • Both parents invited to participate • Standardised questionnaire time-points	Y = 6 N = 3 U = 1 N/A = 0
Firth et al (2011) Qualitative	JBI qualitative	• Interviews recorded by note-taking • Inconsistency of translations • Non-standard GA for data collection • Participant characteristics not reported • Emergent, inductive design, continual analysis • Questionnaire validation	Y = 6 N = 2 U = 1 N/A = 0
Wadephul et al (2015) Qualitative and semi-quantitative longitudinal case studies	JBI qualitative	• Self-selected sample • Unclear if independent or group qualitative analysis • Unsure of researcher relationship to participants • Unclear how questionnaire was administered • Triangulation with research notes • Participant characteristics reported • Multiple time-points sampled	Y = 7 N = 2 U = 1 N/A = 0
Oyen & Aune (2016)	JBI qualitative	• Unclear which researcher(s) conducted interviews	Y = 7

Qualitative		• Generalisability of findings • Randomised sampling • Interview guide used • Detailed qualitative analysis described • Group analysis of interview transcripts	N = 2 U = 1 N/A = 0
Stephenson et al (2016) Qualitative, ethnographic	JBI qualitative	• Unsure of recruitment strategy • Analytical approach not described • Relationship of research team to participants not described • Data collected at specified time points • Dual site study • Semi-structured interview (no guide published) • Observation notes to enrich interview data	Y = 7 N = 2 U = 1 N/A = 0
Westerneng et al (2019) Qualitative	JBI qualitative	• Relationship of research team to participants not described • Only Dutch-speaking women included ? under-representation of population • Purposive sampling • Interview topic list published • Analytical process fully described • Good intercoder agreement	Y = 7 N = 2 U = 1 N/A = 0
Quantitative studies			
Righetti et al (2005) RCT[7]	JBI RCT	• Randomisation procedure/recruitment strategy not described • Unsure of questionnaire deployment/completion (e.g. setting, individually completed?) • Written questions about ultrasound/feelings not published • Unable to blind participants to scan group • Scan procedure not described • Validated bonding questionnaires used • Both parents included	Y = 7 N = 1 U = 4 N/A = 1

[7] Randomised control trial is abbreviated to RCT in this table

		• Participant characteristics stated	
Rustico et al (2005) RCT	JBI RCT	• 4D group had 2D as well • Unsure how questionnaires were administered/completed • Selection process of MAAS sub-set not described • Blinding of assessors to outcome of scan group not stated • Scan protocol described • Sample size calculation used to power study • Validated bonding questionnaire used	Y = 8 N = 2 U = 2 N/A = 1
Boukydis et al (2006) RCT	JBI RCT	• Unsure how questionnaire was completed • Randomisation process not described • Some participants were accompanied for the scan • Matched participant characteristics in both groups • Reliability training for research sonographers • Assessed maternal anxiety and depression scores	Y = 8 N = 2 U = 2 N/A = 1
Sedgmen et al (2006) RCT	JBI RCT	• Differences in time elapsed between scan and completion of 2nd questionnaire • Sample under-representation of population • Small sample size across two GA groups • First-time mothers and uncomplicated pregnancies only • Validated questionnaire • Groups analysed by GA at time of scan	Y = 7 N = 2 U = 3 N/A = 1
Lalor and Devane (2007) Observational, questionnaire	JBI cohort	• Convenience sampling • Expectations and perceptions analysed by parity, information and knowledge analysed by care group • Socio-demographic data not collected • Reliability, validity and pilot testing of questionnaires conducted • Objective questionnaire responses • Questionnaires completed independently with no researcher present	Y = 4 N = 1 U = 5 N/A = 1
Lapaire et al (2007) RCT	JBI RCT	• Non-validated questionnaire • Power calculation based on hypothetical data • Analysed by scan modality rather than group • Likert scale ratings reversed depending on question	Y = 7 N = 2 U = 3 N/A = 1

		• Standardised scan protocol (single operator) • Cross-over design, though no wash-out period • Prospective study	
Edwards et al (2010) Observational, questionnaire	JBI cohort	• Selection bias of participants enrolled when good images obtained • No participant demographics reported • Non-validated questionnaire • Same equipment used • Moderate sample size • Objective questionnaire response	Y = 3 N = 2 U = 3 N/A = 3
de Jong-Pleij et al (2013) RCT	JBI RCT	• Unclear of randomisation process • Participant characteristics unequal between groups • Unclear if research team blinded to participant group during analysis • Control group • No previous experience of 3D/4D ultrasound • Standardised scan protocol	Y = 6 N = 4 U = 3 N/A = 0
Murakami et al (2012) Observational, questionnaire	JBI cross-sectional	• Customised questionnaire • No triangulation methods used • Some participants did not complete all questions • Recruitment from 3 sites • Validity and pilot testing of customised questionnaire • Analysis by participant age, GA, parity	Y = 5 N = 1 U = 1 N/A = 1
Robak-Cholubek et al (2015) Observational, survey	JBI cohort	• Wide gestational age range of participants • No comparison group • Customised survey to evaluate bonding • Administration of survey unclear • Moderate sample size	Y = 2 N = 3 U = 3 N/A = 3
Polizzi et al (2017) Observational, questionnaire	JBI cohort	• Does not consider emotional impact of high-risk pregnancy on bonding level • Similar participant characteristics in both groups • Scan procedure not described • Comparison group included • Validated questionnaire used	Y = 4 N = 2 U = 4 N/A = 1

		• Data collected at time of scan for improved response rate	
Harpel & Barras (2018) Observational, questionnaire	JBI cross-sectional	• Self-selected sample • Separate data sets • Varying intervals between scan and completion of questionnaire • Analysis of variance between parent, parity and presence at scan groups • Questionnaire based on PAI, PAAS, and MFAS	Y = 4 N = 1 U = 2 N/A = 1
Sidi & Josheu (2019) Cross-sectional	JBI cross-sectional	• GA not reported • Scan procedure not described • 11% of returned questionnaires not completed • Prospective design • Reliability and pilot testing of questionnaire	Y = 1 N = 5 U = 0 N/A = 2

3.4.3 Convergent Integrated Pillar data synthesis

Analysis of the included studies identified 58 codes related to prenatal attachment. Six central themes were then developed from the Pillar Integration Process (Table 3.5): 1) the scan experience begins before the scan appointment; 2) the scan as a pregnancy ritual; 3) feeling actively involved in the scan; 4) parents' priorities for knowledge and understanding of the scan change during pregnancy; 5) the importance of the parent-sonographer partnership during scanning; and 6) scans help to create a social identity for the unborn baby. For simplicity, the term sonographer is used throughout the paper to represent any HCP or ultrasound practitioner who performs pregnancy imaging. These themes are described below with illustrative quotations.

Table 3.5 Adapted Pillar Integration Process analysis (Johnson, Grove and Clarke, 2019)

Coded data from quantitative studies	Quantitative categories	Pillar Theme	Qualitative themes	Qualitative codes
---------->		OUTCOME		<----------
• First-time mothers have higher expectations of scan and quality of images (Lalor & Devane, 2007) • Parents create pre-conceptions of scan from gathered information and social interactions (Murakami et al., 2012)	Scan expectations	The scan experience begins before scan appointment	Anticipating the scan (the scan paradox)	• Pre-scan expectations (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Firth et al., 2011; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Cristofalo et al., 2006) • Conflicting emotions (e.g., excited but apprehensive for unexpected news) (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Firth et al., 2011; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019) • Dilemma of finding an anomaly (Ekelin, Crang-Svalenius & Dykes, 2004; Firth et al., 2011; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019)

				• Getting information about the scan (Ekelin, Crang-Svalenius & Dykes, 2004; Firth et al., 2011; Øyen & Aune, 2016; Cristofalo et al., 2006)
• Parents enjoy scans (Murakami et al., 2012) • Parents show a preference for 3D/4D scans compared to 2D (Lapaire et al., 2007; Edwards et al., 2010) • 3D/4D scans are easier to recognise but do not significantly impact overall perception of fetus, satisfaction of scan or bonding (Righetti et al., 2005; Rustico et al., 2005; Sedgmen et al., 2006; Lapaire et al., 2007; Edwards et al., 2010; de Jong-Pleij et al., 2013) • Parent recognition of 3D/4D images dependent on scan quality (Sedgmen et al., 2006) • First-time mothers find it more difficult to recognise 2D images (Sedgmen et al., 2006)	Imaging technology	The scan as a pregnancy ritual	Seeing the baby (parent interaction with imaging)	• Confirmation of pregnancy (Ekelin, Crang-Svalenius & Dykes, 2004; Firth et al., 2011; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016) • Visualisation of the fetus (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan, Marsh & Winter, 2009; Firth et al., 2011; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019) • Creation of fetal images (Stephenson, McLeod & Mills, 2016) • Reaction to imaging/technology (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius &

				Dykes, 2004; Cadogan, Marsh & Winter, 2009; Firth et al., 2011; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019) • Comparison of imaging modalities (Ekelin, Crang-Svalenius & Dykes, 2004; Wadephul, Jomeen & Glover, 2015; Stephenson, McLeod & Mills, 2016) • Reaction to fetal anomalies (Dykes & Stjernqvist, 2001; Cadogan, Marsh & Winter, 2009; Stephenson, McLeod & Mills, 2016; Cristofalo et al., 2006)
• Fathers attending scans feel closer to baby (Harpel & Barras, 2018) • Paternal-fetal bonding not affected by imaging modality (Righetti et al., 2005; Sedgmen et al., 2006) • Mothers more likely to want additional scans (Harpel & Barras, 2018)	Mums and Dads	Feeling actively involved in the scan	Feelings about the scan (parent reaction to imaging)	• Impact of scan (e.g., validation of parent ability to create life) (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Øyen & Aune, 2016) • Feeling involved in scan experience (Ekelin, Crang-Svalenius & Dykes, 2004; Stephenson, McLeod & Mills, 2016)

• It is important for partners to attend scans (Murakami et al., 2012)				• Support of partner at scan (Ekelin, Crang-Svalenius & Dykes, 2004; Øyen & Aune, 2016; Westerneng et al., 2019) • Negative feelings about the scan (Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan, Marsh & Winter, 2009; Firth et al., 2011; Wadephul, Jomeen & Glover, 2015) • Positive feelings about the scan (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan, Marsh & Winter, 2009; Firth et al., 2011; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016) • What parents value at scans (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Westerneng et al., 2019) • Scan is reassuring or a relief (Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan,

				Marsh & Winter, 2009; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Westerneng et al., 2019; Cristofalo et al., 2006)
• What parents need from the scan changes at different gestational ages (Murakami et al., 2012) • Parents want to know if there is a fetal anomaly so they can prepare (Murakami et al., 2012) • Negative health behaviours associated with lower bonding but decrease after scan (Sedgmen et al., 2006) • Knowing the fetal sex helps some parents to prepare for having a baby but is not a priority for all parents, and the result is not always trusted (Robak-Chołubek, Chołubek & Piróg, 2015; Murakami et al., 2012) • Contrary expected fetal sex and fetal presentation thought to affect bonding (Sidi & Josheu, 2019) • Asking questions helps parents to understand and feel better	The fetus as an individual	Parents' priorities for knowledge and understanding of the scan change during pregnancy	Understanding the scan and becoming a parent (parenting behaviours after the scan)	• Safety concerns about scanning (Firth et al., 2011; Øyen & Aune, 2016; Westerneng et al., 2019) • Knowledge/acceptance of fetal anomalies or unexpected news (Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan, Marsh & Winter, 2009; Stephenson, McLeod & Mills, 2016; Cristofalo et al., 2006) • Positive pregnancy related behaviours (Dykes & Stjernqvist, 2001; Cadogan, Marsh & Winter, 2009; Øyen & Aune, 2016; Westerneng et al., 2019) • Different feelings at difference gestational ages and parity (Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Westerneng et al., 2019)

informed about the scan purpose and limitations (Murakami et al., 2012)				• Reasons for having/wanting scans (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan, Marsh & Winter, 2009; Firth et al., 2011; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019) • Cultural differences (Firth et al., 2011) • Knowing the fetal sex (Freeman, 2000; Firth et al., 2011; Øyen & Aune, 2016)
• Interaction with sonographer during scan: o Enhances bonding (Boukydis et al., 2006) o Positively impacts perception of scan (Boukydis et al., 2006) o Significantly reduces anxiety after scan (Boukydis et al., 2006)	Sonographers	The importance of the parent-sonographer partnership during scanning	Communicating during the scan (how parents and sonographers interact)	• Humanising the fetus and sonographer language (Ekelin, Crang-Svalenius & Dykes, 2004; Stephenson, McLeod & Mills, 2016) • What parents value in the sonographer (Ekelin, Crang-Svalenius & Dykes, 2004; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016) • Two-way interaction (Øyen & Aune, 2016)

				• Trust in the sonographer (Freeman, 2000; Firth et al., 2011) • Making enough time for the scan (Westerneng et al., 2019) • Knowledge and understanding of the scan procedure including limitations (Ekelin, Crang-Svalenius & Dykes, 2004; Firth et al., 2011; Øyen & Aune, 2016; Westerneng et al., 2019)
• Bonding occurs irrespective of scan (Righetti et al., 2005; de Jong-Pleij et al., 2013; Polizzi et al., 2017) but parents feel closer to their unborn babies after scans (Sidi & Josheu, 2019) • Bonding measures increase more in unplanned pregnancies, at earlier gestational ages or after first scan than later gestations or repeat scans (Sedgmen et al., 2006; Robak-Chołubek, Chołubek & Piróg, 2015; Sidi & Josheu, 2019)	Bonding	Scans help to create a social identity for the unborn baby	Sharing and thinking (sharing the scan experience with family and friends, recognition of self as a parent)	• Using the scan and souvenirs to share pregnancy news (Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan, Marsh & Winter, 2009; Wadephul, Jomeen & Glover, 2015) • Extended family attending scans (Westerneng et al., 2019) • Perception of bonding before scan (Freeman, 2000; Dykes & Stjernqvist, 2001) • Perceived impact of scan on bonding (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius &

• It is unclear how parity affects bonding (de Jong-Pleij et al., 2013; Harpel and Barras, 2018) • Parents talk about scan with family/friends (Sidi & Josheu, 2019) • Perception of social support is important for bonding (Polizzi et al., 2017) • Scan souvenirs represent baby in a physical presence that others can interact with socially (Murakami et al., 2012)				Dykes, 2004; Cadogan, Marsh & Winter, 2009; Firth et al., 2011; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019; Cristofalo et al., 2006)

3.4.3.1 The scan experience begins before the scan appointment

This theme conceptualises pregnancy scans as experiences that are not confined to the scan room. Prior to the scan, expectant parents sought information from a range of sources, including leaflets provided by scan departments, the internet, and social interactions (Ekelin, Crang-Svalenius & Dykes, 2004; Cristofalo et al., 2006; Firth et al., 2011; Øyen & Aune, 2016), which they used to develop individual expectations about the scan (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Cristofalo et al., 2006; Lalor & Devane, 2007; Firth et al., 2011; Murakami et al., 2012; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016). Parents looked forward to the scan, but were simultaneously apprehensive of the potential to receive unexpected news about their baby (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Firth et al., 2011; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019), with a 'fear that something could be wrong' always present (Cadogan, Marsh & Winter, 2009). This emotional conflict created a paradox, whereby in the excitement of visualising their unborn baby, parents also had to consider the possibility of the scan detecting a fetal anomaly and further antenatal care decisions that may have been needed (Ekelin, Crang-Svalenius & Dykes, 2004; Firth et al., 2011; Stephenson, McLeod & Mills, 2016; Cristofalo et al., 2006).

3.4.3.2 The scan as a pregnancy ritual

Parents regarded scans as a milestone event which they expected, and wanted (Harpel & Barras, 2018):

"One of the first-time mothers even considered the ultrasound examination to be an initiation rite into pregnancy, making it obvious not only to herself but also to others that she really was expecting a baby" (Ekelin, Crang-Svalenius & Dykes, 2004).

Many parents had made the decision to attend the scan before receiving information about it, and were unaware that it is not obligatory in antenatal care (Ekelin, Crang-Svalenius & Dykes,

2004). Parents viewed scans as an opportunity to see their baby (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan, Marsh & Winter, 2009; Firth et al., 2011; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019) and to confirm the presence of a new life (Ekelin, Crang-Svalenius & Dykes, 2004; Firth et al., 2011; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016). Guided by the sonographer's commentary, they used the scan images to create mental images of their baby (Stephenson, McLeod & Mills, 2016). Whilst some parents showed a clear preference for advanced imaging techniques such as 3D/4D ultrasound for ease of recognition (Sedgmen et al., 2006), particularly for first-time mothers (Rustico et al., 2005), scan type did not seem to significantly impact on parents' perception of the fetus or bonding (Righetti et al., 2005; Rustico et al., 2005; Sedgmen et al., 2006; Lapaire et al., 2007; Edwards et al., 2010).

For some, novel modalities felt more exciting and therefore desirable, however they also created uncertainty and feelings of disappointment in parents with high expectations that could not be met (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Cristofalo et al., 2006; Firth et al., 2011; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016).

"All [parents] expected clear, detailed images of the baby, particularly the face, enabling them to see 'what the baby looks like'" (Wadephul, Jomeen & Glover, 2015).

Pregnancy scans also enabled parents to engage with fetal anomalies by providing a visual image (Dykes & Stjernqvist, 2001; Cadogan, Marsh & Winter, 2009; Stephenson, McLeod & Mills, 2016; Cristofalo et al., 2006).

3.4.3.3 Feeling actively involved in the scan

This theme focuses on parents as active participants in the scan (Ekelin, Crang-Svalenius & Dykes, 2004; Stephenson, McLeod & Mills, 2016). Scans were generally felt to be reassuring or a

relief (Ekelin, Crang-Svalenius & Dykes, 2004; Cristofalo et al., 2006; Cadogan, Marsh & Winter, 2009; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Westerneng et al., 2019), and parents reported positive feelings when the baby's health was confirmed (Ekelin, Crang-Svalenius & Dykes, 2004). Parents enjoyed recognising personal characteristics in the baby (Ekelin, Crang-Svalenius & Dykes, 2004; Boukydis et al., 2006), and this helped validate their role as creators of life (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Øyen & Aune, 2016). The presence of fathers at scans was important (Ekelin, Crang-Svalenius & Dykes, 2004; Øyen & Aune, 2016; Westerneng et al., 2019), not only for maternal support (Murakami et al., 2012), but also for enhanced bonding, as fathers who attended scans felt closer to their unborn baby than those who had not (Harpel & Barras, 2018). Partner behaviour changed after the scan to be "more understanding and gentle" towards mothers (Ekelin, Crang-Svalenius & Dykes, 2004). As with mothers, the imaging modality did not seem to significantly impact paternal attachment (Righetti et al., 2005; Lapaire et al., 2007), rather it was being present and active in the real-time, dynamic scan experience which helped them to feel closer to their unborn baby:

> *"The women and their partners used the ultrasound examination in planning the pregnancy process leading towards birth and a new life with the baby"* (Cadogan, Marsh & Winter, 2009).

3.4.3.4 Parents' priorities for knowledge and understanding of the scan change during pregnancy

Interacting with, and understanding the visual images of babies during scan evoked positive pregnancy related behaviours in parents such as reducing alcohol/caffeine consumption and preparing the house for the baby's arrival (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Sedgmen et al., 2006; Øyen & Aune, 2016; Westerneng et al., 2019).

These behaviours represented the developing attachment, and parents' transformation of themselves as a care-giver with *'*feelings of responsibility and concern for fetal development'

(Stephenson, McLeod & Mills, 2016). The pattern to these behaviours was progressive, and as such, the need to inform parents with specific knowledge and understanding from scans changed with gestation (Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan, Marsh & Winter, 2009; Firth et al., 2011; Wadephul, Jomeen & Glover, 2015; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019). At earlier gestations, parents prioritised knowing that their pregnancy was viable (Murakami et al., 2012). At later gestations, it was important for parents to know about the presence of fetal anomalies (Murakami et al., 2012). Knowledge of the fetal sex was highlighted as an important insight for some parents in trying to learn more about their baby (Freeman, 2000; Firth et al., 2011; Øyen & Aune, 2016). However, limitations of fetal sex determination were understood by parents, with reports to suggest doubt, particularly if it did not align with their preferences (Robak-Chołubek, Chołubek & Piróg, 2015; Murakami et al., 2012). This implied that fetal sex does not have a substantial impact on bonding, as parents seemed to value knowing the health of the baby as a priority (Freeman, 2000).

3.4.3.5 The importance of the parent-sonographer partnership during scanning

During scans, sonographers facilitated the connection between expectant parents and their babies (Firth et al., 2011), and contributed to parents' knowledge and understanding of the scan procedure (Ekelin, Crang-Svalenius & Dykes, 2004; Firth et al., 2011; Øyen & Aune, 2016; Westerneng et al., 2019).

Certain aspects of the sonographer's practice influenced parents' perceptions of their overall scan experience (Ekelin, Crang-Svalenius & Dykes, 2004; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016), which impacted on bonding (Boukydis et al., 2006). Parents' confidence in their sonographer was linked with narration of the scan (Freeman, 2000), highlighting the importance of the role of the sonographer in partnership with parents:

"The women also stressed the importance of having had the picture on the screen thoroughly explained" (Dykes & Stjernqvist, 2001).

Two studies noted the importance of language choices for sonographers (Ekelin, Crang-Svalenius & Dykes, 2004; Stephenson, McLeod & Mills, 2016). Limiting the use of non-medical terminology humanised the fetus, implied to parents that the sonographer recognised their unborn baby as an individual, and demonstrated professional investment in their care (Stephenson, McLeod & Mills, 2016). Making parents feel like they had been given sufficient time during the scan to engage with the experience and ask questions (Øyen & Aune, 2016) helped to reduce parental anxiety and was also important to delivering parent-centred care (Westerneng et al., 2019):

"I wish there was more time for the ultrasound so that she could explain more and also go through what can and cannot be seen" (Ekelin, Crang-Svalenius & Dykes, 2004).

3.4.3.6 Scans help to create a social identity for the unborn baby

The final theme represents parents' ongoing scan experience and how they continued to reflect on it to enhance attachment. Many parents centred their news about pregnancies around a scan (Sidi & Josheu, 2019), using it as 'proof' of their unborn baby to others (Ekelin, Crang-Svalenius & Dykes, 2004). Some parents waited until their first scan to tell friends and family about their pregnancies, sharing their pictures or videos (Ekelin, Crang-Svalenius & Dykes, 2004; Cadogan, Marsh & Winter, 2009; Wadephul, Jomeen & Glover, 2015). Scan mementos represented the baby in a physical presence that others could interact with, and this helped create a social identity before birth (Murakami et al., 2012). After birth, both the parents and the parents' social circle had a sense of 'knowing' the baby already (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Cristofalo et al., 2006; Cadogan, Marsh & Winter, 2009; Firth et al., 2011; Øyen & Aune, 2016; Stephenson, McLeod & Mills, 2016; Westerneng et al., 2019).

The perception of social support was an important factor in the developing prenatal attachment (Polizzi et al., 2017) and some mothers chose to bring people other than their partner to scans:

"I took my mother in law and my father…so they are also involved a little bit more with the pregnancy" (Westerneng et al., 2019).

3.5 Discussion

3.5.1 Main findings

This review explored how prenatal attachment is impacted by antenatal imaging. The objectives were to enhance current understanding of parents' experiences of pregnancy imaging, and to identify factors which could impact on attachment. Six pillar themes were identified, each describing an element of the scan experience and how it impacts the developing attachment. The experience begins in advance of the scan with the creation of expectations and continues by sharing pregnancy images and knowledge outside of the parental relationship.

3.5.2 Strengths and limitations

A strength of this review was in using the Pillar Integration Process, which enabled rigorous integration of results from quantitative and qualitative studies. It was chosen above other integration methods because the process is displayed clearly and is therefore replicable by others (Johnson, Grove & Clarke, 2019). An additional strength was the external support received from a subject expert librarian in developing the robust search strategy.

However, a few limitations need to be considered before drawing conclusions. First, the wide publication date range yielded many eligible studies but findings from earlier studies (particularly those involving 3D/4D ultrasound) may not be wholly generalisable to the current context given technological advancements and improvements in image quality (Pulliainen et al., 2019). Additionally, increasing availability of access to pregnancy imaging through private scan clinics may also have an impact on the parent experience which may not be fully represented within older studies.

A meta-analysis of quantitative studies was not conducted due to heterogeneity of data. The richness of common themes across both qualitative and quantitative studies however, highlighted

the importance of using the Pillar synthesis method to ensure these key themes were strong and thematic saturation was achieved between all eligible studies while addressing the conceptual complexity of prenatal attachment and parental experiences in antenatal imaging.

Despite the high yield returned from the searches, a thorough screening process was enabled by use of the EPPI-Reviewer4 software (Thomas, Brunton & Graziosi, 2010). This facilitated management of the records across a shared platform and kept an electronic "audit trail" of the reviewer's judgement against the defined inclusion criteria. Although partial double screening of the records may be considered a limitation of the study, high concordance between reviewers demonstrates the clarity of the inclusion criteria. Finally, to ensure breadth of knowledge in the review, some of the included studies were of low quality. Although it may be argued that this could limit the extent to which the findings can be transferred beyond the review, use of the Pillar Integration Process to synthesise qualitative and quantitative findings helps to mitigate conflicts by highlighting the commonalities across the studies. The need for more methodologically rigorous studies in future research is also emphasised.

3.5.3 Interpretation

Most studies in this review measured or reported increased attachment following scanning (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin, Crang-Svalenius & Dykes, 2004; Righetti et al., 2005; Rustico et al., 2005; Boukydis et al., 2006; Sedgmen et al., 2006; Lalor & Devane, 2007; Edwards et al., 2010; Firth et al., 2011; Murakami et al., 2012; de Jong-Pleij et al., 2013; Robak-Chołubek, Chołubek & Piróg, 2015; Stephenson, McLeod & Mills, 2016; Øyen & Aune, 2016; Sidi & Josheu, 2019). Fetal imaging provided a visual image of the unborn baby that enabled expectant parents to place them in their own familiar reality (Pedreira & Leal, 2015), thus promoting feelings of closeness. Scans gave visual confirmation of the pregnancy, and this reassurance of viability helped to enhance attachment. This is related to parents' pre-scan anxiety of receiving unexpected news,

including that of a fetal anomaly (Brisch et al., 2002; Van der Zalm & Byrne, 2006). Rothman historically described the concept of the 'tentative pregnancy' (Rothman, 1986) where parents delay feelings towards the pregnancy until they are more confident the pregnancy is viable (Rowe, Fisher & Quinlivan, 2009). Similarly, some find it more difficult to develop an attachment to their baby when an anomaly is diagnosed (Boztepe et al., 2016). In this review, one study reported a temporary decrease in attachment after mothers were informed of a fetal brain anomaly (Cristofalo et al., 2006). Detection of a fetal anomaly may be particularly distressing beyond the first trimester, as previous unremarkable scans may create a false sense of security (Ekelin et al., 2008). Parents must address the uncertainty of the diagnosis on their emotional investment to the pregnancy, whilst simultaneously processing the loss of the baby they had initially begun to connect with (Ruschel et al., 2014).

3.5.4 Parent-centred care and implications for sonographers

Parent-centred care by sonographers was highlighted as an essential element of the scan experience to positively enhance attachment (Businelli et al., 2021). When parents feel actively involved, their overall perception of the scan improves (Ranji, Dykes & Ny, 2012). A "good" scan is determined by positive interaction with sonographers (Van der Zalm & Byrne, 2006), which helps to improve parents' recognition of images and strengthen their understanding of the examination (Walsh, 2010; Masroor, Ahmed & Ajmal, 2008). Parents are then more likely to feel satisfied that their expectations for the scan have been met, even if the overall image quality during the scan is limited (Whynes, 2002). The review supports this finding, as whilst novel imaging techniques (e.g., 3D/4D ultrasound) may be considered desirable, any perceived impact on attachment may be attributed by parents to the explanation given to help interpret the image rather than the image itself (Ranji, Dykes & Ny, 2012). This emphasises the integral role of the sonographer during the scan, who personifies the interface between technology and parental knowledge and collaborates with

expectant parents to help construct an identity for the fetus (Roberts, 2012). Whilst the medical purpose of the examination is paramount, viewing the scan more holistically to incorporate parent-centred care practices should also be considered in the provision of sonographic education and training (Walsh, 2020).

Making the scan a satisfactory experience for parents (Chudleigh, 1999) should also be considered in providing parent-centred care, with a focus on promoting open communication (Øyen & Aune, 2016). However, with the extensive clinical requirements of scans placing heavy demand on sonographers (Masroor, Ahmed & Ajmal, 2008) it is not surprising parents may feel their expectations are not met (Ekelin, Crang-Svalenius & Dykes, 2004). Emerging technologies using artificially intelligent algorithms to automate scan processes or provide clinical support for sonographers may help reduce demand (Baumgartner et al., 2018; Sinclair et al., 2018; Yaqub et al., 2019), however further, large-scale prospective testing is required to evaluate the real-world clinical utility and impact on the delivery of parent-centred care (Drukker, Noble & Papageorghiou, 2020).

A cross-cutting theme was the importance of partners at scans. For fathers and non-pregnant partners, the lack of physical cues can make it difficult to accept the reality of the pregnancy, leading to distress, depression and poor attachment (Fenwick, Bayes & Johansson, 2012). Scans help fathers and non-pregnant partners to engage with the pregnancy and get to know the baby through visual cues (Ekelin et al., 2008). The baby represents a project shared between a couple (Cristofalo et al., 2006; Pedreira & Leal, 2015) and the scan is a pregnancy-related event that both parents can experience simultaneously (Fenwick, Bayes & Johansson, 2012). Knowledge about the unborn baby is acquired together, and physical movements can be witnessed in real time during the scan, providing fathers and non-pregnant partners with a glimpse into the otherwise privileged access their partner has of the pregnancy (Harpel and Barras, 2017). The “thrill” of being present cannot be fully felt through images shared afterwards (Firth et al., 2011), and the scan experience may further support the intrapsychic dynamics of the expectant parents by enabling an encounter with their imagined

child (Walsh et al., 2017). When the coronavirus pandemic reached the UK in March 2020, many maternity departments placed temporary restrictions on those accompanying pregnant people to antenatal scans to minimise virus transmission. The impact of these restrictions on prenatal attachment is yet to be formally evaluated, however a recent report concludes there may be long term implications for parents, babies, and families including 'psychosocial functioning, early parenting and child developmental outcomes' (Lalor et al., 2021).

3.5.5 Implications for future research

This review identified the lack of published studies exploring the potential impact of fetal MRI on prenatal attachment. The searches identified two studies reporting the parent's perspective of fetal MRI (Reed, Kochetkova & Whitby, 2016; Lie et al., 2019), however they were excluded because they did not specifically describe the impact on prenatal attachment. As fetal MRI becomes popular to complement conventional ultrasound, the acceptability of this modality to parents and its potential effect on attachment requires further evaluation to facilitate successful integration into clinical pathways. In addition, the studies in this review emphasise pregnancy scans as a visual experience. Advances in 3D printing help the scan experience to be more accommodating for expectant parents who are visually impaired, contributing to attachment (Werner et al., 2016; Coté et al., 2020). These studies were excluded from this review because the 3D print was the research intervention, however they highlight the importance for sonographers performing scans to consider the needs of parents with additional sensory requirements when delivering high-quality, parent-centred care.

3.6 Conclusion

This review highlights antenatal scans as an important pregnancy experience that can enhance prenatal attachment. As well as giving reassurance regarding the health of their unborn

baby, scans also provide a visual image which parents can engage with in real-time and utilise for attachment by attributing physical and psychological characteristics, thus transforming the baby from a medical entity (fetus) to be recognised as an individual person. The success of this transformation is dependent on sonographers interpreting images in a way that becomes accessible to parents. Sonographers can help facilitate the attachment process by providing an interactive, parent-centred scan experience that is tailored to parents' individual emotional needs and requests of information and knowledge for the gestation of pregnancy.

4 UK obstetric sonographers' experiences of the COVID-19 pandemic: Burnout, role satisfaction, and impact on clinical practice (Article 2)

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4.1 Abstract

Introduction

The COVID-19 pandemic placed additional demands and stressors on UK obstetric sonographers, who were required to balance parent safety and service quality, alongside staff safety. Increased pressure can negatively impact a healthcare worker's wellbeing and the provision of person-centred care. The aim of this study was to explore obstetric sonographers' experiences of performing pregnancy ultrasound scans during the pandemic, and to assess the impact on burnout, role satisfaction, and clinical practice.

Methods

An online, anonymous, cross-sectional survey was created to capture sonographers' experience alongside using the Oldenburg Burnout Inventory (OLBI) to evaluate burnout, and the CORE-10 to measure psychological distress.

Results

Responses were received from 138 sonographers. Of those completing the OLBI (n = 89), 92.1% and 91.0% met the burnout thresholds for exhaustion and disengagement respectively. Sonographers with a higher burnout score also perceived that COVID-19 had a greater negative impact on their practice ($p<0.05$). The mean CORE-10 score of 14.39 (SD 7.99) suggests mild psychological distress amongst respondents. A significant decrease in role satisfaction was reported from before to during the pandemic ($p<0.001$), which was associated with higher scores for burnout and psychological distress ($p<0.001$). Change in role satisfaction was correlated with sonographers' perception of safety whilst scanning during the pandemic ($R^2 = 0.148$, $p<0.001$). Sixty-five sonographers (73.9%) reported they were considering leaving the profession, changing their area of practice, or working hours within the next 5 years.

Conclusion

Job and context-specific interventions are required to mitigate burnout and its consequences on the workforce and service provision beyond the pandemic.

Key words: Burnout; COVID-19; Job satisfaction; Obstetrics; Sonographer; Well-being

4.2 Introduction

Occupational burnout syndrome is a psychological phenomenon defined as a "prolonged response to chronic emotional and interpersonal stressors on the job" (Maslach, Schaufeli & Leiter, 2001). The development of burnout in obstetric sonographers can be explained using the job demands-resources model, which identifies two processes leading to the burnout domains of exhaustion and disengagement. In the "job demands" process, exhaustion is a consequence of sustained physical and/or psychological work pressures (e.g., heavy workload, interpersonal interactions, sub-optimal work environment) (Demerouti et al., 2001). Demands specific to obstetric sonographers, which also contribute to the exhaustion domain, include unexpected news delivery in cases of fetal anomaly or miscarriage (Johnson et al., 2019), maintaining concentration while experiencing distractors in the scan room (Najafzadeh, Woodrow & Thoirs, 2019), as well as the physical exertion of scanning a population with increasing body habitus (Hennig et al., 2019). Meeting these demands can be made more challenging by a lack of "job resources", including support from supervisors and opportunities for personal growth, which can lead to disengagement from work (Hakanen, Schaufeli & Ahola, 2008).

High and rising levels of burnout in healthcare practitioners, including sonographers, have been previously acknowledged (Johnson et al., 2018; Shields et al., 2021). Additional stressors of the COVID-19 pandemic (e.g., lack of personal protective equipment (PPE), fear of contracting or transmitting the virus, or working under rapidly changing guidelines) may also have a negative psychological impact on healthcare workers (Chigwedere et al., 2021), thus there is potential for the proportion of sonographers meeting the threshold for burnout post-pandemic to be even higher than previously reported. The consequences of burnout on HCPs are well-known, with established associations between the syndrome, mental health, job performance and patient care (Salyers et al., 2017). During obstetric ultrasound scans, the parent-sonographer partnership is integral to support the delivery of parent-centred care, however there is limited research into burnout in medical

imaging professionals (Shields et al., 2021), and even less regarding the specific impact of sonographer burnout on parental experiences of fetal ultrasound (Cohen, Childs & Maranna, 2021).

An additional challenge faced by obstetric sonographers during the pandemic, was that many clinical departments temporarily restricted the attendance of partners and support persons at scans in an attempt to minimise virus transmission (The Society and College of Radiographers, 2020). In addition to the clinical requirements of the examination, fetal ultrasound scans are often regarded as a milestone event in pregnancy, which provide expectant parents with an opportunity to see their unborn baby. Whilst most parents were understanding of these measures, the profession received critical media attention from expectant parents, other healthcare staff, and parent advocacy groups (Iacobucci, 2020), which may have further contributed to stress in sonographers.

The aim of this study was to explore sonographers' experiences of performing obstetric ultrasound examinations in the UK during the COVID-19 pandemic, to further understand the impact of the pandemic on sonographer burnout and psychological wellbeing, and to consider the implications on the sonographic workforce.

4.3 Methods

A UK-wide, cross-sectional open survey design was used to collect data from an anonymous, online questionnaire, created using the secure Qualtrics XM™ survey platform (www.qualtrics.com). The Checklist for Reporting Results of Internet E-Surveys (CHERRIES) was used to guide the reporting of the survey methods and results (Eysenbach, 2004). This 30 item checklist helps to standardise the reporting of web-based surveys to enable readers to identify potential bias in the methods and establish their own conclusions about the validity of the findings. The questionnaire was divided into four sections: part 1 captured sonographer experiences of obstetric scanning during the COVID-19 pandemic, parts 2 and 3 used the validated Oldenburg Burnout Inventory (OLBI) and CORE-10 tools to evaluate and measure sonographer burnout and psychological distress respectively, and part 4 recorded basic demographic information (e.g., age, geographical location, and employment status) (Appendix 5). Where appropriate, open-ended questions were used (e.g., for participants to provide additional detail if they wished to). These free-text responses will be qualitatively analysed and included in a separate publication as part of a larger doctoral research project (www.blogs.city.ac.uk/afi-study). The questionnaire was piloted for usability with members of the Society of Radiographers' Ultrasound Advisory Group. Their recommendations for minor changes to the wording and display of some questions were incorporated into the final version, prior to launch, for improved accessibility. Participants were prompted (but not forced) to answer all questions and were given the option to review and change answers using navigation buttons within the survey. As the survey contained a mixture of response types (e.g., single click vs. free text), no restrictions were placed on the time allotted for completion. To ensure anonymity, no directly identifying participant information was collected. The survey was designed so that participants were prevented from attempting to complete it more than once.

The questionnaire was live for eight weeks between 9th March-6th May 2021. The recruitment strategy used snowball sampling via social media channels (Twitter, Facebook, LinkedIn), and word-of-mouth through professional networks to circulate a weblink to the questionnaire.

Participants were required to meet all of the following inclusion criteria to be eligible to take part: 1) a qualified sonographer/ultrasound practitioner who has performed obstetric ultrasound scans in the UK since March 2020 (e.g., during the COVID-19 pandemic), 2) aged ≥21 years, and 3) informed consent form completed. No incentives were offered to participants. The data collection period coincided with the UK's third national lockdown which began on 6th January 2021 (Institute for Government, 2021).

4.3.1 Oldenburg Burnout Inventory (OLBI)

The OLBI comprises of 16 items covering two dimensions: exhaustion (OLBI-E) and disengagement (OLBI-D) from work, which reflect the physical and cognitive aspects of occupational burnout. The highest burnout response to each item scores 4 points, and the lowest scores 1 point. The total burnout score was recorded, and average scores for each dimension were calculated and compared against a threshold of ≥2.25 for exhaustion and ≥2.10 for disengagement, which have been used previously to determine burnout in other studies (Peterson et al., 2008; Collin et al., 2019; Tan et al., 2020).

4.3.2 CORE-10

The CORE-10 is a short, generic measure of psychological distress that includes ten items addressing depression, anxiety, trauma, and physical problems. A score of ≥25 indicates severe psychological distress (Connell & Barkham, 2007).

4.3.3 Statistical analysis

Data were analysed using Microsoft Excel (version 2008, Microsoft Corporation, USA) and IBM SPSS Statistics (version 26, SPSS Inc, USA). Q-Q plots demonstrated normally distributed data for

parametric statistical analysis to be performed. Where appropriate, analysis of variance (ANOVA) with post-hoc testing was used to identify any differences between means of the OLBI, CORE-10 and COVID-19 experience sections of the questionnaire in different sociodemographic groups (e.g., education, geographical region, years of clinical experience, and employment status). T-tests were used to further compare means, and the Pearson correlation coefficient was used to quantitively assess for any evidence of a linear relationship between variables. A value of $p<0.05$ was used to determine statistical significance and a value of $R^2>0.7$ was used to determine strong linear correlation. Standard deviation is reported in the results as SD.

4.3.4 Ethical considerations

This study received formal approval from City, University of London (reference: ETH2021-1240, date of approval: 9th March 2021). Although all data were collected remotely and anonymously, participant well-being was considered with the provision of contact details for two UK-based mental health support groups where participants could self-refer and seek support. All participants confirmed their consent electronically via Qualtrics XM™ before they were able to proceed to the questionnaire. All data were managed as per university guidance.

4.4 Results

4.4.1 Participant characteristics

In total, 138 sonographers actively participated in this study. Of those, 63.6% (n=84) completed part 1 in full, 67.4% (n=89) completed parts 2 and 3, and 66.7% (n=88) completed part 4 of the questionnaire. Not all participants answered every question which resulted in some missing data, however all recorded responses were still included in the analysis. The average completeness for the entire questionnaire was 81%. Of those who answered the participant information questions (n=89), the largest proportion of respondents identified as female (n=86, 96.6%), of white/British/Welsh/Scottish/Northern Irish/Gypsy or Irish Traveller ethnicity (n=77, 86.5%), between the ages of 51-60 years (n = 31, 34.8%) and working in the South East region of England (n=20, 22.5%). Full participant characteristics are reported in Table 4.1.

Table 4.1 Participant characteristics

Age Group	21-30, n = 12 (13.48%) 31-40, n = 20 (22.47%) 41-50, n = 24 (26.97%) 51-60, n = 31 (34.84%) 61+, n = 2 (2.25%)
Gender	Female, n = 86 (96.63%) Male, n = 2 (2.25%) Prefer not to say, n = 1 (1.12%)
Ethnicity	White / British/ Welsh / Scottish / Northern Irish / Gypsy or Irish Traveller, n = 77 (86.52%) Asian / Asian British, n = 4 (4.49%) Mixed / Multiple ethnic, n = 2 (2.25%) Other, n = 2 (2.25%) Black / African / Caribbean / Black British, n = 1 (1.12%) Prefer not to say, n = 3 (3.37%)
Education	University degree (postgraduate), n = 79 (87.00%) Diploma in Medical Ultrasound (DMU), n = 5 (5.00%) University degree (undergraduate), n = 3 (3.00%) Prefer not to say, n = 3 (3.00%)
Years of experience	0-5, n = 19 (21.35%) 6-10, n = 13 (14.61%) 11-15, n = 18 (20.22%) 16-20, n = 13 (14.61%) 21-25, n = 9 (10.11%) 26+, n = 17 (19.10%)
Professional memberships	Society of Radiographers, n = 79 British Medical Ultrasound Society, n = 40 Royal College of Midwives, n = 9 International Society of Ultrasound in Obstetrics and Gynecology, n = 2 Royal College of Nursing, n = 1 Other, n = 1 Prefer not to say, n = 1
Geographical location	England – South East, n = 20 (22.47%) England – North West, n = 13 (14.61%) England – South West, n = 13 (14.61%) England – East, n = 10 (11.24%) England – London, n = 9 (10.11%) England – East Midlands, n = 6 (6.74%) England – West Midlands, n = 5 (5.62%) England – Yorkshire and the Humber, n = 4 (4.49%) Wales, n = 3 (3.37%) Scotland, n = 2 (2.25%) Prefer not to say, n = 4 (4.49%)
Employment status	Full-time employment (NHS/public sector), n = 44 (49.44%) Part-time employment (NHS/public sector), n = 42 (47.19%) Part-time employment (private practice), n = 1 (1.12%) Other, n = 1 (1.12%) Prefer not to say, n = 1 (1.12%)

4.4.2 Sonographer experiences of obstetric scanning during COVID-19

Of those answering the question (n = 107), most sonographers (97.2%, n = 104) reported using PPE (either employer provided or self-supplied) when scanning asymptomatic pregnant women or people. For symptomatic pregnant women or people, 97.6% (n = 83) of sonographers answering the question (n = 85) reported using PPE when scanning. There were 17 sonographers who reported they were not scanning symptomatic pregnant women or people at all. Sonographer opinions were sought on a range of issues using scales where 0 = negative response/impact or portrayal and 10 = positive response/impact or portrayal (Figure 4.1). Firstly, sonographers were asked how safe they felt performing pregnancy scans during the pandemic, giving a mean score of 4.25 (SD 2.58). When asked to rate the impact of COVID-19 on their scanning practice, the mean score was 6.40 (SD 2.68). The impact of COVID-19 on communication with expectant parents was rated at an average score of 4.03 (SD 1.87). Sonographers' mean rating of the impact of COVID-19 on the overall parent experience of obstetric ultrasound was 3.27 (SD 1.67).

4.4.3 Portrayal of the sonographic profession in the news during COVID-19

When asked how they felt the profession had been portrayed in the news (e.g., newspapers and online press articles) during the pandemic, the sonographers' mean score was 1.94 (SD 1.74) (Figure 4.1). The lowest mean score was reported in the West Midlands (0.6, SD 0.55) and the highest was in Wales (3.33, SD 2.89) (Figure 4.2).

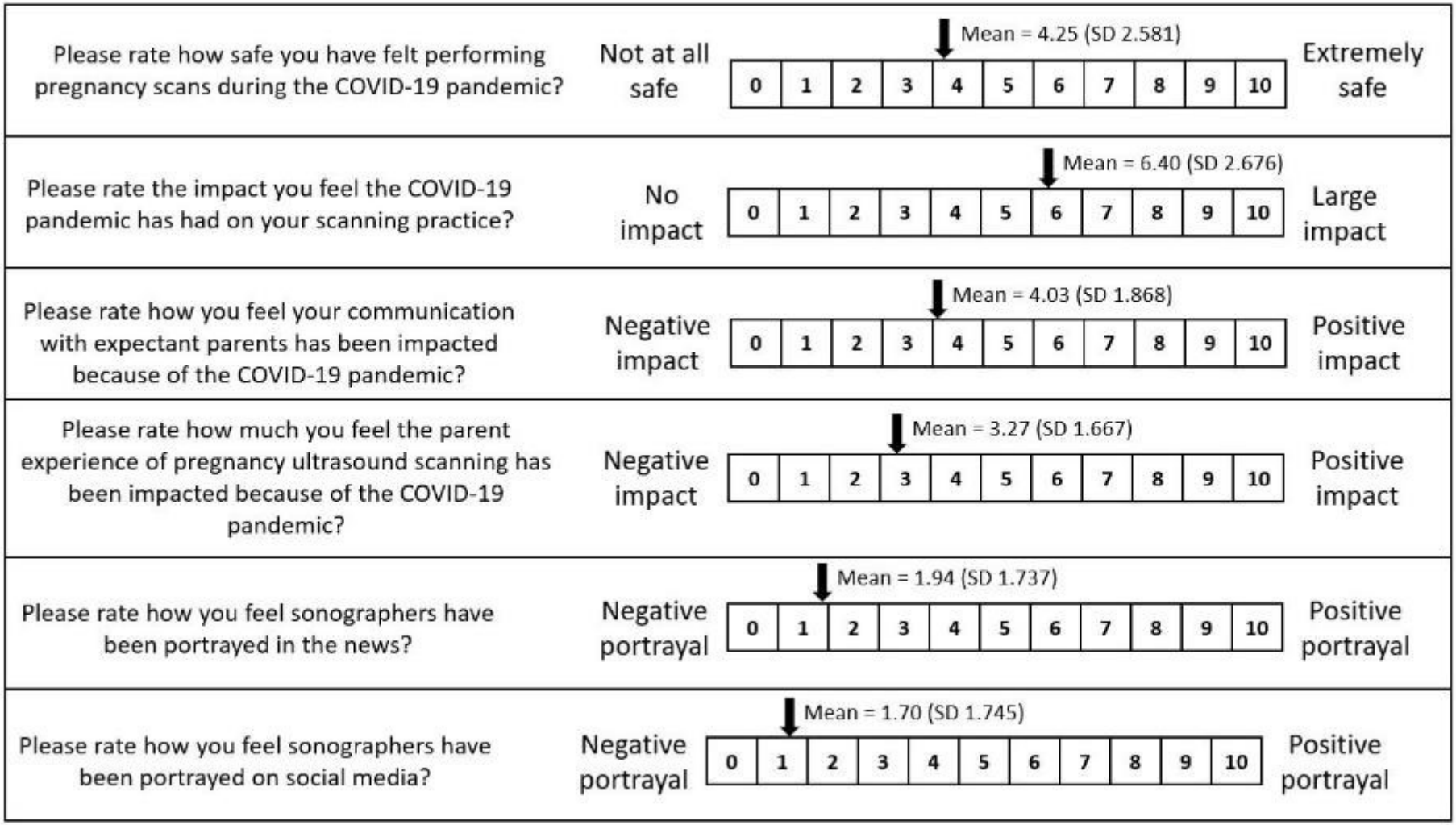

Figure 4.1 Impact of COVID-19 on sonographic practice

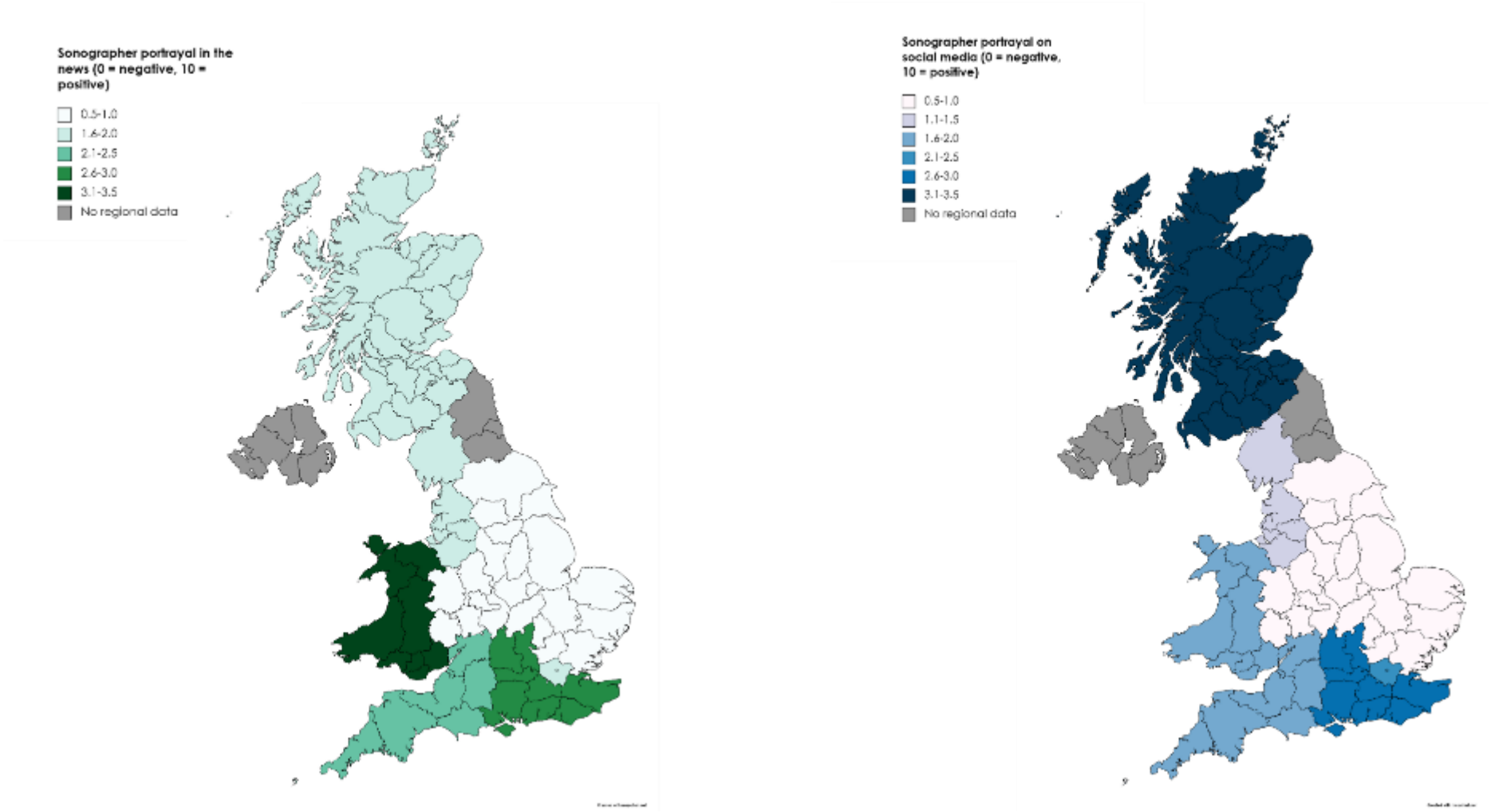

Figure 4.2 Geographical variation in perception of sonographer's portrayal in the media

4.4.4 Portrayal of the sonographic profession on social media during COVID-19

The mean score for the portrayal of the sonographic profession on social media (e.g., Twitter, Facebook) was 1.70 (SD 1.75) (Figure 4.1). The lowest mean score was again reported in the West Midlands (0.40, SD 0.55) and the highest was in Scotland (3.50, SD 2.121). For portrayal of the profession in both the news and on social media, the mean scores by geographical region did not exceed 3.5 (Figure 4.2).

A paired t-test showed the mean difference in sonographer portrayal in the news and on social media was not significant ($p = 0.110$), however a moderate positive correlation was noted between the scores ($R^2 = 0.427$, $p<0.001$). The perceived portrayal of sonographers in the news scored an average of 0.24 more positive than on social media (95% CI [-0.055, 0.529]).

4.4.5 Reliability analysis

Cronbach's Alpha showed good internal consistency of the OLBI for the eight items of the exhaustion dimension ($\alpha = 0.802$), and acceptable internal consistency for the eight items of the disengagement dimension ($\alpha = 0.777$). The reliability analysis performed on the ten items of the CORE-10 showed good internal consistency ($\alpha = 0.881$).

4.4.6 Burnout (OLBI) and psychological distress (CORE-10)

Of a maximum 64 points, the mean total burnout (OLBI) score was 44.47 (SD 7.60). The mean score for the exhaustion domain was 2.96 (SD 0.49), and 2.67 (SD 0.48) for disengagement. The results showed 92.1% of sonographers (n = 82) met the burnout threshold for exhaustion (≥2.25) and 91.0% (n = 81) met the burnout threshold for disengagement (≥2.10). Geographical region, education, years of experience and employment status (e.g., full or part time) did not appear to influence exhaustion scores in this study.

The mean CORE-10 score was 14.39/40 (SD 7.99). This equates to mild psychological distress. No significant differences were identified between grouped participant characteristics and CORE-10 score.

The Pearson correlation coefficient demonstrated a statistically significant linear relationship between total burnout (OLBI) score and psychological distress (CORE-10) score ($R = 0.737$, $R^2 = 0.543$, $p<0.001$). The magnitude of the association was moderate. This shows a positive trend between sonographers with a higher burnout score and higher levels of psychological distress (Figure 4.3).

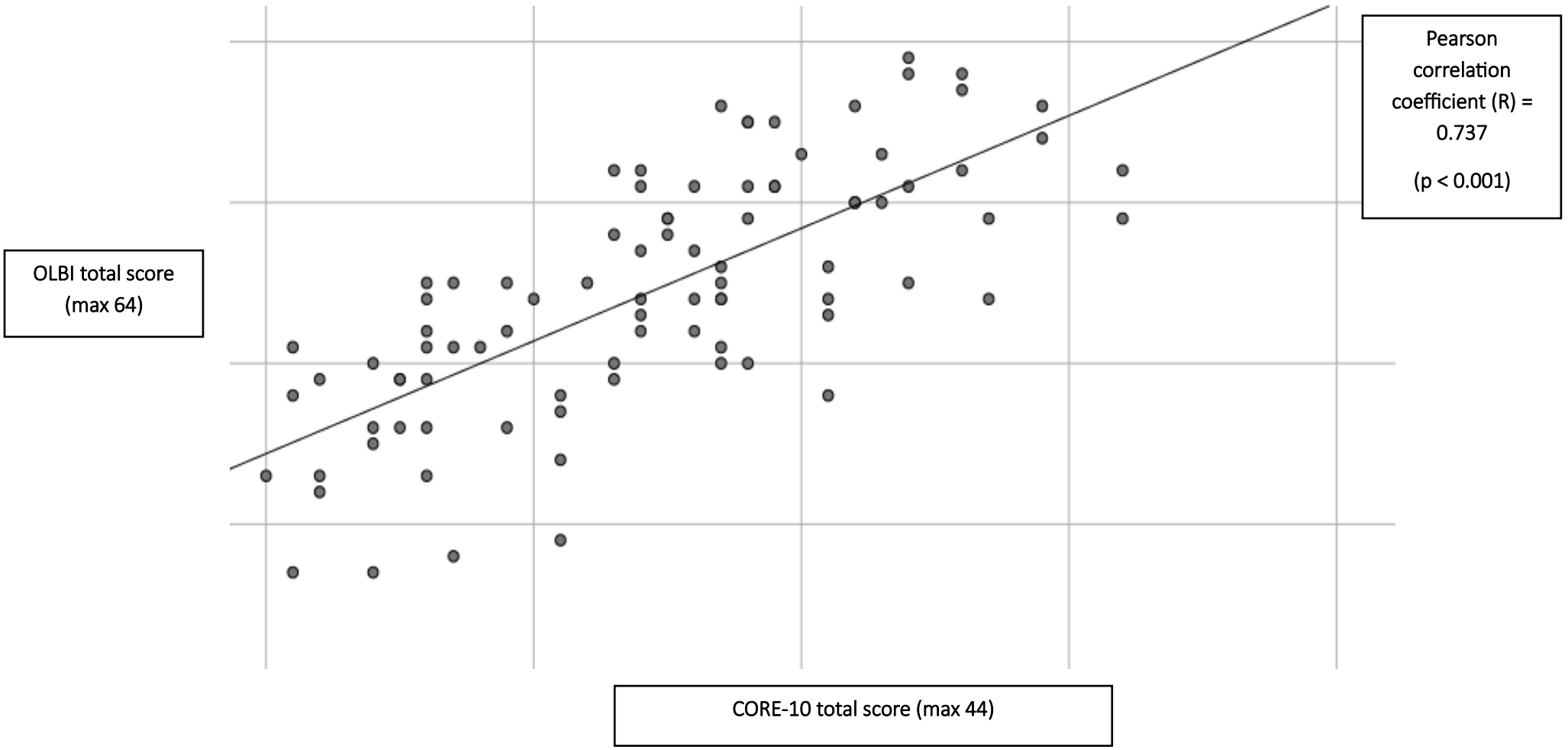

Figure 4.3 Correlation between OLBI and CORE-10 score

4.4.7 Sonographer experiences, burnout, and psychological distress

The Pearson correlation coefficient was calculated to assess the association between different aspects of sonographer experience factors and the total burnout (OLBI) or psychological distress (CORE-10) score. Statistically significant negative linear relationships were demonstrated between sonographers' perception of safety and total burnout score ($R^2 = 0.198$, $p<0.001$) and distress score ($R^2 = 0.079$, $p = 0.008$). A positive trend was observed between the sonographers' perceived impact of COVID-19 on obstetric scanning practice and total burnout score ($R^2 = 0.044$, $p = 0.048$). No other statistically significant associations were demonstrated.

4.4.8 Impact of COVID-19 pandemic on sonographer satisfaction in role

Where 0 = not at all satisfied and 10 = very satisfied, mean satisfaction in the sonographer role prior to the COVID-19 pandemic was 6.99 (SD 2.01). Role satisfaction before the COVID-19 pandemic scored on average 2.87 points higher than during the pandemic (SD 2.58, 95% CI [2.35,3.39]), resulting in a significant change in sonographer role satisfaction from before to during the pandemic ($t_{97} = 10.988$, $p<0.001$). A significant, positive correlation between sonographers' individual pre- and during-pandemic role satisfaction scores was demonstrated ($R^2 = 0.145$, $p<0.001$). No differences were seen in role satisfaction between grouped participant characteristics using ANOVA, however statistically significant linear relationships were demonstrated between the change in satisfaction and total burnout ($R^2 = 0.157$, $p<0.001$), and psychological distress scores ($R^2 = 0.095$, $p=0.003$). In addition, statistically significant negative correlations were also demonstrated between respondents' change in role satisfaction and sonographers' portrayal in the media ($R^2=0.050$, $p = 0.028$), portrayal on social media ($R^2 = 0.066$, $p = 0.011$), and perception of safety ($R^2 = 0.148$, $p<0.001$).

4.4.9 Impact of COVID-19 on working practice

Of the 88 sonographers who answered the question “Are you thinking about leaving the profession, changing your area of practice, or working hours within the next 5 years?”, 73.9% (n = 65) responded “yes” (Figure 4.4). Of these, 67.1% (n = 47) of sonographers said that their practice change would happen sooner than planned because of the COVID-19 pandemic. Nearly a quarter of sonographers (24.6%, n = 16) reported their intention to change their practice by no longer performing obstetric ultrasound examinations. Change of practice was weakly positively correlated with psychological distress (CORE-10) score (R^2 = 1.359E-4) and difference in role satisfaction before and during the pandemic (R^2 = 0.012), however neither were significant associations. Change of practice was weakly negatively correlated with total burnout (OLBI) score (R^2 = 0.010), although this was not significant either.

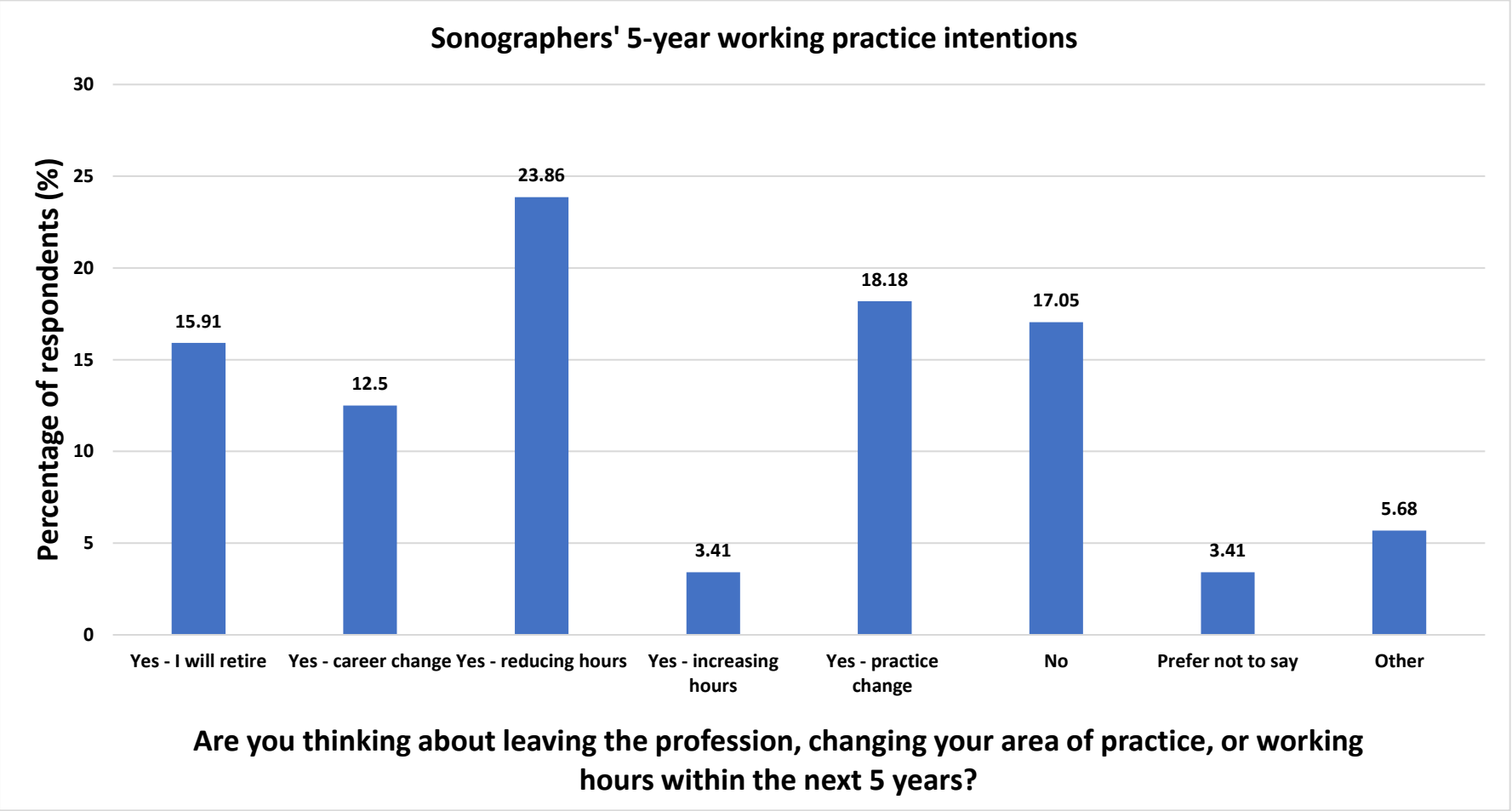

Figure 4.4 Sonographers' 5 year working practice intentions

4.5 Discussion

This study aimed to explore the impact of the COVID-19 pandemic on sonographers performing obstetric ultrasound examinations in the UK. Over 90% of sonographers in this sample who completed the OLBI met the burnout thresholds for exhaustion or disengagement. The findings of this study suggest a greater incidence of burnout amongst the sonographic workforce compared to similar studies using the OLBI to evaluate COVID-19 related burnout in HCPs. For example, Denning et al. identified 67% of healthcare workers from across the UK, Poland, and Singapore as being high risk for burnout (Denning et al., 2021). Tan et al. reported 75.3% and 79.7% of healthcare workers meeting the threshold for exhaustion and disengagement respectively (Tan et al., 2020). In both studies, healthcare workers were identified as doctors, nurses, allied health professionals, and non-clinical/administrative staff. Higher burnout score was associated with being in a clinical role and redeployment to a new clinical area (Tan et al., 2020; Denning et al., 2021), however the site of work (e.g., hospital, community, home-based) was not (Tan et al., 2020).

Tan et al. also found those who scored highly for burnout were more likely to score higher for psychological distress, as demonstrated by a significant, positive correlation (Tan et al., 2020). This finding is supported by Chigwedere et al.'s systemic review, which observed a predictive relationship between high anxiety scores and burnout (Chigwedere et al., 2021). In this study, a higher total burnout score was also significantly associated with a negative perception of the impact of COVID-19 on scanning practice. It was also demonstrated that sonographers who reported a large negative change in role satisfaction before and during the pandemic were more likely to have higher total burnout and distress scores. This implies that reduced job satisfaction contributes to burnout and psychological well-being for sonographers. A similar relationship between job satisfaction and psychological distress in primary healthcare nurses was reported by Stefanovska-Petkovska et al. who also noted a statistically significant association between negative job satisfaction and resignation (Stefanovska-Petkovska et al., 2021). However, in this study, no significant association was demonstrated between change in role satisfaction post-pandemic, and planned changes to practice.

Statistically significant relationships (albeit weak) were observed between sonographers' perceptions of feeling safe whilst scanning and total burnout and distress scores. A recent study reported elevated psychological distress in Israeli dentists and dental hygienists who were fearful of contracting COVID-19 (Shacham et al., 2020), which suggests this may have been an important moderator (Chigwedere et al., 2021).

4.5.1 Impact of burnout on the sonographic workforce

In addition to the negative impact on individuals' well-being (Chigwedere et al., 2021; Hakanen, Schaufeli & Ahola, 2008), high levels of burnout within the workforce have several important implications for sonographic practice. An association between practitioners who score highly for occupational burnout and absenteeism has been reported (Peterson et al., 2008; Ahola et al., 2008). With the sonographic workforce vacancy rate at 12.6% (The Society and College of Radiographers, 2019) and increased sickness rates from COVID-19 and through precautionary measures of self-isolation (Office for National Statistics, 2021), additional absenteeism because of burnout is likely to further heighten the workload and subsequent job demands of other obstetric sonographers. This in turn may contribute to their increased exhaustion. Indirectly, burnout may also affect the sonographic team through its influence on working conditions, leading to dissatisfaction and disengagement with the work, and reduced organisational commitment (Hakanen, Schaufeli & Ahola, 2008). In this study, a significant decrease in sonographer role satisfaction (compared with perceived satisfaction pre-pandemic) was noted during the pandemic. One highly debated response to employee dissatisfaction is that of the Exit-Voice-Loyalty-Neglect (EVLN) typology, whereby in reacting to a problematic event, a worker may resign (exit), attempt to improve the situation (voice), wait to see if the issue will be resolved (loyalty) or passively obstruct potential improvements, for example, through lack of interest (neglect) (Aravopoulou, Mitsakis & Malone, 2017). Of those answering the question in this study, over 70% of sonographers stated they were considering leaving

or changing their practice within the next 5 years. As this was not found to be significantly associated with burnout, psychological distress or role satisfaction, this typology further highlights the negative impact of the pandemic on the workforce by the high proportion of sonographers with the intention to remove themselves from the clinical situation completely (exit) over other responses (e.g., voice or loyalty).

4.5.2 Potential impact of burnout on provision of parent-centred care

Despite concerns regarding the physical barrier of PPE as a hindrance to effective patient-practitioner interaction (Lapow, 2020), sonographers rated the impact of COVID-19 on their communication with parents as mildly negative to none in this study. Although this study was unable to directly assess the impact of burnout on parent care and outcomes, Freudenberger reported that regardless of effort, burnout will affect how efficiently an individual can perform (Freudenberger, 1974). High levels of burnout are associated with poor patient safety outcomes, including increased likelihood of errors (Hall et al., 2016) as well as low-quality patient interaction and care experiences (Salyers et al., 2017). In this study, sonographers indicated that the pandemic had a moderate impact on their scanning practice and perceived a mildly negative impact on the parent's experience of the ultrasound scan. The parent experience of obstetric ultrasound may be enhanced when they are actively involved in the scan (Boukydis et al., 2006), however it is suggested that exhausted HCPs may be more likely to view patient requests for interactivity as demanding (Bakker et al., 2000). Repeated interactions that evoke feelings of cynicism over time can cause practitioners to withdraw and disengage in an attempt to conserve their emotional resources (Bakker et al., 2000). This explanation is based on theories of social equity and reciprocity applied to healthcare settings, whereby a perceived imbalance in the patient-practitioner relationship (e.g., the caregiver feels their investment in the relationship is significantly greater than is reciprocated by the patient) actively contributes to burnout syndrome (Bakker et al., 2000), further impacting on care delivery.

4.5.3 Reciprocity and role satisfaction

Reciprocation from patients through expression of gratitude has been shown to reduce burnout in nurses (Converso et al., 2015). In this study, a negative correlation was demonstrated between how respondents felt the sonographic profession had been portrayed in the news and on social media during the pandemic, and their change in role satisfaction during the pandemic. Interestingly, significant differences were also found between geographical regions and the sonographer's media portrayal, suggesting there may have been areas in the UK where the media attention was more concentrated. During the pandemic, other HCPs also received a lot of public attention, however, much of it was in praise of "heroic" frontline workers (e.g., #clapforheroes). This narrative has been questioned for its potential adverse psychological effects on staff, causing stress through increased moral responsibility (Sriharan et al., 2021), as well as implying that reciprocal social obligations are unrequired (Cox, 2020). In addition, persistent unrealistic expectations about the inter-personal relationship between staff and their patients can also cause imbalance of reciprocity when they are not met, leading to burnout of the individual. This can affect the whole team via the socially-induced model of burnout transmission (Bakker, Demerouti & Schaufeli, 2006). Sonographic teams are typically small and work closely together, thus there is a greater chance of being directly exposed to, and mirroring a colleague's symptoms of exhaustion or disengagement, or reaching burnout because of a change in work conditions initiated by a colleague with burnout (Bakker, Demerouti & Schaufeli, 2006). Many burnout interventions suggested in published literature focus on promoting individual well-being and resiliency, with limited evidence of efficacy demonstrated (Sriharan et al., 2021). Therefore, interventions that address occupation-specific factors contributing to burnout may be more successful in easing exhaustion and disengagement. As per Demerouti et al. (2001), these should aim to reduce job demands (e.g., improving the physical working environment or varying tasks to balance the physical workload) whilst providing greater job resources (e.g., personal support from supervisors, opportunities for career development). This

model suggests that significant action at organisational-level may now be required to alleviate pandemic-induced burnout.

4.5.4 Strengths and limitations of study

A strength of this study was the use of the validated OLBI and CORE-10 tools. These demonstrated good reliability within the study and have clearly defined thresholds which were used to aid interpretation of results. The sample size may be considered relatively small and not representative of the UK obstetric sonographer population, however, it was comparable with other UK sonographer studies (Johnson et al., 2019; Singh et al., 2017). Whilst the results focus on, as needed, the peak of the COVID-19 pandemic, the cross-sectional design of this study limits conclusions of causality (Wang & Cheng, 2020). The self-selected and self-reported participation may skew the results towards those motivated to share negative personal experiences. In addition, the results are susceptible to common method bias (a known limitation of questionnaire design where the same tools are used to collect all data), which can result in artefactual estimates of the relationships between constructs (Jordan & Troth, 2020). Whilst the homogeneity of participant characteristics for gender and ethnic identity improves confidence that the findings accurately represent the study sample, the results cannot be generalised to a wider, more heterogeneous population and are therefore limited beyond this specific demographic (Jager, Putnick & Bornstein, 2017).

4.5.5 Future research

A follow-up survey to compare sonographer wellbeing and role satisfaction after the pandemic would be beneficial to determine whether self-reported burnout scores reduce when the additional stressors of COVID-19 are diminished. This may also help to identify any limitations in the study data incurred through over-reporting of negative personal experiences during the pandemic.

Considering an alternative method of data collection, for example, using impartial assessors to determine burnout, may also be more accurate than using self-reported scores. Qualitative analysis of free text responses collected as part of this questionnaire may provide deeper insight to sonographers' experiences of performing obstetric ultrasound scans during the COVID-19 pandemic to help further inform the quantitative observations. Further research could also consider the impact of individuals' differences (e.g., personality traits, home demands) on burnout and psychological wellbeing (Hakanen, Schaufeli & Ahola, 2008).

4.6 Conclusion

Most respondents in this study met burnout thresholds for exhaustion and disengagement. Sonographers with a higher burnout score also demonstrated higher levels of psychological distress, and negative changes in role satisfaction, which has implications in the delivery of parent-centred care. Sonographers perceived the pandemic to have had a moderate impact on their immediate scanning practice, however the findings of this study suggest the longer-term impact on the workforce is yet to be fully realised as demonstrated in the high proportion of respondents considering a change in their clinical practice within the next 5 years. Urgent interventions are therefore required to mitigate the consequences of burnout within the profession, such as those to reduce job demands and increase resources, improve sonographer role satisfaction, and enhance and promote positive relationships between sonographers and expectant parents in the scan room.

5 “It has been the most difficult time in my career”: A qualitative exploration of UK obstetric sonographers’ experiences during the COVID-19 pandemic (Article 3)

This chapter was published as:

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5.1 Abstract

Introduction

Substantial changes were made to the provision of pregnancy ultrasound services during the COVID-19 pandemic with the intention of minimising virus transmission and maintaining service continuity. Published literature describing the impact of the pandemic on obstetric sonographers is predominantly quantitative in nature, however statistics cannot fully convey sonographers' voices. This study aimed to gain a deeper understanding of the lived experiences of UK obstetric sonographers performing pregnancy ultrasound scans during the pandemic.

Methods

A UK-wide, online, anonymous cross-sectional survey on Qualtrics XM™ was open to responses between 9th March and 6th May 2021. Whilst this survey contained some quantitative elements, open questions were included to capture additional qualitative detail from respondents about their perceptions and experiences of scanning during the pandemic. Key themes were generated from free text responses using thematic analysis.

Results

Written responses were received from 111/138 sonographers participating in the survey. Five themes were generated, depicting the impact of the pandemic on obstetric sonographers: 1) continuity in a crisis; 2) decisions about me, without me; 3) battle scars – the lasting damage of COVID-19; 4) what people think I do vs. what I really do; and 5) the human touch. A cross-cutting theme was sonographers' feelings of disconnection from senior figures and expectant parents which created a sense of abandonment and distrust.

Conclusion

Survey respondents' self-reported experiences of ineffective leadership and management and perceived lack of understanding of the complexity of the sonographer role are potential contributory factors in the high levels of moral injury and occupational burnout reported within the workforce during the pandemic.

Implications for practice

Moral injury support and healing must be prioritised to enable the recovery of the obstetric ultrasound workforce in the post-pandemic era.

Key words: COVID-19; Moral injury; Obstetrics; Pregnancy; Sonographer; Ultrasound

5.2 Introduction

During the COVID-19 pandemic, healthcare services made substantial changes to balance continuity of care with safety of service users, members of the public and staff (Majeed, Maile & Bindman, 2020). Recommended changes to the provision of obstetric ultrasound included reprioritisation of fetal scans because of reduced departmental capacity (Royal College of Obstetricians and Gynaecologists, 2020a), risk assessments (Society of Radiographers, 2021), and temporary restrictions on additional people attending scans (International Society of Ultrasound in Obstetrics and Gynecology, 2020; The Society and College of Radiographers, 2020). Early published literature exploring the experiences of HCPs reported immediate considerations for services, including the supply (or lack) of personal protective equipment (PPE) (Thomas et al., 2020), telehealth in place of in-person appointments (Monaghesh & Hajizadeh, 2020), and screening initiatives to reduce virus transmission in hospitals (NHS England and NHS Improvement, 2020). However, as staff adapted to new working practices, research foci shifted to explore the longer-term psychological impact of the pandemic on workers (Lamb et al., 2021).

5.2.1 Moral injury and burnout in COVID-19

The negative psychological impact of the COVID-19 pandemic on HCPs is well documented (Batra et al., 2020). This has been described in relation to occupational burnout, and attributed to factors such as fear of contracting or transmitting the virus, being redeployed to unfamiliar clinical areas, and increased workloads because of staff shortages (Chigwedere et al., 2021). However, it has been suggested that research exploring occupational burnout in HCPs often fails to give appropriate recognition to the prevalence and influence of moral injury as a precursor to burnout (Rosen, Cahill & Dugdale, 2022).

Moral injury is often described in the military context, whereby individuals experience guilt or shame as a result of their own actions (or lack of), which conflict with their moral values (Litz et

al., 2009). However, it is also experienced through the recurrent violation of normative expectations, or betrayal of trust, by a person in authority (Shay, 2014). Normative expectations are broadly defined as "beliefs about what people *should* do combined with predictions about what they *will* do" (Shale, 2020). When they are felt to be breached, individuals may experience a strong affective response including feelings of cynicism, disengagement resentment, and withdrawal of trust (Jain, Lucey & Crosson, 2020) causing a moral injury (French, Hanna & Huckle, 2022). It is important to make the distinction between occupational burnout and moral injury, as without full appreciation of the underlying cause of an individual's psychological distress, appropriate support and initiatives for recovery cannot be actioned (Dean, Talbot & Dean, 2019).

5.2.2 The impact of COVID-19 on sonographers

There is a growing body of literature reporting the impact of the COVID-19 pandemic on obstetric sonographers working in the UK (McInally & Gardiner, 2022; Skelton, Malamateniou & Harrison, 2022; Skelton et al., 2023a), Australasia (Childs et al., 2021a, 2021b, 2021c), and other countries (Bourne et al., 2022). As with other HCPs, the lack of adequate and available PPE for sonographers was a common finding (Childs et al., 2021b; McInally & Gardiner, 2022; Skelton et al., 2023a), with concerns raised by 71.9% of sonographers across 124 countries (Bourne et al., 2022). Substantial modifications to scanning practices were noted; including reducing the number of scans (Childs et al., 2021a) and length of appointments (Childs et al., 2021b), restricting the number of people permitted to attend (Childs et al., 2021b; McInally & Gardiner, 2022), and making changes to public waiting areas following risk assessments (Skelton, Malamateniou & Harrison, 2022), although these varied between countries. Additionally, increased workloads from rigorous cleaning and infection control procedures (Childs et al., 2021b, 2021c), rapidly changing guidance perceived as ambiguous (McInally & Gardiner, 2022), and unhelpful (Skelton, Malamateniou & Harrison, 2022),

and concerns over personal safety because of aggressive and abusive behaviour towards sonographers from expectant parents and the public are also reported (McInally & Gardiner, 2022).

Although studies reporting the psychological impact of the pandemic on sonographers are fewer, fear of contracting or transmitting the virus is highlighted as a contributing negative factor on sonographers' well-being (Childs et al., 2021c; McInally & Gardiner, 2022), exacerbated by the inability to physically distance whilst scanning (McInally & Gardiner, 2022). In UK obstetric sonographers, high levels of occupational burnout were reported, with over 90% of respondents meeting thresholds for emotional exhaustion and disengagement (Skelton et al., 2023a). In addition, 73.9% of respondents were considering leaving the profession completely, or changing their area of clinical practice within the next five years (Skelton et al., 2023a), which would have a significant impact on the already stretched UK sonographic workforce (The Society and College of Radiographers, 2019).

With one exception (McInally & Gardiner, 2022), published literature regarding sonographers' experiences of scanning during the COVID-19 pandemic is largely based on numerical data and statistics which cannot fully capture individual voices and reflections. The aim of this paper, therefore, was to qualitatively explore UK obstetric sonographers' experiences of performing pregnancy ultrasound scans during the COVID-19 pandemic, and to provide additional, psychosocial context to previously reported quantitative findings (Skelton, Malamateniou & Harrison, 2022; Skelton et al., 2023a), which may be used to underpin workforce recovery strategies in the aftermath of the pandemic.

5.3 Methods

Reporting of the study is guided by the Journal Article Reporting Standards for All Qualitative Research Designs (JARS-Qual) (Levitt et al., 2018). An online, anonymous questionnaire was developed using the QualtricsXM™ platform (Qualtrics, 2020), and the weblink was shared within the UK sonographic community using a snowball sampling technique via social media and professional networking channels (e.g., Twitter, Facebook, LinkedIn). Departmental managers were also approached by the research team to share the weblink with staff who were not active on social media. This approach was used to facilitate rapid collection of a large dataset for the quantitative components of the survey during a period of national lockdown (Institute for Government, 2021), and to adhere to additional restrictions on conducting research activity which were in place during the COVID-19 pandemic (Thornton, 2020). The survey was reviewed by volunteers from the Society of Radiographers' Ultrasound Advisory Group who gave feedback on readability of questions and usability of the QualtricsXM™ platform, resulting in minor changes to the wording of questions for improved clarity. No data was collected during this review phase, and volunteers could still take part in the main study if they wished to. The questionnaire was composed of four sections: 1) sonographer experiences of performing obstetric ultrasound examinations during the COVID-19 pandemic; 2) Oldenburg burnout inventory (Demerouti et al., 2003) to evaluate self-reported levels of occupational burnout; 3) CORE-10 tool (Barkham et al., 2013) to assess psychological distress in respondents; and 4) participant demographics (Appendix 5). Section one featured multiple-choice questions and provided the option for respondents to share further insight into their experiences through free text responses. Further details about the study design and the quantitative results for sections 1-3 have been previously published (Skelton, Malamateniou & Harrison, 2022; Skelton et al., 2023a). This paper presents the qualitative analysis of sonographers' free text survey responses from section one.

5.3.1 Eligibility and informed consent

Sonographers could participate if they were 21 years old or over and had performed obstetric ultrasound examinations during the COVID-19 pandemic (i.e., since March 2020). Exclusion criteria were trainee and non-obstetric sonographers to keep alignment with the research focus. Prior to accessing the questionnaire, respondents were required to read the accompanying information sheet, confirm their eligibility to participate, and complete an electronic declaration of informed consent. Participants were prompted to answer all questions, although they were free to leave blank responses if they wished.

5.3.2 Qualitative analysis

Data were downloaded into Microsoft Excel (version 2008) (Microsoft Corporation, 2018) from the QualtricsXM™ platform (Qualtrics, 2020) after the questionnaire was closed to responses on 6th May 2021. Qualitative data were extracted and imported into NVivo (version 12) (QSR International Pty Ltd, 2018) for thematic analysis. This method was chosen for its flexibility to facilitate a thorough analysis of the large and heterogeneous qualitative dataset acquired through the online questionnaire (Braun et al., 2021). An inductive approach was taken following the 6 step framework described by Braun and Clarke (Braun & Clarke, 2006, 2022). Following familiarisation with the dataset, the free-text responses for individual questions were coded. Codes were reviewed collectively for further exploration of patterns of meaning across the dataset. During this process, similar codes were combined, and new codes were generated to represent the groups. The groups were reviewed against the full dataset, and overarching themes were developed and subsequently refined to reflect the individual codes. Finally, core themes were reviewed during the writing up process, and illustrative quotations were selected from the dataset to provide supportive examples. Prior to submission, a near-final version of the manuscript was reviewed by two sonographers who volunteered to provide feedback on the findings (Tracy, 2010). This was an important process to

validate the findings. These volunteers had not completed the survey themselves, but confirmed the developed themes were reflective of their clinical experiences, therefore no changes were made to the reporting.

5.3.3 Ethical considerations

This study was reviewed and granted ethical approval by City, University of London School of Health and Psychological Sciences Research Ethics Committee (reference: ETH2021-1240, date of approval: 9th March 2021). Due to the sensitive nature of the research topic and timing of data collection, there was a possibility that sonographers' participation may have led to psychological distress in recalling and relaying their experiences. Therefore, contact details for UK-based mental health organisations were provided to all respondents on completion of the questionnaire.

5.4 Results

In total, 138 sonographers actively participated in the questionnaire with a completion rate of 81.0%. Free-text responses were provided by 111 sonographers across 15 questions. Most participants were female (96.6%), of white ethnicity (86.5%) and working in full-time clinical roles within the NHS during the COVID-19 pandemic (49.4%) (Table 5.1). Despite the potential risk of distress, many sonographers expressed gratitude through their responses at the opportunity to take part in this study and share their perspectives.

Table 5.1 Participant characteristics

Age Group	21-30, n = 12 (13.48%) 31-40, n = 20 (22.47%) 41-50, n = 24 (26.97%) 51-60, n = 31 (34.84%) 61+, n = 2 (2.25%)
Gender	Female, n = 86 (96.63%) Male, n = 2 (2.25%) Prefer not to say, n = 1 (1.12%)
Ethnicity	White / British/ Welsh / Scottish / Northern Irish / Gypsy or Irish Traveller, n = 77 (86.52%) Asian / Asian British, n = 4 (4.49%) Mixed / Multiple ethnic, n = 2 (2.25%) Other, n = 2 (2.25%) Black / African / Caribbean / Black British, n = 1 (1.12%) Prefer not to say, n = 3 (3.37%)
Education	University degree (postgraduate), n = 79 (87.00%) Diploma in Medical Ultrasound (DMU), n = 5 (5.00%) University degree (undergraduate), n = 3 (3.00%) Prefer not to say, n = 3 (3.00%)
Years of experience	0-5, n = 19 (21.35%) 6-10, n = 13 (14.61%) 11-15, n = 18 (20.22%) 16-20, n = 13 (14.61%) 21-25, n = 9 (10.11%) 26+, n = 17 (19.10%)
Professional memberships	Society of Radiographers, n = 79 British Medical Ultrasound Society, n = 40 Royal College of Midwives, n = 9 International Society of Ultrasound in Obstetrics and Gynecology, n = 2 Royal College of Nursing, n = 1 Other, n = 1 Prefer not to say, n = 1
Geographical location	England – South East, n = 20 (22.47%) England – North West, n = 13 (14.61%) England – South West, n = 13 (14.61%) England – East, n = 10 (11.24%) England – London, n = 9 (10.11%) England – East Midlands, n = 6 (6.74%) England – West Midlands, n = 5 (5.62%) England – Yorkshire and the Humber, n = 4 (4.49%) Wales, n = 3 (3.37%) Scotland, n = 2 (2.25%) Prefer not to say, n = 4 (4.49%)
Employment status	Full-time employment (NHS/public sector), n = 44 (49.44%) Part-time employment (NHS/public sector), n = 42 (47.19%) Part-time employment (private practice), n = 1 (1.12%) Other, n = 1 (1.12%) Prefer not to say, n = 1 (1.12%)

5.4.1 Findings

Five themes were generated: 1) continuity in a crisis; 2) decisions about me, without me; 3) battle scars – the lasting damage of COVID-19; 4) what people think I do vs. what I really do; and 5) the human touch (Table 5.2). Themes and illustrative quotations are provided below.

5.4.1.1 Continuity in a crisis

Continuity of obstetric ultrasound services during the pandemic was primarily facilitated by sonographers' immense professional pride and duty of care to expectant parents. Despite concerns around contracting the virus because of working in physical closeness to parents, they did not let this stand in the way of them providing high-quality care.

"I am professional and will care for women and their partners as usual."

(Full-time sonographer, aged 51-60)

Efforts required to keep the screening service going were also driven by feelings of satisfaction and accomplishment in the role, particularly when drawing on specialist knowledge to contribute to care management pathways. In contrast, risk mitigation strategies and new guidance issued by professional organisations to assist the safe running of imaging services were not highly regarded, because of their perceived lack of direct benefit to sonographers and ambiguity leading to variation in implementation.

"I feel that the guidelines have been as a result of public pressure as opposed to being actually supportive of sonographers."

(Full-time sonographer, aged 21-30)

The focus from leadership and management personnel on preservation of the *"parental experience"* during scans above the well-being of sonographers, led to solidarity in their shared sense

of abandonment from senior figures, and sonographers seeking compassion from other members of the immediate ultrasound team to keep them going.

"Fellow sonographers have been vital emotional support during a truly difficult professional time."

(Part-time sonographer, aged 31-40)

5.4.1.2 Decisions about me, without me

Sonographers felt excluded from discussions at both local and national levels, about their own working practices, creating a sense of isolation.

"We as sonographers feel as if we were forgotten during the pandemic."

(Part-time sonographer, aged 31-40)

They described indignation at how decisions to reintroduce partners and support persons to scans, as national lockdown restrictions lifted, had been made by non-sonographer colleagues, whilst restrictions and/or virtual appointments remained for other antenatal care consultations. This evoked a feeling of distrust, which was further exacerbated by contradictory risk assessments and mitigation strategies which failed to reassure them of the safety of their working environments.

"The risk assessments were initially done on a generic basis and were found to be lacking. They have since been redone and there is some disagreement between the staff actually working in the environments and what the health and safety advisor and management assessments state…"

(Employment status not shared, aged 31-40)

In addition, sonographers were frequently made to feel like troublemakers for raising concerns over their safety, particularly after the restrictions around partner attendance at scans were lifted around the end of 2020, and described encounters where they had been berated by senior management for speaking out. These events served to reinforce a shared belief that sonographers

were expendable workers whose safety needs could be compromised to avoid confrontation and facilitate *"business as usual".*

"Obstetric ultrasound was the sacrifice given to protect other staff providing antenatal care. The scan was promoted by the Trust as a gift to pregnant women and partners so they wouldn't complain about the reduced antenatal checks without partners."

(Part-time sonographer, aged 51-60)

5.4.1.3 Battle scars – the lasting damage of COVID-19

Most sonographers described how the pandemic had a considerable, and long-standing, negative impact on their psychological and mental health. In the early stages, they experienced significant distress at being *"sat cuddled up to patients"* for extended periods of time whilst scanning, and felt upset at giving unexpected news to pregnant mothers and people who had been scanned without a support person. Later, increasing numbers of parental complaints and episodes of aggression prompted sonographers to withdraw because of emotional exhaustion and burnout. Complaints received were often not considered valid (*"you have ruined my gender reveal scan"*), and sonographers felt personally attacked for encouraging mask-wearing and physical distancing in scan rooms. They were also deeply distressed by abuse received from parents via unmoderated social media platforms, some of which was individually targeted. A heightened perception of public disrespect for sonographers was further reinforced by the stark contrast of praise and recognition given to other healthcare services.

"I felt the population clapped for the NHS but sonographers were abused verbally at work and on social media."

(Full-time sonographer, aged 51-60)

Lack of support from senior staff who failed to respond adequately to online comments further increased anxiety levels in sonographers. This caused sonographers to question their trust in their employers, as well as their future careers, with many actively seeking to leave obstetric ultrasound or sonography as a result.

5.4.1.4 What people think I do vs. what I really do

This theme captures the perceived disconnect between the way sonographers understand their role, and how they consider others to. They expressed disappointment and frustration with the portrayal of scans as entertainment for expectant parents, their families, and friends.

"Feel as though the medical element of ultrasound is no longer important and that patients are obsessed with ultrasound as an entertainment scan and gender scan."

(Part-time sonographer, aged 31-40)

In these scenarios, sonographers felt their clinical expertise was being undermined. An inferred emphasis on the parent experience placed them in an uncomfortable position where they felt the pressure of balancing the potential risk of failing to detect an unexpected fetal condition with that of receiving criticism from parents.

"Constant worry about missing pathology because you are too busy trying to make experience nice for patient […] because you are worried about getting a complaint."

(Full-time sonographer, aged 41-50)

Some sonographers described how parents' use of private ultrasound clinics (both prior to and during the pandemic) contributed to the disparity between medical and social elements of scans by setting unrealistic expectations for parents and conflating ultrasound screening and diagnosis with the promise of a fun, family experience. Respondents called for initiatives to improve public and professional understanding of the role following the pandemic.

"It is imperative we are not seen as entertaining clowns but an essential part of the medical profession."

(Full-time sonographer, aged 41-50)

5.4.1.5 The human touch

Despite its challenges, the pandemic presented an opportunity for some sonographers to return to their core professional values in providing high quality parent-centred care. They were emotionally responsive to expectant parents' needs and desires to share the scan with a fellow human, and whilst attendance restrictions were in place, they extended their roles to act as default companions, offering temporary social support during the scan appointment. This working relationship was gratifying for sonographers who described feeling more engaged and appreciated in their role through the enhanced connection.

"Many [women] interacted with me in a way that they wouldn't if their partner was there."

(Full-time sonographer, aged 51-60)

Without additional attendees, sonographers felt better able to focus their attention on the individual they were scanning. They described how this facilitated a richer, more personal scan experience that was more aligned to the purpose of the scan and created a safe and trusting environment in the scan room. As a result, many observed increased disclosure of additional issues such as domestic violence. These positive interactions helped sonographers to feel valued and satisfied in their roles, despite the challenges of working during the pandemic.

"[I]…did consider leaving the NHS at the beginning but felt that I do love my job and I do feel that I have been important to the women I've scanned."

(Part-time sonographer, aged 31-40)

Table 5.2 Key themes and codes

Theme	Definition	Codes	Illustrative quotations
Continuity in a crisis	The professional and personal values of obstetric sonographers is what really facilitated service continuity during the pandemic	• Actions taken to mitigate risk • Variation in interpretation and implementation of guidance • Parents are the priority • COVID-19 impact on workload • Making a difference • Working in a team	*"…the department has done an incredible job implementing what they can. Keeping the service afloat has been a monumental effort."* *"We were very aware of making the scan as good of an experience as possible…"*
Decisions about me, without me	Feeling excluded and let down by professional colleagues	• What about us? • Distrust in risk assessment procedures • Feeling underrepresented and unsupported • Job demands and (lack of) resources • Sonographers are expendable	*"They [senior management] often changed things without including our opinion or allowing us to discuss them."* *"They [senior management] did not support sonographers when we highlighted that it is not possible to socially distance in some of our smaller scan rooms. The discussion was just shut down and we were told to get on with it."*
Battle scars – the lasting damage of COVID-19	Occupational burnout and psychological distress in the aftermath of the pandemic	• Moral injury • Pouring from an empty cup • Safety in the scan room • Unsocial media • The future of obstetric ultrasound is uncertain	*"I fear that many people will have already made their minds up to walk away from obstetric scanning."* *"The social media campaigns have been demoralising, inane and disgusting towards our profession. This will undoubtably affect sonographers and the future of obstetric ultrasound."*

What people think I do vs. what I really do	Obstetric sonographers' frustration in the public lack of understanding and acknowledgement for the profession	• Scanning is multifaceted • Lack of recognition and understanding of the profession • Public perception of sonographers • The entertainment factor	*"We are not an entertainment industry but skilled medical professionals who deserve appropriate recognition."* *"…many see the scans as a social event and not a diagnostic test with a purpose."*
The human touch	Finding satisfaction in quality interpersonal connections with expectant parents	• Sonographers as support • Positive sonographer experiences • Communication is key to role satisfaction • Feeling valued and important	*"…I felt that I made a real difference…"* *"I still enjoy my job and find it rewarding and that I am important in the role that I do."*

5.5 Discussion

The themes generated depict UK obstetric sonographers' experiences of facilitating the continuity of obstetric ultrasound services during the COVID-19 pandemic. Sonographers relied on their strong professional values and sense of duty to overcome challenges in the interpretation and implementation of new guidance to avoid disruption to antenatal care provision. However, their efforts were not felt to be fully appreciated or supported, resulting in reduced trust and increased disengagement from leadership and management figures. The themes reflect the occurrence of moral injury amongst sonographers, who, despite this, continued to engage with their role, finding satisfaction in team-working, deeper connections with pregnant women and people, and the application of their specialist ultrasound knowledge and skills.

5.5.1 Occupational moral injury

In addition to concerns around the risk of contracting COVID-19 and personal safety within the scan room, disconnect from senior professional colleagues was identified in this analysis as a longer-term influence on the psychological well-being of obstetric sonographers. Feelings of disappointment were consistent across all but one of the themes generated ("the human touch") and were evoked in response to sonographers' perception that their normative expectations of senior management, professional organisations, and the general public had been violated. Sonographers felt let down by senior management and professional organisations because of the perceived inadequacy and lack of visible leadership, which may have been interpreted as contradictory to recommendations emphasising the importance of authoritative figures being present during a time of crisis for staff support (Walton, Murray & Christian, 2020). Sonographers also felt dismissed when concerns shared over safety in the scan room were not taken seriously. This finding was not unique to this analysis, with failures in PPE provision reported as a major cause of distress in UK HCPs (Professional Standards Authority, 2021). A study of Australasian workers also

reported feeling shamed and victimised when asking for higher-grade PPE (Anada-Rajah et al., 2021). Dismissal of concerns by senior managers can be perceived as a lack of care, and causes staff to question their position as a valued team member or dispensable object (Farmer & Bessa, 2011), in this case, merely an extension of the ultrasound machine.

5.5.2 Occupational moral injury and parent-centred care

Occupational moral injury in HCPs has been dubbed as the "hidden pandemic" of COVID-19 (Anada-Rajah et al., 2021), however it was not just ineffective leadership that was identified as morally injurious in this study. Obstetric sonographers also felt let down by expectant parents and the public who displayed threatening behaviour and directed abuse towards them, most often regarding the restrictions around partner attendance. As sonographers identified themselves as the victims in this situation, expectant parents also experienced feelings of disappointment; that these restrictions were not in their best interests (Thomson et al., 2022), resulting in a mutual withdrawal of trust.

Trust is integral to parent-centred care, as it underpins the relationship between the sonographer and the expectant parent (Thomas, O'Loughlin & Clarke, 2016). Trust in HCPs develops from both an understanding and appreciation of clinical skills, as well as demonstration of "humaneness" through compassion and care (Peters & Bilton, 2017). The parent-sonographer relationship is acknowledged as complex (Thomas, O'Loughlin & Clarke, 2020), and development of trust can be challenging in the obstetric setting. As highlighted in this analysis, it was hindered by the COVID-19 pandemic. Survey responses suggested that lack of public recognition and awareness for obstetric sonographers' clinical role could be explained by the absence of statutory regulation for the workforce. This failure to acknowledge sonography as a distinct occupation creates ambiguity around the role, and as such lowers the public profile of sonographers and recognition of specialist clinical skills (Sevens, 2017). This can be further confused by the rise in popularity of private scanning clinics

which promote more social aspects of obstetric ultrasound (Thomas, 2015). In addition, it may be considered that guidance recommending shorter scan times and the restriction of partners and supporting persons at scans during the pandemic (International Society of Ultrasound in Obstetrics and Gynecology, 2020) were not conducive to developing the trusting parent-sonographer relationship and the subsequent perception of high-quality care (Skelton et al., 2024). However, obstetric sonographers did not consider these as significantly impactful on their communication with expectant parents during scans (Skelton et al., 2023a). Instead, efforts to enhance interactions with parents during the peak of the pandemic restrictions, as described in the final theme, suggest incidences of psychological growth in response to the situational trauma (Greenberg et al., 2020), whereby sonographers made positive changes to their practice to ensure the provision of parent-centred care.

5.5.3 Moral repair and recovery

Recovery following moral injury is essential to prevent progression to burnout (Rosen, Cahill & Dugdale, 2022) and the development of deeper psychological trauma (Shay, 2014). The context-driven nature of moral injury and burnout suggests that initiatives at the individual level (e.g., practising mindfulness, resiliency training) are likely to be ineffective in the longer term (Wallace, Lemaire & Ghali, 2009; Sriharan et al., 2021). Therefore, structural reform is urgently required to support post-pandemic recovery of the workforce. However, unlike mitigation for occupational burnout which may attempt to reduce job demands and increase resources for workers (Demerouti et al., 2001), moral repair requires that the “moral equilibrium” between the perpetrator and the victim is re-established, such that trust can be restored (Anderson-Wallace & Shale, 2014).

Shale describes a seven point framework for moral repair that places the notion of acknowledgement firmly at the centre of trust restoration (Shale, 2020). This includes acknowledgement that moral injury has occurred, acknowledgement of responsibility for causing

harm, acknowledging the feelings of those who have been injured, and acknowledging what is required to rectify the wrong. These are fundamental components of an apology, which is used as the first step to facilitate resolution between two parties after a moral violation (Cels, 2017). Apologies are moral acts, integral to the practice of ethical leadership, as they provide an opportunity for individuals to publicise their values and present themselves as figures of integrity who are worthy of trust and respect (Brown & Treviño, 2006).

In the first instance, the findings of this analysis call for effective and ethical leadership in the aftermath of the COVID-19 pandemic, whereby individuals are seen to demonstrate and promote normatively appropriate conduct to their followers (Markey et al., 2021). This leadership approach has been associated with increased job satisfaction and staff morale, and reduces burnout by encouraging positive working environments (Brown, Treviño & Harrison, 2005) because of its focus on two-way communication, reinforcement of common moral values, and practice of shared decision-making (Cels, 2017). Interprofessional teamwork in collaboration with Maternity Voices Partnerships is also needed to rebuild trust between sonographers, parents and professional groups, as highlighted in recent reports reviewing maternity services in England (Ockenden, 2022; Kirkup, 2022) and Wales (The Royal College of Midwives & Royal College of Obstetricians and Gynaecologists, 2019).

5.5.4 Strengths and limitations

The study findings provide qualitative context which help to explain previously reported high levels of occupational burnout in obstetric sonographers (Skelton et al., 2023a). Although limitations inherent in the sampling strategy are acknowledged (Sadler et al., 2010), survey responses were received from sonographers who were working across all regions of the UK during the COVID-19 pandemic, which has enabled good geographical representation of obstetric ultrasound departments. The sample size was comparable with another recent study involving UK sonographers

(Johnson et al., 2019). Respondents were predominantly female and white, which is reflective of the current workforce (Centre for Workforce Intelligence, 2017), and advantageous from the qualitative perspective because the sample is relatively homogeneous (Jager, Putnick & Bornstein, 2017). However, it must be recognised that the experiences of male or ethnic minority sonographers may be different. Due to the cross-sectional nature of the survey, self-selecting population, and timing of data collection, findings may not be transferable outside of the study setting (Wang & Cheng, 2020), and follow-up research may be beneficial. The theoretical principles of thematic analysis preclude the use of established quality practices (e.g., member checking) to determine credibility of the findings (Varpio et al., 2017). An alternative practice (member reflection) was utilised (Tracy, 2010), whereby sonographers reviewed a near-final draft of this manuscript to confirm the developed themes were consistent with their experiences.

5.6 Conclusion

This analysis provides qualitative context to previous research findings of occupational burnout within the workforce, highlighting sonographers' moral injury through perceptions of ineffective and invisible leadership and management during the pandemic as a key contributing factor. Failure to urgently acknowledge and appropriately repair the harm experienced by obstetric sonographers is likely to exacerbate occupational burnout at the detriment of staff well-being and high-quality parent-centred care. Senior figures must work in collaboration with sonographers to rebuild trust and recreate supportive working environments. Additionally, whilst positive interactions with expectant parents in the scan room were identified as integral to role satisfaction, this is often undermined by a lack of understanding of the clinical aspect of pregnancy ultrasound, and future efforts should be made to raise awareness of the sonographer's role amongst service users and the public.

6 The effect of the COVID-19 pandemic on UK parent experiences of pregnancy ultrasound scans and parent-fetal bonding: A mixed methods analysis (Article 4)

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6.1 Abstract

Introduction

Companionship in antenatal care is important for facilitating positive parental experiences. During the COVID-19 pandemic, restrictions on partner attendance at fetal ultrasound scans were introduced nationally to minimise transmission of the virus. This study aimed to explore the effect of these restrictions on maternal and paternal experiences of pregnancy scans and evaluate their potential effect on parent-fetal bonding.

Methods

A UK-wide, anonymous cross-sectional survey was completed by new and expectant parents (n = 714) who had or were awaiting a pregnancy scan during the COVID-19 pandemic. The CORE-10 and an adapted version of the Prenatal Attachment Inventory were used to evaluate psychological distress and prenatal bonding. Additional survey questions captured parental experiences of scans. Separate statistical and thematic analyses of the data were undertaken. A joint display matrix was used to facilitate integration of quantitative and qualitative claims to generate a comprehensive interpretation of study findings.

Findings

When fathers did not attend the scan, feelings of excitement and satisfaction were significantly reduced ($p<0.001$) and feelings of anxiety increased ($p<0.001$) in both parents. Mothers were concerned about receiving unexpected news alone and fathers felt excluded from the scan. Mean paternal bonding (38.22, SD 10.73) was significantly lower compared to mothers (47.01, SD 7.67) although no difference was demonstrated between those who had attended the scan and those who had not. CORE-10 scores suggested low-to-mild levels of psychological distress, although the mean difference between mothers and fathers was not significant. Key themes described both

parents' sense of loss for their desired pregnancy scan experience and reflected on sonographers' central role in providing parent-centred care during scans.

Conclusion

Restrictions on partner attendance at scans during the COVID-19 pandemic had a negative effect on parental experiences of antenatal imaging. Provision of parent-centred care, which is inclusive of partners, is essential for improved parental experiences.

Key words: Antenatal Imaging; Attachment; Bonding; COVID-19; Parent Experience; Pregnancy; Ultrasound

6.2 Introduction

During the COVID-19 pandemic, significant changes were made to the provision of antenatal and intrapartum care to incorporate guidance for physical distancing and minimise virus transmission (Lalor et al., 2021). These recommendations prioritised the safety of the general population and healthcare staff, and aimed to reduce their risk of contracting the virus (Jeffrey, 2020). In addition, restrictions on partner attendance at ultrasound scans were advised by professional organisations (Royal College of Obstetricians and Gynaecologists, 2020a; The Society and College of Radiographers, 2020). However, inconsistent communication around guidelines, which were constantly updated in response to emerging (and often contradicting) knowledge about the virus and public health advice, resulted in confusion and ambiguity in how they were used (Lalor et al., 2021). Concerns were also raised about increasing variation in practice between clinical centres (Iacobucci, 2020). When UK lockdown restrictions began to ease, many partners were still unable to attend pregnancy scans due to reasons such as varying interpretation of guidelines, differing estates, and local risk assessment. Parent advocacy groups considered the on-going restriction of partners at scans to be disproportionate in the response to COVID-19, calling for the guidance to be reviewed, and risks of virus transmission to be re-evaluated against the psychosocial risks in expectant parents (Birthrights, 2020). The risk of psychological harm was especially concerning in parents whose scans demonstrated an unexpected physical fetal condition or fetal loss, as many pregnant women and people received this news alone (Lalor et al., 2021). Research exploring how the pandemic further impacted women who had experienced pregnancy loss suggests that feelings of grief, trauma and anxiety were exacerbated because of inadequate social support (Freedle, Iyer & Miller, 2023), thus highlighting the value of companionship during antenatal care.

6.2.1 Parent-fetal bonding during COVID-19

The maternal prenatal bond is a complex entity thought to be influenced by various contextual and psychosocial factors including support (Hopkins et al., 2018), physical health (Ertmann et al., 2021) and the strength of the parental relationship (Tolman et al., 2021). Maternal anxiety during pregnancy is also considered to have a negative effect on the developing prenatal bond, albeit small (Yarcheski et al., 2009). Pregnancy is a transformational life event during which individuals must make significant changes to adjust to their new circumstances (Biaggi et al., 2016). As a result, there is a high risk of new onset or recurrence of mental illness, including depression and anxiety (Smith et al., 2011). The COVID-19 pandemic presented further stressors in addition to those already experienced by expectant parents, with studies reporting increasing levels of depression (Claridge et al., 2021; King et al., 2023) and anxiety (Mappa, Distefano & Rizzo, 2020) in pregnant women compared to pre-pandemic levels. Prenatal maternal distress has been associated with impaired fetal neurological development and increased risk of mental health problems in later life (van den Bergh et al., 2020). It is also thought that anxiety during the pandemic may have been further increased in mothers of high-risk pregnancies (Sinaci et al., 2020), with a resultant negative impact on prenatal bonding demonstrated (Karaca, Koyucu & Aksu, 2022).

6.2.2 Study rationale and aim

However, research studies exploring the effect of the COVID-19 pandemic on prenatal bonding have focussed predominantly on mothers and are generalised to consider the whole pregnancy experience, including labour and childbirth (Koire et al., 2021; Schaal et al., 2023; Albayrak, 2021). Whilst some do acknowledge antenatal ultrasound as part of the wider analysis, drawing more specific conclusions around the effect of ultrasound scanning during the pandemic on bonding is challenging because of the additional and external moderators. Focused research in this area is therefore warranted to gain a deeper understanding of how the changes to pregnancy

imaging services have affected psychological and social domains of antenatal care (Diamond, Brown & Miranda, 2020). The aim of this study was to gain insight from parents who had accessed pregnancy ultrasound scans during the COVID-19 pandemic, compare the experiences of mothers and fathers or partners, and to evaluate prenatal bonding during this time.

6.3 Materials and methods

The study methods and results are reported as per the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) (Eysenbach, 2004). Although a formal framework for reporting mixed methods research has yet to be published, the Checklist of Elements to Include in a Mixed Methods Manuscript has been used to guide the presentation of the methods and results (Creswell, 2015).

An online, anonymous questionnaire was created using the secure Qualtrics XM™ survey platform (www.qualtrics.com). This was reviewed by parent volunteers and representatives from UK-based antenatal support charity, Antenatal Results and Choices (ARC). In response to their feedback, minimal amendments were made to the phrasing of questions and overall survey structure to improve readability and usability. To improve overall completeness, the survey prompted participants to respond to all questions, however they could choose not to answer if preferred. Participants could also use navigation options within the Qualtrics XM™ platform to move between questions and change their answers if desired. To ensure adequate time was given for all respondents to complete the survey, no restrictions for duration were enforced. For their convenience, participants also had the option to save their progress and return to complete the survey later. However, the "ballot-box stuffing" option was enabled in the platform to prevent multiple attempts at the survey.

The survey contained four sections. Part 1 contained questions regarding scan expectations or experiences. Part 2 included an adapted version of the Prenatal Attachment Inventory (PAI) to assess parent-fetal bonding, and the CORE-10 tool was used in part 3 to evaluate psychological distress. Participants were asked to provide basic demographic information (e.g., geographical location, ethnicity, education status) in part 4 (Appendix 6).

Circulation of the survey's weblink to prospective participants was achieved through snowball sampling via social media platforms (e.g., Twitter, Facebook, LinkedIn) and word-of-mouth sharing. To be eligible for participation, the inclusion criteria required respondents to be an expectant or new parent aged 18 years or over, and either waiting for, or had attended a pregnancy

ultrasound scan in the UK during the COVID-19 pandemic. The survey was open to respondents between 9th March-25th April 2021. During this 6-week data collection period, the UK was in its third national lockdown, which began on 6th January 2021 (Institute for Government, 2021).

A power calculation to determine sample size for this survey was based on estimates from studies using the maternal antenatal attachment scale (Condon, 1993) to compare change in bonding after ultrasound (Righetti et al., 2005; de Jong-Pleij et al., 2013). Using these studies to assume that prenatal bonding may be increased after fetal imaging by an approximate average of 3-points on the scale, an alpha of 0.05, and power of 80%, it was estimated that a minimum sample size of 39 participants was required in each scan group (e.g., waiting for scan vs. had scan) to avoid error in comparative analyses. A target sample size of 500 parent participants was set to absorb anticipated incomplete questionnaires, with the intention for this quota to be divided between the two groups, although this could not be controlled because of the sampling method.

6.3.1 Parent expectations and experiences

This part of the survey captured parent expectations and experiences of pregnancy scans during the COVID-19 pandemic. Topics explored through these questions included searching for information about the scan, what might or did happen during the scan, and thoughts about the scan. A mixture of question types was used, with open-ended questions included to compliment the closed questions so that participants could further elaborate on their answers if they wanted to. Objective parental experience was quantitatively evaluated through closed-questions (e.g., “did you see images of the baby?”). Subjective parental experience was captured in the free-text responses which generated qualitative data. Participants were also asked to report their feelings of anxiety, excitement, and satisfaction regarding their scan using a rating scale.

6.3.2 Prenatal attachment inventory (PAI)

The original version of the prenatal attachment inventory (PAI) contains 21 items which measure the maternal-fetal relationship on a four point Likert scale from “almost never” to “almost always” (Muller & Mercer, 1993). As noted in a previous study (Armstrong, 2004), the PAI was modified for use by both parents in this survey by removing or rephrasing gendered items (e.g., “I try imagining what the baby is doing in there” becomes “I try to imagine what the baby does inside the womb”). The modified PAI contained 16 items and was reviewed by a group of maternal and paternal advisors to evaluate content validity. The response to each item in the PAI receives a score between 1-4, and these are combined to generate the total score. It is often considered that higher scores reflect a more developed bond, although it must be noted that no optimal score has been reported in the literature (Ranjbar, Warmelink & Gharacheh, 2020). For the 16 item adapted PAI, the maximum possible score was 64.

It should be noted that the relationship between expectant parents and their unborn babies is complex, and definitions have evolved over time to reflect the growing body of research into this topic. Within the literature, studies refer to prenatal “attachment” and “bonding” interchangeably, however it has been suggested that the term attachment is less accurate as this implies a reciprocal relationship between the parent and the baby which is limited during the fetal period (Walsh, 2010). For simplicity, in this paper, the parent-fetal relationship is described as the prenatal bond throughout, although literature referring to attachment is also acknowledged and included.

6.3.3 CORE-10

This generic measure of psychological distress contains ten items related to well-being and general functioning. Participants are required to choose from one of five Likert responses (“Not at all,” “Only occasionally,” Sometimes,” “Often,” and “Most or all of the time”) which best reflects how often they have experienced symptoms in the past seven days (Barkham et al., 2013). The highest

distress response to each item scores 4-points, and the lowest scores 0-points. The maximum possible score is 40. The CORE-10 is validated for use in the perinatal population and commended for its brevity (Coates et al., 2020), as well as being simple to interpret with total scores less than 10 considered non-clinical at one end of the scale, and total scores of 25 or above corresponding with severe psychological distress at the other (Connell & Barkham, 2007).

6.3.4 Data analysis

A mixed-methods approach was used for data analysis so that rich quantitative and qualitative insights could be extracted and developed from the data initially, and then combined to generate a more comprehensive perspective to address the research aim (Creswell, 2015).

6.3.4.1 Quantitative data analysis

The gendered terms “mother” and “father” are used throughout this paper as no non-binary parents completed part 4 of the questionnaire.

First, quantitative data were analysed in Microsoft Excel (version 2008, Microsoft Corporation, USA) and IBM SPSS Statistics (version 28, SPSS Inc, USA). In addition to descriptive statistics, parametric statistical analyses were performed as Q-Q plots demonstrated normally distributed data. Cronbach’s alpha was calculated to determine the reliability of the CORE-10 and adapted PAI tools in this study. Pearson and point bi-serial correlation coefficients were calculated to explore possible associations between variables (Stockemer, 2019). Due to differences in group sizes, Welch’s t-test of unequal variances was used to compare means between parents who were waiting for a scan and those who already had been scanned, as well as between maternal and paternal participants. Further analyses of quantitative data from parents who had been scanned were performed to identify differences between maternal and paternal responses. As no fathers who were

waiting for a scan took part in the survey, maternal vs. paternal comparisons could not be made for this group of parents. To identify any variations between the means of the post-scan PAI, CORE-10 and scan anxiety, excitement, and satisfaction scores by timing of scan in relation to COVID-19 restrictions, analysis of variance (ANOVA) was used (Stockemer, 2019). For this, parents were allocated to one of four groups which reflected the national COVID-19 restrictions depending on the timing of the scan (Institute for Government, 2021). Post-hoc testing was performed to further identify differences between groups that reached statistical significance on ANOVA. Statistical significance was determined using a value of $p<0.05$.

6.3.4.2 Qualitative data analysis

Free-text responses to survey questions were collated and managed using NVivo qualitative data analysis software (version 12, QSR International). An inductive, thematic analysis was chosen to further explore parent experiences, primarily because it is well-suited to the study's large and heterogeneous dataset. The flexibility of this approach also facilitated a thorough analysis of the qualitative responses because they could be coded at question or dataset level. The analysis sought to explore the research question, 'what was the parent experience of pregnancy ultrasound scans during the COVID-19 pandemic?'. After initial familiarisation with the dataset, the free-text survey responses were coded at the surface level for each individual question, and four core concepts around parent experiences of scans, partner attendance, parent-centred care, and COVID-19 were generated. These codes were grouped into key concepts and combined with notes made during familiarisation to generate basic descriptive summaries which provided a general overview of the data. A second phase of coding was then undertaken on the whole dataset and provisional themes were developed and refined. During a final review of the data, the codes and provisional themes were then checked against the dataset for alignment and further refined as needed before being finalised as five core themes (Terry & Braun, 2017).

6.3.4.3 Convergence of data

Key quantitative findings and qualitative codes were then recorded into a joint display matrix (Guetterman, Fetters & Creswell, 2015) and triangulated. Connections between the data were assessed to identify where findings could be confirmed or integrated with other findings to provide explanations in the case of contradictions. These were grouped around the core domains of: 1) anxiety; 2) excitement; 3) satisfaction; and 4) bonding, which were based on the structure of the survey questions. This process produced several integrated claims (IC) which could then be further developed or combined to generate a new claim if deeper understanding was required. To help provide a rich perspective on the full dataset, a final meta-inference, or "conclusion that connects or integrates various claims" (Schoonenboom, 2022) was developed using the integrated claims.

6.3.5 Ethical considerations

Ethical approval for the study was received from the School of Health and Psychological Sciences at City, University of London (reference: ETH2021-1240, date of approval: 9th March 2021). Prior to accessing the survey, prospective participants were required to read the study information sheet which explained the purpose of the study, eligibility criteria, and instructions for navigating the online platform. After reading the information, participants were then required to confirm their consent to take part in the study by marking a digital checkbox built into the survey platform (Skelton et al., 2020a). Due to the potential for sensitive issues to be raised by the questionnaire, the psychological well-being of participants was fully considered in the study design. As all responses were anonymous, individual support could not be offered. However, a link to a collection of further online resources where participants could self-refer for UK-based perinatal mental health support was built into the Qualtrics XM™ platform. Data management and research governance procedures were followed as per university guidance.

6.3.6 Reflexivity statement

All authors are female and from a range of clinical academic backgrounds including medical imaging, midwifery, and psychology. The first author is a registered diagnostic radiographer with specialist ultrasound training, and over 10 years' experience of performing obstetric ultrasound examinations. During the COVID-19 pandemic, the first author was working in a full-time research role in a UK higher education institution. All authors believe that inclusive person-centred care is integral for the provision of pregnancy imaging, to facilitate a supportive experience for parents, birth partners and HCPs alike. They also acknowledge the unique challenges raised by the pandemic, and that these impacted the lives of HCPs as well as healthcare service provision.

6.3.7 Public engagement

Seven parents (four mothers and three fathers) who had pregnancy ultrasound scans during the COVID-19 pandemic volunteered to review the preliminary findings and manuscript prior to journal submission. These parents responded to an invitation to review which was posted on social media. An infographic summary of the research was prepared and circulated to the parents, who were asked to comment on how well the findings reflected their personal experiences during this time. All parents providing feedback were entered into a prize draw for a gift voucher in recognition of their time and contributions. Their suggestions were collated and addressed in the final manuscript submission.

6.4 Results

To minimise the potential for unforeseen psychological distress in responding to this survey, participants were free to answer the questions they felt comfortable with. Therefore, some responses are missing from the full dataset. All percentages have been calculated and reported to reflect the number of participants responding to the specific question, therefore these figures will vary.

6.4.1 Participant characteristics

The target sample size was exceeded, as 714 new and expectant parents consented to take part in the online survey. Of these, 96.4% (n = 688) reported they had attended a pregnancy ultrasound scan since March 2020 (Figure 6.1).

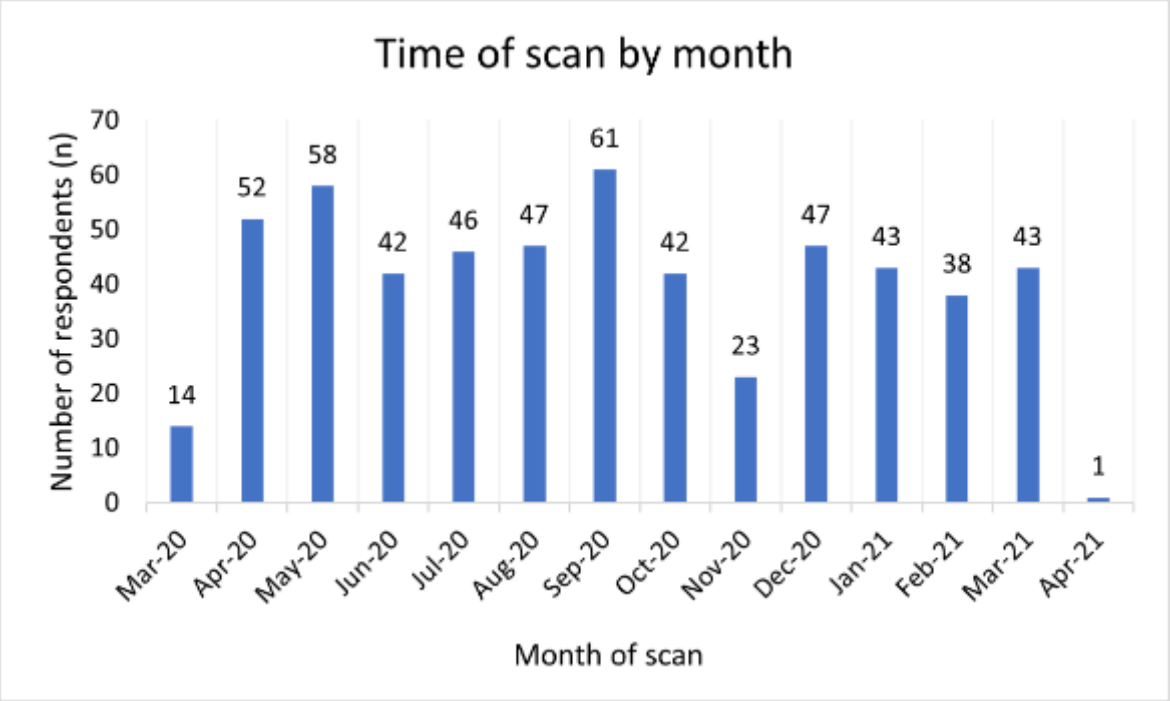

Figure 6.1 Timing of respondents' pregnancy scan appointments during the pandemic

The remaining 3.6% (n = 26) were awaiting a scan at the time of completing the questionnaire. Across both groups of parents, the average completeness for the questionnaire was 79.8%. Most participants who answered the question (96.3%, n = 474) were the mother of the baby who was being, or had been scanned, and of white/British/Welsh/Scottish/Northern Irish/Gypsy or Irish Traveller ethnicity (94.1%, n = 461). In section four of the questionnaire, only 14 respondents answered that they were a father although it is believed that several others did not complete this part of the survey, which likely increases the actual total of fathers represented in the data. Most parents reported the setting for the scan was an NHS or public hospital (98.1%, n = 576). At the time of completing the survey, 47.4% of parents (n = 223) reported the pregnancy was on-going. For other parents, the baby had either been born (n = 220) or the pregnancy had ended (n = 28). Full participant characteristics are reported in Table 6.1.

Table 6.1 Participant characteristics

		Waiting for scan	Had scan	TOTAL RESPONSES
	Consent to survey	26	688	714
	Survey completeness	75.04%	84.50%	Average = 79.77%
Relationship to baby	Mother	17	457	474
	Father	0	14†	14
	Other	0	4	4
Previous scans	Yes	17	556	573
	No	3	178	181
Ethnicity	White	13	448	461
	Asian	2	4	6
	Black	0	3	3
	Mixed	0	7	7
	Prefer not to say	1	1	2
	Other	1	10	11
Education	Secondary	1	28	29
	College	3	115	118
	UG	7	151	158
	PG	5	151	156
	Doctorate	0	20	20
	Prefer not to say	0	2	2
	Other	0	6	6
Employment	Full time	7	309	316
	Part time	4	108	112
	Unemployed	2	25	27
	Student	0	5	5
	Other	2	23	25
Parental disclosure of physical health condition	Yes	4	92	96
	No	12	371	383
Parental disclosure of mental health condition	Yes	6	165	171
	No	10	301	311
Parental disclosure of currently prescribed medication	Yes	5	136	141
	No	11	331	342

†Of these, n=7 fathers attended the scan and n=7 did not attend the scan.

Most parents reported scans during the first (46.9%, n = 271) and second (36.0%, n = 213) trimesters of pregnancy, which coincide with the routine fetal screening examinations offered in the UK as part of the NHS Fetal Anomaly Screening Programme between gestational ages of 11^{+2}-14^{+1} weeks in the first trimester, and 18^{+0}-20^{+6} weeks in the second trimester. For pregnant mothers who had been scanned (n = 565), more than half reported they had been alone during the examination (65.5%, n = 370). Most fathers and partners taking the survey (59.0%, n = 13) had not attended the scan. Eighty-five respondents (12.6%) described partner attendance at some routine scans and non-attendance at others. This seemed to vary between departments with some only allowing partner attendance at the first trimester scan (n = 12), and others only allowing partner attendance during the second trimester (n = 34). Non-routine examinations (e.g., scans in early pregnancy and third trimester) were most reported to have restrictions on partner attendance (n = 48) (Table 6.2).

Table 6.2 Respondents' scan information

		Waiting for scan	Had scan	TOTAL RESPONSES
Geographical location for scan	North East	0	15	15
	North West	3	96	99
	West Midlands	2	17	19
	East Midlands	3	76	79
	Yorkshire	3	15	18
	East	0	78	78
	London	1	57	58
	South East	4	59	63
	South West	3	127	130
	Wales	1	10	11
	Scotland	0	15	15
	NI	0	2	2
Scan setting	NHS/public hospital	19	557	576
	Private	1	10	11
Timing of scan	Early pregnancy (≤10w)	2	23	25
	1st Trimester	6	265	271
	2nd Trimester	3	210	213
	3rd Trimester	9	73	82
Timing of survey	Currently pregnant		223	
	No longer pregnant		243	
	Other		4	

6.4.2 Pregnancy ultrasound scanning during the COVID-19 pandemic

6.4.2.1 Searching for information

The majority of parents waiting for scan (60.0%, n = 12) reported that they had searched for information in advance of the scan, with the most frequently accessed source (75.0%, n = 9) being internet information (e.g., local hospital or NHS webpage). The most searched for information was related to who could attend the scan (91.6%, n = 11). In comparison, only 35.7% (n = 191) of parents who had been scanned stated they had searched for additional information after the examination. Again, the most frequently accessed post-scan resource was internet information (91.1%, n = 174). Following the scan, the most searched for information was regarding the results of the scan (84.2%, n

= 160). There were 22 parents who indicated they had searched for other information related to fetal growth, placental position, and unexpected physical conditions. Most parents (89.5%, n = 171) felt that they had found all the information they were looking for (Table 6.3).

Table 6.3 Parents' self-reported information-searching behaviours

		Waiting for scan (n, %)		Had scan (n, %)	
1. Searched for information about the scan?	Yes	12 (60.0%)		191 (35.7%)	
	No	8 (40.0%)		344 (64.3%)	
2. Source of information searched?	Internet information page	9 (75.0%)		174 (91.1%)	
	Internet forum	3 (25.0%)		88 (46.1%)	
	Family/friends	3 (25.0%)		84 (44.0%)	
	Social media	3 (25.0%)		61 (31.9%)	
	Healthcare professional	4 (30.0%)		55 (29.0%)	
	Someone who attended the hospital	2 (16.0%)		20 (10.5%)	
3. Information searched?		Who can come to the scan	11 (91.6%)	Scan results	160 (84.2%)
		What the scan is for	5 (41.6%)	How baby looked on scan	47 (24.6%)
		What would happen during the scan	3 (25.0%)	What happened during the scan	44 (23.0%)
		What the baby will look like	3 (25.0%)	How I felt after the scan	34 (17.8%)
		Getting results	3 (25.0%)		
		How to prepare for the scan	3 (25.0%)		
4. Found all information required?		Yes, fully	7 (58.3%)	Yes	171 (89.5%)
		Partially	5 (41.6%)	No	21 (11.0%)

†In Table 6.3, n denotes the number of participants selecting the question response. The total number of respondents to each of the questions in this table ranges between 12-20.

6.4.2.2 Expectations for the scan appointment

Most parents who were waiting for a scan expected that they would see images of their baby (85.0%, n = 17), that the sonographer would explain the images during the examination (70.0%, n = 14), and that they would be given a scan picture (65.0%, n = 13) (Table 6.4). The majority (73.7%, n = 14) stated they wanted a scan picture and reported that they would likely keep it as a memento for themselves (88.2%, n = 15).

6.4.2.3 Experiences of the scan appointment

For parents who had been scanned (n = 502), most saw images of the baby (97.0%, n = 487), saw the baby move (89.8%, n = 451) and had the scan images explained to them (86.3%, n = 433) (Table 6.4). A small proportion of respondents (2.0%, n = 10) reported that they had additional imaging performed, although no further details were provided about the type of imaging. Most parents (80.0%, n = 433) indicated they would be having, or did have, other scans in the pregnancy, with several respondents to this question answering that they had either had, or were planning to book private scans (15.7%, n = 68) in addition to those offered by the NHS.

Table 6.4 Expectations and experiences of the scan appointment

	Scan expectations – what will happen during the scan?	Scan experiences – what did happen during the scan?
	Waiting for scan (n, %)	Had scan (n, %)
See images of the baby?	17 (85.0%)	487 (97.0%)
Get a picture?	13 (65.0%)	493 (98.2%)
See baby move?	15 (75.0%)	451 (89.8%)
Sonographer explains images?	14 (70.0%)	433 (86.3%)
Opportunity to ask questions?	15 (75.0%)	369 (73.5%)

†In Table 6.4, n denotes the number of participants selecting the question response. The total number of respondents to each of the questions is 20 for those waiting for a scan, and 502 for those who had been scanned.

6.4.2.4 Pre- and post-scan anxiety, excitement, and satisfaction

The mean anxiety score of parents waiting for scans was 6.40 (SD 2.62). For parents who had been scanned, the mean anxiety score was lower at 4.70 (SD 3.29). Mean excitement was 6.45 (SD 3.09) for parents awaiting scans and 7.25 (SD 2.67) for parents who had been scanned. No significant differences between pre- and post-scan anxiety, or pre- and post-scan excitement were demonstrated (Table 6.5).

Table 6.5 Pre- and post-scan comparisons of anxiety, excitement, bonding, and psychological distress (Welch's t-test)

	Waiting for scan	Had scan	Mean difference	t	Significance
Anxiety (pre- or post-scan)	6.40 (SD 2.62)	4.70 (SD 3.29)	-1.70	2.81	0.10
Excitement (pre- or post-scan)	6.45 (SD 3.09)	7.25 (SD 2.67)	+0.80	-1.14	0.27
PAI[†] (pre- or post-scan)	46.76 (SD 9.79)	46.77 (SD 8.16)	-0.01	0.00	1.00
CORE-10 (pre- or post-scan)	10.88 (SD 5.96)	11.42 (SD 7.11)	-0.54	-0.36	0.72

[†]Only parents whose pregnancy was on-going at the time of taking part in this study were eligible to complete the PAI. There were 17 mothers waiting for scan and 235 parents who had been scanned and gave responses to the PAI.

No statistically significant correlation between pre-anxiety and pre-scan excitement levels was observed (Table 6.6). Negative ($p<0.001$) correlations were noted between post-scan anxiety and excitement ($R = -0.36$), and post-scan anxiety and satisfaction scores ($R = -0.46$). Parents who were more satisfied with their scan also scored more highly for excitement ($R = 0.49$, $p<0.001$). No association was demonstrated between pre-scan anxiety scores and searching for information, however, a higher post-scan anxiety score was correlated ($p<0.001$) with searching for information ($R = -0.34$).

Parents who had been scanned rated their overall satisfaction of the experience at an average of 6.46 (SD 2.75) (where 0 = not at all satisfied and 10 = extremely satisfied). A lower post-scan satisfaction score was associated ($p<0.001$) with information searching ($R = 0.22$).

Table 6.6 Pre- and post-scan correlations between bonding (PAI), psychological distress (CORE-10), and feelings about the scan (anxiety, excitement, satisfaction, and information searching)

Variables	Pearson (R)	R^2	p-value†
PAI and searching for information	-0.05	0.00	0.44
PAI and pre-scan anxiety	0.24	0.06	0.36
PAI and pre-scan excitement	0.05	0.00	0.85
PAI and post-scan anxiety	0.05	0.00	0.42
PAI and post-scan excitement	0.25	0.06	<0.001**
PAI and post-scan satisfaction	0.09	0.01	0.167
PAI and CORE-10	-0.11	0.01	0.10
CORE-10 and searching for information	-0.25	0.06	<0.001**
Pre-scan anxiety and searching for information	-0.05	0.00	0.84
Post-scan anxiety and searching for information	-0.34	0.12	<0.001**
Pre-scan anxiety and excitement	-0.28	0.08	0.23
Post-scan anxiety and excitement	-0.36	0.13	<0.001**
Post-scan anxiety and satisfaction	-0.46	0.21	<0.001**
Post-scan satisfaction and excitement	0.49	0.24	<0.001**
Post-scan satisfaction and searching for information	0.22	0.05	<0.001**

*†In Table 6.6, values marked with ** are significant at the level of p<0.05.*

6.4.3 Reliability analysis

A reliability analysis using Cronbach's alpha showed good internal consistency of the modified PAI ($\alpha = 0.885$) and CORE-10 ($\alpha = 0.847$).

6.4.4 Pre- and post-scan bonding (PAI) and psychological distress (CORE-10)

No significant difference in mean PAI score was seen between parents who were waiting for a scan (46.76, SD 9.79) and parents who had been scanned (46.77, SD 8.16). Pre-scan PAI score was not associated with pre-scan anxiety or excitement (Table 6.6). PAI score was positively correlated ($p<0.001$) with post-scan excitement ($R = 0.25$), although no association was demonstrated between PAI score and post-scan anxiety or satisfaction.

The average CORE-10 scores equate to mild-low level psychological distress within the group of respondents. No significant difference was seen between parents waiting for a scan and parents who had been scanned (Table 6.5). The mean CORE-10 score was higher ($p<0.001$) in parents who also reported a previous mental health condition compared to those with no history of mental health issues. For all parents, the total CORE-10 score was higher ($p<0.001$) in those who searched for more information about their scan ($R = -0.25$). No correlation between total PAI and CORE-10 score was demonstrated.

6.4.5 Comparison of maternal and paternal post-scan bonding and feelings about scan

All maternal participants reported they were the birthing parent, and all fathers reported they were the non-birthing parent, therefore no analyses of same-sex couples could be performed.

Post-scan bonding was significantly higher ($p<0.05$) in mothers (47.01, SD 7.97) compared to fathers (38.22, SD 10.73). Although paternal-fetal bonding was lower, there was no significant difference demonstrated between those who had attended scans and those who had not (Table 6.7). Partner attendance did not significantly affect maternal-fetal bonding either, with a mean PAI score in mothers whose partner had attended the scan of 47.60 (SD 7.41) compared to 45.72 (SD 8.87) of those whose partner had not.

Table 6.7 Comparison of maternal and paternal feelings following pregnancy scan (Welch's t-test)

	Group maternal mean (n = 512)	Group paternal mean (n = 13)	Mean difference	t	Significance
Post-scan anxiety	3.67 (3.036)	3.67 (3.905)	0.00	0.00	0.99
Post-scan excitement	7.48 (2.42)	6.22 (3.80)	1.25	0.98	0.35
Post-scan satisfaction	7.16 (2.45)	6.67 (3.94)	0.49	0.37	0.72
Post-scan PAI	47.01 (7.97)	38.22 (10.73)	8.79	2.43	0.04**
Post-scan CORE-10	11.24 (6.51)	9.00 (6.35)	2.24	0.98	0.36
Mothers only	Scanned with partner mean (n = 155)	Scanned alone mean (n = 305)	Mean difference	t	Significance
Post-scan anxiety	3.23 (2.86)	5.44 (3.25)	-2.21	-7.49	<0.001**
Post-scan excitement	8.00 (2.06)	6.90 (2.83)	1.10	4.73	<0.001**
Post-scan satisfaction	7.94 (1.84)	5.66 (2.82)	2.23	10.36	<0.001**
Post-scan PAI	47.60 (7.41)	45.72 (8.87)	1.88	1.55	0.12
Post-scan CORE-10	10.72 (6.63)	11.90 (7.43)	-1.19	-1.66	0.10
Fathers only	At scan mean (n = 7)	Not at scan mean (n = 7)	Mean difference	t	Significance
Post-scan anxiety	2.86 (2.41)	7.14 (3.44)	-4.29	-2.70	0.02**
Post-scan excitement	8.29 (1.11)	3.57 (3.05)	4.71	3.85	0.005**
Post-scan satisfaction	8.43 (1.40)	3.00 (3.16)	5.43	4.15	0.003**
Post-scan PAI	38.00 (9.92)	38.67 (14.64)	-0.67	-0.07	0.948
Post-scan CORE-10	9.83 (8.06)	9.29 (5.88)	0.55	0.14	0.893

*†In Table 6.7, n denotes the number of participants answering the question. Note that only parents whose pregnancy was on-going at the time of the taking part in this study were eligible to complete the PAI – this was 226 mothers and 9 fathers. The scores are reported in the table as mean (standard deviation). Values marked with ** are significant at the level of p<0.05.*

There was no significant difference (p = 0.36) in psychological distress (CORE-10) demonstrated between mothers and fathers. CORE-10 score was also not significantly affected for either parent by partner attendance at the scan.

When comparing parental mean scores for anxiety, excitement, and satisfaction, no significant differences were noted between mothers and fathers generally. However, anxiety was significantly higher ($p<0.05$) in fathers who had not attended scans (7.14, SD 3.44) compared to those who had (2.86, SD 2.41). Paternal excitement and satisfaction were significantly higher ($p<0.05$) in those who had been present at the scan than those who had not. For mothers who had been scanned with their partners, there were significantly ($p<0.001$) lower levels of anxiety, and higher reported levels of excitement and satisfaction compared to those who had been scanned alone (Table 6.7).

Mean scores were also compared between parents who had prior experience of pregnancy ultrasound scans (either earlier in the current pregnancy or in a previous pregnancy) and those who had not. No significant differences were observed in post-scan anxiety, satisfaction, bonding, or psychological distress (Table 6.8). However, parents with prior scan experience scored significantly higher ($p<0.05$) for excitement (7.67, SD 2.52) than those without (7.04, SD 2.72).

Table 6.8 Post-scan anxiety, excitement, satisfaction, bonding, and psychological distress by parental experience of scans (Welch's t-test)

	No previous scan experience mean	Previous scan experience mean	Mean difference	t	Significance
Anxiety	4.67 (3.33)	4.78 (3.20)	0.111	0.367	0.714
Excitement	7.04 (2.72)	7.67 (2.52)	0.629	2.607	0.009**
Satisfaction	6.51 (2.75)	6.37 (2.74)	-0.137	-0.536	0.592
PAI	46.91 (8.26)	46.50 (8.39)	-0.414	-0.377	0.707
CORE-10	11.78 (7.35)	10.69 (6.50)	-1.092	-1.688	0.092

*†In Table 6.8, the number of participants answering the question ranged from 170-172 for parents with previous scan experience and 318- 353 without. Note that only parents whose pregnancy was on-going at the time of taking part in this study were eligible to complete the PAI – this was 90 with previous scan experience and 162 without. The scores are reported in this table as mean(standard deviation). Values marked with ** are significant at the level of p<0.05.*

6.4.6 Post-scan bonding and feelings about scan by timing of scan

ANOVA testing demonstrated that, in general, as the pandemic progressed, parental anxiety scores decreased while satisfaction scores increased (Table 6.9). However, two exceptions to this were observed. Firstly, there was no significant difference in anxiety score between parents scanned during November 2020 – February 2021 (3.73, SD 3.06) and March – May 2021 (3.26, SD 3.19). No significant difference in satisfaction was demonstrated between parents scanned during July – October 2020 (6.53, SD 2.81) and November 2020 – February 2021 (6.95, SD 2.50). Post-scan excitement, bonding, and psychological distress scores did not significantly differ with the timing of the pregnancy ultrasound scan during the COVID-19 pandemic.

Table 6.9 Post-hoc analysis of post-scan anxiety and satisfaction by timing of scan during the COVID-19 pandemic (Welch's t-test)

	Scanned March 2020-June 2020 (1st UK lockdown) (n = 159)	Scanned July 2020-October 2020 (Local restrictions) (n = 167)	Scanned November 2020 - February 2021 (2nd/3rd UK lockdown) (n = 153)	Scanned March 2021-May 2021 (Local restrictions) (n = 43)	Mean difference	t	Significance
Anxiety	5.70 (3.15)	5.00 (3.29)			0.7	1.97	0.05**
Satisfaction	5.52 (2.80)	6.53 (2.81)			-1.008	-3.23	<0.001**
Anxiety	5.70 (3.15)		3.73 (3.06)		1.975	5.622	<0.001**
Satisfaction	5.52 (2.80)		6.95 (2.50)		-1.428	-4.741	<0.001**
Anxiety	5.70 (3.15)			3.26 (3.19)	2.444	4.469	<0.001**
Satisfaction	5.52 (2.80)			7.95 (2.00)	-2.435	-6.447	<0.001**
Anxiety		5.00 (3.29)	3.73 (3.06)		1.275	3.598	<0.001**
Satisfaction		6.53 (2.81)	6.95 (2.50)		-0.420	-1.410	0.160
Anxiety		5.00 (3.29)		3.26 (3.19)	1.744	3.177	0.002**
Satisfaction		6.53 (2.81)		7.95 (2.00)	-1.426	-3.802	<0.001**
Anxiety			3.73 (3.06)	3.26 (3.19)	0.470	0.860	0.380
Satisfaction			6.95 (2.50)	7.95 (2.00)	-1.006	-2.748	0.007**

*†In Table 6.9, n denotes the average number of participants answering the question. The scores are reported in the table as mean(standard deviation). Values marked with ** are significant at the level of p<0.05.*

6.4.7 Qualitative findings

Five core themes were developed in relation to parental experiences of pregnancy ultrasound scans during the pandemic: 1) the pandemonium of pandemic pregnancy scans; 2) fathers as the forgotten parent; 3) a pregnancy in isolation; 4) sonographers as the gatekeepers to the information about the fetus; and 5) remote connections: missed opportunities for bonding. These themes and their corresponding codes are presented in Figure 6.2. Illustrative quotations are used to underpin each theme's description below.

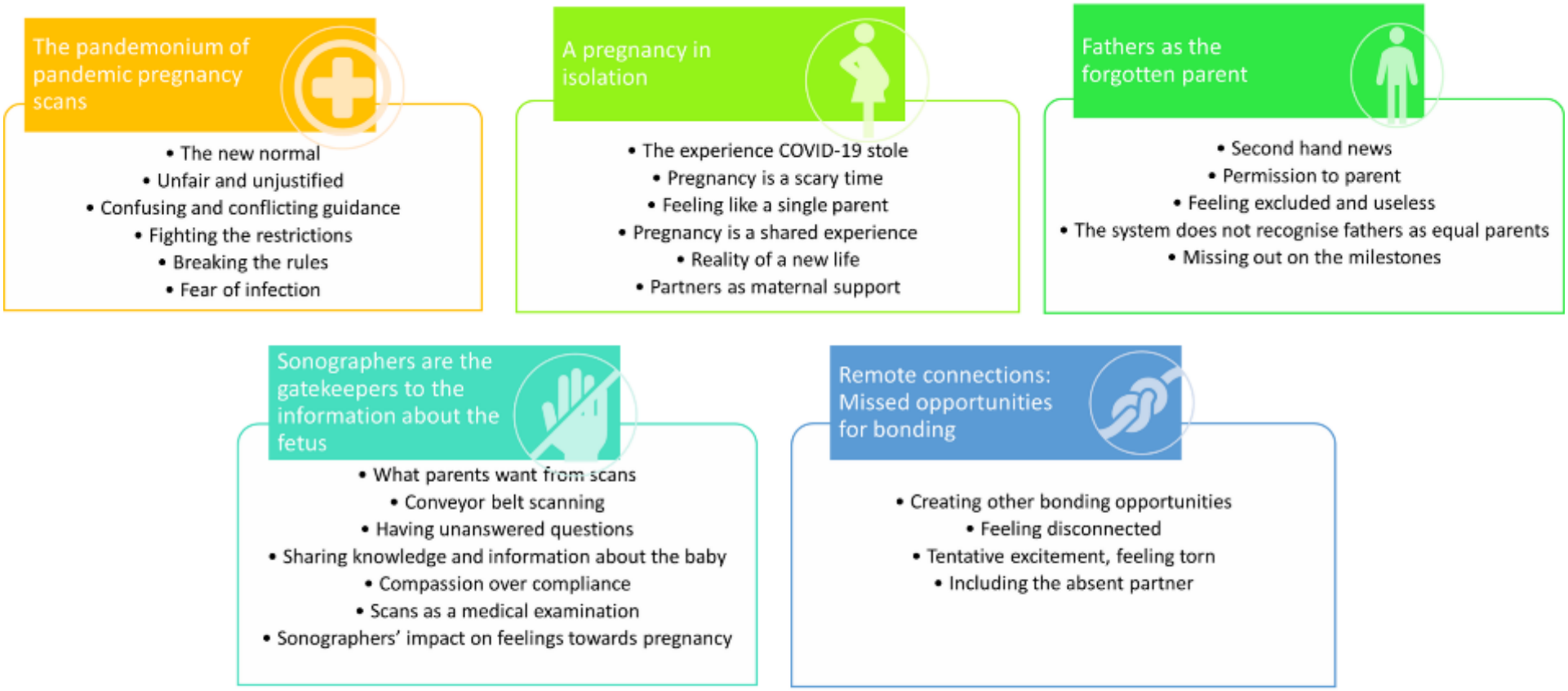

Figure 6.2 Key themes and codes

6.4.7.1 The pandemonium of pandemic pregnancy scans

This theme captured expectant parents' perceptions of how the COVID-19 pandemic had impacted on their pregnancy scans, creating uncertainty and stress, specifically in relation to restrictions on partner attendance. Parents were understanding of the measures initially, but as lockdown restrictions began to ease around the country, the rationale for not reinstating partner attendance became a point of contention:

"I understand why these are the way things are but think a priority for our society should be getting scans back to normal first instead of allowing pubs and restaurants and socialising…"

Parents' scepticism of the restrictions was further intensified by perceived inconsistencies in their enforcement, alongside other COVID-19 safety measures.

"People were walking round the hospital with no masks including hospital staff. COVID rules were not adhered to at the hospital but yet my partner was not allowed to attend…"

Examples of *"double-standards"* were often described, with parents receiving mixed messages from clinical departments about partner attendance. Some parents had received written confirmation that partners would be allowed into the scan room, only to be told on arrival at the hospital that this was not the case. This ambiguity raised questions of credibility, and parents rejected previous justifications for partner restrictions based on attempts to minimise virus transmission, claiming it was "*based on rubbish."* Parents who were co-habiting found the restrictions particularly exasperating:

"If you live in the same household, what difference does it make?!"

Despite the guidance being issued nationally, this sense of unfairness was so profound that some parents felt compelled to actively contest the restrictions, seeking support for their efforts from legal and governmental sources. Challenging the right to have a partner attend the scan became a battle against the healthcare system with anger that was often projected onto the

sonographers as they were the first point of in-person contact for parents. The overall perception of lack of transparency around the restrictions created contempt and frustration, and parents felt their best interests had not been fully considered.

"Whilst I appreciate the need to keep staff safe, I really feel that the impact on parents due to the changes made to Maternity services as a whole and in particular ultrasound scans have not been thought through properly during the pandemic."

6.4.7.2 Fathers as the forgotten parent

Measures introduced in response to COVID-19 served as a reflection of how partners are viewed by the healthcare system as an adjunct to pregnancy rather than an equal parent with their own rights.

"…he was discriminated against for not being the one physically carrying the baby, despite it being just as much his child as mine."

Both mothers and fathers perceived that guidance unfairly favoured HCPs' needs over their own, criticising ill-thought-out actions that served to further emphasise how partners had been seen as a low priority.

"I wasn't allowed in due to COVID but a student was. Really couldn't make it up."

Parents largely described partner attendance or non-attendance at scans by using terms such as "allowed" or "not allowed" which implied antipathy at the prospect of needing permission from the system in order to be a part of the experience. Non-attendance at scans led to fathers feeling excluded from the pregnancy experience and undermined as a parent. The feeling of "missing out" on both the scan event and what it symbolised in the on-going pregnancy was evident. Scans can be an opportunity for fathers to acquire new knowledge about the pregnancy and their baby at the same time as their pregnant partner, temporarily placing them into a privileged position to which

they do not otherwise have access. Having to learn about their unborn baby and the scan from their partner meant that fathers were completely reliant on their partner to relay details, which often failed to satisfy their individual needs for information:

"I was still very nervous in case my wife missed telling me something."

Having restricted access to information about the pregnancy emphasised the disconnect experienced by many partners who could not attend the scan, and instead were required to wait outside of the hospital building. The feeling of being excluded, however, was not just limited to those who did not attend the scan. Partners also reported feeling excluded within the scan room as they sat behind screens and were not acknowledged by sonographers.

"…the person doing the scan did not include him / talk to him."

6.4.7.3 A pregnancy in isolation

Due to changes in service provision, parents were required to adjust their expectations for scanning and as a result were resentful towards the pandemic for denying them the opportunity to share the scan experience with their partner. They described feeling as if something irreplaceable had been taken away, and how this had affected their overall attitude towards their pregnancy.

"It was not having my partner there that made the whole experience completely different and not what I wanted, expected or ever [want] to go through again."

Fathers overwhelmingly described how they had wanted to attend the scan to provide support for their pregnant partner. In their first act of parenting, they saw their primary role as protector and advocate for their future family, wanting to take some of the responsibility of antenatal care from their partner:

"It was a high-risk pregnancy, our first, and my wife needed support during scans and appointments which I could not give to her. There were times when the medical professionals were not listening to her and her needs, and I needed to be there advocate for her when she felt helpless and alone."

In attending their scans and other antenatal appointments alone, mothers saw themselves as single parents, highlighting the impact that being separated from their partners had on the perception of their family as a whole. This placed the onus of pregnancy exclusively on them, further exacerbating worries about potential complications and having to relay information to their partners.

"Pregnant women … need the support of their partners during all scans and appointments. I have felt so anxious and stressed prior to and during scans that I have not been able to hear and process the important medical information provided."

Parents also spoke of their concerns regarding the potential impact that the additional stress of partner restrictions may have had on the pregnancy:

"All the extra stress of having to go through this alone, scans and other appointments, isn't good for mum or baby."

Anxiety surrounding the scan was described by almost all parents but was more evident in those who had experienced pregnancy-related complications and were being followed-up by clinical teams. Instead of alleviating maternal apprehension, it often seemed to exacerbate it.

"…I was actually made to feel like a nuisance and was brought to tears once I left as the experience was so awful."

6.4.7.4 Sonographers as the gatekeepers to the information about the fetus

Parents often attended for their appointment with the fundamental expectation that the scan would provide a chance to receive additional knowledge about their baby. The level of information about the baby that parents could access was perceived to be governed by the

sonographer performing the scan. When sonographers openly shared information about the baby, parents described a more positive experience.

"The lady doing it made me feel at ease. She would let me know what she was doing. She'd show me the baby and what he [the baby] was up to…pointing out body parts."

However, this was not the case for all parents, and some felt as if they had been actively kept in the dark about what had happened during the scan and the results. For mothers particularly, this placed them in an uncomfortably passive role during the scan process, where the scan was largely done to them without their involvement and resulted in a lack of knowledge afterwards.

"I couldn't see the screen to know what was going on. Most of the scan was done in silence and I was handed the photographs at the end without even being sure everything was okay."

Many of those who felt uninformed following the scan later went on to search for further information, particularly after additional or unexpected findings were identified and not fully discussed, which often did not provide the reassurance that had been hoped for:

"I wasn't told what it would mean [my daughter having a small head] so ended up Googling it and ended up increasing my anxiety."

When sonographers narrated and explained the scan appearances, parents felt more included in the process and felt that they had received a higher quality scan and a more personal care experience. Conversely, the concept of *"conveyor belt scanning"* was alluded to by the parents who had been given little in the way of information about the scan and their baby and were left with the impression that they had been a waste of the sonographers' time. This impacted negatively on parents' overall perception of the scan experience and feelings towards their pregnancy:

"She [the sonographer] completely took away any excitement I could have felt because of the way she was."

Not all parents shared this view, however, highlighting the need to improve parental awareness of the medical rationale behind pregnancy ultrasound examinations, and manage expectations around the more social elements of scanning.

"Whilst it's nice for the sonographer to explain and take questions and have a good bedside manner, all that really needs to be done is the health screening and it would help if more women realised this."

6.4.7.5 Remote connections: Missed opportunities for bonding

Pregnancy scans were generally considered to be a positive event, whereby expectant parents could see and connect with their unborn babies in "real-time". Although most parents were given pictures from the scan as a memento, this was not seen as an adequate substitute for the live experience. For partners who could not attend the scan, this was perceived as having had a considerable impact on their developing bond with the baby and how they then processed the reality of the pregnancy.

"He felt disconnected from the pregnancy and not as involved as he could be."

This disengagement of partners also affected mothers, who described feelings of guilt for having enjoyed the scan and time with their unborn baby in the absence of their partner. To mitigate this personal conflict, they would purposely downplay their scan experience when relaying it back to their partners:

"I didn't want to appear over excited (even though I was) as I could see the heartbreak in his face missing out on such a special moment for us…"

Many parents described how they created their own opportunities for bonding by booking non-medical scans at private clinics, although this was recognised as a privilege.

"We were lucky that we were in a position to be able to pay for a private scan but not everyone can."

During these scans, parents could experience three and four-dimensional imaging of their baby, something which is not routinely offered by the public health services. Parents felt these scans would enable them to *"properly see"* their babies in a way that they had not been able to in hospital departments. At later gestations, the timing of these was carefully considered to complement the clinical scans and *"check-in with baby"*. However, in light of the partner restrictions many parents also chose to be scanned in very early pregnancy to avoid the possibility of receiving unexpected news without partner support:

"I absolutely couldn't face finding out if the pregnancy had failed on my own which was my concern."

Parents commented on the use of digital alternatives such as video-calling or taking short recordings of the scan that could be shared with partners to overcome the challenge of not being physically present. However, parents reported inconsistencies in this practice, which created a further source of confusion for parents alongside partner restrictions, and was considered to be unjust:

"I felt I could have easily called my partner or taken a video so that he could have been part of such a special moment. I can't see why this would have been a problem which was the most frustrating thing."

6.4.8 Integration of quantitative and qualitative data

Integration of key quantitative and qualitative data through the joint display matrix facilitated triangulation to offer insight and further clarity on the findings. These were largely explanatory and centred around partner attendance at scans during the COVID-19 pandemic. The integrated claims were further explored using other claims generated through the matrix to try to provide a comprehensive, overarching meta-inference. The interwoven nature of the survey domains, quantitative claims, and qualitative codes is demonstrated in Figure 6.3.

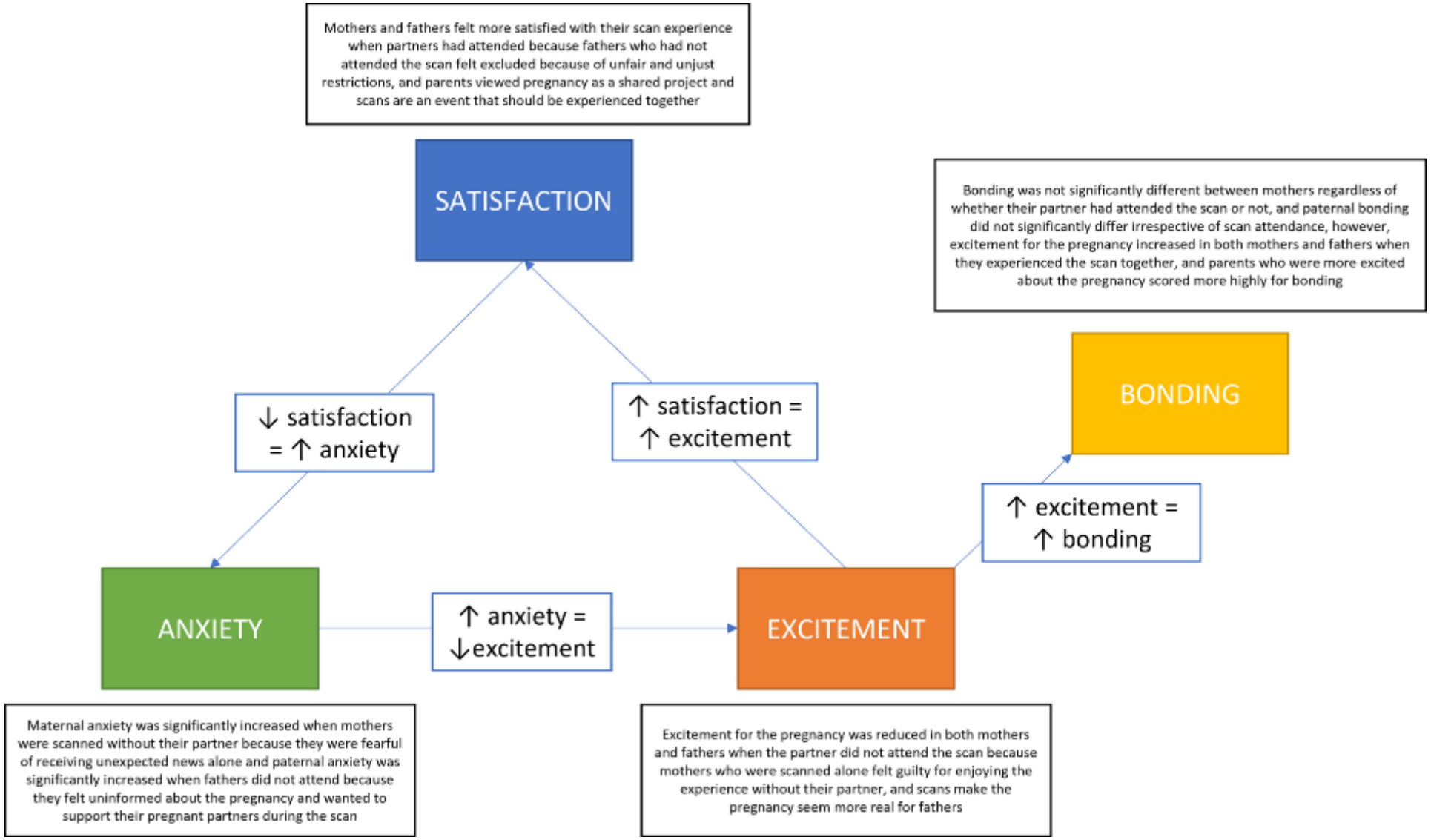

Figure 6.3 Visual representation of integrated claims developed for each domain

The following meta-inference was developed from the study data (Table 6.10):

During the COVID-19 pandemic, maternal anxiety was significantly increased when mothers were scanned without their partner because they were fearful of receiving unexpected news alone. Paternal anxiety was significantly increased when they did not attend the scan because they felt uninformed about the pregnancy and wanted to support their pregnant partners during the scan. Excitement for the pregnancy was reduced in both mothers and fathers when the partner did not attend the scan. This is because mothers who were scanned alone felt guilty for enjoying the experience without their partner, and scans make the pregnancy seem more real for fathers. In addition, mothers and fathers felt more satisfied with their scan experience when partners had attended because those who had not attended the scan felt excluded, and parents viewed scans as a pregnancy-related event that should be experienced together. Although bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not, and paternal bonding did not significantly differ irrespective of scan attendance, excitement for the pregnancy increased in both mothers and fathers when they experienced the scan together, and parents who were more excited about the pregnancy scored more highly for bonding.

Table 6.10 Display matrix for development of the meta-inference

Domain	Quantitative claim	Qualitative code(s)	Integrated claims	Connection between quantitative claim and qualitative code	Illustrative quotation
Anxiety	Maternal anxiety was significantly increased when mothers were scanned without their partner	Feeling like a single parent Scans as a medical examination	[IC1] Maternal anxiety was significantly increased when mothers were scanned without their partner **because** mothers were fearful of receiving unexpected news alone	Explanation	*"I was extremely anxious about anything being wrong and being on my own with my husband not allowed to attend"*
	Paternal anxiety was significantly increased when fathers did not attend the scan	Partners as maternal support Second hand news	[IC2] Paternal anxiety was significantly increased when they did not attend the scan **because** they felt uninformed about the pregnancy **and** wanted to support their pregnant partners during the scan	Explanation	*"My wife needed support during scans […] which I could not give to her […] I needed to be there to advocate for her when she felt helpless and alone"*
Excitement	Excitement for the pregnancy was reduced in both mothers and fathers when the partner did not attend the scan	The experience COVID-19 stole Missing out on the milestones Reality of a new life	[IC3] Excitement for the pregnancy was reduced in both mothers and fathers when the partner did not attend the scan **because** mothers who were scanned alone felt guilty for enjoying the experience without their partner, **and** scans make the pregnancy seem more real for fathers	Explanation	*"I didn't want to appear over excited (even though I was) as I could see the heartbreak in his face missing out on such a special moment for us"*

Satisfaction	Mothers and fathers felt more satisfied with their scan experience when partners had attended	Feeling excluded and useless Unfair and unjustified Pregnancy is a shared experience What parents want from scans	[IC4] Mothers and fathers felt more satisfied with their scan experience when partners had attended **because** fathers who had not attended the scan felt excluded **because** of unfair and unjustified restrictions **and** parents viewed pregnancy as a shared project and scans are an event that should be experienced together	Explanation	*"It led to anxiety from not being present rather than the joy of seeing our baby"*
Bonding	Bonding was not significantly changed between mothers waiting for scans and those who had been scanned	Tentative excitement, feeling torn Scans as a medical examination	[IC5]† Bonding was not significantly changed between mothers waiting for scans and those who had been scans **because** after the scan, mothers maintained some emotional distance from the baby in case of an unexpected outcome	Explanation	*"Still have a long way to go until a safe delivery of a baby"*
Bonding	Bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not	Feeling disconnected	[IC6]† Bonding was not significantly different between mothers whose partners attended the scan and those whose partner did not **but** mothers whose partners did not attend the scan perceived their emotional connection to the baby was reduced	Contradiction	*"I just felt I was going through the motions and couldn't be excited as my partner had missed out"*
Bonding	Paternal bonding did not significantly differ irrespective of scan attendance	The system does not recognise fathers as equal parents Missing out on the milestones	[IC7]† Paternal bonding did not significantly differ irrespective of scan attendance, **but** mothers perceived that not attending the scan had been detrimental to their partner's bonding	Contradiction	*"One of the only ways he could bond with the baby during pregnancy had been taken away from him"*

Bonding	Bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not	Scan as a medical examination Sharing knowledge and information about the baby	[IC8] Bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not, **and** paternal bonding did not significantly differ irrespective of scan attendance, **however** excitement for the pregnancy increased in both mothers and fathers when they experienced the scan together, **and** parents who were more excited about the scan scored more highly for bonding	Juxtaposition	*"Sharing the experience was amazing, got us even more excited about the baby"*
Bonding	Paternal bonding did not significantly differ irrespective of scan attendance	Partners as maternal support			
Excitement	Excitement for the pregnancy increased in both mothers and fathers when they experienced the scan together	Pregnancy is a shared experience			
Excitement	Parents who were more excited about the scan scored more highly for bonding	Reality of a new life			

Integrated Claims	Meta-inference	Illustrative quotation
[IC1] Maternal anxiety was significantly increased when mothers were scanned without their partner because mothers were fearful of receiving unexpected news alone	Maternal anxiety was significantly increased when mothers were scanned without their partner because they were fearful of receiving unexpected news alone. Paternal anxiety was significantly increased when they did not attend the scan because they felt uninformed about the pregnancy and wanted to support their pregnant partners during the scan. Excitement for the pregnancy was reduced in both mothers and fathers when the partner did not attend the scan. **This is because** mothers who were scanned alone felt guilty for enjoying the experience without their partner, and scans make the pregnancy seem more real for fathers. **In addition,** mothers and fathers felt more satisfied with their scan experience when partners had attended **because** fathers who had not attended the scan felt excluded and parents viewed scans as a pregnancy-related event that should be experienced together. **Although** bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not, **and** paternal bonding did not significantly differ irrespective of scan attendance, excitement for the pregnancy increased in both mothers and fathers when they experienced the scan together, **and** parents who were more excited about the pregnancy scored more highly for bonding.	*"Having a partner there would have completely changed the experience"*
[IC2] Paternal anxiety was significantly increased when they did not attend the scan because they felt uninformed about the pregnancy and wanted to support their pregnant partners during the scan		
[IC3] Excitement for the pregnancy was reduced in both mothers and fathers when the partner did not attend the scan because mothers who were scanned alone felt guilty for enjoying the experience without their partner, and scans make the pregnancy seem more real for fathers		
[IC4] Mothers and fathers felt more satisfied with their scan experience when partners had attended because fathers who had not attended the scan felt excluded and parents viewed pregnancy as a shared project and scans are an event that should be experienced together		
[IC8] Bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not, **and** paternal bonding did not significantly differ irrespective of scan attendance, **however** excitement for the pregnancy increased in both mothers and fathers when they experienced the scan together, **and** parents who were more excited about the pregnancy scored more highly for bonding		

†In Table 6.10, integrated claims 5-7 have been further developed to generate integrated claim 8 for use in the meta-inference.

6.5 Discussion

The findings from this study demonstrate how pandemic-related changes with regards to partner attendance at pregnancy ultrasound scans created further anxiety for partners in addition to their general concerns around fetal health and wellbeing. This had a significant effect on scan satisfaction and overall excitement for the pregnancy. For mothers, this also resulted in a perceived negative effect on their emotional connection to their unborn baby. Partner attendance at the scan was highlighted in four of the five key themes developed from the survey responses. Many parents also commented how this was a central factor in determining the scores they gave for anxiety, excitement, and satisfaction. In keeping with these findings, Schaal et al. reported that the greatest worry for pregnant women during the pandemic, was that their partners would not be present during birth or that they would not be visited whilst in hospital (Schaal et al., 2023). This highlights the importance of partners for maternal support and companionship throughout the pregnancy.

6.5.1 COVID-19 effect on prenatal bonding

Several tools to assess prenatal bonding are used in research literature, although the most common are variations of the PAI, Maternal Antenatal Attachment Scale (MAAS) and Maternal-Fetal Attachment Scale (MFAS) (Muller & Mercer, 1993; Condon, 1993; Cranley, 1981). Despite these objective measures, determining an optimal bonding score is challenging because whilst a score may be statistically significant within an analysis, this may not represent clinical significance (Ranjbar, Warmelink & Gharacheh, 2020). Previous studies using the MAAS define a threshold of 80% of the global score to differentiate between low and high bonding (Ertmann et al., 2021; Koire et al., 2021). Using this definition, the average scores of parents completing the modified PAI in this study would be classified as low bonding. However, these findings are more comparable with those of Albayrak who reported mean bonding scores using the Turkish version of the PAI as 75.8% and 70.8% in mothers with low and high anxiety and obsession around COVID-19 respectively (Albayrak, 2021).

As no significant difference in bonding was demonstrated between mothers in this study regardless of scan status (e.g., waiting for scan, scanned alone, or scanned with partner), this may suggest that any interpretation of low bonding in this sample is more likely to be related to the wider impact of the pandemic on levels of maternal anxiety (Albayrak, 2021) rather than directly attributable to the changes to the provision of pregnancy ultrasound scans performed during this time. Anxiety during pregnancy has been previously associated with decreased prenatal bonding (Hopkins et al., 2018). This is thought to be because mothers who are preoccupied with other stressors may be distracted from thinking about their pregnancy, resulting in a decrease in emotional connection towards their unborn baby (Göbel et al., 2018). This explanation may reflect findings from the thematic analysis of the free-text parental responses which described mothers' feelings of reduced bonding, even though the PAI scores were unaffected. Alternatively, some parents may not have been comfortable to reveal their true feelings in this survey, and therefore may have modified their responses to the PAI. The reluctance to disclose information that could leave parents feeling vulnerable to negative judgement by others (including HCPs) is not uncommon in the perinatal setting, and has been identified as a barrier to parents seeking further support (Harrison, Moore & Lazard, 2020).

In this study, bonding was significantly lower in fathers and partners than in mothers. However, no significant difference in bonding score was demonstrated between those who had attended the scan and those who had not. This implies that amongst this survey's respondents, the scans did not influence bonding. The finding of lower paternal and partner bonding is consistent with other studies that report lower levels of bonding compared to mothers (Condon, 1993; Ustunsoz et al., 2010; Kaur & Sagar, 2017). The development of the prenatal bond is thought to be an ongoing process which intensifies during pregnancy as parents engage more on an emotional level with their unborn baby. For this reason, it could be hypothesised that the maternal prenatal bond is accelerated as a result of their privileged embodied knowledge of the pregnancy (Harpel & Barras, 2018). In relation to scanning, it has been suggested that changes to paternal bonding may be

dependent on the timing of the scan during the pregnancy (Righetti et al., 2005), with earlier scans which confirm the viability of the pregnancy and the subsequent reality of impending parenthood, appearing to be more influential (Tolman et al., 2021). Fathers' response to pregnancy ultrasound is thought to be a predictor for prenatal bonding (Tolman et al., 2021), and this has potentially significant implications considering the further association between paternal support, maternal bonding and postnatal attachment (McNamara, Townsend & Herbert, 2019).

6.5.2 COVID-19 effect on scan experiences

Many parents described a sense of loss for their imagined pregnancy scan experience which had been taken away by COVID-19. This finding was also evident in recent studies evaluating the wider pregnancy and birthing experience, and reflects how parents have felt their expectations for care have not been met (Kolker et al., 2021; Vasilevski et al., 2022; Goyal et al., 2022). Managing parental expectations of imaging in pregnancy became more challenging as sonographers attempted to balance parent-centred care and the social restrictions imposed by COVID-19. Pregnancy is generally considered to be a social event (Thomson et al., 2022) and scans provide an opportunity for parents and their wider support networks to "meet" and get to know the baby before birth (Skelton et al., 2024). The prospect of a personalised care experience that can be shared and enjoyed with others is often how private providers promote their scan packages (Thomas, 2015), which can include additional extras not offered during clinical examinations such as 4-dimensional imaging, high-quality prints, and recordings of the fetal heartbeat.

In this survey, 48 parents mentioned they had booked or were planning to book a private scan in addition to those offered as part of their antenatal care pathway. Nearly all explained that this was so both parents could experience the scan together. Sharing the scan experience was important to parents for two reasons; firstly, for support in the event of unexpected news, and secondly for fathers and partners to feel involved with the pregnancy. As fathers lack embodied

knowledge of the pregnancy, scans provide an opportunity for both parents to acquire new insights about their unborn baby simultaneously (Harpel & Barras, 2018). Sharing the scan experience can also create a sense of "togetherness" which helps to provide pregnant people with security and reassurance of their partner's investment in, and commitment to, the pregnancy and postnatal emotional and practical support (Alio et al., 2013). Goyal et al. reported that mothers felt detached from their partners when they had not attended antenatal appointments (Goyal et al., 2022). A key finding from this survey was how mothers perceived the absence of their partner at the scan to have had a negative effect on bonding. Although this was not confirmed by the PAI scores which remained unchanged, this finding has been previously acknowledged by Göbel et al, who reported that increased maternal anxiety may lead to mothers' perception of reduced emotional proximity to their baby (Göbel et al., 2018). It may also be suggested that mothers were also concerned about the possible negative effect of the restrictions on their relationship with their partner (Alio et al., 2013), which may have further influenced their feelings towards their baby. The findings demonstrated that parents who were scanned at a later timepoint during the COVID-19 pandemic had significantly lower anxiety. This may be explained by a combination of increased information and understanding of the pandemic over time, as well as the removal of restrictions on partner attendance at scans towards the end of 2020 (NHS England, 2020).

6.5.3 The role of the sonographer during the COVID-19 pandemic

Despite their frustration about the restrictions, parents recognised the distress that adhering to guidance around partner attendance at scans had caused for sonographers, particularly where unexpected or difficult findings had been identified during the examination. A sub-theme of "compassion over compliance" was developed from the survey responses to capture parents' reflections of how sonographers had demonstrated empathy for those whose scan experiences had been affected by the restrictions by giving printed scan photos at no charge and *"sneaking"* partners

into the scan room to be given unexpected news as a couple. Other studies have reported that parents appreciated when HCPs validated their feelings of disappointment with the situation (Goyal et al., 2022), and used technology to facilitate inclusion of partners from outside of the scan room (Vasilevski et al., 2022). Whilst this was no substitute for having been physically present, it was considered better than missing out completely, and so when video-calling options were not available, this became a further source of anxiety and stress in parents who felt like they were being given inconsistent and ambiguous guidance (Wilson et al., 2022).

6.5.4 Pregnancy companionship

"Fathers as the forgotten parent" was a key theme developed, and further supports a previously acknowledged lack of a family-centric approach to antenatal care (Hodgson et al., 2021). During the pandemic, changes were made to care provision which prioritised infection control above psychological stress, and ultimately conceptualised partners as visitors rather than as parents and birth companions (Thomson et al., 2022). The concept of companionship in antenatal care is often described in relation to labour and childbirth, and it is considered by the World Health Organisation as integral to facilitating a positive parental experience (World Health Organization Recommendations, 2018). Companionship may be provided by fathers and partners, family members, friends and HCPs who give information, advocacy, practical support, and emotional support to pregnant women and people (Bohren et al., 2019). The benefits of companionship on infant outcomes and parental mental health are also acknowledged; associations between maternal health behaviours in pregnancy (e.g., cessation of smoking and consumption of alcohol) (Plantin, Olukoya & Ny, 2011) and improved pre and postnatal bonding (Cuijlits et al., 2019) have been reported when mothers feel adequately supported during pregnancy.

In restricting partner attendance during the COVID-19 pandemic, partners not only missed out on seeing their unborn baby during the ultrasound scan, but the potential to access to mental

health services. For example, opportunities for sonographers to check-in with partners' well-being and facilitate support interventions in a timely manner may have been lost, and this has been shown previously within the wider antenatal care pathway to have serious negative implications on maternal and fetal/infant outcomes (Poulos et al., 2022). The importance of adopting a parent-centred approach to care has also been previously identified as essential to a satisfactory scan experience, with the role of the sonographer considered integral to co-constructing parental knowledge and understanding about their unborn baby through their interpretation and narration of ultrasound images (Skelton et al., 2024). In this study, parental satisfaction increased as the COVID-19 pandemic progressed, and lockdown restrictions were lifted. Satisfaction of experience may be a significant moderator for perinatal mental health, indeed dissatisfaction with the birth process from inadequate partner support has been previously associated with postpartum depression (Benoit et al., 2007).

6.5.5 Strengths and limitations

As this was a UK-wide survey of parents, the responses provided are not limited to a single healthcare facility. In addition, the CORE-10 and modified PAI tools used demonstrated high reliability with Cronbach's alpha. The convenience of the online and anonymous survey made it easier for parents to express their thoughts freely, which increases confidence that the findings are reflective of the experiences during this time. Separate quantitative and qualitative analyses not only produced rich findings, but new insights were generated because of the integration process (Guetterman, Fetters & Creswell, 2015). This process also demonstrated trustworthiness as the quantitative and qualitative findings were largely complimentary.

A limitation associated with cross-sectional surveys is that they only capture a single moment in time, and results can be exaggerated by extreme responses from those who are more motivated to take part (Jordan & Troth, 2020). In addition, despite recruitment flyers explicitly stating that all

parents were eligible to complete the survey, the proportion of parents waiting for scans and the number of fathers and partners was low. No non-binary parents took part in this study. When the survey was live, the intention was to have comparable numbers of respondents within the parent groups, however the final totals were skewed towards mothers who had been scanned. This could make statistical interpretation or generalisation more challenging as the results are not as powerful as if the optimal sample sizes had been achieved. Low uptake of fathers and partners is not uncommon in antenatal research and indeed antenatal care more holistically. Partners are often underrepresented, perceiving that, as they are not pregnant themselves, their perspectives are not relevant (Panter-Brick et al., 2014). Similarly, there was limited variation in the ethnicity of parents completing this survey. At the time the survey was live, many other researchers were utilising online questionnaires whilst face-to-face data collection methods were restricted. This could have led to some prospective participants feeling over-researched and thus deciding not to take part in this study. Homogeneity within the population may also have occurred if the snowball sampling did not effectively reach underrepresented groups of parents. The lack of diversity in COVID-19 related antenatal research has been acknowledged (Koire et al., 2021; Goyal et al., 2022) and highlights the need for more inclusive practices in research design and recruitment to gain a deeper understanding of all parents' experiences during this time. Furthermore, other information could be collected in future studies to provide deeper insight and explanation to the findings. For example, postnatal data may be useful to explore potential associations between parental anxiety and pregnancy outcome. In addition, this survey did not ask participants to provide in-depth information about their obstetric history or personal life, which may be important factors to consider when interpreting data around parental anxiety (Bayrampour et al., 2018).

6.5.6 Recommendations for practice

This study has highlighted the immediate effect of the restrictions on partner attendance at scans during the pandemic on parent experiences of antenatal imaging and prenatal bonding, although the longer-term implications for parents and their infants may not be fully understood for several years. However, some recommendations for future practice can be developed from the literature.

1. Unexpected changes to the pregnancy and birthing experience because of COVID-19 have been associated with symptoms of anxiety and post-traumatic stress disorder (Liu et al., 2021), therefore parents who experienced antenatal care during the pandemic may benefit from additional follow-up and mental health interventions in the post-pandemic era. Opportunities for parents to access perinatal mental health services could be extended and made more inclusive of partners (Darwin et al., 2021), and specialist training for HCPs by psychological therapy teams may facilitate screening during pregnancy to improve early identification of parents in need of support (National Institute for Health and Clinical Excellence, 2014). In their parent-facing role, sonographers may be ideally positioned to recognise parents experiencing mental health difficulties and introduce resources, however this additional responsibility must be carefully balanced alongside existing clinical duties so as not to further increase workload and job demands within the profession (Skelton et al., 2023a).

2. Similarly, initiatives to promote staff wellbeing during the pandemic should be continued to alleviate burnout (van den Berg et al., 2022) and help to mitigate high sonographer attrition from obstetric services specifically of the NHS workforce in general in response to the pandemic (Skelton et al., 2023a). As sonographers are central to parental experiences of pregnancy scans, promoting, offering training about, and practicing parent-centred care that is inclusive of fathers and partners as birth companions rather than visitors (Thomson et al., 2022) may also contribute to improved satisfaction and perception of care, and enhanced prenatal bonding in the future.

3. More formalised, publicly available, and versatile (in terms of content and format) information about what service users could expect from antenatal scans might be useful (McInally & Gardiner, 2022), as some parents in this study indicated they still had unanswered questions despite searching for additional information either prior to the scan, or after the appointment. Sonographers could be key in working with parents to co-develop that resource. More formalised training for sonographers on key concepts and practices of parent-centred care would be vital to ensure they are equipped and empowered to address service user queries and manage expectations.

6.6 Conclusion

Restrictions on partner attendance at scans were introduced with the intention of minimising virus transmission during the COVID-19 pandemic. Significant differences in parental feelings of anxiety, excitement, and satisfaction between parents were correlated with partner attendance at the scan. Partner attendance was important to parent satisfaction, which was increased when both parents were present at the scan. When partners did not attend the scan, parental anxiety was higher, thus parents who had pregnancy scans during the COVID-19 pandemic may benefit from additional mental health support in early parenthood. Although no demonstrable change in prenatal bonding because of the restrictions was recorded in this study, the findings of this UK-wide survey demonstrated that bonding was lower in fathers compared to mothers. Data triangulation suggested maternal guilt in enjoying the scan without their partner, and paternal frustration at being excluded from the scan and being unable to provide support to their pregnant partner. Parental feelings of excitement about the pregnancy were positively correlated with increased prenatal bonding, highlighting the power of antenatal ultrasound scans as an opportunity for expectant parents to engage with their unborn babies, and the integral role of sonographers in providing individualised, parent-centred care to support this.

7 The influence of antenatal imaging on prenatal bonding in uncomplicated pregnancies: A mixed methods analysis (Article 5)

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7.1 Abstract

Background

Prenatal bonding describes the emotional connection expectant parents form to their unborn child. Research acknowledges the association between antenatal imaging and enhanced bonding, but the influencing factors are not well understood, particularly for fathers or when using advanced techniques like fetal magnetic resonance imaging (MRI). This study aimed to identify variables which may predict increased bonding after imaging.

Methods

First-time expectant parents (mothers = 58, fathers = 18) completed a two-part questionnaire (QualtricsXM™) about their expectations and experiences of ultrasound (n = 64) or fetal MRI (n = 12) scans in uncomplicated pregnancies. A modified version of the Prenatal Attachment Inventory (PAI) was used to measure bonding. Qualitative data were collected through open-ended questions. Multivariate linear regression models were used to identify significant parent and imaging predictors for bonding. Qualitative content analysis of free-text responses was conducted to further understand the predictors' influences.

Results

Bonding scores were significantly increased after imaging for mothers and fathers ($p<0.05$). MRI-parents reported significantly higher bonding than ultrasound-parents ($p = 0.02$). In the first regression model of parent factors (adjusted $R^2 = 0.17$, $F = 2.88$, $p<0.01$), employment status ($\beta = -0.35$, $p<0.05$) was a significant predictor for bonding post-imaging. The second model of imaging factors (adjusted $R^2 = 0.19$, $F = 3.85$, $p<0.01$) showed imaging modality ($\beta = -0.53$), imaging experience ($\beta = 0.42$) and parental excitement after the scan ($\beta = 0.29$) were significantly associated with increased bonding. Seventeen coded themes were generated from the qualitative content

analysis, describing how scans offered reassurance about fetal well-being and the opportunity to connect with the baby through quality interactions with imaging professionals. A positive scan experience helped parents to feel excited about parenthood. Fetal MRI was considered a superior modality to ultrasound.

Conclusion

Antenatal imaging provides reassurance of fetal development which affirms parents' emotional investment in the pregnancy and supports the growing connection. Imaging professionals are uniquely positioned to provide parent-centred experiences which may enhance parental excitement and facilitate bonding.

Keywords: Attachment; Bonding; Fetal; Imaging; MRI; Parent; Ultrasound

7.2 Background

Ultrasound is used to evaluate fetal viability, development, and well-being, and to identify occasions where medical intervention during pregnancy or shortly after birth may improve post-natal outcomes (National Institute for Health and Care Excellence, 2019). Yet, its efficacy as an imaging tool can be compromised by inherent limitations including fetal lie, maternal body habitus, and operator technique (Oates & Taylor, 2016). As scan acquisition methods advance, fetal magnetic resonance imaging (MRI) has become popular to complement ultrasound in prenatal diagnosis because it provides increased anatomical detail for some physical conditions (Aertsen et al., 2020). However, the imaging procedure is markedly different, and pregnant women and people may experience anxiety because of loud MRI machine noises, claustrophobia whilst in the MRI scanner, and discomfort in lying still for an extended period of time (Leithner et al., 2008). Compared to ultrasound examinations which do not usually exceed 30minutes in duration, fetal MRI appointments may be scheduled for 60minutes (although not all of this time is devoted to image acquisition) (Brugger & Prayer, 2012).

In addition to medical value, psychological benefits of fetal imaging are reported for expectant parents in providing an opportunity to see and connect with their unborn baby before birth (Skelton et al., 2024). For the non-pregnant parent, scans are also an opportunity to engage with the pregnancy and provide companionship and support to partners (Walsh et al., 2017). Broadly, parent-fetal bonding refers to the emotional connection that expectant parents feel towards their unborn babies during pregnancy (Muller & Mercer, 1993). This definition acknowledges the unidirectional nature of the parent-to-fetal relationship and considers the construct of bonding as theoretically distinct from original conceptualisations of attachment which are characterised by a system of care-seeking and care-giving behaviours after birth (Redshaw & Martin, 2013). Quality prenatal bonding is associated with parental wellbeing and positive behaviours during pregnancy (e.g., smoking cessation) that subsequently contribute to healthy infant brain and neurological development and parental wellbeing (Glover & Capron, 2017). Prenatal bonding is also thought to

predict postnatal attachment (Trombetta et al., 2021), and further links between parent-fetal bonding (particularly the paternal-fetal relationship) and the child's cognitive and socio-economic development also highlight the importance of studying this construct (Ramchandani et al., 2013). However, there are varying definitions in the literature and as such, different approaches are utilised in attempts to evaluate not only the strength of the bond itself (Redshaw & Martin, 2013), but also the effect of interventions designed to facilitate its development (Borg Cunen et al., 2017). Subsequently, inconsistent methodological approaches and varying quality in existing research studies have produced conflicting findings (Borg Cunen et al., 2022).

Fetal ultrasound images are thought to facilitate parents' connection to the baby by providing visual knowledge that can be used to further enhance mental representations of the imagined child (Trombetta et al., 2021). A recent literature review including 23 studies concluded that parent-fetal bonding was enhanced following antenatal imaging (Skelton et al., 2024). In particular, the role of the sonographer (a healthcare professional who performs ultrasound scans) in creating a parent-centred scan experience was highlighted as an important factor to facilitate bonding. Expectant parents rely on sonographers not only to assess fetal health, but also to transform the medical entity captured within the acquired images into relatable individuals with whom they can interact, and place in their own realities (Roberts, 2012). MRI images, like ultrasound, are also dependent on expert clinical interpretation (Reed, Kochetkova & Molyneux-Hodgson, 2016), however, they are less familiar to expectant parents than ultrasound, and there is little understanding of how parents respond to these highly detailed anatomical visualisations of their unborn baby (Skelton et al., 2024).

MRI is not currently part of the routine fetal screening pathway in England (NHS Fetal Anomaly Screening Programme, 2021), but is used for more complex clinical investigations where ultrasound is inconclusive, or in research studies aiming to improve understanding of human development. Although the images produced are considered higher quality because they are not

affected by the previously described limitations associated with ultrasound, it is unlikely that it will replace it due to increased financial cost and limited availability of specialist fetal MR imaging services (Reed, Kochetkova & Molyneux-Hodgson, 2016). This means that many studies reporting expectant parents' experiences and perceptions of MRI are set in the context of a prenatal diagnosis where increased parental anxiety and distress may be a moderator of bonding (Leithner et al., 2008; Lie et al., 2019). They are also retrospective, therefore many variables or confounding factors are missing, or cannot be controlled for. Prospective research is required to further understand parental experiences and the potential influence of MRI on bonding. Additionally, research exploring the paternal-fetal bond is limited compared to maternal studies (Lagarto & Duaso, 2022). As fathers and partners are now increasingly involved in pregnancy (Walsh et al., 2017), it is important to better understand their perceptions, experiences, and individual needs around accessing antenatal care in order for services to be inclusive and supportive (Hodgson et al., 2021).

Based on other literature exploring bonding and scan experiences in pregnancy (Skelton et al., 2024), it was hypothesised that parent-fetal bonding scores would increase after imaging. Therefore, this study aimed to further identify parental and scan variables which may be associated with enhanced parent-fetal bonding after ultrasound or MRI, and qualitatively explore how they may facilitate the developing connection.

7.3 Methods

The STROBE checklist was used to guide reporting (von Elm et al., 2007). A two-part questionnaire was developed for data collection, hosted on the Qualtrics XM™ platform (www.qualtrics.com).

Recruitment ran between October 2021-December 2022. First-time expectant parents (≥18 years) attending a London hospital for fetal imaging (routine ultrasound or research MRI) between 18-36 weeks gestation in uncomplicated pregnancies were eligible to participate. Convenience sampling was used; ultrasound-parents were identified by clinical staff following completion of their routine first trimester screening scan between 11^{+2}–14^{+1} weeks of pregnancy (NHS Fetal Anomaly Screening Programme, 2021), and MRI-parents were identified by perinatal imaging researchers when booking their research MRI scan. An introductory email was sent to prospective parents containing links to the participant information video and electronic informed consent form, which was designed according to good practice recommendations (Skelton et al., 2020a). Once recruited, participants were allocated a unique identification number which they used to access the questionnaire. Two weeks before the imaging appointment, the weblink to part one of the questionnaire (pre-imaging) was shared. The link to part two (post-imaging) was shared one week after the scan (Figure 7.1). Reminders to complete the relevant parts of the questionnaire were sent at seven and 14 days after they were initially shared.

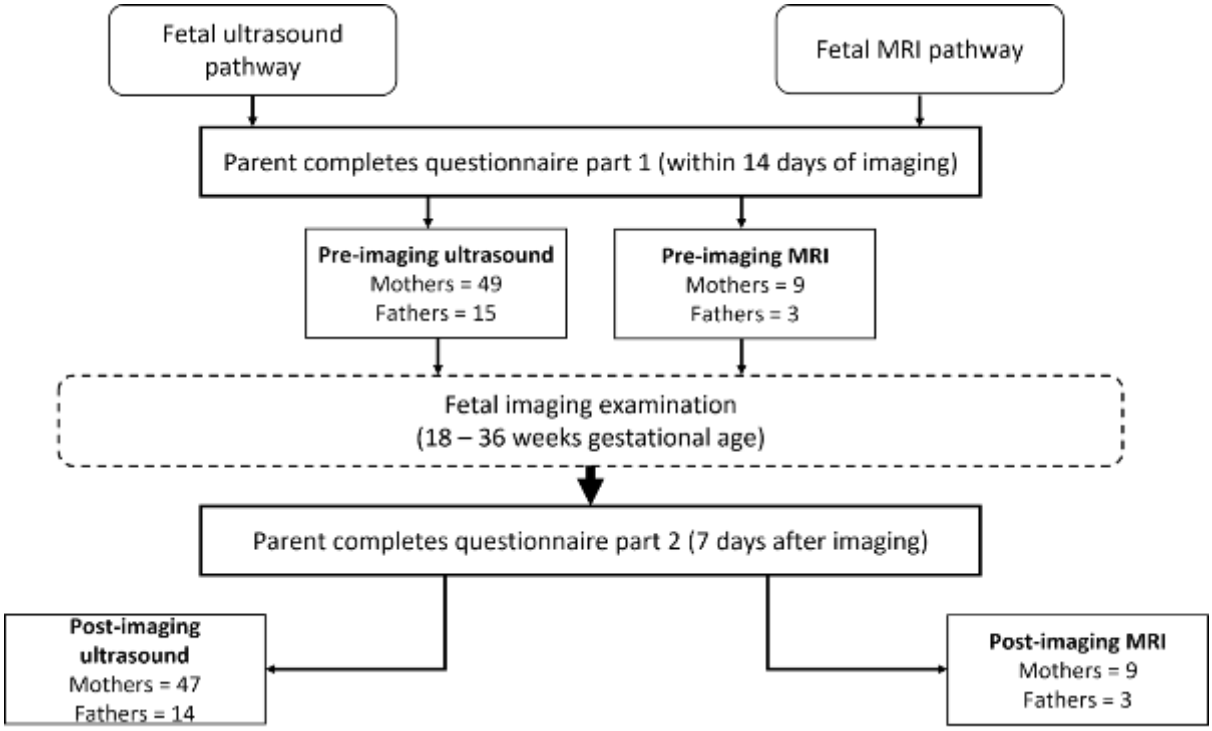

Figure 7.1 Schedule of participation

7.3.1 Measures

Part one of the questionnaire contained four sections, and part two was composed of three (Figure 7.2). Demographic information was only collected in the first part (Appendix 7).

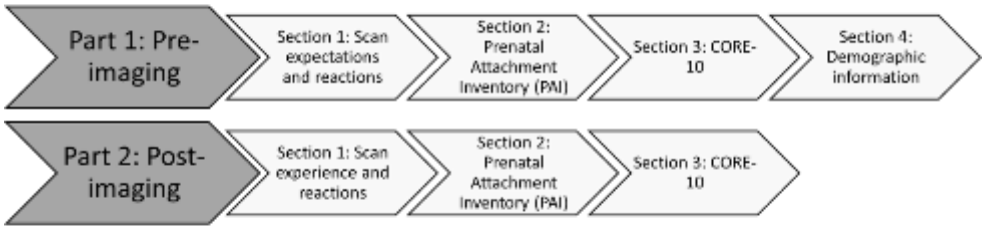

Figure 7.2 Questionnaire structure

7.3.1.1 Prenatal attachment inventory (PAI)

A modified version of the Prenatal Attachment Inventory (PAI) (Muller & Mercer, 1993) was used to measure parent-fetal bonding. Gendered items were removed or rephrased so that both mothers and fathers could respond to the same questions (e.g., "I tell others what the baby does inside me" became "I tell others what the baby does inside the womb"). For each item, parents were asked to select a Likert-response of "Almost Never," "Sometimes," "Often," or "Almost Always." A value between 1-4 was allocated to each response, and the total PAI score was calculated. Higher scores are associated with a more developed bond (Ranjbar, Warmelink & Gharacheh, 2020), and in this 16 item PAI, the maximum possible score was 64. Good reliability of the modified PAI is previously established (Armstrong, 2004; Skelton et al., 2023c). In this study, Cronbach's alpha (α) was 0.90, indicating excellent internal consistency.

7.3.1.2 CORE-10

Psychological distress in participants was evaluated using the CORE-10 (Barkham et al., 2013), which has been validated for use in the perinatal population (Coates et al., 2020). Participants were asked to respond to 10 items using one of five Likert-responses ranging from "not at all," to "most or all of the time" based on their experiences during the preceding week. Responses were allocated a value between 0-4 and combined. Total scores of ≥25 are associated with severe psychological distress (Connell & Barkham, 2007). Cronbach's alpha (α) for the CORE-10 was 0.84.

7.3.1.3 Parental expectations, experiences, and reactions to antenatal imaging

Exisiting measures of parental expectations and experiences of antenatal imaging (Ekelin, Svalenius & Dykes, 2008) were not suitable for the current study's focus on bonding so a measure was developed specifically for this study based on prior literature findings and research studies (Skelton et al., 2023c, 2024). For statistical comparison, expectation and experience factors were

matched (Figure 7.3). An overall score was calculated from the total number of factors (maximum 5 score).

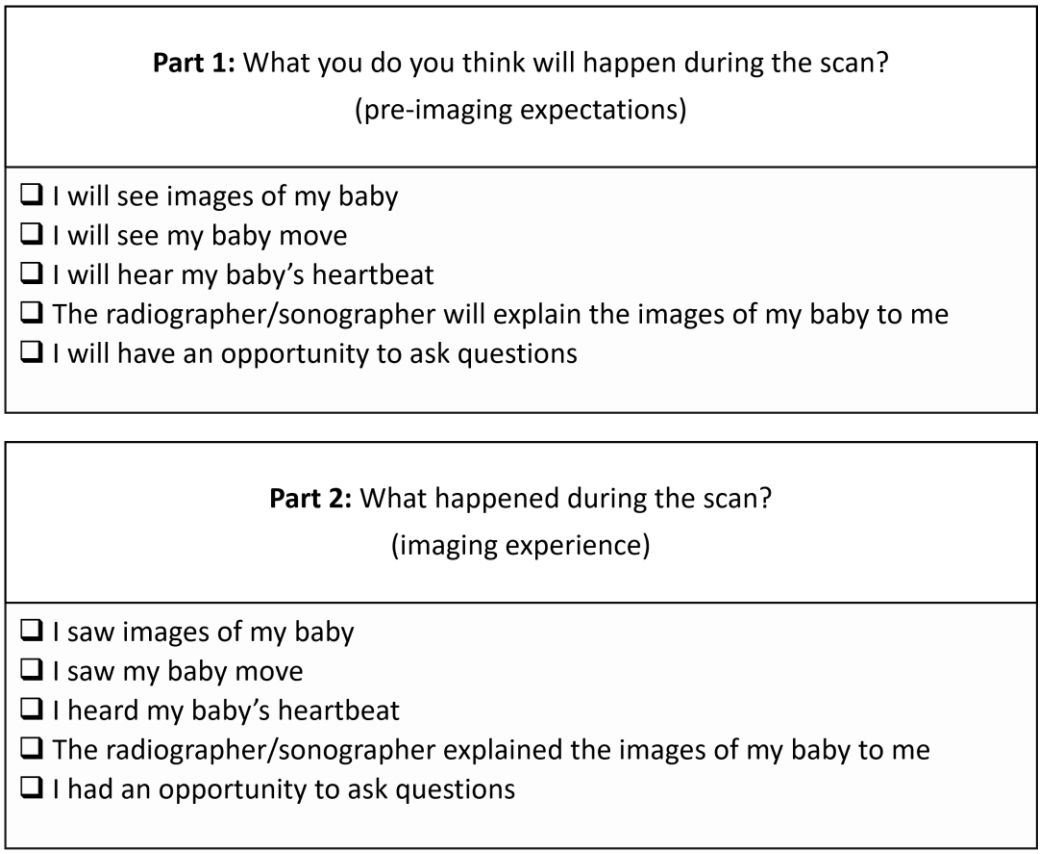

Figure 7.3 Matched questions to evaluate pre-imaging expectations and post-imaging experience

Rating scales (where 0 = not at all and 10 = extremely) were utilised for participants to report their reactions to imaging (anxiety and excitement prior to imaging, and anxiety, excitement, and satisfaction after imaging). Open questions (e.g., What are you least looking forward to about your scan? What did you most enjoy about your scan?) were also included to further capture parental perspectives.

Representatives from UK-based support charities, Antenatal Results and Choices (ARC) and Fathers Reaching Out, were invited to review the questionnaire and provide feedback regarding readability and usability. This resulted in minor amendments to the presentation (e.g., change of rating scale slider) for ease of use on a mobile device. Prior to launch, the questionnaire was piloted

by parent volunteers (n = 7). The QualtricsXM™ platform contained instructions for navigating the questionnaire, including the use of directional tools to move between sections for editing. Participants could complete the questionnaire with no time limit enforced. The option to save and return to an incomplete questionnaire at a different time was also available.

7.3.2 Data analysis

Sample size for paired analysis was informed by a power calculation based on previous studies evaluating the change in maternal-fetal bonding after antenatal ultrasound (Righetti et al., 2005; de Jong-Pleij et al., 2013). From these, it was assumed that bonding scores may be increased by an average of three points. Using an alpha level of 0.05 and power of 80%, the minimum sample size required for this study was estimated as n = 70. Sample size for regression analysis was guided by published literature suggesting the number of subjects per independent variable should lie between 5-20 (Austin & Steyerberg, 2015). Therefore, it was aimed to include 10 subjects per variable in each model.

Quantitative data were analysed using Microsoft Excel (version 2008) and IBM SPSS Statistics (version 29). Frequencies and descriptive statistics including average scores for imaging expectations and experience, PAI, and CORE-10 scores were calculated for each parent group. Kolmogorov-Smirnov tests indicated normally distributed data, therefore parametric statistical analyses were performed (Mishra et al., 2017). Independent and paired t-tests (assuming unequal variances where Levene's statistic was significant) were used to compare means. Hedge's g statistic (g) determined effect size. Cases were excluded from some analyses where paired data was unavailable. Two multivariate linear regression analyses were run to identify predictors significantly associated with enhanced bonding after imaging. Parent variables (e.g., parent demographics and social factors) were entered into the first model and scan variables (e.g., imaging modality, experience, and parental reactions) were entered into the second. Categorical variables were converted to binary-

coded dummy variables (e.g., ethnicity became majority/white or minority/non-white) to enable their inclusion in the regression analysis whilst minimising the potential for overfitting in the models (Alkharusi, 2012). Statistical significance was determined at $p<0.05$.

Qualitative content analysis of free-text responses was undertaken to help explain findings of the regression models. This was chosen over more interpretative methods because the brevity of responses was not conducive to deep analysis (Kleinheksel et al., 2020). A deductive coding system was developed by ES (a sonographer with 12 years' experience in obstetric ultrasound) using the significant predictors identified in the regression models as coding clusters (Hsieh & Shannon, 2005). Responses were first organised into clusters and abstracted into units of meaning. Identified units were recontextualised and grouped into initial coded themes and reviewed against the original data. Coded themes were refined before being checked against the coding clusters to ensure their appropriate classification (Bengtsson, 2016). To evaluate reliability of the coding system, re-coding of a randomised 10% of the qualitative responses was independently performed by DC (a paediatrician and clinical research fellow with 5 years' experience of fetal MRI). Following this, minor changes to the coding descriptors were made for improved clarity. Inter-coder agreement on 10% of the content was 96% following resolution of discrepancies.

7.3.3 Ethics

Ethical approval was received by the NHS West of Scotland REC 3 (REC reference: 20/WS/0132, date of approval: 12th November 2020) and School of Health and Psychological Sciences at City, University of London (REC reference: ETH1920-1680, date of approval: 30th November 2020). Due to the sensitive nature of this research, only participants who were committed to continuing their pregnancy were approached to participate. The potential risk of parental anxiety caused by taking part was low, however a contact list of perinatal mental health support resources was shared after completing part one of the questionnaire. An emergency referral pathway was

developed in conjunction with the local perinatal mental health team to provide urgent support for parents who scored highly for psychological distress although its use was never required.

7.4 Results

All parents stated they were either the mother or father of the baby. A total of 76 expectant parents (58 mothers, 18 fathers) completed part one of the questionnaire. Of these, 64 had ultrasound and 12 had fetal MRI. Sixteen sets of parents were in a couple. Three parents did not respond to the invitation to complete part two, resulting in paired data for 73 parents (56 mothers, 17 fathers).

Mean maternal age was 32 (range = 23-39), and mean paternal age was 34 (range = 28-41). Most parents were educated to postgraduate degree level (n = 39, 51.3%), of white ethnicity (n = 57, 75.0%) and in full-time employment (n = 64, 84.2%). Sixteen parents (21.1%) disclosed a pre-existing physical health condition, and twenty (26.3%) reported receiving a previous diagnosis of, or support for, a mental health condition (Table 7.1).

Table 7.1 Participant characteristics

	Ultrasound-Mothers	Ultrasound-Fathers	MRI-Mothers	MRI-Fathers
Questionnaire part 1	n = 49	n = 15	n = 9	n = 3
Questionnaire part 2	n = 47	n = 14	n = 9	n = 3
Mean age	32.22 (SD=3.15)	34.40 (SD=3.76)	32.22 (SD=3.96)	32.67 (SD=2.89)
Ethnicity				
White	n =34 (69.39%)	n=13 (86.67%)	n=8 (88.89%)	n=2 (66.67%)
Mixed	n=4 (8.16%)	n=1 (6.67%)	n=0	n=1 (33.33%)
Black	n=3 (6.12%)	n=0	n=0	n=0
Asian	n=5 (10.20%)	n=0	n=0	n=0
Other	n=3 (6.12%)	n=1 (6.67%)	n=1 (11.11%)	n=0
Education level				
College (A-Levels)	n=3 (6.12%)	n=2 (13.33%)	n=0	n=0
Undergraduate degree	n=15 (30.61%)	n=6 (40.00%	n=5 (55.56%)	n=2 (66.67%)
Postgraduate degree	n=29 (59.18%)	n=5 (30.33%)	n=4 (44.4%)	n=1 (33.33%)
Doctorate	n=2 (4.08%)	n=2 (13.33%)	n=0	n=0
Employment status				
Full-time	n=41 (83.67%)	n=13 (86.67%)	n=7 (77.78%)	n=3 (100%)
Part-time	n=4 (8.16%)	n=2 (13.33%)	n=0	n=0
Student	n=1 (2.04%)	n=0	n=0	n=0
Unemployed	n=2 (4.08%)	n=0	n=1 (11.11%)	n=0
Other	n=1 (2.04%)	n=0	n=1 (11.11%)	n=0
Mental health condition				
Yes	n=17 (34.69%)	n=1 (6.67%)	n=2 (22.22%)	n=0
No	n=30 (61.22%)	n=14 (93.33%)	n=6 (66.67%)	n=3 (100%)
Prefer not to say	n=2 (4.08%)	n=0	n=1 (11.11%)	n=0
Physical health condition				
Yes	n=12 (24.49%)	n=1 (6.67%)	n=3 (33.33%)	n=0
No	n=37 (75.51%)	n=14 (93.33%)	n=6 (66.67%)	n=3 (100%)

Fetal imaging was performed between October 2021-December 2022. Mean gestational age in weeks and days at the time of the scan was 21^{+1} (range: 18^{+6}–33^{+2}) for ultrasound and 27^{+1} (range: 18^{+4}–35^{+4}) for MRI.

7.4.1 Parent-fetal bonding (PAI)

Bonding was significantly increased in mothers ($p<0.001$) and fathers ($p = 0.04$) after imaging. Mean increase was larger in mothers (4.71, g = -0.81) than fathers (3.06, g = -0.53). No significant differences in mean scores were observed between mothers and fathers pre- or post-

imaging (Table 7.2). MRI-parents had significantly higher bonding scores than ultrasound-parents, both before and after imaging. The pre-imaging mean difference in PAI was 7.25 (p = 0.01, g = -0.85). Post-imaging, the mean difference was 6.46 (p = 0.02, g = -0.74).

Table 7.2 Parent-fetal bonding (PAI pre- and post-imaging t-tests)

	Pre-imaging PAI	Post-imaging PAI	Mean difference	t	Effect size (Hedge's g)
All-mothers (paired data for n = 56)†	38.02 (SD 8.47)	42.73 (SD 8.90)	4.71	-6.11**	-0.81
All-fathers (paired data for n = 17)†	35.53 (SD 8.45)	38.59 (SD 8.26)	3.06	-2.29*	-0.53
Mothers vs. Fathers	All-mothers	All-fathers	Mean difference	t	Effect size (Hedge's g)
Pre-imaging PAI	38.19 (SD 8.41)	36.94 (SD 10.16)	-1.25	0.52	0.14
Post-imaging PAI	42.73 (SD 8.90)	38.59 (SD 8.26)	-4.14	1.71	0.47
Ultrasound vs. MRI	All-ultrasound	All-MRI	Mean difference	t	Effect size (Hedge's g)
Pre-imaging PAI	36.75 (SD 8.77)	44.00 (SD 6.21)	7.25	-2.73*	-0.85
Post-imaging PAI	40.70 (SD 8.86)	47.14 (SD 7.04)	6.46	-2.38*	-0.74

**Significant at p<0.05, **significant at p<0.001, †participants with unmatched data were excluded from these analyses.*

7.4.2 Predictors of bonding after imaging

Eight parent variables were entered into the first multivariate regression model (Table 7.3). This model was significant (adjusted $R^2 = 0.17$, $F = 2.88$, $p<0.01$) and showed that employment status was significantly predictive of parent-fetal bonding after imaging ($\beta = -0.38$, $p<0.05$), with unemployed and part-time working parents scoring higher on the PAI than those in full-time work.

Table 7.3 Multivariate linear regression model for parent variables predicting post-imaging bonding

Independent variable	Standardised coefficient (β)
Step 1: demographics	
Parent type (mother or father)	0.17
Parent age	-0.06
Ethnicity	0.20
Step 2: social factors	
Education	0.02
Employment status	-0.38*
Step 3: physical and mental health	
Mental health condition	0.08
Physical health condition	-0.24
Post-imaging CORE-10	-0.01
Model summary	F = 2.88 (p<0.01) Adjusted R^2 = 0.17

**significant at p<0.05.*

The second model was also significant (adjusted R^2 = 0.19, F = 3.85, p<0.01). Three of the six imaging variables (Table 7.4) were significantly predictive of bonding. These were imaging modality type (β = -0.53, p<0.05), imaging experience (β = 0.42, p<0.05), and parental excitement after imaging (β = 0.29, p = 0.02). Issues of multicollinearity were not indicated as variance inflation factors in the models were between 1.12–2.33 (tolerance = 0.54–0.87).

Table 7.4 Multivariate linear regression model for scan variables predicting post-imaging bonding

Independent variable	Standardised coefficient (β)
Step 1: ultrasound or MRI	
Imaging modality	-0.53*
Step 2: scan factors	
Gestational age at scan	-0.06
Step 3: experience	
Imaging experience	0.42*
Step 4: post-imaging reactions	
Excitement	0.29*
Anxiety	0.09
Satisfaction	-0.15
Model summary	F = 3.85 (p<0.01) Adjusted R^2 = 0.19

**significant at p<0.05.*

7.4.3 Parental expectations, experience, psychological distress, and reactions to imaging

7.4.3.1 Pre- vs. post-imaging

Average CORE-10 scores in all parents (including those with a prior mental health condition) were <10 which indicated low-level psychological distress (not of clinical concern). Mothers' pre- and post-scan CORE-10 scores were similar, however fathers' scores were significantly decreased after imaging ($p<0.001$). Anxiety significantly decreased after imaging in mothers ($p<0.001$) and fathers ($p = 0.01$). Fathers' post-imaging excitement was significantly higher ($p = 0.01$), although this increase was not observed in mothers. No significant difference between pre-scan expectation and post-scan experience score was noted for mothers or fathers (Table 7.5).

Table 7.5 Parental expectations, experience, psychological distress, and reactions to imaging (pre- and post-imaging)

All mothers (paired data for n = 56)	Pre-imaging	Post-imaging	Mean difference	t	Effect size (Hedge's g)
Anxiety	4.30 (SD 2.42)	2.14 (SD 2.34)	-2.16	7.17**	0.95
Excitement	7.38 (SD 2.01)	7.63 (SD 2.29)	0.25	-0.78	-0.10
CORE-10	8.86 (SD 5.00)	8.38 (SD 5.94)	0.48	0.94	0.12
Expectations (pre-imaging) or experience (post-imaging)	4.54 (SD 0.87)	4.61 (SD 0.62)	0.07	-0.66	-0.09
All fathers (paired data for n = 17)	Pre-imaging	Post-imaging	Mean difference	t	Effect size (Hedge's g)
Anxiety	2.41 (SD 1.33)	1.47 (SD 0.94)	-0.94	2.89*	0.67
Excitement	7.47 (SD 2.50)	9.12 (SD 1.05)	1.65	-2.75*	-0.63
CORE-10	6.88 (SD 3.74)	4.82 (SD 3.01)	2.06	4.15**	0.96
Expectations (pre-imaging) or experience (post-imaging)	4.65 (SD 0.70)	4.53 (SD 1.01)	0.12	0.46	0.11

**significant at p<0.05, **significant at the level p<0.001, parental satisfaction was only rated post-imaging.*

7.4.3.2 Mothers vs. Fathers

Although mean values suggest low anxiety in both parents, it was still significantly ($p<0.001$) higher in mothers (4.21, SD = 2.45) compared to fathers (2.39, SD = 1.29) pre-imaging. Post-imaging, the mean difference between fathers' (9.12, SD = 1.05) and mothers' excitement (7.63, SD = 2.29) was also significant ($p<0.001$). Fathers' post-imaging satisfaction (9.12, SD = 1.05) was also significantly higher than mothers' (8.36, SD = 1.78) although the effect size was small ($p = 0.04$, $g = 0.46$). A final significant difference ($p = 0.02$) was noted between mothers' and fathers' post-imaging CORE-10 scores, with mothers scoring higher (8.38, SD = 5.94) than fathers (4.82, SD = 3.09). No significant differences in pre-imaging excitement, pre-imaging CORE-10, or post-imaging anxiety were observed between mothers and fathers (Table 7.6).

Table 7.6 Parental expectations, experience, psychological distress, and reactions to imaging (mothers vs. fathers)

	All mothers	All fathers	Mean difference	t	**Effect size (Hedge's g)**
Pre-imaging:					
Anxiety†	4.21 (SD 2.45)	2.39 (SD 1.29)	-1.82	4.11**	0.81
Excitement	7.38 (SD 2.03)	7.50 (SD 2.43)	0.12	-0.21	-0.60
CORE-10	8.64 (SD 5.07)	7.17 (SD 3.82)	-1.47	1.13	0.30
Expectations	4.55 (SD 0.86)	4.56 (SD 0.78)	0.01	-0.02	-0.00
Post-imaging:					
Anxiety†	2.14 (SD 2.34)	1.47 (SD 0.94)	0.67	1.74	0.32
Excitement†	7.63 (SD 2.29)	9.12 (SD 1.05)	1.49	-3.74**	-0.71
Satisfaction†	8.36 (SD 1.78)	9.12 (SD 1.05)	0.76	-2.18*	-0.46
CORE-10	8.38 (SD 5.94)	4.82 (SD 3.09)	-3.55	2.36*	0.65
Imaging experience	4.61 (SD 0.62)	4.53 (SD 1.01)	-0.08	0.39	0.11

**significant at p<0.05, **significant at p<0.001, †equal variances not assumed, parental satisfaction only rated post-imaging.*

7.4.3.3 Ultrasound vs. MRI

There were very few differences between parents who had ultrasound or MRI. Ultrasound-parents had significantly higher pre-imaging expectation scores than MRI-parents ($p = 0.01$). Imaging experience scores between the modalities were also significantly different ($p = 0.01$), with ultrasound-parents scoring higher (4.75, SD = 0.47) than MRI-parents (3.75, SD = 1.14). No significant differences were observed between mean scores for anxiety, excitement, post-imaging satisfaction, or CORE-10 in ultrasound-parents compared to MRI-parents.

7.4.4 Qualitative findings

Of the four statistically significant predictors, qualitative data relating to parental employment were not collected, therefore this was not included as a coding cluster in the content analysis. A fourth category (parent type) was developed to further explore perspectives of mothers and fathers. Seventeen coded themes were generated (Table 7.7), representing 78.05% of the content. Coded themes are presented by statistical importance as per the regression analyses.

Table 7.7 Final clusters and coding themes

Coding cluster	Coded theme	Description	Quotations	Frequency of occurrence (n)	Percentage of free-text content (%)
Imaging modality	MRI as an advanced fetal imaging modality	Parents viewed fetal MRI as superior to US	*"We'd had ultrasound scans before, but I wasn't prepared for how amazingly detailed the MRI would be."*	13	1.04%
Imaging experience	Scans for confirmation of fetal health	Pregnancy scans considered a tool for reassurance about the pregnancy	*"I'm most looking forward to the confirmation that the pregnancy remains low risk and that all is as expected."*	174	12.94%
	The potential for unexpected news	Parents felt anxious about the possibility of receiving unexpected news from the scan	*"I'm just worried that something is wrong with the baby and I get bad news."*	111	8.12%
	Satisfaction with the scan experience	Parents felt satisfied with their scan experience when their expectations for care were adequately met	*"I do not think there are any improvements to be made. I was kept informed, well prepared, and made comfortable."*	84	6.19%
	Interaction with healthcare professionals	Parental experiences were supported by good communication during the scan to alleviate anxiety	*"The sonographer was professional but warm, sharing her expertise in an accessible and calm-inducing way. She talked through every step of the scan, the image, and also what might take a bit longer to see (but that didn't mean there was a problem with the fetus) – i.e., managing our anxiety pre-emptively."*	67	4.40%
	Facilitating improved care experiences	Parent-centred care requires sufficient time to experience the scan and ask questions	*"Unfortunately, they made it feel rushed and it's such a huge moment for us that it felt like we were another tick off the list."*	65	4.63%

	Uncomfortable scans	Despite some maternal discomfort, both scan procedures were tolerated because of their potential benefits	*"It was quite uncomfortable [in the MRI scanner], but of course I would get all necessary scans if there any concerns about my baby's health."* *"It was a little bit uncomfortable at one point when the baby's head was very low down and the sonographer was trying to get the right angle to see the face clearly."*	37	2.92%
	Attending hospital during a pandemic	Infection control measures were stressful for parents, especially as they were not supportive of partners' attendance	*"It made everything harder to wait outside the hospital […] it made the entire process far more stressful and unpleasant. Pregnancy is not just for women – partners need to be involved at all times."*	37	2.47%
	Scan extras	Some parents wanted more from their scans than can be offered in practice	*"I would love to have seen everything in 3D."*	25	1.63%
	The unknowns of pregnancy scanning	Some parents did not feel fully prepared for scans	*"It took a long time and I wasn't aware upfront exactly how long [it would take]."*	19	1.15%
Parent excitement	Seeing baby for oneself	Parents were reassured by seeing their babies and enjoy the visual interaction	*"It was a lovely period of time to get to spend looking at the baby and seeing how they're growing. It reassured me that everything was progressing as it should be."*	197	13.43%
	Knowing baby's sex	Parents were excited to learn the fetal sex as it helped to personify their baby	*"I would have welcomed a girl or boy equally, but finding out the gender helps me visualise the reality of the baby coming into our lives…"*	78	3.77%

	Becoming a parent for the first time	The scan as a catalyst for the transition to parenthood	*"The scan completely changed how I felt about my baby…I definitely prioritised my baby more – my prior concerns about my career just don't seem as pressing now."*	66	4.77%
	Scans for bonding	The scan experience helped parents to feel more connected to their babies and each other	*"This scan really helped us to be in a better place mentally and to bond with our baby."*	31	1.84%
Parent type	Fathers' excitement to be involved	Scans provided an opportunity for fathers to be involved in the pregnancy	*"Being a Dad-to-be in this process, the scan is the only time I get to see the baby and interact with it."*	62	4.78%
	Tentative motherhood	Mothers withheld excitement until they felt reassured by their scans	*"Having confirmation that the baby was growing as normal allowed me to be more excited and start to believe properly that the baby would be born without complications…"*	41	3.05%
	Mothers' responsibility for scans	Mothers felt a greater sense of responsibility for the scan outcome	*"The baby wouldn't move […] this was stressful as I felt I needed to do something about it […] but was unable to make him move. I felt like I'd done something wrong."*	13	0.92%

7.4.4.1 Imaging modality

MRI-parents perceived the imaging technique as superior to ultrasound, however, in contrast to its importance in the regression analysis, it was not a high frequency theme in their open-text responses (n = 13, 1.04%).

7.4.4.2 Imaging experience

Parents regarded imaging as a tool to provide reassurance about fetal health (n = 174, 12.94%), although they were simultaneously anxious of the potential to receive unexpected news about a fetal anomaly or pregnancy complication (n = 111, 8.12%). Satisfaction in the experience was reported by parents who had their expectations for care adequately met (n = 84, 6.19%), which included feeling informed about the scan procedure. This was facilitated by positive interactions with radiographers and sonographers (n = 67, 4.40%), although the rushed "conveyor belt" experience was also described by some parents and identified as an area to address for improved provision of parent-centred care (n = 65, 4.63%). Discomfort in the scan procedure was reported for both modalities (n = 37, 2.92%). Ultrasound-mothers were uncomfortable because of transducer pressure on their abdomen, particularly if the fetal lie was unfavourable, and being scanned with a full bladder. MRI-mothers noted feelings of claustrophobia, loud scanner noises, and lying still for an extended period as causes of discomfort. Parental dissatisfaction was expressed in relation to hospital waiting times and COVID-19 infection control measures which were unsupportive of partner attendance (n = 37, 2.47%), as well as a lack of information about the scan (n = 19, 1.15%). Increased options for imaging extras including choosing souvenir photos, recording video clips, having 3-dimensional ultrasound offered as standard, and receiving MRI images immediately after the scan were suggested as further means to improve experiences (n = 25, 1.63%).

7.4.4.3 Parent excitement

References to "*seeing baby*" were most frequently observed in the free-text responses (n = 197, 13.43%). Parents enjoyed visualising fetal movement and cardiac activity during scans as it provided reassurance. Images helped parents to personify the fetus, creating a sense of familiarity that was further intensified by learning the fetal sex (n = 78, 3.77%). For some parents, the scan marked a pivotal moment to accept the reality of pregnancy and embrace the transition to parenthood (n = 66, 4.77%). The scan experience was perceived by both parents as beneficial, particularly for fathers in enhancing their emotional connection with the baby, and strengthening the partner relationship (n = 31, 1.84%).

7.4.4.4 Parent type

Many parents reported that in the absence of any physical experience of pregnancy, imaging provided a unique and exciting opportunity for fathers' engagement (n = 62, 4.78%). Mothers reported greater apprehension prior to scans due to the possibility of an unexpected finding, and actively supressed excitement until receiving confirmation of fetal health (n = 41, 3.05%). Mothers' anxiety was also created by assuming greater responsibility for the scan or pregnancy outcome (n = 13, 0.92%), for example fetal sex or position.

7.5 Discussion

In this study, parent-fetal bonding scores were significantly increased following imaging in both parents which is consistent with existing literature (Skelton et al., 2024). However, in contrast to other studies (Condon, 1993; Ustunsoz et al., 2010; Kaur & Sagar, 2017; Skelton et al., 2023c), bonding scores were not observed to be significantly different between mothers and fathers. Four variables were identified as significant predictors of parent-fetal bonding after imaging: scores were significantly higher in parents who had MRI, who scored their imaging experience and excitement levels higher, and who were not in full-time employment. Parental excitement in visualising their baby and the positive experience of receiving confirmation of fetal health were the most frequent references in the qualitative content analysis.

7.5.1 Interpretation

Many parents regarded imaging as a tool for reassurance of fetal development and wellbeing, and, mothers in particular, described how they attempted to supress excitement about the pregnancy until receiving confirmation of fetal health (Rowe, Fisher & Quinlivan, 2009). Whilst it has been suggested that conceptualisations of the "tentative pregnancy" may indicate detachment from the fetus in parents' reluctance to embrace the developing bond (Rothman, 1986), it has been argued that this response (often perceived as anxiety or worry about a possible unexpected physical condition or pregnancy loss) actually demonstrates the presence of this connection as fear that the imagined baby may not become reality (Borg Cunen et al., 2022).

The high frequency of references made to 'seeing baby' shows how scans provided powerful visual evidence used by parents to further validate assurances of fetal health offered by HCPs (Thomas, Roberts & Griffiths, 2017). However, in addition to reassurance, the images could be regarded as a source of uncertainty, creating anxiety if parents are not guided in how to interpret them (National Institute for Health and Care Excellence, 2019). Further uncertainty may also be

created by communication around the limitations of prenatal screening (Pilnick & Zayts, 2014), particularly if acquired images are low-quality (Oates & Taylor, 2016). Anxiety was significantly decreased for both parents after imaging, suggesting scans helped to mitigate this reaction. Additionally, some parents may not identify as anxious before the scan, however, expressing relief post-imaging may imply suppressed anxiety (Ekelin, Svalenius & Dykes, 2008). It has been suggested that the need for reassurance arises from anxiety created by the scan itself and uncertainties in fetal screening (Harpel, 2008). This may partly explain why parents perceived MRI as superior, due to its reputation as a more objective, diagnostic modality (Reed, Kochetkova & Whitby, 2016). The wider field-of-view also enables parents to visualise the whole fetus instead of a series of 2-dimensional cross-sectional images. However, as with ultrasound, MRI images require skilful interpretation, which is dependent on a clinician's specialist knowledge and experience (Reed, Kochetkova & Molyneux-Hodgson, 2016), therefore it may not actually be considered completely objective.

Other explanations may be offered to further understand the association between MRI and higher bonding scores. First, it could be argued that as these scans occurred at a more advanced gestational age (and these parents would have already received reassurance about fetal health from routine ultrasound screening scans) their emotional connection was more developed (Close, Bateson & Douglas, 2020). However, although higher MRI bonding scores were consistently noted compared to ultrasound, gestational age was not found to be a significant predictor in the regression analysis. Secondly, it must be acknowledged that unlike ultrasound, MRI scans were performed for research purposes. Parents may volunteer for pregnancy research because of its perceived benefits to the fetus (van der Zande et al., 2018), which suggests emotional investment through demonstration of responsible parenting (Williams, 2006). Alternatively, parents experiencing a deeper connection may have been more motivated at the opportunity to see their baby again (Westerneng et al., 2019).

The findings also suggest how parental excitement is increased after imaging, and why this may help to enhance bonding. Parents reported feeling excited to 'see the baby' and 'hear the

heartbeat'. Visual and audial scan cues may substantiate fetal presence, and facilitate growing tangibility of the baby (Borg Cunen et al., 2022). After scanning, some parents remarked how the pregnancy felt more 'real' and expressed excitement imagining the baby in their lives. This may highlight scans as a 'trigger moment' where the bond is initiated or intensified (Lagarto & Duaso, 2022), and parents are prompted to engage with their new caregiving role (Walsh, 2010). For some, the scan was an opportunity to learn the fetal sex, which further contributed to feelings of closeness to the baby and excitement. Yet, it has been argued that knowing the fetal sex may actually be problematic for bonding (Borg Cunen et al., 2022), particularly if it does not align to parental preferences, or is inaccurate, as this mismatch in expectations requires parents to adjust their existing mental depictions (Harwood, McLean & Durkin, 2007).

Regardless of imaging modality, fathers' excitement was noted to be consistently and significantly higher than mothers. Whilst some free-text responses alluded to fathers' lack of awareness or anxiety for unexpected news to explain this (Kowalcek et al., 2003), it may also be considered that fathers were increasingly excited about the opportunity to be involved in an aspect of antenatal care (Walsh et al., 2017). Fathers and partners are more likely to attend ultrasound scans than other antenatal checks (Redshaw & Henderson, 2013). Nevertheless, being present does not guarantee a positive experience for either parent, especially if HCPs fail to fully acknowledge the partner's role (Thomson et al., 2022). Pregnancy is regarded as a psychologically demanding time for fathers transitioning into their parental role (Genesoni & Tallandini, 2009), and conflicting emotions experienced during this time may be associated with feelings of chaos or loss of control (Finnbogadottir, Svalenius & Persson, 2003).

It has been suggested that HCPs are not adequately trained to engage with partners (Yogman & Garfield, 2016) which leads to their exclusion from care interactions (Dolan & Coe, 2011; Alio, 2017) and further contributes to feelings of confusion and isolation (Salzmann-Erikson & Eriksson, 2013). In this study, COVID-19 infection control measures in the ultrasound department requiring

fathers to wait in a separate area of the hospital to their partners created stress for both parents. This reflects findings reported in relation to the COVID-19 pandemic when partners were temporarily restricted from attending scans (Skelton et al., 2023c). As they do not physically experience pregnancy, providing support through companionship is thought to be a key aspect of how expectant fathers conceptualise their role during the prenatal period (Lagarto & Duaso, 2022). Being unable to fulfil this role reinforces feelings of inadequacy, which can negatively affect the sense of connection to the pregnancy (Chin, Hall & Daiches, 2011). Partner inclusion is important for prenatal bonding and to support maternal emotional wellbeing (Cuijlits et al., 2019), therefore, HCPs should make efforts to involve partners by acknowledging the importance of their presence (Finnbogadottir, Svalenius & Persson, 2003), providing father-focused information (Hodgson et al., 2021), and directing conversation to both parents (Widarsson et al., 2015). 'Interactions with healthcare professionals' was developed to highlight the integral role of the imaging professional in facilitating good communication, which contributed to positive parental experiences and reduced anxiety. Thoroughly explaining the scanning process and images, being open to questions and not rushing through the appointment were identified as central to parent-centred care. Indeed, previous literature has reported improved satisfaction in the scan experience associated with increased feedback from HCPs (Ekelin, Svalenius & Dykes, 2008; Masroor, Ahmed & Ajmal, 2008). However, recent research suggests that moral injury and occupational burnout experienced by UK obstetric sonographers because of the COVID-19 pandemic may present substantial challenges to the provision of parent-centred care (Skelton et al., 2023a, 2023b).

Whilst the influence of parental employment (e.g., unemployed or part-time working) to enhance bonding was not further qualified, it may be that parents in full-time employment have reduced cognitive capacity to engage in imaginative practices which are essential to facilitate the developing bond, as they may be preoccupied with procedural and operational aspects of their work (Condon & Corkindale, 1997). A similar explanation relating to cognitive capacity was proffered pertaining to the negative effect of anxiety related to COVID-19 pandemic on parent-fetal bonding

(Karaca, Koyucu & Aksu, 2022), where it was argued that increasing preoccupation with pandemic-related anxiety in mothers decreased their capability to think about the baby (Göbel et al., 2018).

7.5.2 Clinical implications

Although various scales attempt to quantify parent-fetal bonding (van den Bergh & Simons, 2009), the clinical use of this metric is uncertain. Whilst higher scores are typically considered to reflect a more developed bond, no optimal value has been reported (Ranjbar, Warmelink & Gharacheh, 2020). A positive correlation between bonding and GA has been previously observed (Yarcheski et al., 2009), and supports the theory of key 'trigger moments' throughout pregnancy to intensify the bond (Lagarto & Duaso, 2022). However, this implies that bonding is a linear process, which may not be reflective of all parents' experiences. Instead, it has been suggested that even if 'low' bonding scores are recorded by parents earlier in the pregnancy, their developing connection is likely to be comparable with other parents at the end of the pregnancy (Borg Cunen et al., 2022). As such, it is possible to inaccurately label a prenatal bond as dysfunctional, which may cause expectant parents to feel inadequate, and thus have substantial implications, not only for the developing bond, but postnatal infant attachment (Lee, Schoppe-Sullivan & Kamp Dush, 2012). In addition, it may be argued that the development of an optimal value based on self-reported scores would not adequately reflect the theoretical complexity of the prenatal bonding construct, and therefore should not be considered in isolation to guide the provision of enhanced support for expectant parents. Thus, it is recommended in the first instance that a parent-centred approach to care which recognises and meets the individual needs of expectant parents is adopted within fetal imaging services to facilitate supportive experiences that may, in turn, promote enhanced parent-fetal bonding. Indeed, studies reporting the positive effect of healthcare consultations on prenatal bonding further reflect the findings of this study (Masroor, Ahmed & Ajmal, 2008; Pulliainen et al.,

2019), and suggest that the care interaction experienced during fetal imaging may be an important moderator to consider in the antenatal setting (Walsh, 2020).

7.5.3 Strengths and limitations

Prospective data collection facilitated engagement with different parent groups and modalities to enable focused comparisons to be made. Additionally, many studies evaluating parent-fetal bonding after imaging are purely quantitative; in this study, free-text responses provided qualitative context to extend the statistical findings (Kibiswa, 2019). A further strength was the use of validated instruments for data collection in all parents which permitted direct comparisons to be made between parent groups. However, self-reported bonding scores may be limited by social desirability bias (Krumpal, 2013). In this context, parents completing the questionnaire may have altered their responses to achieve a higher score (Lee, Schoppe-Sullivan & Kamp Dush, 2012). It has also been suggested that fathers may not disclose negative feelings if they think doing so may detract professional care and attention from their partner, or if they do not believe they are entitled to (Darwin et al., 2017). Another limitation was the predominance of ultrasound-mothers in the sample. Lack of fathers' engagement in pregnancy research is acknowledged (Panter-Brick et al., 2014), and despite targeted efforts to recruit fathers into this study, numbers are low, reflecting the need to further improve approaches. In addition, recruitment of eligible MRI-parents was affected by continued disruption of research studies after the peak of the COVID-19 pandemic (Thornton, 2020). Although the pre-determined target sample size of n = 70 was achieved, it is likely that a greater number of participants would provide further power in the quantitative findings (Riley et al., 2020). However, it should be noted that in addition to the challenging experiences in recruiting fathers into antenatal research, as a relatively new imaging modality in pregnancy, the provision of fetal MRI in the UK is limited. Thus, these initial findings serve to provide preliminary insight into expectant parents' experiences of this technology, and future work should seek to build on this. Enlarging the

dataset and extending the sample population would also be beneficial to include greater representation of parents (including same-sex couples or non-binary parents), ethnicities, and educational level.

7.6 Conclusion

A detailed understanding of the influence of antenatal imaging on the developing parent-fetal bond is essential to ensure the provision of supportive and inclusive care for expectant parents accessing imaging services. This work extends existing knowledge by directly comparing mothers and fathers, and introduces new insights related to the use of fetal MRI in uncomplicated pregnancies. Bonding scores were significantly increased in both parents after imaging, however no differences between mothers and fathers were observed. Bonding was greater in parents after MRI compared to ultrasound although this may reflect the more developed emotional connection at later gestational ages. Parental excitement and experience were also identified as important variables, and qualitative analysis suggested they may be influenced by the professional conduct of imaging professionals during the scan. Effective communication helped parents to interpret scan images and offered reassurance of fetal wellbeing, contributing to a positive experience. Visualisation of the fetus provided evidence of its presence, which intensified parents' sense of connection to the baby and increased excitement in imagining future parenthood. Imaging professionals should therefore adopt an informed, parent-centred approach to care to best support expectant parents.

8 “It’s not just the medical aspects that are important”: A qualitative exploration of first-time parents’ experiences of antenatal imaging and their influence on parent-fetal bonding (Article 6)

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8.1 Abstract

Introduction

Antenatal imaging provides clinical information regarding fetal growth and development. The additional benefit afforded by imaging for expectant parents in developing an emotional connection (bond) to the unborn baby is also acknowledged. However, the relationship between imaging and bonding is not fully understood, particularly where there are differing parental and pregnancy circumstances, for example use, of advanced imaging techniques or the prenatal diagnosis of a congenital fetal condition. This study aimed to explore the role of antenatal imaging in enhancing the developing parent-fetal bond in first-time parents.

Methods

A descriptive, qualitative design was used. Semi-structured telephone interviews were conducted with first-time expectant parents attending a London hospital for clinical ultrasound (n = 20) or research MRI (n = 8) imaging during pregnancy. The sample included parents receiving specialist antenatal care for a diagnosed fetal cardiac condition (n = 8). Thematic analysis was conducted.

Results

The analysis generated three themes: 1) our baby, our scan too; 2) destination parenthood; and 3) being in the dark, then finding the light. These themes highlight the important, but transient role of antenatal imaging in enhancing parent-fetal bonding, as well as the differing care needs of expectant parents. The integral role of HCPs in providing a personalised, supportive imaging experience to facilitate bonding is also reflected.

Conclusion

Adopting parent-centred care approaches which involve expectant parents in fetal imaging influences bonding by helping parents to consider the reality of their impending parenthood. Knowledge acquired during scans is used to create an identity for the unborn baby, to which parents can develop an emotional connection.

Implications for practice

To optimise the potential for enhanced parent-fetal bonding, care provision in fetal imaging should be tailored to the individual needs of expectant parents.

Key words: Attachment; Bonding; Fetal Imaging; MRI; Parent-centred care; Pregnancy; Ultrasound

8.2 Introduction

Imaging is integral to antenatal care, providing insights into fetal development to inform clinical management pathways (National Institute for Health and Care Excellence, 2019). B-mode ultrasound is most frequently used, however technological advances enable application of additional techniques like 3- and 4-dimensional ultrasound, and fetal magnetic resonance imaging (MRI). Although fetal MRI is not routine in pregnancy, its value in acquiring highly detailed anatomical information to compliment ultrasound is acknowledged (Pasupathy, Denbow & Rutherford, 2019; Davidson et al., 2021; Fileva et al., 2023).

The psychosocial benefits of antenatal imaging for expectant parents are also reported, and current literature explores the association between imaging and enhanced parent-fetal bonding (Skelton et al., 2024). The emotional connection which parents feel towards their unborn child is associated with fetal development (Branjerdporn et al., 2017) and parental well-being (Kluny & Dillard, 2022). Establishing a quality bond involves developing a new parental identity and building an emotional relationship with the fetus (Doan & Zimerman, 2008). Fetal imaging is thought to support bonding as it transforms pregnancy from an abstract concept into a reality by providing visual evidence of fetal personhood (Borg Cunen et al., 2022). Some parents may use fetal imaging to validate and document their new identity in the social setting, a behaviour which has been linked to enhanced bonding (Harpel, 2018). It is believed sharing scan images with family and friends involves others in the pregnancy, contributes to the development of a fetal identity, and helps to establish a social network for supporting the new family unit (Chalklen & Anderson, 2017).

The biopsychosocial model of healthcare acknowledges the importance of imaging for providing medical information (biological), facilitating parent-fetal bonding (psychological) and supporting parents' unique experiences of pregnancy (social). This model may be applied to antenatal imaging in considering the interplay between biological, psychological, and social factors of scanning, and how these may influence expectant parents' experiences of pregnancy scans (Lehman,

David & Gruber, 2017). However, it has been criticised for its integration difficulties across healthcare (Smith, 2021). More complex scan protocols, workforce shortages and high levels of occupational burnout in HCPs makes finding a balance between the biological and psychosocial domains of fetal imaging challenging, especially following the COVID-19 pandemic (Skelton et al., 2023a). Inadequate acknowledgement by HCPs of parents' psychological needs and expectations during fetal imaging can lead to parents' perception of a medico-centric approach to care and subsequent feelings of disempowerment and indifference in the process which may be detrimental to the developing parent-fetal bond (Jackson et al., 2023). An alternative to the biopsychosocial model is the concept of person-centred care. This shares some similarities in promoting a humanistic approach to involve individuals in their care (Santana et al., 2018). Yet, in pregnancy, it must be further adapted to recognise the unique and additional needs of the expectant parent and incorporate the wider family unit (Brady et al., 2019).

Parent-centred care is important for improved parental satisfaction and pregnancy outcomes (Park et al., 2018), and its positive influence on parent-fetal bonding. Greater role satisfaction and mitigation of occupational burnout in obstetric sonographers has also been reported (Skelton et al., 2023a, 2023b). However, care may be hindered by organisational challenges and, additionally, there is currently no accepted definition or model in fetal imaging or obstetrics, although recent work seeks to address this (Dong, Jameel & Gagliardi, 2022). This may be partly due to gaps in knowledge; research into fathers' experiences of antenatal care is limited, despite their increasing involvement in pregnancy and childcare (Chin, Hall & Daiches, 2011). Furthermore, expectant parents' care requirements may differ depending on their previous experiences of care. For example, scans in pregnancies following an unexpected outcome may trigger distressing flashbacks for parents (O'Leary, 2005), with stress and anxiety noted to be particularly high at the same gestational age to the initial diagnosis (Beauquier-Maccotta et al., 2022). Finally, the effect of new and advancing technologies (e.g., fetal MRI) on parent experiences are yet to be fully evaluated. Imaging acquisition processes of fetal MRI are different to ultrasound, and it has been suggested that expectant parents

may not be prepared for loud scanner noises, feelings of claustrophobia, and discomfort in lying still for an extended period (Leithner et al., 2008). Additional considerations surround parental responses to seeing highly detailed fetal images, particularly if a congenital condition has been diagnosed in the unborn baby (Skelton et al., 2024).

This study aimed to explore the research question: how does antenatal imaging influence prenatal bonding in first-time expectant parents? A qualitative approach is used to extend current knowledge by providing deeper insight into the role of pregnancy imaging in supporting the developing parent-fetal connection, and further understanding of how this may change with differing parental circumstances and pregnancy outcomes.

8.3 Methods

A descriptive, qualitative methodology was used in this study, located within a pragmatist paradigm. The flexibility of this approach allows the researcher to choose the most appropriate method to address the research question (Yardley & Bishop, 2015). Semi-structured interviews were therefore conducted to enable in-depth exploration of parental experiences and perceptions of antenatal imaging. Data were analysed using reflexive thematic analysis (Braun & Clarke, 2022). The JARS-Qual checklist (Levitt et al., 2018) was used to guide reporting of this study.

8.3.1 Participants

Convenience sampling was utilised. First-time expectant parents (≥18 years) were approached by HCPs during clinical or research imaging appointments at a London hospital. All parents had attended for fetal imaging (clinical ultrasound or research MRI) between 18-36 weeks gestation of pregnancy. For some parents, scans were offered as part of the antenatal care pathway in uncomplicated pregnancies (NHS Fetal Anomaly Screening Programme, 2021). Some parents were receiving specialist care following a fetal diagnosis of congenital heart disease (CHD). These parents were only approached if they were committed to the pregnancy, willing to support research, and their care team believed participation would not be distressing. An information video and written information further detailing the purpose of the study, participation schedule, and options for withdrawal were shared with parents who expressed their interest to be involved. Parents were given time to ask questions and consider their participation before providing consent and permission for illustrative quotations to be included in publications through an electronic informed consent form (Skelton et al., 2020a). Based on feedback received during public involvement activities undertaken to inform the methods, no incentives were offered to parents.

8.3.2 Data collection

Individual interviews were arranged within four weeks of the fetal imaging examination. All were conducted by the lead author via telephone between October 2021-December 2022 because of restrictions around face-to-face research activity during the COVID-19 pandemic (Kroenke, Bair & Sachs, 2021). As all interviews were remote, participants could choose the environment they felt most comfortable to talk in, most being at home. No participants were previously known to the research team. A semi-structured interview guide (Appendix 8) was developed to address the research question based on findings from a systematic review of published literature (Skelton et al., 2024), and reviewed by parent volunteers and project collaborators (Antenatal Results and Choices, Fathers Reaching Out). The interview guide was piloted with three parent volunteers, resulting in some changes to the question phrasing for improved response clarity (e.g., 'tell me about your experience of the scan' became 'tell me what happened during your scan appointment?'). The interview guide empowered participants to lead the conversation with occasional prompts by the interviewer to maintain alignment with the research question. Sample size was guided by a model of information power (Malterud, Siersma & Guassora, 2016). This model identifies five items (aim, specificity, theory, dialogue, and analysis) which may inform sample size considerations. For example, the broad aim and exploratory nature of the study to capture experiences across differing case scenarios (including parent type, imaging modality used, routine or specialist antenatal care pathway) suggests a larger sample size is required for adequate information power. Therefore, we aimed to interview approximately 10 parents per scenario.

Member reflections were utilised during the interview (e.g., repeating phrases and checking understanding) and analysis (e.g., review and feedback on themes). This helped to ensure accurate interpretation and portrayal of participant responses in the final report (Tracy, 2010). Interviews were recorded using an encrypted Dictaphone and transcribed verbatim for qualitative analysis by a professional service. Contracts were in place to conform to data compliance regulations. All

transcripts were reviewed for accuracy prior to analysis, and identifying information (e.g., names or specific personal details) was edited to preserve participant anonymity.

8.3.3 Analysis

Transcribed interviews were imported into NVivo for analysis (v14, QSR International Pty LTD). A six step framework was followed utilising a reflexive, inductive approach so that codes and themes could be developed from the data whilst also acknowledging the researcher's reflexivity in generating meaning (Braun & Clarke, 2006, 2022). Following a period of familiarisation with the data, each transcript was individually coded. The initial codes were reviewed collectively and further developed through combining similar codes and generating new codes. The codes were grouped into core themes and named. In keeping with the principles of reflexive thematic analysis, all analyses were conducted by the lead author and only discussed with other authors at the point of finalisation. Further details of the analytical process are provided in Appendix 9.

8.3.4 Ethics

Ethical approval was given by the NHS West of Scotland REC 3 (REC reference: 20/WS/0132, date of approval: 12th November 2020) and School of Health and Psychological Sciences REC at City, University of London (REC reference: ETH1920-1680, date of approval: 30th November 2020). Due to the nature of the research, the lead author attended an external training session on sensitive interviewing practices prior to starting data collection. This built on their existing communication skills and professional experience of conducting difficult conversations in the clinical setting. Opportunities to provide further care and support to parents during their participation in the study were also considered in the study design; debriefing was offered immediately following the interview, and an information leaflet with contacts for further support was also shared with all parents by email after the interview. The lead author also had access to psychological support and debriefing provided by senior members of the research team.

8.3.5 Positionality

The lead author is a sonographer with over 12 years of clinical experience of obstetric ultrasound, and four years' experience of conducting and publishing research in the topic area. The wider authorship team are composed of male and female clinical and academic professionals with substantial experience across domains including medical imaging, midwifery, paediatrics, and psychology. All recognise the potential implications and influence of their positions on the research.

8.4 Findings

Twenty-eight parents were interviewed (18 mothers, 10 fathers). Of these, eight parents attended for fetal MRI. There were eight pregnancies with a known fetal cardiac condition: six had ultrasound and two had fetal MRI (Table 8.1). The average interview length was 55 minutes (range: 39-76 minutes). Of all parents who gave their consent to be interviewed, none requested withdrawal from the study.

Table 8.1 Participant characteristics

	Mothers-1 (n = 8)	Mothers-2 (n = 4)	Mothers-3 (n = 4)	Mothers-4 (n = 2)	Fathers-1 (n = 6)	Fathers-2 (n = 2)	Fathers-3* (n = 2)
Modality	Ultrasound	Ultrasound	MRI	MRI	Ultrasound	Ultrasound	MRI
Fetal cardiac condition?	No	Yes	No	Yes	No	Yes	Yes=1 No=1
Average GA at scan	20w 2d	25w 4d	26w 3d	33w 6d	22w 1d	20w 4d	31w 1d
Average GA at interview	23w 3d	29w 1d	29w 4d	35w 1d	26w 4d	27w 1d	33w 5d
Average parental age	32	29	34	25	27	35	31
Ethnicity (self-reported)	White British=5 Asian British=1 Latin American=1 White Jewish=1	White British=3 Black Caribbean=1	White British=3 European=1	White British=2	White British=5 Mixed ethnic=1	White British=2	White British=2
Education	Undergraduate degree=3 Postgraduate degree=5	College=2 Undergraduate degree=2	Undergraduate degree=2 Postgraduate degree=2	College=1 Undergraduate degree=1	College=2 Undergraduate degree=2 Postgraduate degree=2	College=1 Postgraduate degree=1	College=1 Undergraduate degree=1
Employment status	Full-time=8	Full-time=4	Full-time=4	Full-time=2	Full-time=6	Full-time=2	Full-time=2
Pseudonyms assigned	Sara Elizabeth Jennifer Stephanie Jessica Alisha Nicole Kayla	Rachel Leah Mia Rebecca	Amanda Lauren Danielle Megan	Abigail Caitlin	Joshua Ryan Andrew Nicholas Rob Christopher	Matthew William	Joseph David

**Grouped characteristics to provide participant information whilst preserving individuals' anonymity.*

Three themes were developed: 1) our baby, our scan too; 2) destination parenthood; and 3) being in the dark, then finding the light (Table 8.2). Collectively, these themes placed fetal imaging as pivotal for expectant parents in developing the emotional connection to their unborn baby, transitioning into new caregiving roles, and establishing their new family unit. All parent names used in direct quotations below are pseudonyms that preserve anonymity but maintain authenticity of the process and the human-centric focus of this research.

8.4.1 Our baby, our scan too

The duality of antenatal imaging is represented in this theme, highlighting the importance of adopting a parent-centred approach to scans. Expectant parents welcomed the medical focus of scans for providing assurance of fetal development, but also craved the opportunity to engage with their unborn baby on a deeper emotional level. Parents also expressed their desire to be actively involved in scans. Those who were involved perceived a better overall experience. This was particularly evident for fathers who experienced challenges in navigating their role as a non-pregnant parent.

"I think sometimes as a partner when you go to a scan and all the conversation is directed at the pregnant woman then you sometimes feel like a bit of a spare part and, like, you're not particularly useful in the whole thing." [David]

Fathers appreciated being welcomed into the clinical space and being included in conversations with HCPs. Feeling looked after and working with HCPs to understand and interpret fetal images were also important for supporting and including both parents during scans. They felt empowered when the importance of their new parenting role was acknowledged, experienced joy in seeing the baby, and felt reassured by listening to and watching the fetal heartbeat. This was symbolic of on-going life, even for parents of babies with a cardiac condition. Being made to feel comfortable, receiving a clear explanation of scan findings, and having the opportunity to ask

questions were characteristics of good care. Fetal MRI scanning was highlighted to be a greater challenge for parents than ultrasound, both physically and psychologically. Mothers developed strategies to help them through the scan, including reminding themselves of the health benefits and counting down the remaining acquisition time with HCPs. Both parents also acknowledged feelings of isolation during fetal MRI; mothers felt alone in the scan room and fathers felt separated from the experience and their partner as they waited in another room. In both modalities, imbalances in parent-centred care delivery were perceived when the parents' needs were overshadowed by HCPs' medical focus of the scan.

"If you tell a patient 'Oh you may have gestational diabetes', unfortunately that this is going to be their take-home message […] Everything else has been normal, that's what you need to take away from the scan." [Alisha]

Parents receiving specialist care also appreciated when HCPs did not solely focus on the condition but took time to acknowledge the baby too. This was especially important for parents participating in clinical imaging research projects where a physical condition was being studied. Finding a balance between the medical and psychosocial aspects of scans was crucial to facilitate positive parental experiences of care.

"When you're put in a big machine and it's all very technical and just research, research, research […] I'm not a lab rat, my baby's not a lab rat, so it's quite nice to just bring the human side of it, you know, they understand you're still a parent…" [Abigail]

8.4.2 Destination parenthood

Fetal imaging represented a milestone in the pregnancy journey and transition to parenthood. Scans provided expectant parents with a metaphorical compass to provide future direction for the pregnancy and prompted many new caregiving behaviours. Collectively, these

behaviours reflected individuals' acceptance of, and adjustment to their new parental roles, varying from recognisable "nesting" traits (e.g., buying things) to more subtle psychological tasks such as sharing news of the pregnancy with family and friends and building a social support network. Parents described delaying these behaviours until after the scan, wanting to feel fully reassured of the continuing pregnancy before fully committing.

"I was really hesitant with telling people […] because I was like you know, anything can happen. Maybe we'll have the second scan and maybe it won't be okay?" [Danielle]

However, the influence of fetal imaging on the creation of a new parental identity and simultaneously developing parent-fetal bond was transient and time-sensitive. Scan images provided early proof of fetal presence in the absence of later-manifesting physical cues like a visible pregnancy bump. Many parents felt closer to their baby following scans, although were not always able to articulate exactly why this was. Some referred to a greater sense of *"knowing baby"*, attributed to the recognition of personal or familial characteristics identified on scan images. However, parents' connection was not to the images themselves, but to the individual they were creating in their minds based on knowledge acquired from scans. Following scans, parents' visions of their baby rapidly shifted from a generic entity existing in the womb to their imagined child. At later gestations though, the superior influence of fetal imaging on bonding was replaced by a greater sense of connection through fetal movements.

"I literally feel everything all the time. I feel like that really connects me with the baby more than seeing the images." [Lauren]

8.4.3 Being in the dark, then finding the light

Fetal imaging was transformational for first-time expectant parents as it provided an opportunity to resolve uncertainties they had encountered during pregnancy. Scans facilitated a shift

from the unknown to the known, helping to inform parents about the progression of the pregnancy. Much of the uncertainty was centred around parents' fear of receiving unexpected news from the scan. This "scanxiety" was felt by all parents in the sense that pregnancy is never guaranteed, though was experienced most strongly in those influenced by previous complicated pregnancies or vicarious experience of pregnancy complications shared by family and friends.

"One of my sisters had a really bad experience […] and so that has kind of coloured my expectations of how difficult it can be and what can go wrong…" [Rob]

In moments of uncertainty, parents sought to exert some control over the situation. For some, this meant actively searching for and arming themselves with information. For others, it meant simply deciding to put their faith in the HCPs and *"go with the flow"*. Parents who received a fetal cardiac diagnosis experienced an additional transformation; one which required them to rapidly adjust their expectations of pregnancy and parenthood and adapt to a new reality. After receiving news of a diagnosis, parents described initial reactions of shock, confusion, and grief for the previously imagined child. With the support of their HCPs, they described a move from uncertainty to empowerment and acceptance of their baby's diagnosis. This was achieved by adopting a positive mindset and embracing the further opportunities afforded by specialist clinical care, including learning more about their baby through fetal MRI.

"As strange as it is to say, it's quite lucky in a way to be able to have seen that. It's such an incredible view of your baby and it's just quite an incredible experience." [Joseph]

Table 8.2 Key themes and codes

Theme	Definition	Codes	Illustrative quotations
Our baby, our scan too	The importance of parent-centred care to balance the medical and psychosocial aspects of fetal imaging	• Active participants, not observers • Checking in with baby • Dual-purpose imaging • Feeling cared for • Important moments for imaging • Making it through the MRI scan • More than a diagnosis • Understanding images	*"As [I am] not the parent carrying the child … this additional visualisation helps you feel even closer to it." [Ryan]* *"When they showed me all the pictures, they were showing a parent-to-be their baby for the first time." [Danielle]* *"I feel like from the NHS' point of view, they're taking it very much from a very pragmatic, biological, practical side. And it's like well that's all well and good but actually there's a huge emotional side to all of this as well." [Stephanie]* *"It's nice to feel that someone cares about you as well. Because of course they're there for the baby and everything else, they're also very much making sure that you're okay as well." [Rebecca]* *"She started explaining what she was doing and kept up almost a commentary the whole way through. I feel like I had an understanding of what she was doing." [Joshua]* *"My natural instinct is to just try and get out of the [MRI] machine … I tried to remember*

			logically why I was doing it … having someone reassuring you and knowing that someone's there with you, knowing that perhaps you're gonna have that picture or video at the end, knowing that you're gonna help, it's definitely worth it." [Abigail] *"You're not just looking at it like a case study of a condition, that is your baby, you are looking at your baby." [Abigail]*
Destination parenthood	Fetal imaging as a milestone and influence in the transition to parenthood	• Accepting new roles and responsibilities • Building a village • Getting to know you • Keeping a distance • Meeting the milestones • Power of the physical connection	*"When you see it on the scan, it just brings it all home and it makes you confront the reality." [Rob]* *"Close family and friends they have really journeyed with us, over the last two to three years, we have shared it [scan photo] with them." [Alisha]* *"…even sort of seeing that detail of like little fingers and things like that it really started to feel like a baby, rather than just a sort of idea… It started to make me feel that the baby had a bit of personality." [Elizabeth]* *"Just to see your little boy before he's actually here, I think that's a beautiful thing." [Joseph]*

			"I feel like I kind of held back a little bit sometimes […] kind of want to make sure they are actually here before you throw yourself into it 100%, but you already are in it anyway regardless as to what you tell yourself." [Rachel] *"I don't think a day has gone by where we haven't talked about something to do with the baby […] whereas I think before the twenty week scan it possibly wasn't something that came up every single day because it didn't seem like there was that much to talk about at that point." [Elizabeth]* *"Seeing the blood kind of going through the placenta and into the baby […] seeing that connection and then realising, actually, there is a physical bit where I and baby meet […] the baby is separate but it's also very much part of me as well." [Stephanie]*
Being in the dark, then finding the light	The role of fetal imaging in navigating the uncertainties of pregnancy	• Against all odds and expectations • Changing expectations • Making the best of the situation • "Normal for us" • Preparing for the worst, hoping for the best • Scanxiety is real	*"If we're talking about numbers, it's the fact that [the baby] has come about against tremendous odds." [Nicholas]* *"It's quite hard to process having a cardiac baby … you have an idea of what having a baby should be like to the have your world kinda spun upside down." [Abigail]*

		• Taking control • The journey ahead • Trusting the professionals • Unknowns of fetal imaging • Vicarious experiences • When the unexpected happens	*"Everyone always wanted to tell you a story about somebody that something bad has happened to, but if you actually think about it, all the people that you know, that have gone through a healthy pregnancy, have given birth at the end to a healthy baby." [Leah]* *"Relief…it's not the right way of saying it, but it was a relieving moment […] it very much, sort of, it solidified things, and it made me feel much more relaxed within the pregnancy period." [Andrew]* *"I was really reassured by what [the HCP] said around the development of the baby […] I'm a big worrier on these things and my concern was that we were gonna get the scan and there was gonna be something slightly suboptimal or abnormal and that we were gonna worry." [David]* *"We've both got the mentality of, we can't change it so let's just get on with it. We're in the best hands possible, the care plan's in place, we're lucky cos it's been picked up … I actually think I've had a really positive outlook." [Leah]*

			"I wanted to make sure that I was there with my husband to kind of both get the information because I feel like sometimes when you get that information you don't really process it until afterwards and you both take different information from it." [Rachel]

8.5 Discussion

Consistent with previous literature (Skelton et al., 2024), antenatal imaging was perceived by this group of parents to have a positive effect on bonding. The findings from this study suggest that first-time expectant parents utilised fetal imaging examinations to support two important processes for bonding; establishing a new parental identity and developing a connection to the unborn baby (Doan & Zimerman, 2008). Both were informed by knowledge created and acquired during scans, although the superior influence of fetal imaging over other pregnancy milestones was time sensitive.

Parents' use of fetal imaging to validate and explore their changing identities was observed, although fathers felt more uncertain in their role. Traditional and anthropological views of parenting associate caregiving tasks with mothers, and play-based, interactional learning with fathers (Deutsch, 2001; Machin, 2015), and whilst acts of maternal caregiving may begin during (and even before) pregnancy, the paternal role may be less well-defined until the baby's birth (Condon, 2006). Pregnancy is a psychologically challenging time for fathers who, in the absence of any physical cues, experience pregnancy through their partner (Fenwick, Bayes & Johansson, 2012). Consequently, many consider their primary role is in providing support and companionship for their pregnant partner (Lagarto & Duaso, 2022), which may draw focus away from developing their emotional connection to the fetus. This may explain previously observed differences in measured bonding scores between mothers and fathers (Condon, 1993; Kaur & Sagar, 2017; Skelton et al., 2023c). Research highlights fathers' participation in the scan experience and visualising fetal movement as more impactful than viewing images (Harpel & Barras, 2018), and fathers' exclusion from antenatal care and subsequent negative impact on their parental role has been previously discussed (Salzmann-Erikson & Eriksson, 2013). However, in keeping with existing literature (Finnbogadottir, Svalenius & Persson, 2003; Widarsson et al., 2015; Hodgson et al., 2021), fathers in this study identified how HCPs created opportunities for involvement. As fathers may experience greater challenges in adjusting to their new parental identity than mothers, early involvement helps support their transition and prevent disengagement from the pregnancy (Genesoni & Tallandini, 2009).

Whilst many expectant parents consider fetal imaging to be a source of reassurance for fetal health, it also caused parental anxiety (Pilnick & Zayts, 2014). In this analysis, many parents spoke of their concerns of receiving unexpected news about fetal development prior to the scan, regardless of whether they had previous experience of pregnancy complications or not. Indeed, research suggests that anxiety levels in parents peak immediately before fetal imaging (Businelli et al., 2021). Historically, it was believed that strong pre-occupation with concerns about fetal health may impair development of the parent-fetal bond as less time is spent fantasising about the future child (Leifer, 1980). For some parents, previous experience of loss may make it more difficult to navigate feelings of closeness to a new baby whilst grieving for the first baby (O'Leary, 2004). The importance of identifying previous psychological trauma in expectant parents to inform sensitive care delivery is therefore highlighted (O'Leary, 2005).

Although parents of babies diagnosed with a cardiac condition acknowledged their altered experience of pregnancy imaging compared to others, this did not seem to affect their feelings of connection to their baby. Whilst research is limited in this field, studies have attempted to observe quantifiable differences in measures of parent-fetal bonding between pregnancies with a fetal condition and uncomplicated pregnancies. However, the findings are often conflicting and vary depending on the type and severity of the anomaly (Tesson et al., 2022). Fetal imaging offers parents the opportunity to visualise a physical condition, which may be beneficial to support clinical explanations and parents' understanding of a diagnosis (Lalor, Devane & Begley, 2007). A study exploring fetal MRI in suspected brain conditions reported that parents found these images empowering in enhancing their own conceptualisations of the fetal identity, and helpful in challenging an often negative, medicalised, view of the pregnancy (Lie et al., 2019). Rather than the fetal condition itself being a predictor for bonding, it may be argued that the potentially detrimental impact of the condition on the parental pregnancy experience may be more influential. For example, if multiple specialist care appointments are perceived as burdensome, this may contribute to a negative experience of pregnancy (Kucharska, 2021). Interactions with HCPs may also affect how

parents cope with unexpected news, with experiences of poor communication contributing to increased psychological distress (Kratovil & Julion, 2017). Expectant parents therefore need clear, empathetic, and consistent communication to feel adequately supported and satisfied with their care experience (Jackson et al., 2023).

8.5.1 Implications for practice

The findings from this study suggest that in fetal imaging, there is no "one size fits all" approach to parent-centred care. In supporting psychosocial factors of imaging, the dual role of HCPs as skilled professionals and communicators is acknowledged (Brasseur, 2012). Literature reports the positive effect of an "imaging consultation" for reduced maternal anxiety and enhanced bonding (Boukydis et al., 2006; Masroor, Ahmed & Ajmal, 2008). This approach focuses on quality communication between HCPs and parents to improve clinical knowledge of the scan procedure, and promote parent-fetal interaction during the examination to assist with recognition and understanding of the developing fetus (Pulliainen et al., 2019). As reflected in this study, the importance of good communication to support parents is of particular importance in prenatal diagnosis (Kratovil & Julion, 2017). Additional recommendations for parent-centred care in fetal imaging developed from the study findings are also informed by literature (Skelton et al., 2024) and models of person-centred care in antenatal domains (Dong, Jameel & Gagliardi, 2022). These include: providing adequate and accessible information to support decision-making; respecting parent choices and autonomy; responding to parental psychological and emotional needs; acknowledging the importance of social relationships during pregnancy; and establishing a collaborative alliance between HCPs and parents for best outcomes.

Trustworthiness of this study is supported in several ways (Braun & Clarke, 2023). Triangulation of field notes and analytical memos aided theme development by adding depth to the interview transcripts (Varpio et al., 2017). Member reflections from participants were also utilised to

improve confirmability (Tracy, 2010). As reflexive thematic analysis is conducted independently, the personal influence of the researcher over the findings is acknowledged. Practising reflexivity and including a detailed report of the analytical process provided transparency for others to understand the researcher's position in the analysis (Murphy & Yielder, 2010). Still, this study is not without limitations. The broad scope of the research question did not facilitate in-depth exploration of the experiences of different parent groups included in the sample (e.g., fathers, specialist care, fetal MRI). Whilst principles of information power were adopted to inform the sample size (Malterud, Siersma & Guassora, 2016), it may be argued that the dataset would benefit from expansion, particularly for fathers and parents who had fetal MRI, as recruitment of these participants was limited by ongoing disruption in the aftermath of the COVID-19 pandemic. Purposive sampling may also be advantageous to include better representation of minority sociodemographic characteristics.

8.6 Conclusion

As fetal imaging is fundamental to antenatal care, it is critical for HCPs to understand the psychological importance it holds for expectant parents in connecting with their unborn baby. This study suggests it is not only fetal images which parents value for bonding, but the interactions with HCPs during the examination that help to shape fetal personhood, validate new parental identities, and provide reassurance of parents' emotional investment in the pregnancy. The provision of parent-centred care to address parents' differing psychosocial needs is essential for improved experiences of care and bonding. Whilst this study provides some recommendations for practice, further research is required to better understand imaging experiences in various parent groups (e.g., other ethnicities, same-sex couples, different fetal conditions) and develop a more comprehensive framework for care, inclusive of all parents and their needs beyond the clinical aspect of fetal imaging.

9 Discussion

9.1 Overview of discussion

Existing literature reports that parent-fetal bonding may be enhanced with antenatal imaging, although the underlying psychological process and extent of its effect on the developing emotional connection is not well understood, especially in fathers, when a fetal condition is suspected or diagnosed, or when advanced imaging technologies (e.g., fetal MRI) are utilised. The overall aim of this thesis was to provide a more detailed understanding of parental experiences of imaging during pregnancy and determine how they may facilitate a prenatal bonding. Additional research aims were developed in response to the global COVID-19 pandemic, to provide new insight into the experiences of parents accessing, and HCPs (obstetric sonographers) providing fetal imaging services during this time. Findings from the studies presented in this thesis support and extend current knowledge by further investigating the role of parent-centred care in antenatal imaging and its influence on parent-fetal bonding.

This discussion is presented in four sections. First, the main findings from each article are synthesised and summarised to demonstrate how they collectively address the overall research focus. These findings are critically discussed in relation to existing literature to further explore their contribution to the knowledge base and identify areas of agreement or contention. Secondly, the strengths and limitations of this body of work are broadly examined. Thirdly, the disciplinary implications of this thesis are considered across the domains of theory and concept, clinical practice, and research, with recommendations for fetal imaging service provision and parent-centred care, and priorities for future research identified. Finally, an overall conclusion of the thesis is provided.

9.2 Summary of key findings

Chapter 1 of this thesis critically explored theories of parent-fetal bonding and introduced the concept of parent-centred care in antenatal imaging. Key findings from Chapters 3-8 (Articles 1-6) are summarised in Table 9.1.

Table 9.1 Summary of key findings from each article included in this thesis

Chapter	Key Findings
3 (Article 1)	A systematic review of published literature concluded that: - Ultrasound scans in pregnancy can enhance parent-fetal bonding - Sonographers help expectant parents to interpret and understand fetal images - Interactive, parent-centred scan experiences help to facilitate bonding - There is limited research on the effects of fetal MRI on bonding
4 (Article 2)	An online survey of UK obstetric sonographers during the COVID-19 pandemic found that: - Occupational burnout in sonographers was likely exacerbated by the COVID-19 pandemic - Sonographer burnout was associated with psychological distress and decreased role satisfaction - Sonographers reported a moderately negative impact of the pandemic on their scanning practice - There was a need for urgent intervention to mitigate the consequences of burnout and its potential impact on parent-centred care provision
5 (Article 3)	Thematic analysis of free-text responses collected from an online survey of UK obstetric sonographers during the COVID-19 pandemic reported that: - Moral injury experienced through perceptions of ineffective and invisible leadership and management was a key contributing factor for occupational burnout in sonographers - Sonographers felt disconnected from senior figures and expectant parents - Positive interactions with expectant parents are integral for role satisfaction in sonographers - Care interactions with expectant parents may be undermined by lack of awareness of the sonographer's role and understanding of the clinical elements of pregnancy ultrasound
6 (Article 4)	An online survey of new and expectant parents' experiences of fetal imaging during the COVID-19 pandemic highlighted that: - Parental experiences of pregnancy imaging were negatively affected by restrictions for partners or supporting persons at scans - Self-reported anxiety in mothers and fathers was higher when partners did not attend the scan - Levels of parent-fetal bonding were similar in those who had been scanned compared to those who had not - Bonding in fathers was significantly lower than in mothers - Parental excitement after the scan was associated with increased parent-fetal bonding
7 (Article 5)	A two-part, online survey of first-time expectant parents completed before and after fetal imaging appointments observed that after ultrasound or fetal MRI scans:

	- Bonding in mothers and fathers was significantly increased - Bonding was significantly higher in expectant parents who had fetal MRI - Employment status, modality type, imaging experience, and parental excitement were identified as predictors for enhanced bonding after imaging - Fetal MRI was perceived as a superior imaging technique - Anxiety decreased significantly after imaging for mother and fathers - Positive communication with healthcare professionals helped to alleviate parental anxiety - Parental satisfaction was higher when care expectations were adequately met
8 (Article 6)	Semi-structured telephone interviews with first-time expectant parents after fetal imaging concluded that: - Parents want to be involved in their scan experiences - Healthcare professionals should find a balance between the medical and psychosocial domains of fetal imaging to support parent-centred care - Fetal MRI can be more physically and psychologically challenging for expectant parents - The influence of fetal imaging on parent-fetal bonding is time-sensitive - The presence of a fetal physical condition may not affect bonding but perceived negative experience may be a moderating factor

Chapter 3 (Article 1) presented a systematic review and analysis of 23 published research studies. This review aimed to explore the research question: “what is the effect of antenatal imaging on prenatal bonding?” and provide a detailed understanding of the existing evidence base in this area to inform the rest of the work of this thesis. In total, 16 of the included studies found that parent-fetal bonding increased following ultrasound scans in pregnancy. Synthesis of the mixed quantitative and qualitative studies using the Pillar Integration Process generated six overarching themes: 1) the scan experience begins before the scan appointment; 2) the scan as a pregnancy ritual; 3) feeling actively involved in the scan; 4) parents’ priorities for knowledge and understanding of the scan change during pregnancy; 5) the importance of the parent-sonographer partnership during scanning; and 6) scans help to create a social identity for the unborn baby.

The first theme captured how expectant parents’ experiences of fetal imaging began in advance of the scan appointment through the process of information gathering and setting of expectations. Parents reported feelings of excitement to see the unborn baby, but simultaneous apprehension for the possibility of receiving unexpected news about the pregnancy. Imaging is now a

routine component of antenatal care in most healthcare systems, and the second theme describes how most parents expected to be offered scans, viewing them as a milestone event in the pregnancy. This theme also suggested that the effect of advanced ultrasound techniques (3 and 4-dimensional imaging) on parent-fetal bonding was negligible. Whilst parents enjoyed the novelty of the modality, it could create unrealistic expectations for the scan leading to disappointment if they were unmet. In the third theme, parents expressed their desire to be actively involved in the scan and engage with the real-time scan experience. This was particularly important for expectant fathers who used scans as an opportunity to connect with their unborn baby and provide emotional support and companionship to their pregnant partner. Expectant parents' knowledge and informational needs during scans were further explored in theme four, which identified different priorities according to the pregnancy gestation and individual preferences and highlighted the association between knowledge and the instigation of behaviours in response to the developing bond such as making healthy lifestyle choices. Theme five further built on this by capturing the importance of positive interactions with imaging professionals during pregnancy scans to facilitate parent-fetal bonding. Expectant parents worked with sonographers to learn about their baby through the scan images, and valued sonographers' use of non-medical, accessible language regarding the fetus, which humanised the scan experience. The final theme recognised how, even after the scan was over, expectant parents continued to reflect on their experience, especially with those in their immediate support network. Scan mementos were often used to represent the physical presence of the unborn baby and help create their social identity to feel "known" within the group.

Overall, the findings showed a positive influence of imaging on parent-fetal bonding, with the underlying importance of quality parent-centred care approaches to support the developing emotional connection crossing multiple themes. However, some gaps in knowledge were identified from the review. Firstly, no studies measuring prenatal bonding in expectant parents having fetal MRI were identified for inclusion, demonstrating the lack of research evidence to inform clinical practice and support parental experiences of this fetal imaging modality. Furthermore, only six of the studies

included fathers, again highlighting the paucity of work in this topic area. The findings from this review were used to inform the research questions and data collection tools used in Articles 5 and 6.

Chapters 4 and 5 (Articles 2 and 3) present results of the online survey of the experiences of 138 UK obstetric sonographers performing fetal ultrasound examinations during the COVID-19 pandemic (thesis research study 1). Quantitative results of the survey were reported in Chapter 4 (Article 2) and a thematic analysis of the free-text survey responses was conducted for Chapter 5 (Article 3). High levels of occupational burnout were observed within the sonographic workforce with over 90% of participants meeting thresholds for the burnout domains of emotional exhaustion and disengagement (Chapter 4, Article 2). There were significant associations between burnout, psychological distress, and role satisfaction, with sonographers reporting a moderately adverse impact of the pandemic on their scanning practice. These results raised the possibility of negative implications for the provision of parent-centred care.

Findings from the qualitative analysis reported in Chapter 5 (Article 3) were used to gain a deeper understanding of the lived experiences of obstetric sonographers during the pandemic and how these may have contributed to occupational burnout. Five themes were developed during this analysis: 1) continuity in a crisis; 2) decisions about me, without me; 3) battle scars – the lasting damage of COVID-19; 4) what people think I do vs. what I really do; and 5) the human touch. Collectively, these themes reflected how incidences of moral injury relating to perceptions of ineffective and invisible leadership and management exacerbated already high pre-pandemic levels of burnout in sonographers. Increased occurrences of negative interactions with expectant parents and poor representation of the workforce in the news and on social media because of the restrictions on partner attendance may have further contributed to moral injury leading to decreased role satisfaction and disengagement from work. The analysis also identified an important consideration in that positive interactions with expectant parents could be undermined by lack of

awareness of the sonographer's role and understanding of the clinical aspect of obstetric ultrasound by parents and non-sonographer HCPs.

Chapter 6 (Article 4) explored parental experiences of pregnancy ultrasound imaging in the UK during the COVID-19 pandemic collected via an online survey (thesis research study 2). This survey collected quantitative and qualitative data, and primarily aimed to evaluate how these experiences may have influenced parent-fetal bonding. Statistically, and in contrast to the findings of Chapter 3 (Article 1), there was no difference in bonding scores between parents who were waiting for scans and those who had already been scanned. The findings suggested a negative effect of temporary restrictions on partner attendance at antenatal scans on parental anxiety, excitement, and satisfaction of the overall experience. However, no associations between partner attendance (or lack of) and parent-fetal bonding in mothers or fathers were observed, suggesting that parental reactions to the scan experience may have been most influential. Following separate quantitative (statistical) and qualitative (thematic) data analyses, the findings were integrated using a joint display matrix to enable further interpretation through the generation of an overarching meta-inference. This suggested that partner restrictions increased parental anxiety because mothers were apprehensive of receiving unexpected news by themselves, and fathers felt uninformed and excluded from the pregnancy and scan experience. Parental excitement, which was significantly and positively correlated with bonding was also affected because parents wanted to share the scan experience together. Three main recommendations were developed from the study, reflecting the potential need to provide additional psychological support to parents who had experienced pregnancy care during the pandemic, promoting well-being initiatives for staff providing care, and reviewing the content, accessibility, and availability of information for expectant parents regarding antenatal imaging to assist in expectation management.

Chapter 7 (Article 5) also utilised an online survey to capture data from 76 first-time expectant parents (58 mothers, 18 fathers) having fetal ultrasound or MRI in uncomplicated

pregnancies and identify variables which were significantly associated with increased bonding scores after imaging. Multivariate linear regression analyses revealed four significant parental and scan predictors for enhanced bonding in the data set, and a qualitative content analysis of free-text survey responses was conducted to further explain the influence of the predictors. Firstly, parental employment status was associated with bonding. The analysis found that parents in full-time employment scored lower for bonding than parents who were unemployed or on a part-time contract. Previous literature has suggested that increased cognitive demand can reduce parental capacity for thinking about their unborn baby, thus affecting the development of the emotional connection (Condon & Corkindale, 1997). The imaging modality used for scanning was also a significant predictor, as parents who had fetal MRI scored more highly for bonding that those who had ultrasound. Correlation analyses eliminated advanced gestational age as an influencing factor for bonding, however free-text responses suggested that the novelty of fetal MRI and perception of improved image quality elicited a sense of superiority in the modality. An alternative explanation of the impact of parental personality characteristics (e.g., motivation to volunteer for research participation) on bonding scores was identified as a consideration for further research. Parent scan experience and excitement scores were also found to be significant predictors for bonding, suggesting that an enjoyable and satisfactory experience of care during scans contributed to strengthening the emotional connection.

Finally, Chapter 8 (Article 6) reported the findings from a thematic analysis of semi-structured telephone interviews with expectant parents about their experiences of fetal imaging (ultrasound or MRI), in uncomplicated pregnancies or those with a diagnosis of a cardiac condition in the fetus. Three key themes were generated: 1) our baby, our scan too; 2) destination parenthood; and 3) being in the dark, then finding the light. Collectively, these conceptualised fetal imaging as transformational for parent-fetal bonding in growing fetal tangibility, transitioning into new caregiving roles, and establishing the new family unit. The first theme was developed from codes reflecting the dual-purpose nature of antenatal imaging in providing medical information about fetal

health and well-being whilst also satisfying expectant parents' needs of the psychosocial elements of scans. The importance of involving both parents in the scan experience was embedded in this theme; literature has previously reported the benefits of scans as an opportunity for father's engagement in pregnancy, however the interview data also reflected how mothers could feel overlooked in the process when the focus was solely on the clinical elements of the scan procedure. This theme also acknowledged the physical and psychological challenges of fetal MRI for both parents in comparison to ultrasound, noting issues of claustrophobia, isolation, and exclusion during scans. The second theme presented fetal imaging as a milestone in the journey to parenthood. It served as a marker in the pregnancy from which many positive bonding behaviours (e.g., accepting new roles and responsibilities, buying things for the baby's arrival, and building a social support network) were instigated. However, it also acknowledged that the influence of imaging on bonding was time-sensitive, and when other physical cues such as a visibly growing bump and feeling they baby's movements were apparent, the significance of fetal imaging was less important for supporting the emotional connection but still valued for providing additional information about the pregnancy. The final theme further reflected the concept of fetal imaging as a source of information and reassurance, whilst considering that it is also, by its very nature and purpose, a cause of parental anxiety and apprehension. The presence of a fetal physical condition was also considered in this theme, with no detrimental effect on bonding implied but potential implications for quality care practices and subsequent negative pregnancy experiences identified. The findings from this chapter again emphasise the importance of parent-centred approaches in antenatal imaging care provision to support individual's needs in developing their emotional connection to the unborn baby and their on-going transition to parenthood.

9.2.1 Main considerations

The main considerations from the work of this thesis are discussed in the following section. These are: 1) the positive influence of antenatal imaging on parent-fetal bonding; 2) parents' individual needs for care, and 3) individual and organisational challenges to providing parent-centred care in antenatal imaging. These were selected for focused discussion as they directly align with the thesis aims and research questions. Additional findings from this thesis are briefly considered at the end of this section.

9.2.1.1 The positive influence of antenatal imaging on parent-fetal bonding

The findings from Chapters 7 and 8 (Articles 5 and 6) aligned with those of the systematic review (Chapter 3, Article 1) to demonstrate a positive influence of antenatal imaging on parent-fetal bonding. Chapter 8 (Article 6) noted this effect to be time-sensitive and less influential at later gestations when fetal movements were better established, a finding also reported in early obstetric ultrasound literature (Lumley, 1990). This influence is further discussed in the sections below in relation to the role of imaging in informing fetal personhood and facilitating greater acceptance, exploration, and validation of new parental identities. On the contrary, Chapter 6 (Article 4) did not demonstrate a significant change in measured parent-fetal bonding scores after imaging. This is likely explained by the altered experience of pregnancy ultrasound and resulting lack of opportunities to practice parent-centred care because of the COVID-19 pandemic.

Informing fetal personhood

The studies presented in this thesis support those of existing literature to illustrate how antenatal imaging contributes to parent-fetal bonding by providing new knowledge and insight about the unborn baby. Fundamentally, visualisation of cardiac activity and fetal movements were symbolic

of on-going life (Chapter 8, Article 6). The information elucidated by imaging helps to support parental awareness of the growing fetal presence, transforming the fetus from an abstract concept to a tangible individual to whom parents can develop an emotional connection (Borg Cunen et al., 2022).

Information acquired through scans can also contribute to the development of fetal personhood, for example, demonstrating familial physical characteristics to which parents can relate (Condon, 1993). Technological advances in ultrasound and fetal MRI have also now enabled the production of detailed, 3-dimensional rendered images of fetal faces which are believed to be easier for expectant parents to interpret than their 2-dimensional counterparts (Ji et al., 2005). It is thought that fetal personification contributes to bonding by informing mental representations of the unborn baby created by parents (Pedreira & Leal, 2015) This theory aligns with the accounts reported in Chapter 8 (Article 6) whereby parents described how they felt emotionally close to the infant created in their mind as opposed to the scan image of the fetus. It is noted throughout this work that parental understanding of scan images is reliant on interpretative guidance provided by HCPs, highlighting the importance of the parent-practitioner partnership in the co-creation of fetal images. However, it also implies deeper philosophical ramifications which require further consideration beyond the scope of this thesis. These are described more specifically in relation to the commercial imaging setting, in that the information provided by HPCs is likely to be influenced by their epistemological approaches which may not entirely reflect those of the expectant parents (Kroløkke, 2010).

Acceptance, exploration, and validation of new parental identities

The studies also demonstrated how expectant parents used imaging during pregnancy to support the development of their new care-giving roles. For example, Chapters 3 and 8 (Articles 1 and 6) showed that parents regarded scans as an opportunity to interact with their unborn baby, and

to demonstrate responsible parenting in learning about the baby's health and development. Ultrasound scans at earlier gestations provided visual confirmation of the new life to parents (Chapter 3, Article 1) which evoked a sense of reality and further acceptance of the pregnancy as parents received some validation of their emotional investment. Indeed, a frequent remark from the expectant parents participating in these research studies was how the scans made *"everything feel more real"*. This is aligns with previously described theories of "trigger moments" during pregnancy which act as a catalyst for the developing emotional connection (Lagarto & Duaso, 2022).

Unlike fetal MRI which separates the image acquisition process from the image review and interpretation phase, ultrasound scans can establish a "real-time" connection to the fetus in which expectant parents can also begin to explore their new identity. Published literature reports how expectant parents may explore their new role by lightly reprimanding an un-cooperative fetus or reflecting on their approach to parenting during the scan, and this may be guided by input from the sonographer (Kroløkke, 2011). Chapter 8 (Article 6) found that exploration of the parental identity largely occurred outside of the scan appointment, as expectant parents reflected on their future caregiving journey on a more individual basis. However, the participants' experiences captured in this body of work suggest that antenatal imaging also served an important purpose in validating the new parental identity. As described in Chapter 3 (Article 1), scans are considered a milestone in pregnancy, and for expectant parents they also signify a rite of passage, as one of the first acts of responsible parenting (Williams, 2006). Thus, the combination of being present at the imaging appointment and later sharing souvenirs from the scan, helps to provide validation for expectant parents in their new role (Chapter 7, Article 5).

Furthermore, development of the parent-fetal bond is largely dependent expectant parents' capacity and willingness to engage in thinking about their unborn baby (Borg Cunen et al., 2022). Chapter 7 (Article 5) found that employment status was a significant predictor for enhanced bonding after antenatal imaging, with parents in full-time employment scoring lower on the PAI than those

who were unemployed or working in part-time roles. It has been previously suggested that employment status (and indirectly, higher education qualification) may place additional demands on expectant parents' time thereby limiting opportunities to think about their unborn baby (Cuijlits et al., 2019). Therefore, it could be argued that antenatal imaging appointments may be especially valuable to support the developing bond in busy, working expectant parents as they provide a dedicated opportunity for emotional connection.

Parent-centred care in antenatal imaging to support bonding

Two of the four variables identified in Chapter 7 (Article 5) as significant predictors for enhanced bonding after imaging (imaging experience and parental excitement), can be associated with the provision of parent-centred care during the imaging examination. The systematic review (Chapter 3, Article 1) first highlighted that expectant parents' perception of good care during imaging appointments was linked with feelings of satisfaction in the scan experience. This association is also recognised in the wider healthcare literature with person-centred care practices being further attributed to improved patient outcomes (Severinsson et al., 2017).

Chapters 7 and 8 (Articles 5 and 6) captured examples where HCPs created opportunities to deliver parent-centred care. Specifically, expectant parents valued moments in which HCPs provided adequate time to ask questions, and actively involved both parents in the care experience. Literature proposes that when HCPs actively engage with patients on a psychosocial level, the individuals' care needs are addressed in addition to the medical tasks, thus reducing objectivity in the care interaction and humanising the experience (Hebblethwaite, 2013). In antenatal imaging, this engagement helps to demonstrate to expectant parents that the HCP recognises the newly evolving family dynamic alongside the medical objectives of the scan. Chapter 6 (Article 4) found a statistically significant correlation between parental anxiety and satisfaction, and it may therefore be suggested that quality,

parent-centred interactions have a considerable role in facilitating a positive care experience by alleviating parental anxiety.

Of the three parental reactions to antenatal imaging (anxiety, excitement, and satisfaction) measured in Chapters 6 and 7 (Articles 4 and 5), excitement was a significant predictor for enhanced bonding. It may be speculated that excitement is important for bonding as it reflects expectant parents' desire to be close to the unborn baby (Ji et al., 2005). Again, this finding highlights the importance of HCPs in providing a positive imaging experience which may evoke feelings of parental excitement, but also considers the expectations that parents may have in advance of the scan appointment. Harwood, McLean and Durkin suggest that some first-time mothers may find it difficult to psychologically adjust to parenthood when their experiences do not align with prior expectations (Harwood, McLean & Durkin, 2007). Although their study was focused on postnatal experiences of parenthood, a similar hypothesis related to unmatched expectations leading to negative outcomes may be considered within the context of fetal imaging; it has previously reported that parents may experience disappointment when their high expectations of scans are not met (Ekelin, Crang-Svalenius & Dykes, 2004).

9.2.1.2 Parents' individual needs for care

The following section discusses the antenatal imaging care considerations for different parent groups, and their subsequent effect on parent-fetal bonding.

Mothers vs. Fathers

Research has previously observed that prenatal bonding scores are higher in expectant mothers than in fathers (Condon, 1993; Ustunsoz et al., 2010; Kaur & Sagar, 2017). This is thought to be because mothers experience embodied knowledge of the unborn baby through physical cues such

as fetal movements from an earlier timepoint than fathers (Harpel & Barras, 2018). Whilst Chapter 6 (Article 4) did find a significant difference in bonding scores between mothers and fathers both pre- and post-imaging (likely exacerbated by the COVID-19 restrictions on partner attendance to pregnancy ultrasound scans during the pandemic), Chapter 7 (Article 5) did not. Although this finding cannot be fully explained by the study data collected, it could be hypothesised that parents who volunteered to take part in this study did so because they already had an established emotional bond with their unborn baby and thus felt comfortable to share their feelings and experiences for research purposes. Alternatively, it could be proposed that as most fathers were introduced to the study by their pregnant partners, this may reflect the dynamics of the couples' relationship (e.g., dyadic adjustment) which is thought to influence feelings of closeness to the unborn baby, particularly in fathers (Bouchard, 2011; Göbel et al., 2019). Research also suggests that whilst mothers' transition to parenthood is more dependent on internal elements such as their own adult attachment style or maternal-fetal bond, fathers' feelings of closeness to the unborn baby may be more affected by dyadic emotional and behavioural dynamics (e.g., marital quality and maternal bonding scores) (Luz et al., 2017). The influence of the parenting alliance (e.g., how individuals work together to deliver parenting) is also noted as a potential determinant for prenatal bonding and postnatal attachment, once again emphasising the importance of adopting parent- and family-centred approaches within antenatal care to support the parental relationship (Luz et al., 2017).

Parental reactions to their imaging experiences were also noted to differ between expectant mothers and fathers. For example, Chapters 6 and 7 (Articles 4 and 5) both observed that mothers' pre- and post-scan anxiety levels were significantly higher compared to fathers. Qualitative findings reported in Chapters 6-8 (Articles 4-6) suggest that expectant mothers feel a greater sense of responsibility for fetal development and overall pregnancy outcome, and this is likely reflected in their anxiety scores, although not surprising given that anxiety and depression is more prevalent in women than men (Altemus, Sarvaiya & Neill Epperson, 2014). Feelings of responsibility are thought to reflect changes in expectant mothers' behaviours which prioritise the health of their unborn baby

during pregnancy (Darvill, Skirton & Farrand, 2010), and it is understandable that this may be delayed for fathers until later in the pregnancy, or even birth. In addition, parental excitement was also identified as an important predictor for enhanced bonding after imaging (Chapter 7, Article 5). This article also found that expectant fathers rated their post-scan excitement significantly higher than mothers. It is thought that fetal imaging provides a unique opportunity for expectant fathers to feel involved with antenatal care (Walsh et al., 2017). Furthermore, Chapters 6 and 7 (Articles 4 and 5) reported that fathers' satisfaction of antenatal imaging was associated with attendance at the scan and feeling included in the care experience by the HCP. The transition to parenthood is noted to be stressful for expectant fathers in particular whose roles during pregnancy may not be well established compared to mothers (Condon, 2006). This was highlighted in Chapter 8 (Article 6), and supports the discussion in Chapter 6 (Article 4) around fathers' desire to provide companionship and advocacy for their partners during pregnancy (Lagarto & Duaso, 2022), which was not felt to be fully achieved by some parents because of pandemic-related restrictions in antenatal imaging services.

Ultrasound vs. Fetal MRI

In evaluating the influence of different imaging modalities on parent-fetal bonding in uncomplicated pregnancies, Chapter 7 (Article 5) found that the type of imaging experienced was an important predictor of enhanced post-imaging bonding, and that expectant parents who had fetal MRI had significantly higher bonding scores than those who had ultrasound. Unlike previous studies (Close, Bateson & Douglas, 2020), gestational age was not found to be a significant predictor for bonding in this sample, thus two possible explanations for this finding were proffered in Chapters 7 and 8 (Articles 5 and 6). Firstly, it was considered that as the fetal MRI scans in uncomplicated pregnancies were conducted for research purposes, the parents who volunteered to take part may already have a well-established emotional connection to their baby (Williams, 2006). Secondly, and inclusive of the views of parents who underwent fetal MRI for a fetal cardiac diagnosis, it was also

qualitatively illustrated that expectant parents considered fetal MRI to be a novel way of imaging their unborn baby. Parents expressed their amazement and excitement at seeing their whole baby (as opposed to a series of standard ultrasound imaging planes) moving around within the womb with fetal MRI, which evoked thoughts of superiority in the modality compared to ultrasound. However, it may be argued that this idea of superiority is somewhat of a logical fallacy that may lead to a cognitive bias; just because the technology is newer or seems more advanced, it may not necessarily work better or truly improve outcomes (Canadian Foundation for Healthcare Improvement, 2014), or in the context of this work, enhance parent-fetal bonding.

One major difference identified between ultrasound and fetal MRI through this work was in expectant parents' experiences of the imaging technique itself. Although most parents were familiar and therefore comfortable with the ultrasound procedure, fetal MRI was acknowledged to be more physically and psychologically challenging for both parents (Chapter 8, Article 6). Any MRI examination may be intolerable for individuals who experience an intense fear of confined spaces (Munn et al., 2015), and some parents in this work disclosed new and surprising feelings of claustrophobia because of the small gantry, abdominal coil placement, and requirement to lay still during the scan acquisitions. In a study of 36 women who had MRI during their pregnancy (Leithner et al., 2013), anxiety levels were noted to be higher 12 months after having the scan than at the time of the scan, irrespective of the pregnancy outcome. Particular areas of distress were identified as the length of the scan, the noise during the scan, and worry for the baby during the scan (Leithner et al., 2013). Although it has been previously noted that expectant parents feel reasonably well-informed about the clinical reasons for fetal MRI (Leithner et al., 2009), it has also been suggested that they may not be fully prepared for the actual scan experience (Derntl et al., 2015). This has also been studied in more recent literature with recommendations for comprehensive information about fetal MRI to be made available to expectant parents well in advance of the imaging appointment to mitigate pre-scan anxiety and emotional distress surrounding the scan (Plunkett et al., 2023). In addition, Chapter 8 (Article 6) further highlighted that as no other individual is usually permitted in

the MRI scan room except for the pregnant person, parental separation during the scan contributes to feelings of isolation in both mothers and fathers. Physiological stress (measured by skin conductance levels) in pregnant women undergoing fetal MRI has been noted to be consistently high in those who are unaccompanied during the scan compared with those who are accompanied, and it has also been observed that their stress levels decline towards the end of the examination (Derntl et al., 2015). This study reported how stress during the scan was altered by pregnant women's use of coping strategies, a finding which was also observed in Chapter 8 (Article 6). Collectively, these findings may suggest that follow-up for parents after fetal MRI may be of psychological benefit, highlighting important considerations for psychological care of expectant parents before, during, and long-after fetal MRI scans.

Despite these considerations, the overall management of the fetal MRI scan appointment seemed to be preferable in comparison to ultrasound. Chapters 3, 6 and 7 (Articles 1, 4 and 5) alluded to the concept of a scanning "conveyor belt" in obstetric ultrasound, in which some parents felt rushed by HCPs who were required to complete their imaging tasks whilst simultaneously providing results. Parents wanted more time to enjoy the moment of connection with their baby and to ask questions of the HCP, and this was noted to have been achieved well in fetal MRI by separating the scan acquisition process from the later image review consultation (Chapters 7 and 8, Articles 5 and 6). The consultation style of appointment, which includes dedicated time for HCPs to provide feedback to expectant parents, has been previously associated with improved parental satisfaction in the scan experience (Ekelin, Svalenius & Dykes, 2008; Masroor, Ahmed & Ajmal, 2008). It may therefore be recommended that clearer boundaries between the technical and conversational components of the scan are established during fetal ultrasound appointments to minimise the sense of "multi-tasking" and create opportunities for positive interactions. But, it is prudent to acknowledge the potential time implications associated this recommendation, as lack of time has previously been identified as a challenge for the implementation of person-centred care approaches in medical imaging (Hyde & Hardy, 2021b). In response, artificially intelligent healthcare technologies

are more frequently being developed and deployed alongside claims of increased person-centredness because time-savings in clinical practice may be subsequently used to facilitate improved patient-practitioner relationships (Topol, 2019). However, caution must still be exercised; this outcome requires ethically responsible implementation of the technologies, as departments driven by the "payment by results" approach to healthcare may prioritise the benefits for increased through-put of patients over the potential opportunities for enhancing care (Sauerbrei et al., 2023).

Routine antenatal care vs. Fetal cardiac condition

Chapter 8 (Article 6) was the only study to purposively include a cohort of expectant parents receiving additional specialist antenatal care because of a confirmed or suspected diagnosis of a congenital cardiac condition in the fetus. Contrary to prior expectations, the qualitative findings presented in Chapter 8 (Article 6) highlighted more similarities in the care needs between the parent groups than differences. Irrespective of the care pathway, parents wanted to feel involved in the imaging experience and highlighted the importance of clear, accessible, and timely information to support them. A significant correlation between parental anxiety and information searching was observed in Chapter 6 (Article 4), suggesting that HCPs could play a part in alleviating anxiety by responding to parental needs for information about the pregnancy. In addition, Chapter 8 (Article 6) noted that in cases of known or suspected fetal cardiac conditions, appropriate and sensitive provision of information helped expectant parents to feel empowered after a diagnosis, reaffirming their commitment to the pregnancy and adjusting their expectations. However, it should be acknowledged that, as reported in Chapters 3 and 8 (Articles 1 and 6), not only do parents' priorities for information change with gestation, the amount of information provided must also be adjusted to suit individuals' needs.

Furthermore, Chapter 8 (Article 6) also found that expectant parents' psychosocial needs were not always met by HCPs because of the strong medical focus on antenatal imaging. It may be

suggested that parental desire to interact with their unborn baby on a deeper level during imaging demonstrates curiosity to learn more about the baby, desire to feel emotionally close to the baby, and reflects the presence of the developing parent-fetal bond (Condon, 1993). Similarly, anxiety expressed by parents in Chapters 6-8 (Articles 4-6) over the outcome of the pregnancy are also likely to reflect an establishing emotional connection, as it may be argued that these feelings would not be experienced if the individual was not already emotionally invested in the pregnancy (Göbel et al., 2018). A systematic review of literature relating to the effect of receiving a prenatal diagnosis of a fetal condition on the parent-fetal bond reports that many parents will experience a period of grief immediately following the diagnosis, representing their reaction to the loss of their previously imagined child (Gaspar, 2022). For parents continuing in the pregnancy, an important process of psychological adjustment must occur, whereby parents must re-imagine their unborn baby and their future parenting roles which may need to accommodate further care practices (McKechnie, Pridham & Tluczek, 2015). Thus, expectant parents may find that interactions with HCPs who adopt a predominantly medical focus and do not create space to consider the wider implications of a prenatal diagnosis during subsequent imaging for fetal congenital conditions are not fully supportive of their psychosocial needs. This highlights the potential value of HCPs in undertaking specialist training in perinatal mental health and counselling to provide important psychological care to expectant parents. Indeed, all parents interviewed in Chapter 8 (Article 6) were fully supported by clinical nurse specialists at the imaging centre and this is positively reflected in their recollections of care.

9.2.1.3 Individual and organisational challenges for providing parent-centred care in antenatal imaging

Despite the evidence presented in this thesis to suggest the importance of parent-centred care to support parent-fetal bonding, challenges to the provision of care were also identified because

of occupational burnout, inadequate emotional support, and HCPs' biomedical focus during antenatal imaging.

Chapter 4 (Article 2) reported high-levels of occupational burnout and reduced job satisfaction in UK obstetric sonographers, attributed in Chapter 5 (Article 3) to experiences of moral injury within the workforce during the COVID-19 pandemic. These findings may be considered a significant challenge to the provision of parent-centred care in antenatal imaging, as the detrimental impact of burnout on healthcare is previously acknowledged (Salyers et al., 2017). However, whilst social equity and reciprocity theory suggest that sonographers' perceived imbalance of care interactions may have contributed to burnout (Bakker et al., 2000), this is juxtaposed with the findings from Chapter 5 (Article 3) which highlighted the relationship between positive care interactions with service users and sonographers' increased role satisfaction. This connection has also been observed in nursing literature and further linked with improved quality of care (den Boer, Nieboer & Cramm, 2017). As role satisfaction is associated with staff attrition (Stefanovska-Petkovska et al., 2021), it could therefore be argued that facilitating the implementation of parent-centred care practices in obstetric ultrasound should be considered a priority at the organisational level to help address current shortages in the sonographic workforce.

The articles presented in this thesis suggest another challenge in that HCPs providing fetal imaging services may not be adequately supported to deliver quality parent-centred care (Chapters 4 and 5, Articles 2 and 3). Recent literature has explored the application of professional supervision to support psychological well-being and professional development in the sonographic workforce (Coleman & Hyde, 2022). However, a survey of 59 sonographers practising in the NHS found that more than half of the respondents (56%) did not have access to professional supervision, and emotional support was lacking (Carr & White, 2023). The emphasis on professional supervision for career development over its potential restorative function (e.g., supporting emotional well-being) suggests a lack of person-centredness in management approaches, which may subsequently be

reflected in care provision to service users (Hebblethwaite, 2013). Indeed, a strategic approach adopted in a large clinical NHS trust outlined the importance of person-centred management in the first instance to overcome barriers associated with care provision by empowering staff and improving retention (Stokes, 2004).

It may also be posited that standardisation of fetal imaging practices may present a challenge for parent-centred care, particularly in ultrasound. Working to rigorous protocols, such as those of the NHS Fetal Anomaly Screening Programme, may limit opportunities for parent-centred care as HCPs subsequently develop a task-oriented, standardised approach to care (Bourgault, 2023). Chapter 8 (Article 6) highlighted expectant parents' experiences of HCPs emphasis on the medical aspects of antenatal imaging and desire for further acknowledgement of the psychosocial side of the care interaction. This finding is not unique to antenatal imaging, and the resultant mismatch between service users' expectations and experiences of care as HPCs inadvertently neglect the service user's wider care needs is acknowledged in other healthcare domains (Ekman et al., 2011). Published literature suggests that integration of more holistic approaches into healthcare settings may be challenging if colleagues in leadership emphasise the biomedical domain and neglect psychosocial aspects (Malik, Hilders & Scheele, 2018). This narrowed focus on diagnosis and intervention is characteristic of the technocratic paradigm of healthcare described by Davis-Floyd, which places high value on technology and objectifies individuals by considering the human body as a machine, separating the physical being from the individual's mind, and thus reducing the onus on HCPs to take any responsibility for psychological care (Davis-Floyd, 2001). For this reason, the technocratic paradigm is incompatible with the values of person and parent-centredness, and this conflict in values has been identified as a source of tension when attempting to implement humanistic care approaches (Hebblethwaite, 2013).

9.2.1.4 Additional considerations

This thesis presents the first quantitative analysis of the effect of imaging modality type on the developing parent-fetal bond (Chapter 7, Article 5). In this dataset, expectant parents who experienced fetal MRI during pregnancy had significantly higher bonding scores than parents who had ultrasound. Possible explanations for this were elicited from qualitative analysis of free-text responses and considered in Chapters 7 and 8 (Articles 5 and 6). These included parental curiosity and desire for novel technology, participation in pregnancy research and the potential association with a well-established bond, and parental perceptions of the superiority of the modality compared to conventional ultrasound. This latter point may be attributed to expectant parents' over-familiarity (and perhaps complacency) with the use of ultrasound in pregnancy, and thus the novel experience of fetal MRI and the detailed images produced leads to a fallacy in which parents' perceptions could be over-estimated (Hoffmann & Del Mar, 2015). Furthermore, the finding of higher bonding in parents having fetal MRI compared to ultrasound, and any potential explanations proffered for this, must be interpreted with caution due to the relatively low numbers of participants included in these analyses.

Although there is some inconsistency in reported findings, demographic and psychosocial factors are generally recognised as important predictors for parent-fetal bonding (Yarcheski et al., 2009; Cuijlits et al., 2019). However, this work is the first to evaluate parental reactions to fetal imaging in the context of bonding and identify a positive correlation between parental excitement and prenatal bonding. This finding may be of particular importance given the restrictions on partner attendance at scans during the COVID-19 pandemic. For example, in Chapters 6-7 (Articles 4-5) expectant fathers who attended fetal imaging scans reported greater excitement compared to mothers following scans. This finding of parental excitement as a predictor for enhanced prenatal bonding supports existing research which posits that the powerful visual (and occasionally audial) stimulus of fetal imaging provides parents with evidence of fetal tangibility, which subsequently enhances feelings of excitement for impending parenthood and strengthens the sense of emotional

investment and connection to the unborn baby (Borg Cunen et al., 2022). This finding also offers further insight to understand the previously proposed concept of "trigger moments" for prenatal bonding, which are especially poignant for fathers who do not experience the physicality of pregnancy (Lagarto & Duaso, 2022).

Another factor which has been previously associated with increased parent-fetal bonding is expectant parents' knowledge of the fetal sex (Lewis, 2008; Robak-Chołubek, Chołubek & Piróg, 2015). National screening protocols do not refer to fetal sex determination (NHS Fetal Anomaly Screening Programme, 2021), although, some HCPs may offer a discretionary opinion based on their interpretation of scan images. It is thought that this knowledge further personifies the unborn baby and enhances expectant parents' mental representations of their child (Denbow, 2019). This finding was briefly alluded to in Chapter 7 (Article 5). However, it is also important to acknowledge early studies which found that bonding is not affected in expectant parents who decide not to learn the sex of their unborn baby (Grace, 1984; Wu & Eichmann, 1988). Whilst the age of these studies could limit the generalisability of their findings, this thesis did not find that knowledge of the fetal sex was an important factor for bonding either. Although it was not evaluated quantitatively, expectant parents in thesis research study 3 (semi-structured interviews) were asked about their intentions to find out the sex of their baby. However, analysis of these responses did not result in the development of a key theme centred on fetal sex. Instead, parents' views on fetal sex determination were recognised as a code within the overarching theme of "Destination parenthood" (Chapter 8, Article 6). Demographic and socioeconomic factors including race other than white, lower educational level, and fathers not in full-time employment have previously been associated with parents' desire to find out the sex of their unborn baby (Shipp et al., 2004). These are not reflective of the parent population included in this study, and therefore may explain why knowledge of the fetal sex was not found to be a substantial influence on parent-fetal bonding for expectant parents in this thesis.

9.3 Strengths and limitations

Strengths and limitations of the individual articles included in this thesis have been discussed in each chapter (3-8). This section presents an overview of the wider methodological strengths and limitations of the thesis. Paradoxically, the COVID-19 pandemic is considered as both a strength and limitation of this work.

9.3.1 Strengths

Broadly, the research presented in this thesis contributes to the evolving conceptualisation of parent-centred care approaches in antenatal imaging to support parent-fetal bonding and provides empirical evidence which could be used in the future development of a formalised framework for practice. This thesis also presents the first study evaluating self-reported parent-fetal bonding scores after fetal MRI (Chapter 7, Article 5). The longitudinal aspect of thesis research study 3 (bonding in expectant parents) can also be considered a strength given that thesis research studies 1 (obstetric sonographers during COVID-19) and 2 (new and expectant parents during COVID-19) were cross-sectional. In addition to the strengths previously discussed for each article (Chapters 3-8), further merits of the overall thesis are considered including the use of a mixed-methods approach, methodological contributions to ethically designed remote research methods, and public involvement and engagement activities.

9.3.1.1 COVID-19

Changes to the provision of antenatal imaging services in response to the COVID-19 pandemic enabled the work of this thesis to be extended beyond its original planned scope, providing additional insights on experiences during the pandemic. First, the temporary restriction of partners and supporting persons at pregnancy ultrasound scans in the UK during times of national lockdown presented an extraordinary opportunity to naturally observe the subsequent impact of this

enforced measure on parental experiences of antenatal imaging and parent-fetal bonding (Chapter 6, Article 4). Second, the perspectives of UK obstetric sonographers performing ultrasound scans during this unique time were also captured and explored. The importance of parent-centred care to support parent-fetal bonding had been previously recognised in the systematic review (Chapter 3, Article 1), therefore it was important to gain a deeper understanding of the experiences of HCPs to inform data analysis and interpretation of later work which was conducted for this thesis. As well as the two chapters reporting the obstetric sonographers' experiences during the COVID-19 pandemic (Chapters 4 and 5, Articles 2 and 3), a further paper was published from data collected as part of the online sonographer survey (Skelton, Malamateniou & Harrison, 2022). To date, this is the only work to specifically explore the impact of the pandemic on UK obstetric sonographers and consider the implications for workforce recovery and service delivery, with an emphasis on visible and effective leadership. Whilst beyond the scope of the overall aims of this thesis, its original contribution to policy and practice is valuable in the broader context of obstetric ultrasound.

9.3.1.2 Mixed-methods research design

As highlighted in Chapter 1, parent-fetal bonding is a complex phenomenon with multiple influencing factors. Thus, a complex research design was required to support the overall aims of this thesis. A mixed-methods approach was ideally suited to address the research questions developed for this thesis, which contained both quantitative and qualitative elements. Quantitative tools were used to acquire objective measurements of parent-fetal bonding and occupational burnout in obstetric sonographers (Chapters 4, 6, and 7, Articles 2, 4, and 5), and enable exploration of statistical trends within the dataset. Qualitative methods (Chapters 5-8, Articles 3-6) facilitated incorporation of participant voices to provide a deeper, narrative insight to the statistics.

Mixed-methods research has been previously defined as "research in which the investigator collects and analyses data, integrates the findings and draws inferences using both quantitative and

qualitative approaches" (Tashakkori & Creswell, 2007). As well as utilising mixed-methods for data collection, integration of methods and subsequent findings is essential to fully harness the power of this research design. In this thesis, several approaches have been utilised to achieve this, most frequently through the creation of joint display matrices to uphold inferential transparency and support data integration. In Chapter 3 (Article 1), the 4-stage Pillar Integration Process (Johnson, Grove & Clarke, 2019) was used to methodically combine findings extracted from quantitative and qualitative studies included in the systematic review (Chapter 3, Article 1). This resulted in the generation of five central (pillar) themes reflecting a synthesis of findings, and facilitating a deeper understanding of research literature to inform the empirical studies. Theme four ("the importance of the parent-sonographer partnership during scanning" provides an illustrative example of this: in isolation, the quantitative findings of Boukydis et al. (2006), who reported that interactions with HCPs during fetal imaging contributed to enhanced bonding and influenced parent perceptions of scans, offer little to further contextualise these observations. However, integration with codes generated from qualitative research studies provided additional, practical insight around effective communication (e.g., choice of language to humanise the fetus), parental values (e.g., trust in the HCP), and care experienced by parents during the scan (e.g., not feeling rushed).

Two further integrated analyses were also undertaken for Chapters 6 and 7 (Articles 4 and 5) but for different purposes. For triangulation purposes (e.g., evaluating the extent to which findings converge or refute), claims developed from the quantitative survey data were combined with findings from the thematic analysis of free-text responses to develop an overarching meta-inference to summarise the findings reported in Chapter 6 (Article 4). The meta-inference is an important outcome of mixed-methods research as it represents the integration of quantitative and qualitative claims (Schoonenboom, 2022). The process of developing the meta-inference utilised a joint-display matrix to organise and present the key quantitative and qualitative findings (McCrudden, Marchand & Schutz, 2021). This enabled side-by-side comparison of claims and classification of the connection between them (e.g., explanation, contradiction, or juxtaposition), which could prompt further

analysis as needed. For example, a contradiction was identified between mothers' qualitative accounts of feeling emotionally disconnected form their pregnancy (i.e., perceived low bonding) if their partners had not attended the scan, and their self-reported bonding scores which demonstrated no differences between mothers whose partners had attended, and mothers whose partners had not. This claim was further developed by integrating other claims, and it was subsequently found that non-attendance of a partner negatively impacted maternal feelings of excitement about the pregnancy, which ultimately influenced their feelings of closeness to the baby. This integrated claim was then used to explain the positive correlation which had been observed between parental feelings of excitement and their bonding scores.

Finally, findings from the qualitative content analysis conducted on questionnaire data acquired during thesis research study 3 were used in a complimentary manner to provide possible explanations for the statistical predictors associated with enhanced parent-fetal bonding after imaging (Chapter 7, Article 5). Statistically, the most important predictor for enhanced bonding was found to be the imaging modality used, as parents who had fetal MRI had higher bonding scores. However, the statistical importance of this predictor was not fully reflected in the qualitative content analysis, and the low frequency of this theme (i.e., few parents commented) suggested that this finding may be, in part, explained by expectant parents' impression of superiority in the modality rather than directly increasing feelings of closeness to the unborn baby. The complimentary use of qualitative data therefore resulted in a more accurate conclusion being reached regarding the importance of fetal MRI for enhanced parent-fetal bonding.

9.3.1.3 Ethical electronic informed consent for remote research

In response to advice given to avoid face-to-face research methods during the COVID-19 pandemic, remote approaches of online surveys, telephone interviews, and electronic informed consent (e-consent) were utilised to enable research continuity for this thesis. Praised for its

versatility (e.g., it can be used in-person during face-to-face consultations or accessed completely remotely by a research participant) and potential to extend reach to groups who are otherwise not well represented in research (Heller et al., 2014; Hamel et al., 2016; Khairat et al., 2018), e-consent is now recognised by the NHS Health Research Authority (HRA) and Medicines and Healthcare products Regulatory Agency (MHRA) as a credible option for informed consent processes (Health Research Authority, 2018). However, increasing use of e-consent as an alternative to paper-based approaches highlighted a need for accessible, evidence-based recommendations for its ethical use and implementation in remote research. A narrative review of best practice was therefore published prior to conducting the empirical thesis research (Skelton et al., 2020a), providing a valuable contribution to research methodology in summarising the advantages and challenges of e-consent, as well as proposing a series of recommendations for researchers. This paper proposed an updated conceptual framework of the process of informed consent to include electronic methods and promote ethical and standardised practice. A total of 18 studies were critically discussed in the review and key recommendations were developed around five primary themes of: 1) accessibility and user-friendliness of the e-consenting system; 2) user-engagement and comprehension; 3) customisability to participant preferences and demographics; 4) data security; and 5) impact on research teams.

First, it was highlighted that whilst e-consent is generally well received by research participants and reflective of modern lifestyles, individuals may still prefer using traditional methods for informed consent (Harle et al., 2018). There is no universally superior approach (Grady et al., 2017), thus the choice of electronic or paper-based forms should be offered to participants in future studies. The review also acknowledged unique advantages of e-consent for enhanced participant engagement and interaction with digital information resources (Lawrence et al., 2020), as well as for improved understanding of research processes, although emphasised the need for research team members to offer opportunities for real-time conversations with prospective participants (Simon et al., 2018). Thirdly, e-consent platforms should be designed with the end-user in mind to ensure accessibility and adherence to all elements of informed consent (Khairat & Obeid, 2018).

Recommendations for data security and management regulations (e.g., data confidentiality, storage, and disposal) were also developed to maintain standards of ethics and integrity in the informed consent process. Finally, the practicalities of e-consent were considered. Although associated with greater satisfaction in recruitment processes owing to the lack of lengthy paper documentation and reduced burden of administrative processing tasks (Warriner et al., 2016), research teams are still advised to fully consider the implications on cost, workflow, and participant experience before implementing it within the research design.

9.3.1.4 User involvement and research dissemination

The work of this thesis was underpinned by strong public involvement and engagement. As noted in Chapter 2, input from parent volunteers, collaborators from UK based organisations and charities (Fathers Reaching Out, Antenatal Results and Choices) and imaging professionals was essential to the development of the study design, pilot data collection methods, and review the results. The impact of user involvement on research, research participants and the public and wider community as well as the researchers themselves is acknowledged (Staley, 2009), and aligns with the Society and College of Radiographer's principles for person-centred radiography research which recognises the value of collaborating with service users (The Society and College of Radiographers, 2018). Participant reflections were used in Chapters 5, 6, and 8 (Articles 3, 4, and 6) to evaluate trustworthiness of the qualitative findings, and future work to develop formalised recommendations for best practice in antenatal imaging will be a collaborative effort with parents and relevant stakeholders.

The thesis by publication format was well suited to ensure rapid dissemination of research findings to HCPs and inform practice changes. This was particularly important to the time-sensitive nature of the work related to COVID-19. Dissemination of research findings was achieved during this project through conference presentations, invited talks, and published journal articles. The articles

produced for this thesis are now incorporated as key reading texts across professional issues and obstetric ultrasound modules in a UK postgraduate medical ultrasound training programme. In addition, work from this thesis has also been cited in recent guidance published by the Society of Radiographers to support the development of high-quality obstetric ultrasound services (Society of Radiographers, 2023).

9.3.2 Limitations

Individual limitations of each article are addressed in Chapters 3-8. However, additional limitations of the overall thesis must be also acknowledged. Broadly, these relate to considerations around recruitment and sampling, and confounding variables.

9.3.2.1 COVID-19

Despite the previously discussed additional benefits, the COVID-19 pandemic also presented some limitations for this work. Although NHS and HRA ethical approval for the originally planned study was received in November 2020, the backlog created by the pandemic for the NHS Research and Development department at the imaging centre because of national lockdowns resulted in a substantial delay to this project being reviewed locally. It was initially intended that recruitment for the studies reported in Chapters 7 and 8 (Articles 5 and 6) would begin in early 2021, however this eventually commenced in September 2021 after receiving confirmation of capacity and capability to support participant identification activities at the NHS site. Data was successfully collected from the first participant in October 2021, and the project timeline was subsequently re-organised to ensure completion of the thesis as planned.

The data collection period did not coincide with any further national lockdowns in the UK. However, cases of COVID-19 were still at high recorded levels and as such, increased measures to

prevent virus transmission in the clinical departments, such as the requirement for expectant parents to present a negative lateral flow test (LFT) and partners to wait in a separate area outside of the ultrasound scan clinic prior to the appointment, were still in place. As highlighted in Chapters 6-8 (Articles 4-6), the COVID-19 pandemic had a vast influence on parental experiences on antenatal imaging which undoubtably affected the overall findings. Whilst the effect of the pandemic was considered and reported for each of the studies individually, the overall impact on the whole thesis should be further acknowledged as a potential limitation to the generalisability of the findings beyond the data collection period. For this reason, it may be prudent to replicate the study at a later timepoint, to compare the findings obtained during and after the pandemic and develop a greater understanding of the true impact of the pandemic on the conclusions generated from this thesis.

9.3.2.2 Recruitment and sampling

The COVID-19 pandemic also hindered recruitment processes for the expectant parent studies presented in Chapters 6-8 (Articles 4-6). The subsequent limitations relating to sample size and parent demographics are discussed in the following section.

Sample size

Considerations of sample size limitations are made with reference to Chapter 7 (Article 5) specifically. It was originally intended that the dataset would include matched samples for modality (ultrasound vs. fetal MRI) and parent type (mothers vs. fathers), and a power calculation performed to inform the study design suggested that a sample size of n = 39 per group would be sufficient to power the study. This was increased to n = 50 to account for participant withdrawal or incomplete data. Several actions were implemented to support recruitment and achieve the minimum sample size including: 1) receiving approval from the NHS research ethics committee to display posters

advertising the study in the ultrasound scan department; 2) sharing an information flyer and the researcher's contact details with prospective parents who wanted more time to consider their involvement before giving their details; 3) creating an accessible online blog and YouTube video to provide more information about the study; 4) giving short presentations about the study to members of staff at the research site so they felt fully informed and comfortable when making the initial introduction and approaching prospective participants; and 5) using a completely electronic approach to consenting processes and data collection for improved participant convenience.

However, it became apparent eight months into the data collection period that reaching the sample size target for the questionnaires used in thesis research study 3 (reported in Chapter 7, Article 5) would not be achievable within the study's timeframe for two reasons. Firstly, the number of fetal MRI research scans being offered to expectant parents of uncomplicated pregnancies was vastly reduced because of the COVID-19 pandemic as imaging services and staff were re-prioritised for clinical purposes. Despite access to prospective participants in several fetal MRI research studies through the recruitment team at King's College London, the pandemic-related disruption to these services had a significant impact on recruitment to this study which was beyond the control of this research.

Secondly, the number of fathers included in the study was lower than anticipated. Engagement of fathers in pregnancy research is known to be challenging, often because as the non-pregnant parent, they do not feel the research is relevant to them (Panter-Brick et al., 2014). In total, 18 fathers completed the online questionnaire reported in Chapter 7 (Article 5), compared to 58 mothers. Despite targeted attempts to recruit expectant fathers into the study by the staff at the research site, the final numbers achieved were largely because mothers who had already expressed an interest to take part in the research were asked if their partners would also like to be involved.

The possibility of submitting an amendment to the ethical approvals to offer an incentive to parents and improve recruitment was considered, however, this was not felt to be appropriate so far

into the data collection process given that some parents had already completed their participation without being offered any compensation. With no other feasible options to mitigate the recruitment challenges and increase the sample size, a decision was made to review the analytical approach and conduct multiple regression analyses rather than rely on comparative analyses performed in unequal groups which can be susceptible to Type 2 error (e.g., failure to reject the null hypothesis due to lack to statistical power) (de Winter, 2013). The smaller sample size required to power the regression analyses was achievable, and the changes made to the analytical approach enabled the identification of significant predictors for enhanced parent-fetal bonding after imaging which further extended the contribution of this study.

Parent demographics

The majority of expectant parents included in this study were white and well-educated which is often expected in a self-selecting samples in pregnancy research studies (Lovell et al., 2023). Whilst the advantages of homogeneity in the sample are acknowledged for purposes of generalisability (Jager, Putnick & Bornstein, 2017), the lack of representation of other ethnic groups is a limitation of this work, as the developed recommendations may not fully reflect the variation of needs for individualised antenatal care. Although the use of remote approaches in this study did facilitate the collection of rich research data at a time when face-to-face measures were restricted, it may have indirectly limited engagement with expectant parents who had difficulty accessing digital technologies.

It had been previously arranged that support for participant identification activities at the NHS site would be present in the ultrasound scan clinic on a named day during the week (although this was not possible in the fetal MRI department because of visitor restrictions). It was intended that expectant parents who had expressed their interest to participate in the study during their scan appointment would be offered the opportunity to further speak in-person with the researcher whilst

they were still in the department. This approach had three main advantages: 1) to provide further information about the study and requirements for participation; 2) to build an immediate rapport with prospective participants to support research engagement and involvement; and 3) to alleviate additional pressures of recruitment on the clinical staff. However, due to restrictions on the number of persons present in the consultation offices, this was not always permitted. It may be possible that increased visibility of the researcher in the department would have further supported diversity in the sample characteristics through the opportunity to build trusting relationships in-person, and promote feelings of being a valued contributor to the study rather than a "research subject" which has been previously recognised as a barrier to inclusive research in pregnancy (Lovell et al., 2023).

9.3.2.3 Confounding variables

This thesis acknowledges that parent-fetal bonding is a complex phenomenon which may be influenced by multiple, interacting factors. These are known as confounding variables and because they are related to both an independent and dependent variable, can alter the relationship observed between the two (MacKinnon & Luecken, 2008). Where possible, steps were taken to control for confounding variables such as the sole inclusion of first-time expectant parents who were having scans at a single clinical site. However, it was always anticipated that the self-reported bonding scores collected during this study may be moderated by various external, and unknown factors outside of the control of this research design. This must be acknowledged as an inherent limitation when interpreting the results. In addition to this consideration, three specific considerations regarding the influence of confounding variables on the findings of the thesis are identified as: 1) demand characteristics; 2) social and parental characteristics; and 3) the lack of a defined scan protocol for the thesis research studies.

Demand characteristics

Demand characteristics must be acknowledged as a potential limitation of the findings presented in this thesis. Demand characteristics are observed when participants respond in a certain way to research processes, for example modifying responses to be a "good" participant (Nichols & Edlund, 2015), and can introduce bias to the findings.

The concept of social desirability bias (Krumpal, 2013) is considered in Chapter 7 (Article 5), whereby expectant parents participating in the study may have falsified their responses to the bonding questionnaire because of concerns they may be judged for what might be perceived as a "low" score. It is possible that parents completing the online survey reported in Chapter 6 (Article 4) may also have falsified their responses, although not for the reason of social desirability. For example, parents who were aggrieved by the disruption to their pregnancy ultrasound experience because of the restrictions on partner attendance during the pandemic may have felt more motivated to participate in the study, and therefore consciously exaggerated their responses to demonstrate their disdain with the situation. It is also very likely that some parents completed the survey whilst experiencing a heightened emotional state which may have further affected their responses. A similar observation of the findings of high levels of occupational burnout and low role satisfaction in obstetric sonographers was also noted (Chapter 4, Article 2), and associated with the limitations of using a cross-sectional survey design (Wang & Cheng, 2020). A follow-up study should therefore be considered for both groups to enable comparison of the datasets and further understand the extent to which the results could be influenced by the environmental circumstances at the time of completing the survey.

A further consideration of the influence of demand characteristics is related to the researcher's professional background as a clinical sonographer. It is possible that when expectant parents learnt of this from the introductory resources, they may have felt uncomfortable discussing negative aspects of their imaging experience and therefore modified their responses.

Social and parental characteristics

Whilst the potential impact of parental psychological distress (e.g., CORE-10 tool), ethnicity, education level, and employment status on the developing bond were considered in this work, it may be important when interpreting the findings from Chapters 6-8 (Articles 4-6), to consider the influence of other social and parental characteristics that were not evaluated in the studies in this thesis. Research suggests that additional factors including household income and social support may affect how expectant parents feel towards their unborn baby. For example, it is thought that financial security and a strong network of support are reassuring for parents who may have concerns about their transition into a parental, caregiving role (Hopkins et al., 2018). Whilst the findings of the thematic analysis presented in Chapter 8 (Article 6) also highlight the importance of social support for new parents, the impact of financial security is not so clear. In Chapter 7 (Article 5), employment status was identified as a significant predictor for enhanced bonding after imaging, with expectant parents who were unemployed or working in part-time roles having greater bonding scores than parents in full-time employment. Although full-time employment may give a greater sense of financial security, it was suggested that the demands of full-time employment may reduce parental capacity for pre-occupation with their unborn baby, thus hindering the developing emotional connection.

It has been previously suggested that due to the contextual nature of the prenatal bond, influencing factors (in this case, antenatal imaging) should not be investigated in isolation, rather their interactions with other variables should also be considered (Bouchard, 2011). Other factors not studied in this body of work, but which may influence parent-fetal bonding are relationship satisfaction, adult attachment style, and personality traits. High relationship satisfaction, secure adult attachment style (Luz et al., 2017), and extraversion (Zolfaghari et al., 2019) have been individually associated with enhanced prenatal bonding. However, the interconnectedness of these variables is also acknowledged. For example, anxious or avoidant adult attachment styles (in which the individual

is hypervigilant to cues from the attachment figure or is uncomfortable being close to others) may be associated with personality traits such as neuroticism and introversion which may then impact their romantic relationships (Schindler, Fagundes & Murdock, 2010) and subsequent emotional connection to the unborn baby. Indeed, a study exploring the association between maternal expectations and actual experiences of parenthood concluded that optimism and positive perception of the partner relationship were important influencing factors for parenting self-efficacy (e.g., confidence in parenting abilities) and adjustment to parenthood (Harwood, McLean & Durkin, 2007).

When developing the study designs for the articles presented in this thesis, it was considered that incorporating additional measures to evaluate these factors in the context of antenatal imaging and parent-fetal bonding may: 1) be too complex for the scope of this thesis and detract from the research questions, and 2) place high demands for data collection on expectant parents which may impact their decision to participate. However, this section of the discussion has highlighted an important consideration for future studies of parent-centred care in fetal imaging in fully acknowledging and understanding the potential influences of expectant parents' individual differences and subsequent needs during the pregnancy period.

Lack of a defined scan protocol for the thesis research studies

A final consideration is given to the lack of research control over the ultrasound and fetal MRI scan procedures experienced by expectant parents. As the imaging examinations were performed independently of this study, unknown imaging professionals were entirely responsible for the conduct of the scans. Whilst this may be advantageous in observing variation in imaging practice, broader research questions were required to ensure relevance to participants and capture the potential breadth of experiences. As a result, it is more challenging to draw specific conclusions from the findings, therefore future studies may benefit from the use of a clearly defined scan protocol to

support a more focused approach to the research investigation, although there may still be inherent limitations with this.

9.4 Implications

Specific implications have been discussed with reference to each individual article in Chapters 3-8. Key implications for theory, clinical practice, and research derived from the overall thesis are discussed in this section.

9.4.1 Theoretical and conceptual implications

This section considers the implications associated with measurement and conceptualisation of the parent-fetal bond highlighted through the work of this thesis.

Thesis research studies 2 and 3 attempted to objectively measure parent-fetal bonding using a modified version of the PAI (Muller & Mercer, 1993). Utilising the PAI infers adoption of its associated definition of prenatal attachment: “the unique, affectionate relationship that develops between a woman and her fetus” (Muller, 1990 p. 11 cited in Muller and Mercer, 1993). However, this definition is only concerned with the maternal-fetal relationship, and thus it could be argued, does not reflect the paternal-fetal bond which was also evaluated in these research studies using the PAI. The paucity of literature around fathers has been previously discussed in this thesis, and although a recent review has attempted to reach a consensus definition on paternal bonding (Suzuki et al., 2022), this still conflates prenatal and postnatal bonding, which assumes they are similar constructs.

Another implication identified by this thesis relates to the definitions and terms of parent-fetal bonding. Muller’s definition in the PAI uses the terminology of “attachment” which implies a reciprocal relationship between the parent and the unborn baby, instead of reflecting the

unidirectional nature of the parent-fetal relationship (Walsh, 2010). From a conceptual standpoint, this definition may also be considered inadequate as it fails to incorporate the broader psychological, social and environmental moderators for prenatal bonding (Yarcheski et al., 2009). Chapter 7 (Article 5) identified four important predictors for enhanced bonding after fetal imaging (imaging modality, parental excitement, parental experience, and employment), none of which are captured in this overarching definition. Without due reference to other factors, the true complexity and individuality of the parent-fetal bond is not fully realised, further reflecting the tension between parsimony and real-world validity.

Furthermore, the complexity of the concept of parent-fetal bonding is also observed in the findings of this thesis, as when asked directly, expectant parents found it challenging to articulate how they conceptualise "bonding" (Chapter 8, Article 6). Most parents described intensified feelings of closeness, and desire to protect their unborn baby, which may be broadly recognised as a "love" that continues beyond pregnancy, and into childhood (de Cock et al., 2016). This finding is not isolated to this research, indeed, Condon's model of adult attachment claims love as the core experience of attachment (Condon, 1993). However, much like prenatal bonding, the construct of love is also conceptually challenging and thus difficult to define and measure (Hendrick & Hendrick, 2019). Yet, suggesting that developing the theoretical framework of prenatal bonding should be a priority for further research in the field may not be appropriate. In fact, over-refinement for the purpose of measurement could be problematic, with a risk that the theory may become too narrow, and inadvertently pathologise otherwise healthy parent-fetal relationships that do not align.

It may therefore be posited that objective measurement of the prenatal bond in isolation is limited – for example, Borg Cunen et al. (2017) ask whether it is possible, or even methodologically appropriate, to evaluate this construct when it can be conceptualised in so many ways? Although this thesis did attempt to measure prenatal bonding pre- and post-fetal imaging, a paradigmatic tension is recognised in doing so. A positivist approach assumes a single reality and places high value on an

objective measurement. However, the underpinning pragmatic stance of this thesis supports the premise that given the challenges associated with measuring bonding, it may be more practical not to do so at all (Maarouf, 2019). Perhaps, given the strong link between parent-fetal bonding and parent-centred care identified in this thesis, it could also be argued that further attempting to reach a consensus definition of bonding is contradictory to the very ethos of individualised, parent-centred care? The value of objectifying parent-fetal bonding must be considered given the implications for providing support interventions to expectant parents, and the associated stigma in the case of perceived low bonding scores (Borg Cunen et al., 2017). Thus, it may be beneficial for theory development, and subsequent assessment of the prenatal bond, to adopt a more holistic approach to future studies of the parent-fetal relationship, which incorporates a greater emphasis on qualitative methods, and as demonstrated through this thesis, provides a more comprehensive insight into expectant parents' individual conceptualisations of their emotional connection to the unborn baby. A qualitative, or hybrid approach to more formal evaluation of the parent-fetal bond, may therefore be more effective in facilitating access to additional support for expectant parents as required during their transition to parenthood.

9.4.2 Implications for clinical practice

The work of this thesis places imaging professionals in a unique position to contribute to quality parent-fetal bonding through positive care experiences during pregnancy scans focused on effective communication and facilitation of active parental involvement (Chapters 3 and 6-8, Articles 1 and 4-6). These consistently highlight the important link between the provision of parent-centred care in antenatal imaging and the developing parent-fetal bond which has not been studied in this depth previously. Two important implications for parent-centred care in clinical practice - challenges for the integration of parent-centred care in fetal imaging, and the need for improved education for expectant parents around fetal imaging - are considered in the following section.

9.4.2.1 Challenges for integration of parent-centred care in fetal imaging

Some challenges for achieving integration of parent-centred care approaches in clinical practice were highlighted by HCPs, particularly in response to the COVID-19 pandemic (Chapters 4 and 5, Articles 2 and 3). This thesis found that the psychological well-being of HCPs was an important factor in the provision of parent-centred care. Recommendations proposed in Chapters 4 and 5 (Articles 2 and 3) call for organisational change to alleviate occupational burnout in obstetric sonographers by ensuring adequate resources are available to support the demands of the role. This should be a priority for service managers and senior/executive leadership teams within departments, although it may be difficult to implement without trade union or professional body support. As sonography is currently a non-regulated profession in the UK (Thomson & Paterson, 2014), this highlights the need for targeted action within organisations who are associated with imaging practitioners.

The temporary restrictions of partners and support persons to fetal imaging appointments during the COVID-19 pandemic demonstrates that in antenatal care, there is a lack of awareness of the importance of parent and family-centred approaches. Findings from Chapter 6 (Article 4), in which parents' experiences of fetal imaging were negatively affected by restrictions on partner attendance, emphasise the importance of recognising pregnancy as a shared experience between a couple. The emotional cost of excluding partners and support persons from antenatal care interactions during the COVID-19 pandemic is also highlighted. Although the long-term implications of these restrictions may not yet be fully apparent (Lalor et al., 2021), the findings from this study should be used to inform policy and practice in the event of similar circumstances in the future, to ensure that expectant parents' psychological and emotional needs are fully considered if making changes to service provision and delivery.

The research presented in this thesis also supports previous observations that HCPs delivering antenatal care may have difficulty engaging with fathers (Yogman & Garfield, 2016),

particularly if they do not see this as a priority of their medically focused work. Although Chapters 6-8 (Articles 4-6) provide many positive examples of HCPs actively involving fathers, some still reported feeling overlooked during scans. It has been previously suggested that HCP's lack of engagement with expectant fathers may be attributed to healthcare organisations' traditional perspectives on gender-based roles in antenatal settings (Widarsson et al., 2015; Hodgson et al., 2021).

This may lead to exclusion from care interactions (Dolan & Coe, 2011; Alio, 2017) and feelings of confusion when navigating a new parental identity (Salzmann-Erikson & Eriksson, 2013). For this reason, it is recommended that the philosophy of parent-centred care practice should be embedded into all training curricula for staff working in fetal imaging services. In addition to exploration and application of theory to practice, the involvement of parental experts by experience in the delivery of parent-centred approaches may be advantageous, and previous studies have demonstrated the benefits of including service users to support principles of person-centred care in undergraduate radiography education and training (Strudwick & Harvey-Lloyd, 2013). However, it is noted that whilst there is a growing evidence base for service user involvement in radiographic education, there is a lack of research specifically exploring the involvement of parents in fetal imaging training programmes.

Similarly, parents should be invited to contribute to the development of recommendations for future practice. Whilst this thesis identifies some key moments for parent-centred care during fetal imaging examinations, further collaboration is required to ensure these are truly reflective of the needs of parent service users. This could be achieved through formation of a dedicated special interest group or by undertaking public engagement activities as an adjunct to the research undertaken for this thesis.

9.4.2.2 Improving education around fetal imaging for expectant parents

Finally, parent-centred care provision may also be enhanced through updated approaches to education of expectant parents in fetal imaging. Chapters 3 and 6-8 (Articles 1 and 4-6) identified that parental needs for information regarding imaging fetal imaging were not always met for various reasons including the quantity, timing, and presentation of information. For this reason, parent-facing resources should be reviewed for accessibility, relevance, and user-friendliness. Traditional paper-based information leaflets could be replaced with short videos which would provide a more interactive, visual reference to help inform parent expectations of the imaging experience. Indeed, initiatives for improving information provision in antenatal imaging to reduce parental anxiety around the fetal anomaly screening ultrasound scan at 20 weeks' gestation have already been described (Ong, 2020), and may benefit from further development and adaptation for different parental circumstances. Further opportunities for public engagement may also help to increase awareness of the sonographer's role specifically and promote collaborative working partnerships between parents and obstetric sonographers to facilitate improved experiences of ultrasound in pregnancy and support the developing parent-fetal bond.

9.4.3 Implications for research

Several implications for future research have been identified from this thesis. Firstly, greater diversity in the sample characteristics is required to better understand and apply the findings in this thesis more generally. Further research should be focused on fathers, minority ethnic groups, and families with differing social backgrounds to better reflect variation in the population accessing antenatal imaging services. Studies with a larger number of expectant parents experiencing fetal MRI in pregnancy are also needed to increase statistical power of the quantitative findings pertaining to the influence of imaging modality on bonding scores. As previously discussed, the influence of other factors such as parental personality traits and attributes on parent-fetal bonding after antenatal

imaging warrant further exploration, however this may require additional data collection measures and these studies should therefore be carefully designed to ensure that participants are not overburdened by the level of involvement required (Baker, Lavender & Tincello, 2005).

Secondly, the work presented in this thesis was heavily affected by the COVID-19 pandemic and the resultant changes to antenatal imaging services. Whilst the impact of the pandemic on the findings presented is carefully considered, it may be prudent to conduct follow-up research after the COVID-19 pandemic and enable comparisons to be made between the datasets. This research implication is not only applicable to expectant parents, but obstetric sonographers who also participated in this research. Re-evaluating occupational burnout in the sonographic workforce outside of the pandemic will be important for several reasons; to gauge recovery within the workforce, and to determine the impact of the recommendations for organisational change which were developed from the studies presented in Chapters 4 and 5 (Articles 2 and 3), or indeed, if they were implemented at all.

Finally, this thesis highlights that models of person-centred care may require modification in the context of fetal imaging. In the first instance, a formalised model of parent-centred care in fetal imaging should be developed for use as a framework. Future research is also needed to inform service design and delivery, as well as identify the practical and logistical considerations which will be required for successful implementation. These may include staff education and training, improved access to psychological support services for HCPs, and rigorous evaluation of the impact of the implementation of formalised parent-centred approaches to care on clinical workflow pipelines. Implementation would require “buy-in” from staff and senior management and leadership figures, therefore future work would benefit from the use of a collaborative, transdisciplinary approach to research in which key stakeholders are involved (Concannon et al., 2019). This may focus on identifying and setting priorities for research in the first instance (Grill, 2021). Expectant and experienced parents should also be included as valued key stakeholders in pregnancy-related

research to improve outcomes and ensure that studies use acceptable methods and provide meaningful contributions (Goodwin, Skrybant & Kenyon, 2021).

9.5 Developing recommendations for parent-centred fetal imaging

Although the development of a formal framework for parent-centred fetal imaging was not feasible within the scope of this thesis, the findings of the studies do provide empirical evidence which have been used to suggest considerations of best practice recommendations for professional organisations and service providers, and to inform future training (Table 9.2). Key findings for the provision of supportive parent-centred care are presented as per the eight principles outlined by the Picker Institute (Picker Institute, n.d.).

Table 9.2 Suggested considerations and evidence to inform and guide recommendations for parent-centred fetal imaging

Picker principle of person-centred care (Picker Institute, n.d.)	Suggested considerations for parent-centred care recommendations	Empirical evidence from thesis	Chapter reference(s)
Fast access to reliable healthcare advice	Information for parents and services users about antenatal imaging should be more publicly available, accessible, and versatile	Some parents did not feel fully prepared for their scans	Chapters 6-8
Effective treatment delivered by trusted professionals	HCPs must find balance between technical competency/professionalism, and psychological/social domains of antenatal imaging to facilitate quality care experiences	Positive parental experiences of the scan and confidence in HCPs were linked with good communication and alignment to care expectations HCPs felt satisfaction in their role when contributing to care management pathways Balancing the biomedical and psychosocial elements of antenatal imaging was important to supporting parent-centred care	Chapters 3, 7, 8 Chapter 5 Chapter 8
Continuity of care and smooth transitions	Changes to imaging service provision or care management should be effectively communicated to expectant parents Ensure timely communication and counselling after a fetal physical condition is detected	Poor communication of changes to antenatal imaging service provision during the COVID-19 contributed to feelings of anxiety, uncertainty, and frustration in parents Some parents felt anxious because of delays in receiving scan results, particularly in cases of a fetal physical condition	Chapters 6,7 Chapters 7,8
Involvement and support for family and carers	HCPs must acknowledge and work to support the positive influence of expectant parents' social relationships on imaging experiences and transition to parenthood	The presence of fathers at scans was important for maternal support and enhanced paternal-fetal bonding Expectant parents wanted members of their wider support network to be involved with the pregnancy and sometimes chose people other than their partner to accompany them for support at scans	Chapters 3, 6, 7, 8 Chapters 3, 7, 8

Clear information, communication, and support for self-care	HCPs should use appropriate language to aid expectant parents' interpretation and understanding of the imaging examination, and cater to their individual informational needs Communication must be multi-directional, with parents given sufficient time to ask questions and share their knowledge of the pregnancy	Expectant parents were guided by HCPs to interpret fetal images and create a mental representation of their baby Expectant parents' needs for information about their pregnancy changed with gestation and individual circumstances Limiting the use of non-medical terminology humanised the fetus Expectant parents' perceptions of imaging experience improved when they felt they had time to fully experience the scan and ask questions	Chapters 3, 7, 8 Chapters 3, 8 Chapters 3, 8 Chapters 3, 7, 8
Involvement in decisions and respect for preferences	The collaborative partnership (therapeutic alliance) between expectant parents and HCPs should be promoted to support parental and practitioner autonomy	Parents felt like passive observers to antenatal imaging during the COVID-19 pandemic Poor inter-personal relationships between HCPs and expectant parents may have contributed to occupational burnout	Chapter 5 Chapter 5
Emotional support, empathy, and respect	Adequate training in parent-centred care (which may include awareness of psychological therapies) is required to improve parental experiences of antenatal imaging and support HCPs providing care HCPs should have continuous access to specialised emotional support to repair occupational burnout in the aftermath of the COVID-19 pandemic and to support future care delivery	HCPs felt undervalued and unsupported by leadership and management figures during the COVID-19 pandemic, resulting in long-standing psychological distress Expectant mothers felt more anxious about the possibility of receiving unexpected news about the pregnancy compared with fathers Previous obstetric trauma influenced expectant parents' future pregnancy expectations and experiences	Chapter 5 Chapter 7 Chapter 8

Attention to physical and environmental needs	The psychological, physical, and environmental needs of parents and HCPs should be appropriately assessed and accommodated during fetal imaging examinations to ensure comfort and safety for all	HCPs feelings of safety in the workplace were associated with burnout and psychological distress	Chapters 4,5
		HCPs felt excluded from decisions about care provision during the COVID-19 pandemic, and lack of understanding of the HCP's role by non-imaging colleagues, service users, and the public contributed to suboptimal working environments	Chapters 5,6
		HCPs felt better able to perform in their roles when distractions in the scan room were minimised	Chapter 5
		Expectant mothers reported discomfort during ultrasound and fetal MRI procedures	Chapters 7,8

9.6 Future work and directions

In addition to the development of specific recommendations for parent-centred care in fetal imaging, this thesis highlights several other considerations for future work.

1. Extend the dataset – recruitment challenges during the study period resulted in limited representation of expectant fathers and parents having fetal MRI within the samples. Extending the current dataset would be beneficial for increased power in the findings, and to provide greater insight into parental experiences of fetal imaging services beyond the COVID-19 pandemic. Additional groups with differing parental and pregnancy circumstances should also be acknowledged for focused study, to further inform recommendations for truly individualised care. For example, these groups may include parents of ethnic minorities, same-sex couples, and neurodivergent individuals.
2. Build on current models – this thesis highlighted the lack of an established framework for parent-centred care in antenatal imaging. Current models for person-centred care in medical imaging (e.g., Hyde et al, 2021b), could be adapted to reflect expectant parents' care needs from fetal imaging services. This may be achieved by incorporating new empirical evidence generated from this body of work, and would facilitate further exploration of potential relationships between key variables identified in this thesis.
3. Co-develop recommendations – although initial recommendations for parent-centred care are presented in Table 9.2, further collaboration with expectant parents, HCPs, and institutions for person-centred care is required to ensure their relevance. Wider recommendations to include reference to training, ethical leadership, and emotional support for HCPs should also be developed to empower radiographers and sonographers in facilitating parent-centred imaging experiences whilst supporting workforce recovery in the aftermath of the COVID-19 pandemic.

9.7 Conclusion

The studies conducted for this research project present a comprehensive exploration of expectant parents' experiences of imaging during pregnancy, and how these experiences may influence parent-fetal bonding. The positive effect of obstetric ultrasound imaging on parent-fetal bonding is previously acknowledged in existing literature, however this thesis provides an original contribution to extend current knowledge in the field by evaluating parental experiences and self-reported bonding scores associated with fetal MRI for the first time. In addition, the differing experiences of expectant parents are also evaluated, with commonalities and individual requirements for care during antenatal imaging identified.

Ultimately, this thesis recognises parent-centred care as an important factor in enhancing parental experiences, however tensions are acknowledged for HCPs in fully implementing this approach to care within antenatal imaging services. These are due to occupational burnout, inadequate emotional support, and the historical biomedical focus of healthcare. Inadequate education and training in parent-centred care for HCPs was also acknowledged as a potential barrier for implementation. The disruption to service provision and resultant impact on parent-fetal bonding during the COVID-19 pandemic is also captured in the studies presented, providing a unique insight into this historical event, and highlighting the detrimental consequences of restrictions on the attendance of fathers and partners at scans on parental experiences of pregnancy ultrasound and parent-fetal bonding during this time.

This work is strengthened by the use of a mixed-methods approach to enable deep exploration of the research area through triangulation, and rigorous processes to ensure methodological quality and trustworthiness of the resultant findings. Additionally, the findings from this thesis may be used to provide rich, empirical evidence to inform and support the development of recommendations for parent-centred care practices in antenatal imaging. However, some limitations relating to demand characteristics due to the nature of the research, and small sample

size of under-represented groups such as fathers are acknowledged which may affect the overall interpretation of the findings. These should be addressed in future work. New avenues for research highlighted through the work of this thesis, such as the development of a dedicated model to support parent-centred care in antenatal imaging could also be explored.

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11 Appendices

11.1 Appendix 1 - REC approval from School of Health and Psychological Sciences, City, University of London (thesis research studies 1 and 2)

City, University of London

Dear Emily

Reference: ETH2021-1240

Project title: Maternal, paternal and sonographer experiences of antenatal imaging in the UK during the coronavirus pandemic, and the potential effect on parent-fetal attachment (bonding)

Start date: 9 Mar 2021

End date: 31 Dec 2021

I am writing to you to confirm that the research proposal detailed above has been granted formal approval from the School of Health Sciences Research Ethics Committee. The Committee's response is based on the protocol described in the application form and supporting documentation. Approval has been given for the submitted application only and the research must be conducted accordingly. You are now free to start recruitment.

The approval was given with the following conditions:

- No additional conditions

Please ensure that you are familiar with City's Framework for Good Practice in Research and any appropriate Departmental/School guidelines, as well as applicable external relevant policies.

Please note the following:

Project amendments/extension

You will need to submit an amendment or request an extension if you wish to make any of the following changes to your research project:

- Change or add a new category of participants;
- Change or add researchers involved in the project, including PI and supervisor;
- Change to the sponsorship/collaboration;
- Add a new or change a territory for international projects;
- Change the procedures undertaken by participants, including any change relating to the safety or physical or mental integrity of research participants, or to the risk/benefit assessment for the project or collecting additional types of data from research participants;
- Change the design and/or methodology of the study, including changing or adding a new research method and/or research instrument;
- Change project documentation such as protocol, participant information sheets, consent forms, questionnaires, letters of invitation, information sheets for relatives or carers;
- Change to the insurance or indemnity arrangements for the project;
- Change the end date of the project.

Adverse events or untoward incidents

You will need to submit an Adverse Events or Untoward Incidents report in the event of any of the following:

a) Adverse events

b) Breaches of confidentiality

c) Safeguarding issues relating to children or vulnerable adults

d) Incidents that affect the personal safety of a participant or researcher

Issues a) and b) should be reported as soon as possible and no later than five days after the event. Issues c) and d) should be reported immediately. Where appropriate, the researcher should also report adverse events to other relevant institutions, such as the police or social services.

Should you have any further queries relating to this matter, please do not hesitate to contact me. On behalf of the School of Health Sciences Research Ethics Committee, I do hope that the project meets with success.

Kind regards

Nicholas Drey

School of Health Sciences Research Ethics Committee

City, University of London

Ethics ETH2021-1240: Miss Emily Skelton (Medium risk)

11.2 Appendix 2- NHS REC/HRA approval (thesis research study 3)

WoSRES
West of Scotland Research Ethics Service

NHS
Greater Glasgow and Clyde

Prof Susan Ayers
City, University of London
Northampton Square
London
EC1V 0HB

West of Scotland REC 3
Research Ethics
Clinical Research and Development
Ward 11
Dykebar Hospital
Grahamston Road
Paisley PA2 7DE

Date 12 November 2020
Direct line 0141 314 0212
E-mail WoSREC3@ggc.scot.nhs.uk

Please note: This is the favourable opinion of the REC only and does not allow you to start your study at NHS sites in England until you receive HRA Approval

Dear Prof Ayers

Study title: **Maternal and paternal experiences of antenatal imaging and their potential effect on parent-fetal attachment (bonding)**
REC reference: **20/WS/0132**
Protocol number: **1**
IRAS project ID: **279632**

Thank you for your letter of 01 October 2020, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information was considered in correspondence. A list of the Sub-Committee members is attached.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

The REC favourable opinion is subject to the following conditions being met prior to the start of the study.

Confirmation of Capacity and Capability (in England, Northern Ireland and Wales) or NHS

management permission (in Scotland) should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements. Each NHS organisation must confirm through the signing of agreements and/or other documents that it has given permission for the research to proceed (except where explicitly specified otherwise).

Guidance on applying for HRA and HCRW Approval (England and Wales)/ NHS permission for research is available in the Integrated Research Application System.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of management permissions from host organisations

Registration of Clinical Trials

It is a condition of the REC favourable opinion that **all clinical trials are registered** on a publicly accessible database. For this purpose, 'clinical trials' are defined as the first four project categories in IRAS project filter question 2. Registration is a legal requirement for clinical trials of investigational medicinal products (CTIMPs), except for phase I trials in healthy volunteers (these must still register as a condition of the REC favourable opinion).

Registration should take place as early as possible and within six weeks of recruiting the first research participant at the latest. Failure to register is a breach of these approval conditions, unless a deferral has been agreed by or on behalf of the Research Ethics Committee (see here for more information on requesting a deferral: https://www.hra.nhs.uk/planning-and-improving-research/research-planning/research-registration-research-project-identifiers/

As set out in the UK Policy Framework, research sponsors are responsible for making information about research publicly available before it starts e.g. by registering the research project on a publicly accessible register. Further guidance on registration is available at: https://www.hra.nhs.uk/planning-and-improving-research/research-planning/transparency-responsibilities/

You should notify the REC of the registration details. We will audit these as part of the annual progress reporting process.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

After ethical review: Reporting requirements

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study, including early termination of the study
- Final report

The latest guidance on these topics can be found at https://www.hra.nhs.uk/approvals-amendments/managing-your-approval/.

Ethical review of research sites

NHS/HSC sites

The favourable opinion applies to all NHS/HSC sites listed in the application subject to confirmation of Capacity and Capability (in England, Northern Ireland and Wales) or management permission (in Scotland) being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Non-NHS/HSC sites

I am pleased to confirm that the favourable opinion applies to any non-NHS/HSC sites listed in the application, subject to site management permission being obtained prior to the start of the study at the site.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Copies of advertisement materials for research participants [AFI Recruitment flyer]	1	01 August 2020
Copies of advertisement materials for research participants [AFI Resources for parents]	1	01 August 2020
Interview schedules or topic guides for participants [AFI Interview guide]	1	01 August 2020
IRAS Application Form [IRAS_Form_01092020]		01 September 2020
Letter from funder [Confirmation of funding from CoR]		02 July 2019
Non-validated questionnaire [AFI Questionnaire]	2 (clean copy)	01 October 2020
Non-validated questionnaire [Tracked]	2.0	01 October 2020
Other [AFI REC/HRA responses]	2	01 October 2020
Participant consent form [AFI Informed consent form (interview)]	1	01 August 2020
Participant consent form [AFI Informed consent form (questionnaire)]	2	01 October 2020
Participant consent form [AFI Informed consent form (interview)]	2	01 October 2020
Participant information sheet (PIS) [AFI Participant information sheet]	1	01 August 2020
Participant information sheet (PIS) [AFI Participant information sheet]	2 (clean copy)	01 October 2020
Participant information sheet (PIS) [AFI Participant information sheet (interview only)]	2 (clean copy)	01 October 2020
Participant information sheet (PIS) [PIS Interview Only (Tracked)]	2.0	01 October 2020
Participant information sheet (PIS) [PIS]	2.0	01 October 2020
Protocol [Tracked]	2.0	01 October 2020
Research protocol or project proposal [AFI research study protocol]	2 (clean copy)	01 October 2020
Response to Request for Further Information	2.0	01 October 2020
Summary CV for Chief Investigator (CI) [CI Susan Ayers CV 2020]		
Summary CV for student [Emily Skelton CV 2020]		
Summary, synopsis or diagram (flowchart) of protocol in non technical language [Study flowchart: Maternal and paternal experiences of antenatal imaging and their potential effect on parent-fetal attachment (bonding)]	1	01 August 2020

Document	Version	Date
Summary, synopsis or diagram (flowchart) of protocol in non technical language [AFI participant pathway]	1	01 October 2020

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

User Feedback

The Health Research Authority is continually striving to provide a high quality service to all applicants and sponsors. You are invited to give your view of the service you have received and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website: http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance/

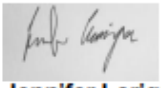
HRA Learning

We are pleased to welcome researchers and research staff to our HRA Learning Events and online learning opportunities– see details at: https://www.hra.nhs.uk/planning-and-improving-research/learning/

IRAS project ID: 279632 Please quote this number on all correspondence

With the Committee's best wishes for the success of this project.

Yours sincerely



Jennifer Lorigan
REC Manager
on behalf of
Dr Anne-Louise Cunnington
Chair

Enclosures: List of names and professions of members who were present at the meeting and those who submitted written comments
"After ethical review – guidance for researchers"

Copy to: Ms Emily Skelton
Lead Nation England: approvals@hra.nhs.uk

Ymchwil Iechyd a Gofal Cymru
Health and Care Research Wales

NHS
Health Research Authority

Prof Susan Ayers
City, University of London
Northampton Square
London
EC1V 0HB

Email: approvals@hra.nhs.uk
HCRW.approvals@wales.nhs.uk

01 December 2020

Dear Prof Ayers

HRA and Health and Care Research Wales (HCRW) Approval Letter

Study title:	**Maternal and paternal experiences of antenatal imaging and their potential effect on parent-fetal attachment (bonding)**
IRAS project ID:	**279632**
Protocol number:	**1**
REC reference:	**20/WS/0132**
Sponsor	**City, University of London**

I am pleased to confirm that **HRA and Health and Care Research Wales (HCRW) Approval** has been given for the above referenced study, on the basis described in the application form, protocol, supporting documentation and any clarifications received. You should not expect to receive anything further relating to this application.

Please now work with participating NHS organisations to confirm capacity and capability, in line with the instructions provided in the "Information to support study set up" section towards the end of this letter.

How should I work with participating NHS/HSC organisations in Northern Ireland and Scotland?
HRA and HCRW Approval does not apply to NHS/HSC organisations within Northern Ireland and Scotland.

If you indicated in your IRAS form that you do have participating organisations in either of these devolved administrations, the final document set and the study wide governance report (including this letter) have been sent to the coordinating centre of each participating nation. The relevant national coordinating function/s will contact you as appropriate.

Please see IRAS Help for information on working with NHS/HSC organisations in Northern Ireland and Scotland.

How should I work with participating non-NHS organisations?
HRA and HCRW Approval does not apply to non-NHS organisations. You should work with your non-NHS organisations to obtain local agreement in accordance with their procedures.

What are my notification responsibilities during the study?

The standard conditions document "*After Ethical Review – guidance for sponsors and investigators*", issued with your REC favourable opinion, gives detailed guidance on reporting expectations for studies, including:

- Registration of research
- Notifying amendments
- Notifying the end of the study

The HRA website also provides guidance on these topics, and is updated in the light of changes in reporting expectations or procedures.

Who should I contact for further information?
Please do not hesitate to contact me for assistance with this application. My contact details are below.

Your IRAS project ID is **279632**. Please quote this on all correspondence.

Yours sincerely,
Rekha Keshvara

Approvals Manager

Email: approvals@hra.nhs.uk

Copy to: *Ms Emily Skelton*

List of Documents

The final document set assessed and approved by HRA and HCRW Approval is listed below.

Document	*Version*	*Date*	
Copies of advertisement materials for research participants [AFI Recruitment flyer]	1	01 August 2020	
Copies of advertisement materials for research participants [AFI Resources for parents]	1	01 August 2020	
Contract/Study Agreement template [AFI Model_NC_PIC_Agreement_v1 dated 01 December 2020]			
Interview schedules or topic guides for participants [AFI Interview guide]	1	01 August 2020	
IRAS Application Form [IRAS_Form_01092020]		01 September 2020	
Letter from funder [Confirmation of funding from CoR]		02 July 2019	
Non-validated questionnaire [AFI Questionnaire]	2 (clean copy)	01 October 2020	
Non-validated questionnaire [Tracked]	2.0	01 October 2020	
Other [AFI REC/HRA responses]	2	01 October 2020	
Participant consent form [AFI Informed consent form (interview)]	1	01 August 2020	
Participant consent form [AFI Informed consent form (questionnaire)]	2	01 October 2020	
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Participant information sheet (PIS) [PIS]	2.0	01 October 2020	
Participant information sheet (PIS) [AFI Participant information sheet]	1	01 August 2020	
Participant information sheet (PIS) [AFI Participant information sheet]	2 (clean copy)	01 October 2020	
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Summary, synopsis or diagram (flowchart) of protocol in non technical language [AFI participant pathway]	1	01 October 2020	

11.3 Appendix 3 - REC approval from School of Health and Psychological Sciences, City, University of London (thesis research study 3)

City, University of London

Prof Susan Ayers

Division of Midwifery & Radiography

School of Health Sciences

City, University of London

London

EC1V 0HB

30th of November 2020

FULL INDEMNITY

Dear Susan,

Reference: ETH1920-1680

Project Title: Maternal and paternal experiences of antenatal imaging and their potential effect on parent-fetal attachment (bonding): Attachment in fetal imaging study

Start Date: 1st of February 2021

End Date: 1st of February 2026

Thank you for uploading the relevant approval letter for an externally approved project. This letter confirms that City, University of London agrees to act as Sponsor for this project.

The Principal Investigator must ensure that any relevant local governance policies and procedures are adhered to. You are now free to start recruitment.

Please ensure that you are familiar with City's Framework for Good Practice in Research and any appropriate Departmental/School guidelines.

Project amendments/extensions

Note that you must complete an amendment/extension form if one of the following occurs:

- Change or add a new category of participants;
- Change or add researchers involved in the project, including PI and supervisor;
- Change to the sponsorship/collaboration;
- Add a new or change a territory for international projects;
- Change the procedures undertaken by participants, including any change relating to the safety or physical or mental integrity of research participants, or to the risk/benefit assessment for the project or collecting additional types of data from research participants;
- Change the design and/or methodology of the study, including changing or adding a new research method and/or research instrument;
- Change project documentation such as protocol, participant information sheets, consent forms, questionnaires, letters of invitation, information sheets for relatives or carers;
- Change to the insurance or indemnity arrangements for the project;
- Change the end date of the project.

Adverse events or untoward incidents

- Adverse events;
- Breaches of confidentiality and/or inappropriate disclosure of personal data under GDPR;
- Safeguarding issues relating to children or adults at risk;
- Incidents that affect the personal safety of a participant or researcher.

Adverse events and breaches of confidentiality and/or inappropriate disclosure of personal data under GDPR should be reported as soon as possible and no later than five days after the event. Incidents that affect the personal safety of a participant or researcher and safeguarding issues relating to children or adults at risk should be reported immediately. You should also report adverse events to the relevant institutions, including police or social services.

As a condition of the sponsorship, the School reserves the right to audit compliance with the School Research Governance Framework. Further information on the audit process is available from the Chair of the School Research Ethics Committee.

Under the School Research Governance Framework you are required to contact Alison Welton once the project has been completed, and will be asked to complete a brief progress report 6 months/1 year after registering the project.

Kind regards,

Dr Katherine Curtis Tyler

Maternal and Child Health Proportionate Review Committee

City, University of London

Ethics ETH1920-1680: Prof Susan Ayers (External approval)

11.4 Appendix 4 - Full list of searches from systematic review (Article 1)

Filters: Published date = 01/01/2000-14/04/2021, Narrow by language = English

TI = title

Table 11.1 Detailed search strategy (Article 1)

Search #	Query
1	TI (mother* or maternal or mum*) AND TI (magnetic resonance imaging or mri) OR TI (ultrasound or sonography or sonogram or ultrasonography) AND TI (bonding or attachment or relationship or behaviour or experience)
2	TI (father* or paternal or dad*) AND TI (magnetic resonance imaging or mri) OR TI (ultrasound or sonography or sonogram or ultrasonography) AND TI (bonding or attachment or relationship or relationship or behaviour or experience)
3	TI anomaly or abnormality or "prenatal diagnosis"
4	1 and 3
5	2 and 3
6	TI obstetric* or prenatal or antenatal or antepartum or pregnan*or pre-natal or in utero
7	1 and 6
8	2 and 6
9	TI attach* or bond* or relationship or behaviour* or experience
10	TI (imaging or screening or scan or assessment or examination) AND TI (mri or magnetic resonance imaging or mr) OR TI (ultrasound or sonography or sonogram or ultrasonography)
11	9 and 10
12	6 and 11
13	TI parent or parental
14	9 and 13
15	10 and 14

11.5 Appendix 5 - Thesis research study 1: COVID-19 sonographer questionnaire (v1.4, dated 08/03/2021)

SONOGRAPHER C19 QUESTIONNAIRE

Title of Study: Sonographer experiences of antenatal imaging during COVID-19

Thank you for taking part in this research study. Research ethics approval for this study has been granted by City, University of London (ref: ETH2021-1240).

To take part in this study, you must be a qualified sonographer or ultrasound practitioner who has performed pregnancy ultrasound scans in the UK during the COVID-19 pandemic. You must be 21 years old or over and give your consent to participate.

The questions below will ask about you and your experiences of performing pregnancy ultrasound scans in the UK during the COVID-19 pandemic. We will also ask you some questions about your feelings towards your ultrasound role and your emotional wellbeing.

If you feel comfortable to do so, please answer all the questions as best as you can.

You will be prompted to answer all the questions but if you wish to leave an answer blank, you are able to do so.

The questionnaire should take approximately 30 minutes to complete.

All your answers will be anonymous to ensure that you can share your perspectives freely. We will ask for some basic details about you so we can gain a better understanding of your experience.

We understand that some of these questions may ask you about sensitive issues around your role and emotional wellbeing which may be upsetting for you. Although we cannot give

you individual support through this questionnaire, we have provided a link to some resources at the end which you may find helpful.

I consent to take part in this research study. I understand my responses will be anonymous, and agree that my anonymised quotations may be used in research publications.

	I agree
	I do not agree

Part One: Scanning during COVID-19

The following questions will ask you about your experiences of performing pregnancy ultrasound scans during the COVID-19 pandemic.

1. Which of the following guidance related to pregnancy ultrasound scanning during COVID--19 are you aware of? (Select all that apply)

	SoR/BMUS - COVID-19 Frequently asked questions for sonographers		NHS England - Supporting pregnant women using maternity services during the coronavirus pandemic: Actions for NHS providers
	SoR/RCOG/RCM/BMUS – Obstetric ultrasound examinations during the COVID-19 pandemic		RCOG – Guidance for antenatal screening and ultrasound in pregnancy in the coronavirus (COVID-19) pandemic
	I am not aware of any guidance		Other (please specify)

2. Which of the following guidance related to pregnancy ultrasound scanning during COVID-19 have you read? (Select all that apply)

	BMUS/SoR - COVID-19 Frequently asked questions for sonographers		NHS England - Supporting pregnant women using maternity services during the coronavirus pandemic: Actions for NHS providers
	SoR/RCOG/RCM/BMUS – Obstetric ultrasound examinations during the COVID-19 pandemic		RCOG – Guidance for antenatal screening and ultrasound in pregnancy in the coronavirus (COVID-19) pandemic
	Other (please specify)		

3. To what extent do you feel these guidelines have been useful to your clinical practice?

Not at all useful				**Neutral**				**Very useful**

4. Please explain your answer to Q3.

5. Has any of the following guidance been used or referred to within your current departmental policy? (Select all that apply)

	SoR/BMUS - COVID-19 Frequently asked questions for sonographers		NHS England - Supporting pregnant women using maternity services during the coronavirus pandemic: Actions for NHS providers
	SoR/RCOG/RCM/BMUS – Obstetric ultrasound examinations during the COVID-19 pandemic		RCOG – Guidance for antenatal screening and ultrasound in pregnancy in the coronavirus (COVID-19) pandemic
	No guidance currently implemented		Other (please specify)

6. Are you aware of any difficulties faced by your department in implementing COVID-19 guidance?

	Yes		No
	Not sure		

7. If you answered yes to Q6, what difficulties are you aware of?

	Lack of PPE provision		Physical space limitations
	Impact on workflow / time constraints		Ventilation
	Resistance from sonographers		Resistance from management
	Resistance from other maternity colleagues		Resistance from public/service users
	Prefer not to say		Other (please give details)

8. Are you aware of a risk assessment being carried out in your department, specific to the maternity ultrasound service? (Select all that apply)

	Yes – I carried out the risk assessment		Yes – an ultrasound colleague carried out the risk assessment
	Yes – my line manager carried out the risk assessment		Yes – the risk assessment was carried out by the senior management team
	Yes – unsure of who carried out the risk assessment		I am not aware that a risk assessment has been carried out

9. If yes to Q9, were any of the following factors highlighted during the risk assessment? (Select all that apply)

Risks highlighted	Identified on risk assessment	Not identified on risk assessment	Unsure / Not applicable
Access to the department			
Space in the waiting area			
Space in the scan room			
Ventilation in the scan room			
PPE requirements			
Individual staff risks (e.g. shielding, pregnant staff)			
Other (please give details)			

10. Were any changes made to mitigate the risk after the assessment was carried out? (Select all that apply)

Risks highlighted	Some changes made in response to risk assessment	No changes made in response to risk assessment	Unsure / Not applicable
Access to the department			
Space in the waiting area			
Space in the scan room			
Ventilation in the scan room			
PPE requirements			
Individual staff risks (e.g. shielding, pregnant staff)			
Other (please give details)			

11. Do you wear PPE whilst scanning <u>asymptomatic</u> pregnant people?

	Yes – provided by my employer		Yes – self-supplied
	Not always available		No
	Other (please explain)		

12. If you answered yes to Q11, what PPE do you wear whilst scanning <u>asymptomatic pregnancy people</u>? (Select all that apply)

	Surgical mask		Respirator (e.g. N95, FFP2/3)
	Eye protection		Apron
	Overalls		Other (please give details)

13. Do you wear PPE whilst scanning <u>symptomatic</u> pregnant people?

	Yes – provided by my employer		Yes – self-supplied
	Not always available		No
	Other (please explain)		

14. If you answered yes to Q13, what PPE do you wear whilst scanning <u>symptomatic</u> pregnant people?

	Surgical mask		Respirator (e.g. N95, FFP2/3)
	Eye protection		Apron
	Overalls		Other (please give details)

15. Please rate how safe you have felt performing pregnancy ultrasound scans in your workplace during the COVID-19 pandemic on the scale below:

Not at all safe				**Neutral**				**Very Safe**

16. Please explain why you feel like that:

17. Please rate your overall satisfaction in your role <u>before the COVID-19 pandemic</u> on the scale below:

Not at all satisfied				**Neutral**				**Very Satisfied**

18. Please explain why you feel like that:

19. Please rate your overall satisfaction in your role <u>during the COVID-19 pandemic</u> on the scale below:

Not at all satisfied				**Neutral**				**Very Satisfied**

20. Please explain why you feel like that:

21. Please rate the impact that you feel the COVID-19 pandemic has had on your scanning practice on the scale below:

No impact				**Moderate impact**				**Large impact**

22. Please explain why you feel like that:

23. Please rate how supported you have felt during the COVID-19 pandemic by the following:

	Not at all supported		Neutral		Very supported
Ultrasound colleagues					
Other maternity colleagues					
Line manager					
Senior management/leadership team					
Professional organisations (e.g. SoR, BMUS, RCOG)					

24. Please explain your responses to Q23:

25. Please rate how you feel Sonographers/Ultrasound Practitioners have been portrayed <u>in the news</u> (e.g. newspapers, online press articles) during the COVID-19 pandemic on the scale below:

Negative portrayal				Neutral / no opinion				Positive portrayal

26. Please explain why you feel like that:

27. Please rate how you feel Sonographers/Ultrasound Practitioners have been portrayed <u>on social media</u> (e.g. Twitter, Facebook) during the COVID-19 pandemic on the scale below:

Negative portrayal				Neutral / no opinion				Positive portrayal

28. Please explain why you feel like that:

29. Please rate how you feel your communication with parents has been impacted because of the COVID-19 pandemic on the scale below:

Negative impact				**No impact**				**Positive impact**

30. Please explain why you feel like that:

31. Please rate how you feel the parent experience of pregnancy scans has been impacted because of the COVID-19 pandemic on the scale below:

Negative impact				**No impact**				**Positive impact**

32. Please explain why you feel like that:

33. Is there anything else you would like to say?

Part Two: Your wellbeing during the COVID-19 pandemic

We would like to ask you some questions about your feeling towards your role in ultrasound during the COVID-19 pandemic.

You may find some of the following questions difficult to answer, or they may cause you to feel upset or anxious. Whilst we are unable to offer you individual support through this questionnaire, we have included details of some contacts that you may find helpful at the end.

Please rate your agreement to the following statements by selecting the response (ranging from “strongly agree” to “strongly disagree”) which best describes how you are currently feeling.

When thinking about my role in ultrasound…

1. I always find new and interesting aspects in my work	Strongly Agree	Agree	Disagree	Strongly Disagree
2. There are days when I feel tired before I arrive at work	Strongly Agree	Agree	Disagree	Strongly Disagree
3. It happens more and more often that I talk about my work in a negative way	Strongly Agree	Agree	Disagree	Strongly Disagree
4. After work, I tend to need more time than in the past in order to relax and feel better	Strongly Agree	Agree	Disagree	Strongly Disagree
5. I can tolerate the pressure of my work very well	Strongly Agree	Agree	Disagree	Strongly Disagree
6. Lately, I tend to think less at work and do my job almost mechanically	Strongly Agree	Agree	Disagree	Strongly Disagree
7. I find my work to be a positive challenge	Strongly Agree	Agree	Disagree	Strongly Disagree
8. During my work, I often feel emotionally drained	Strongly Agree	Agree	Disagree	Strongly Disagree
9. Over time, one can become disconnected from this type of work	Strongly Agree	Agree	Disagree	Strongly Disagree
10. After working, I have enough energy for my leisure activities	Strongly Agree	Agree	Disagree	Strongly Disagree
11. Sometimes I feel sickened by my work tasks	Strongly Agree	Agree	Disagree	Strongly Disagree
12. After my work, I usually feel worn out and weary	Strongly Agree	Agree	Disagree	Strongly Disagree

13. This is the only type of work that I can imagine myself doing	Strongly Agree	Agree	Disagree	Strongly Disagree
14. Usually I can manage the amount of work well	Strongly Agree	Agree	Disagree	Strongly Disagree
15. I feel more and more engaged in my work	Strongly Agree	Agree	Disagree	Strongly Disagree
16. When I work, I usually feel more energised	Strongly Agree	Agree	Disagree	Strongly Disagree

Reference: Demerouti, E., Bakker, A.B., Vardakou, I. and Kantas, A., 2003. The convergent validity of two burnout instruments: A multitrait-multimethod analysis. European Journal of Psychological Assessment, 19(1), 12.

We would now like to ask you about your emotional wellbeing.

You may find some of the following questions difficult to answer, or they may cause you to feel upset or anxious. Whilst we are unable to offer you individual support through this questionnaire, we have included details of some contacts that you may find helpful at the end.

Please select the answer which comes closest to how you have felt **in the past 7 days**, not just how you feel today.

In the last week:

1. I have felt tense, anxious or nervous

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

2. I have felt I have someone to turn to for support if needed

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

3. I have felt able to cope when things go wrong

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

4. Talking to people has felt too much for me

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

5. I have felt panic or terror

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

6. **I made plans to end my life**

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

7. I have had difficulty getting to sleep or staying asleep

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

8. I have felt despairing or hopeless

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

9. I have felt unhappy

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

10. Unwanted images or memories have been distressing me

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

Reference: Barkham, M., Bewick, B., Mullin, T., Gilbody, S., Connell, J., Cahill, J., Mellor-Clark, J., Richards, D., Unsworth, G. and Evans, C., 2013. The CORE-10: A short measure of psychological distress for routine use in the psychological therapies. Counselling and Psychotherapy Research, 13(1), 3-13.

On completion of the CORE-10, this message will be displayed to all participants:

If you need to speak with someone urgently or if there is immediate risk of serious harm or injury please contact:

The Samaritans – call 116 123 or visit https://www.samaritans.org

Mind – call 0300 123 3393 or visit https://www.mind.org.uk

UK Emergency Services – call 999 or 111

OR Attend your local **Accident and Emergency** (A&E) Department

Part Three: About you

Finally, we would like to know a little bit more about you. This is so we have a better understanding of your perspective.

1. What gender do you identify as?

	Male		Non-binary / 3rd gen
	Female		Trans
	Other (please specify):		Prefer not to say

2. What is your age?

	21-30		31-40
	41-50		51-60
	61+		Prefer not to say

3. What is the highest degree level you have completed?

	University degree (undergraduate)		University degree (postgraduate)
	Doctorate		Other (please specify):
			Prefer not to say

4. What is your ethnicity?

	White / British / Welsh / Scottish/ Northern Irish / Gypsy or Irish Traveller		Mixed / Multiple ethnic
	Asian / Asian British		Black / African / Caribbean / Black British
	Other (please specify):		Prefer not to say

5. Where in the UK do you currently work?

	England – North East		England – North West
	England – West Midlands		England – East Midlands
	England – Yorkshire and the Humber		England - East
	England – London		England – South East
	England – South West		Wales
	Scotland		Northern Ireland
	Other (please specify):		Prefer not to say

6. What best describes your employment status?

	Full-time employment (NHS/Public sector)		Part-time employment (NHS/Public sector)
	Full-time employment (Private practice)		Part-time employment (Private practice)
	Other (please specify):		Prefer not to say

7. How many years of pregnancy scanning experience do you have?

	0-5		6-10
	11-15		16-20
	21-25		26+

8. Are you a member of any of the following professional organisations? (please tick all that apply)

	Society of Radiographers		British Medical Ultrasound Society
	Royal College of Midwives		Other (please specify):
	Prefer not to say		

9. Are you thinking about leaving the profession, area of sonographic practice, or changing your working hours within the next 5 years?

	Yes – I will retire		Yes – career change
	Yes – leaving obstetric ultrasound		Yes – reducing hours
	Yes – increasing hours		No
	Prefer not to say		Other (please explain)

10. If you answered yes to Q9, has working during the Covid-19 pandemic impacted this decision?

	Yes – I will be leaving the profession/area of sonographic practice or changing my hours sooner than planned		Yes – I will be leaving the profession/area of sonographic practice or changing my hours later than planned
	No		Prefer not to say

Thank you for taking the time to complete this questionnaire.

You can find further information about this study at: http://blogs.city.ac.uk/afi-study/

You can find resources to support your emotional wellbeing at: www.covid19.sor/wellbeing-emotional-and-mental-health/support-and-resources or www.sor.org/mental-health

If you have any questions about this study, please email: emily.skelton@city.ac.uk (Doctoral Researcher) or christina.malamateniou@city.ac.uk (Academic Supervisor).

11.6 Appendix 6 - Thesis research study 2: COVID-19 parent questionnaire (v1.3, dated 08/03/2021)

ATTACHMENT AND EMOTIONAL WELLBEING QUESTIONNAIRE

Title of Study: Maternal and paternal experiences of antenatal imaging and their potential effect on parent-fetal attachment (bonding) during C-19

Thank you for taking part in this research study. Research ethics approval for this study has been granted by City, University of London (ref: ETH2021-1240).

To take part in this study, you must be a new or expectant parent who has either had a pregnancy ultrasound scan in the UK during COVID-19 since March 2020, or is due to have one within the next few weeks. You must be aged 18 or over and give your consent to participate in this study.

The questions below will ask about you and your experiences of pregnancy ultrasound scans during the COVID-19 pandemic. You will also be asked about your feelings towards your baby and your emotional wellbeing.

If you feel comfortable to do so, please answer all the questions on your own and as best as you can. You will be prompted to answer all questions but if you wish to leave an answer blank, you are able to.

This questionnaire should take approximately 30 minutes to complete.

All answers will be anonymous to ensure you can share your feelings freely. We will ask some basic details about you so we can get a better understanding of your perspectives.

We understand that some of these questions may ask you about sensitive issues around your pregnancy and emotional wellbeing which may be upsetting for you. Although we

cannot give you individual support, we have provided links to some resources that you might find useful throughout this questionnaire.

I consent to take part in this research study. I understand my responses will be anonymous.

	I agree
	I do not agree

Please select the option which best describes your scan status at this moment:

	I am/my partner is currently pregnant and **waiting for a pregnancy ultrasound** scan
	I have/my partner has **had a pregnancy ultrasound scan since March 2020**

Part One: About the scan (pre-imaging)

We would like to ask you some questions about the pregnancy ultrasound scan you are currently waiting for.

1. Please choose the option which best describes the pregnancy ultrasound scan you are currently waiting for:

	I am being scanned
	My partner is being scanned

2. Is this your first pregnancy:

	Yes
	No (please give details)

3. What month is this pregnancy ultrasound scan planned for? (mm/21)

4. How many weeks pregnant will you/your partner be at the time of this ultrasound scan?

WEEKS		**DAYS**	

5. Where in the UK will you be having the ultrasound scan?

	England – North East		England – North West
	England – West Midlands		England – East Midlands
	England – Yorkshire and the Humber		England - East
	England – London		England – South East
	England – South West		Wales
	Scotland		Northern Ireland
	Other (please specify):		Prefer not to say

6. In which setting will this ultrasound scan be performed?

	NHS/Public hospital
	Private provider

7. Have you had any previous scans in this pregnancy?

	Yes, Ultrasound		No
	Yes, MRI (magnetic resonance imaging)		

8. If yes, how many weeks pregnant were you/your partner at the time of the scan(s)?

9. Have you searched for any information about your pregnancy ultrasound scan?

	Yes
	No

10. If yes, where did you search for information?

	Internet information (e.g. local hospital/NHS webpage)		Social media (e.g. Facebook, Twitter, Instagram)
	Internet forum/discussion board		Asked family and friends
	Asked a healthcare professional		Asked someone who had attended the hospital/clinic
	Other (please give details)		

11. What information were you trying to find out about the scan? (tick all that apply)

	What would happen during the scan		Who could come to the scan
	What the scan is for		How to prepare for the scan
	What the baby would look like on the scan		How I will get the results of the scan
	Other (please give details)		

12. Did you find the information you wanted?

	Yes, fully
	Yes, mostly
	No (please specify what information you were unable to find)

13. Please rate how <u>anxious</u> you feel about going for the ultrasound scan on the scale below:

Not at all anxious				**Neutral / no opinion**				**Very anxious**

14. Please explain why you feel like that:

15. Please rate how <u>excited</u> you feel about going for the ultrasound scan on the scale below:

Not at all excited				**Neutral / no opinion**				**Very excited**

16. Please explain why you feel like that:

17. What do you think will happen during the ultrasound scan? (select all that apply)

	I will see images of my baby		I will see my baby move		I will be able to get a picture of my baby
	The sonographer/ultrasound practitioner will explain the images of my baby to me		I will have an opportunity to ask questions		Other (please give details):

18. What aspect(s) of your ultrasound scan are you most looking forward to?

19. What aspect(s) of your ultrasound scan are you least looking forward to?

20. If you have a partner, how do you think your partner is feeling about the ultrasound scan?

21. Do you want a picture of your baby from this pregnancy ultrasound scan?

	Yes		**Unsure**
	No		**Other (please explain)**

22. If you answered yes to Q21, what will you do with this picture?

	Keep it for myself/my partner		**Show it to close family**
	Show it to family and friends		**Share it on social media**
	Haven't decided		**Other (please explain)**

23. Would you like to find out the sex of your baby during the pregnancy? (Please explain your answer)

	Yes		**Not sure**
	No		**Other**

24. What questions would you like to ask the healthcare professionals who will care for you about the ultrasound scan?

25. Is there anything else you would like to say about the ultrasound scan you have planned?

Part One: About the scan (post-imaging)

We would like to ask you some questions about your experience of pregnancy ultrasound scans during the COVID-19 pandemic.

1. Please choose the option which best describes you pregnancy ultrasound scan experience:

	I was scanned with my partner present
	I was scanned alone
	My partner was scanned and I attended
	My partner was scanned and I did not attend
	Other (please explain)

2. When was the pregnancy ultrasound scan? (mm/yy)

3. How many weeks pregnant were you/your partner at the time of the ultrasound scan?

WEEKS		**DAYS**	

4. Was this your first pregnancy ultrasound scan:

	Yes – first scan for this pregnancy
	No – I have had/attended another scan(s) earlier in this pregnancy
	No – I have had/attended another scan(s in a previous pregnancy
	Other (please explain)

5. Where in the UK was the ultrasound scan performed?

	England – North East		England – North West
	England – West Midlands		England – East Midlands
	England – Yorkshire and the Humber		England - East
	England – London		England – South East
	England – South West		Wales
	Scotland		Northern Ireland
	Other (please specify):		Prefer not to say

6. In which setting was the pregnancy ultrasound scan performed?

	NHS/Public hospital
	Private provider

7. FILTER FROM Q1: If you did not attend the ultrasound scan, please choose the option which best explains why:

	It was my personal choice not to attend
	I was unable to attend because of the departmental COVID-19 policy
	I was unable to attend because of another commitment

8. FILTER FROM Q1: If you were unable to attend the scan, how did it make you feel?

9. FILTER FROM Q1: If you were unable to attend the scan, did you:

	See images of your baby?		See a video of your baby?
	Have an opportunity to ask questions?		Other (please give details)

10. FILTER FROM Q1: If you attended the ultrasound scan, did you:

	See images of your baby?		See your baby move?		Have the images of your baby explained to you?
	Have any additional imaging performed? (e.g. 3D Ultrasound)		Have an opportunity to ask questions?		Other (please give details)

11. FILTER FROM Q1: What was the best thing about the scan?

12. FILTER FROM Q1: What did you least enjoy about the scan?

13. Was there anything that could have been improved about your scan experience?

	Yes (please give details)
	No

14. If you have a partner, how do you think they felt about the ultrasound scan?

15. Were you able to take home any pictures or videos from the scan?

	Yes
	No (please explain)

16. If yes to Q15, did you share your ultrasound scan pictures with family and friends?

	Yes
	No (please explain)

17. Did you find out the sex of your baby during the pregnancy ultrasound scan? (Please explain your answer)

	Yes, I wanted to know
	Yes, but I didn't want to know
	No, I didn't want to know
	No, I was unable to find out

18. Will you be having any more scans in this pregnancy?

	Yes (please give details e.g. NHS or private scans)
	No
	Not sure
	Other (please give details)

19. Have you searched for any additional information since your scan?

	Yes
	No

20. If yes, where did you search for information?

	Internet information (e.g. local hospital/NHS webpage)		Social media (e.g. Facebook, Twitter, Instagram)
	Internet forum/discussion board		Asked family and friends
	Asked a healthcare professional		Asked someone who had attended the hospital/clinic
	Other (please give details)		

21. What information were you searching for? (tick all that apply)

	What happened during the scan		How I felt after the scan
	The results of the scan		Other (please give details)
	How my baby looked on the scan		

22. Did you find the information you wanted?

	Yes
	No (please specify what information you were unable to find)

23. Looking back, are there any questions that you would have liked to ask the healthcare professionals who cared for you/your partner during the ultrasound scan?

	Yes (please give details)
	No

24. Please rate how <u>anxious</u> you feel after the ultrasound scan on the scale below:

Not at all anxious				**Neutral / no opinion**				**Very anxious**

25. Please explain why you feel like that:

26. Please rate how <u>excited</u> you feel after the ultrasound scan on the scale below:

Not at all excited				**Neutral / no opinion**				**Very excited**

27. Please explain why you feel like that:

28. Please rate your <u>overall satisfaction</u> of the ultrasound scan experience on the scale below:

Not at all satisfied				**Neutral / no opinion**				**Very satisfied**

29. Please explain why you feel like that:

30. Is there anything else you would like to say about the ultrasound scan?

Part Two: About the pregnancy (pre and post imaging)

We would like to ask you some questions about your feelings towards the pregnancy.

The following sentences describe thoughts, feelings and experiences during pregnancy. Please choose the answer which comes closest to how you have felt in the past 7 days, not just how you feel today.

Thinking about the pregnancy…

1. I wonder what the baby looks like now

	Almost never		Often
	Sometimes		Almost always

2. I imagine calling the baby by name

	Almost never		Often
	Sometimes		Almost always

3. I enjoy feeling the baby move

	Almost never		Often
	Sometimes		Almost always

4. I think that the baby already has a personality

	Almost never		Often
	Sometimes		Almost always

5. I know things I do will make a difference to the baby

	Almost never		Often
	Sometimes		Almost always

6. I plan the things I will do with the baby

	Almost never		Often
	Sometimes		Almost always

7. I try to imagine what the baby is doing inside the womb

	Almost never		Often
	Sometimes		Almost always

8. I tell others what the baby does inside the womb

	Almost never		Often
	Sometimes		Almost always

9. I imagine what part of the baby I am touching

	Almost never		Often
	Sometimes		Almost always

10. I can make the baby move

	Almost never		Often
	Sometimes		Almost always

11. I buy/make things for the baby

	Almost never		Often
	Sometimes		Almost always

12. I feel love for the baby

	Almost never		Often
	Sometimes		Almost always

13. I dream about the baby

	Almost never		Often
	Sometimes		Almost always

14. I share secrets with the baby

	Almost never		Often
	Sometimes		Almost always

15. I know the baby hears me

	Almost never		Often
	Sometimes		Almost always

16. I get very excited when I think about the baby

	Almost never		Often
	Sometimes		Almost always

Reference: Muller, M.E. and Mercer, R.T., 1993. Development of the prenatal attachment inventory. Western journal of nursing research, 15(2), 199-215.

Part Three: About you (pre and post imaging, both parents)

We would like to know a little bit more about you and your pregnancy. This will give us a better understanding of your perspectives.

1. What gender do you identify as?

	Male		Non-binary / 3rd gen
	Female		Trans
	Other (please specify):		Prefer not to say

2. What is your age?

	18-25		26-30
	31-35		36-40
	41-45		46+

3. How best describes your relationship with your baby?

	I am the baby's mother and I am pregnant		I am the baby's mother and my partner is pregnant
	I am the baby's father and my partner is pregnant		I am the baby's father and I am pregnant
	Other (please specify):		Prefer not to say

4. What is your ethnicity?

	White / British / Welsh / Scottish/ Northern Irish / Irish / Gypsy or Irish Traveller		Mixed / Multiple ethnic
	Asian / Asian British		Black / African / Caribbean / Black British
	Other (please specify):		Prefer not to say

5. What is the highest degree or level of education you have completed?

	Secondary school (e.g. GCSEs)		University degree (postgraduate)
	College (e.g. A-Levels, HND, NVQ)		Doctorate
	University degree (undergraduate)		Other (please specify):
			Prefer not to say

6. What best describes your relationship status?

	Single		Civil partnership
	In a relationship (cohabiting)		In relationship (living apart)
	Married		Other (please specify):
			Prefer not to say

7. What best describes your employment status?

	Full-time employment		Retired
	Part-time employment		Other (please specify):
	Unemployed		Prefer not to say
	Student		

8. Do you have any pre-existing physical health conditions?

	Yes (please give details)		Prefer not to say
	No		

9. Have you even been diagnosed with or received support for a mental health problem?

	Yes (please give details)		Prefer not to say
	No		

10. Are you currently taking any prescribed medication?

	Yes (please give details)		Prefer not to say
	No		

Part Four: How are you feeling? (pre and post imaging)

We would like to ask some questions about your emotional wellbeing.

You may find some of the following questions difficult to answer, or they may cause you to feel upset or anxious. Whilst we are unable to offer you individual support through this questionnaire, we have included details of some contacts that you may find helpful at the end.

Please choose the answer which comes closest to how you have felt **in the past 7 days**, not just how you feel today.

In the last 7 days…

1. I have felt tense, anxious or nervous

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

2. I have felt I have someone to turn to for support if needed

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

3. I have felt able to cope when things go wrong

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

4. Talking to people has felt too much for me

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

5. I have felt panic or terror

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

6. **I made plans to end my life**

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

7. I have had difficulty getting to sleep or staying asleep

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

8. I have felt despairing or hopeless

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

9. I have felt unhappy

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

10. Unwanted images or memories have been distressing me

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

On completion of the CORE-10, this message will be displayed to all participants:

If you need to speak with someone urgently or if there is immediate risk of serious harm or injury please contact:

Improving Access to Psychological Therapies (IAPT) – call 24-hour support hotline: 0800 731 2864 or visit https://www.nhs.uk/service-search/find-a-psychological-therapies-service

The Samaritans – call 116 123 or visit https://www.samaritans.org

Mind – call 0300 123 3393 or visit https://www.mind.org.uk

UK Emergency Services – call 999 or 111

OR attend your local **Accident and Emergency** (A&E) Department

Reference: Barkham, M., Bewick, B., Mullin, T., Gilbody, S., Connell, J., Cahill, J., Mellor-Clark, J., Richards, D., Unsworth, G. and Evans, C., 2013. The CORE-10: A short measure of psychological distress for routine use in the psychological therapies. Counselling and Psychotherapy Research, 13(1), 3-13.

Thank you for taking the time to complete this questionnaire.

You can find further information about this study at: http://blogs.city.ac.uk/afi-study

If you have been affected by any sensitive issues raised in this questionnaire, or would like to speak to someone about your wellbeing, you can find resources for perinatal mental health support at http://blogs.city.ac.uk/afi-study/resources-for-parents.

If you have any further comments or questions about this study, please contact Emily Skelton (PhD Researcher): emily.skelton@city.ac.uk or Dr Christina Malamateniou (Academic Supervisor): christina.malamateniou@city.ac.uk

11.7 Appendix 7- Thesis research study 3: Parent questionnaire (v2, dated 01/10/2020)

ATTACHMENT AND EMOTIONAL WELLBEING QUESTIONNAIRE

Title of Study: Maternal and paternal experiences of antenatal imaging and their potential effect on parent-fetal attachment (bonding): AFI study

Thank you for taking part in this research study.

The questions below will ask about you and your feelings towards your baby and the pregnancy. If you feel comfortable to do so, please answer all the questions as best as you can.

You will be prompted to answer all questions but if you wish to leave an answer blank, you are able to.

Part One: About your scan (pre-imaging)

1. What type of imaging appointment are you attending?

	Fetal ultrasound (I am being scanned)		Fetal MRI (I am being scanned)
	Fetal ultrasound (my partner is being scanned)		Fetal MRI (my partner is being scanned)

2. What is the estimated due date for your baby?

DAY		**MONTH**		**YEAR**			

3. Have you had any previous scans in this pregnancy?

	Yes, Ultrasound		No
	Yes, MRI (magnetic resonance imaging)		

4. If yes, how many weeks pregnant were you/your partner at the time of the scan(s)?

5. Have you used the internet/social media to search for any information about your scans?

	Yes
	No

6. If yes, where did you search for information?

	Internet information webpage		Social media (e.g. Facebook, Twitter, Instagram)
	Internet forum/discussion board		Other (please give details)

7. What information were you searching for? (tick all that apply)

	What would happen during the scan		Who could come to the scan
	What the scan is for		How to prepare for the scan
	What the baby would look like on the scan		Other (please give details)

8. Did your searches provide the information you wanted?

	Yes
	No (please specify what information you were unable to find)

9. Please rate how you feel about going for the scan on the scale below:

Not at all anxious				**Anxious**				**Very anxious**

10. Please explain why you feel like that:

11. Please rate how you feel about going for the scan on the scale below:

Not at all excited				**Excited**				**Very excited**

12. Please explain why you feel like that:

13. What do you think will happen during the scan? (select all that apply)

	I will see images of my baby		I will see my baby move		I will hear my baby's heartbeat
	The radiographer/sonographer will explain the images of my baby to me		I will have an opportunity to ask questions		Other (please give details):

14. What aspect(s) of your scan are you most looking forward to?

15. What aspect(s) of your scan are you least looking forward to?

16. How do you think your partner is feeling about the scan?

17. Will you share your scan pictures with family or friends?

	Yes		**Haven't decided**
	No		

18. What questions would you like to ask the healthcare professionals who will care for you about the scan?

19. Is there anything else you would like to say about the scan you will be attending?

Part One: About your scan (post-imaging)

1. During your scan did you:

	See images of your baby?		See your baby move?		Hear your baby's heartbeat?
	Have the images of your baby explained to you?		Have an opportunity to ask questions?		Have any additional imaging performed? (e.g. 3D US)

2. What was the best thing about your scan?

3. What did you least enjoy about your scan?

4. How do you think your experience could have been improved?

5. How do you think your partner felt about the scan?

6. Did you share your scan pictures with family and friends?

	Yes
	No

7. Will you be having any more scans?

	Yes
	No
	Not sure

8. Have you used the internet/social media to search for any further information since your scan?

	Yes
	No

9. If yes, where did you search for information?

	Internet information page		Social media (e.g. Facebook, Twitter, Instagram)
	Internet forum/discussion board		Other (please give details)

10. What information were you searching for? (tick all that apply)

	What happened during the scan		How I felt after the scan
	The results of the scan		Other (please give details)
	How my baby looked on the scan		

11. Did your searches provide the information you wanted?

	Yes
	No (please specify what information you were unable to find)

12. Are there any questions that you would have liked to ask the healthcare professionals who cared for you during your scan?

	Yes (please give details)
	No

13. Please rate how you feel after your scan on the scale below:

Not at all anxious				**Anxious**				**Very anxious**

14. Please explain why you feel like that:

15. Please rate how you feel after the scan on the scale below:

Not at all excited				**Excited**				**Very excited**

16. Please explain why you feel like that:

17. Please rate your overall satisfaction of your scan experience on the scale below:

Not at all satisfied				**Satisfied**				**Very satisfied**

18. Please explain why you feel like that:

19. Is there anything else you would like to say about your scan?

Part Two: About your pregnancy

We would like to ask you some questions about the pregnancy and how you have been feeling about your baby.

The following sentences describe thoughts, feelings and experiences during pregnancy. Please tick (√) the answer which comes closest to how you have felt in the past 7 days, not just how you feel today.

1. **I wonder what the baby looks like now**

	Almost never		Often
	Sometimes		Almost always

2. **I imagine calling the baby by name**

	Almost never		Often
	Sometimes		Almost always

3. **I enjoy feeling the baby move**

	Almost never		Often
	Sometimes		Almost always

4. **I think that the baby already has a personality**

	Almost never		Often
	Sometimes		Almost always

5. **I know things I do will make a difference to the baby**

	Almost never		Often
	Sometimes		Almost always

6. **I plan the things I will do with the baby**

	Almost never		Often
	Sometimes		Almost always

7. I try to imagine what the baby is doing inside the womb

	Almost never		Often
	Sometimes		Almost always

8. I tell others what the baby does inside the womb

	Almost never		Often
	Sometimes		Almost always

9. I imagine what part of the baby I am touching

	Almost never		Often
	Sometimes		Almost always

10. I can make the baby move

	Almost never		Often
	Sometimes		Almost always

11. I buy/make things for the baby

	Almost never		Often
	Sometimes		Almost always

12. I feel love for the baby

	Almost never		Often
	Sometimes		Almost always

13. I dream about the baby

	Almost never		Often
	Sometimes		Almost always

14. I share secrets with the baby

	Almost never		Often
	Sometimes		Almost always

15. I know the baby hears me

	Almost never		Often
	Sometimes		Almost always

16. I get very excited when I think about the baby

	Almost never		Often
	Sometimes		Almost always

Part Three: How are you feeling?

We would now like to ask some questions about your emotional wellbeing. This is so we can provide help and support to you if you need it, and also because how you are feeling can affect how you feel towards the pregnancy and your baby.

Please tick (√) the answer which comes closest to how you have felt **in the past 7 days**, not just how you feel today.

In the last week:

1. **I have felt tense, anxious or nervous**

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

2. **I have felt I have someone to turn to for support if needed**

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

3. **I have felt able to cope when things go wrong**

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

4. **Talking to people has felt too much for me**

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

5. I have felt panic or terror

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

6. **I made plans to end my life** *(note: any response other than "not at all" will trigger an immediate alert to the doctoral researcher)*

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

7. I have had difficulty getting to sleep or staying asleep

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

8. I have felt despairing or hopeless

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

9. I have felt unhappy

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

10. Unwanted images or memories have been distressing me

	Not at all		Often
	Only occasionally		Most or all of the time
	Sometimes		

Part Four: About you (pre imaging only)

Finally, we would like to know a little bit more about you and your pregnancy. This is because individual characteristics and personal circumstances can affect how you may be feeling towards your baby or the pregnancy.

1. **What gender do you identify as?**

	Male		Other (please specify):
	Female		Prefer not to say

2. **What is your age?** ☐

3. **How best describes your relationship with your baby?**

	I am the baby's father		I am the baby's mother and my partner is pregnant
	I am the baby's mother and I am pregnant		Other (please specify):

4. **What is your ethnicity?**

	White / British / Welsh / Scottish/ Northern Irish / Irish / Gypsy or Irish Traveller		Mixed / Multiple ethnic
	Asian / Asian British		Black / African / Caribbean / Black British
	Other (please specify):		Prefer not to say

5. **What is the highest degree or level of education you have completed?**

	Secondary school (e.g. GCSEs)		University degree (postgraduate)
	College (e.g. A-Levels, HND, NVQ)		Doctorate
	University degree (undergraduate)		Other (please specify):
			Prefer not to say

6. **What best describes your relationship status?**

	Single		Civil partnership
	In a relationship (cohabiting)		In relationship (living apart)
	Married		Other (please specify):
			Prefer not to say

7. **What best describes your employment status?**

	Full-time employment		Retired
	Part-time employment		Other (please specify):
	Unemployed		Prefer not to say
	Student		

8. **Do you have any pre-existing physical health conditions?**

	Yes (please give details)		Prefer not to say
	No		

9. **Have you even been diagnosed with or received support for a mental health problem?**

	Yes (please give details)		Prefer not to say
	No		

10. **Are you currently taking any prescribed medication?**

	Yes (please give details)		Prefer not to say
	No		

Participant ID _____

Date _____

11.8 Appendix 8 - Thesis research study 3: Semi-structured interview schedule (v1, dated 01/08/2020)

Table 11.2 AFI study interview guide

Expectations of scan	**Experience of scan**	**Relationship with baby**	**Feelings about parenthood**	**Visualisation of images**	**Parent-centred care**
What do you know about the reasons for having the scan?	Starting from your arrival in the department, can you tell what happened during your scan?	How did the scan make you feel about your baby?	How did the scan make you feel about being a parent?	What did you think of the images on the screen during the scan? Were these explained to you? If so, how?	What information were you given about the scan? Did you find it helpful?
What did you think would happen during your scan?	What was the most important part of the scan for you? Why was this?	Did you find out the sex of your baby during the scan? Were you able to? Was this important to you?	Did you notice a change in how you felt or behaved after the scan?	How did seeing the images of your baby make you feel?	How would you describe the care you experienced during your scan?

How did you feel about going for the scan? Why?	What was your overall perception of the scan? Did you feel anything could have been done differently?	Do you think seeing your baby on the scan helped you to feel closer to them? Can you explain why?	Had you made any preparations for the arrival of your baby before the scan? Have you made any preparations since the scan?	Were you given pictures of the scan to take home? If yes, have you looked at them since the scan? Did you share the pictures with family/friends?	How would you describe the communication you had with the Sonographer/ Radiographer?
Did you have any concerns about going for the scan?	Was there anything that you thought would happen during the scan which didn't?	**What were your initial thoughts when you were told there was an unexpected finding on the scan which needed discussing?**		**Were you shown the images of "x" (the fetal condition as described by parent)?** **What could you see?** **Were you given any choice about how the findings were discussed with you?** **Was there anything that you would have preferred?**	How would you describe your level of "feeling included in" or "a part of" the scan?
Did you think that you might be told that there was an unexpected finding on the scan which needed discussing?	**Do you feel that your baby's diagnosis changed your scan experience? How?**			**Do you think seeing the images was helpful or not?** **Why?**	Did you receive any support or advice after your scan?

				If yes, what support/advice did you receive? If not, do you think this would have been helpful?
Is there anything else you would like to say or ask me?				

11.9 Appendix 9 - Reflexivity during analytical process (Chapter 8, Article 6)

Phase of analysis	Description of process
1. Familiarisation with the data	The familiarisation phase was an important opportunity to re-connect with the dataset. As I had completed the interviews six months before, I needed this time to fully immerse myself in the data and prepare for the analysis. Although there had been a delay between completing the interviews and beginning the analysis, I do not think this was detrimental as it meant I could come back to the dataset with fresh perspectives. This phase also gave me the time and space to consider my position in relation to the dataset. I am an experienced obstetric sonographer who has been studying this topic area for several years. However, as a non-parent, I was initially concerned that my lack of personal lived experience would prevent me from not being able to fully relate to expectant parents' comments and thus not fully understand the dataset. It transpired quite soon into familiarisation that this would not be an issue, as I realised that my empathy skills are well-honed from years of clinical practice, and I could draw on my own experiences as a sonographer of similar situations to those being described by expectant parents. On reflection, my position actually placed me in a position of privilege to be able to understand and appreciate the dynamic within the imaging environment as described by the expectant parents, whilst retaining some emotional distance which enabled me to preserve their interpretations of their experiences without inadvertently imposing my own experiences to confound my interpretation of them. To familiarise myself with the data, I read each transcript several times. During the first read, I added to my initial notes taken during the interview. On the second read, I played the audio recording at the same time so that I could listen for any further (non-verbal) cues which may provide further insight into how a phrase or term had been used by the

	expectant parent. After the third read, I wrote a short paragraph to provide a brief summary of my initial response to the interviews overall, and to highlight any aspects that I thought would be of particular interest for the analysis. An example excerpt is given below: *"These are interviews with first-time expectant parents about their experiences of imaging during pregnancy. For some, they disclose a history of miscarriage or have known someone go through a pregnancy which has ended in loss. Some parents also have received a diagnosis of a cardiac condition in their unborn baby. What they all have in common however, is that they are in a transitional period of their life – they are navigating their new identities and future family dynamics alongside the busyness of everyday life. I got the feeling from many of the interviews that these expectant parents had not really had the space and time previously to fully consider and explore their new concepts of "self", and so it felt like rather than asking lots of questions to elicit responses for my work, I was more in the role of a facilitator, guiding a reflective activity.* *There was a lot of overlap with many of the topics discussed and in parental responses to questions – many were consistent with themes I had already encountered in literature. This was partly reassuring as it felt confirmatory of my research interview technique, but additionally concerning that my work was too shaped by my prior expectations based on literature. I initially began to question my impartiality to the work – was I just looking for answers I knew to be "right" because other studies had reported them? However, this feeling was eventually rejected because after a few interviews I could quickly acknowledge "stock" responses to questions such as "scans make everything feel more real". When I heard this, it was my cue to probe a little deeper and this directed the conversation away from what I would consider to be the more common-sense responses."*

	In compiling the respondent characteristics, it was interesting to note the homogeneity across ethnicity, education, and employment status. Whilst this may ultimately be advantageous for theme generation and generalisability within the dataset, it does highlight the need for further studies to focus on under-represented demographics within parents. In earlier work, a previous quantitative analysis found employment status to be a significant predictor for enhanced prenatal bonding after imaging. It was theorised that expectant parents in full-time employment would have decreased cognitive capacity to think about their unborn baby because of increased work demands so it will be interesting to see how this may influence the themes developed from this analysis.
2. Coding	All transcript files were imported into NVivo for coding. Each transcript was reviewed individually, and initial codes were attributed to data which I thought would contribute to addressing the research question. Around 180 codes were created after completion of this phase; these were mainly coded at the descriptive (semantic) level and reflected the language used by the parents while sharing their experiences with me (e.g., 'needing an explanation of scan images'). This was important to ensure that the experiences were accurately captured before I began to further interpret them and, unavoidably, add my influence. Some of the more abstracted codes were created on recognition of concepts similar to those reported in existing literature (e.g., transition to parenthood). This initial coding phase was largely data-driven, however I also referred to my observation and familiarisation notes and created additional codes for data elements that had previously stood out to me. As I coded, I also used the annotation and memo features on NVivo to make interpretative notes to guide the later stages of theme development and to support the report writing stage. After all transcripts had been coded, I undertook several rounds of review and refinement. Firstly, I combined similar codes to remove repeated ideas and ensure that each of the final themes would have clearly defined boundaries. Some of the combined codes kept an original name, but some were updated to reflect its development and the evolution of my interpretation. After this, I went back through the data content of each code. As a result of changing the order I

	reviewed the data in, I realised that some segments were actually better suited to a different code than the one I had originally assigned. Where required, coding labels were refined to reflect the newly added data segment. At the end of this phase, the number of codes was 66.
3. Generating initial themes	In the first stage of generating initial themes, I printed a hardcopy of the codebook. Each code was cut out and placed in a random order before I re-organised them into groups (patterns of meaning) reflecting the initial themes I was generating. I found that completing this exercise separately to NVivo helped me to move away from the systematic coding process and think more about the 'bigger picture' of the dataset and how it worked to address my research question. Turning to pen and paper and sketching out various iterations of thematic maps also helped in theme generation as it provided a visual reference of how I was starting to relate the codes and concepts.
4. Developing and reviewing themes	Once I was happy with the initial themes, I went back to NVivo and grouped the individual codes by theme. This then enabled me to review the coded segments against the initial theme and check the relevance by re-engaging with the original dataset. During this review process, I considered whether my initial themes addressed five key elements as suggested by Braun & Clarke (2022). These were: theme viability; defined boundaries; meaningful data; coherence; and importance. As I worked through the review and evaluated the initial themes, I also created more analytical memos to act as reminders for my thoughts as I got deeper into the data interpretation and theme development. As the themes developed and I created more patterns across the data, it became evident that some data extracts required re-coding and so I returned to the second step of this process and reviewed the data in the context of the initial themes.
5. Refining, defining, and naming themes AND	I decided to group the reporting of these final two stages together. Although they may be completed independently, I found that theme refinement was facilitated by beginning to write up and present my findings. For each theme, I identified the central organising concept and wrote a short, overarching definition to succinctly capture it's meaning and provided clear focus for the narrative. As I started to write up, I was aware that my reporting style of the findings seemed too descriptive, and that my words were more of a summary of the theme rather than reflecting my

6. Writing up	analysis and wider interpretation. However, this was an important realisation for theme refinement because I was able to recognise that I had drifted from the study aim and was instead trying to represent the whole dataset in the themes, rather than reflect the central organising concept which addressed the research question. At this point, I returned to my original memos and maps for guidance. In further reviewing and re-arranging the codes, I made new connections in the data. From here, the original five themes were consolidated into three. This allowed for greater interpretation and exploration within the theme, and for the central organising concept to be more clearly defined. In the later stages of writing up, I selected a series of illustrative quotations from the interview transcripts to support the analysis. I also finalised the theme names after reviewing some of the initial ideas I had against the write-up and theme definition. Re-visiting earlier steps was an essential part of the process for theme development, and I felt it important to document this back-and-forth movement in this summary to demonstrate the iterative nature of the analytical process. During the remainder of the write-up, I reflected on my interpretations of the data in the context of existing literature which helped with further refinement of the themes. When considering existing published literature in this field, it was interesting to note that, unlike other studies, this was among the first to highlight the concept of parent-centred care in antenatal imaging in the context of parent-fetal bonding. I suspect I naturally gravitated towards this focus because of my clinical background and personal interest, and after completing the discussion section of the manuscript, I could clearly see how my work was positioned to extend this body of knowledge. Once I was happy with the first draft of the manuscript, it was circulated to all co-authors for review. Feedback was requested regarding theme development (e.g., including themes, definitions and illustrative quotations extracted from the interview transcripts) and the overall flow of the narrative. The findings section of the paper was also shared with two parent participants who had expressed an interest to review the results of the analysis. Unlike practices of

	member checking which seek to confirm accuracy in the results, they were instead invited to share their reflections on the findings to ensure that what I had reported was meaningful and respectful of the personal experiences that parents had shared with me for this study.

11.10 Appendix 10 - Published Article 1

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The impact of antenatal imaging on parent experience and prenatal attachment: a systematic review

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ABSTRACT

Introduction: Medical imaging in pregnancy (antenatal imaging) is routine. However, the effect of seeing fetal images on the parent–fetal relationship is not well understood, particularly for fathers or partners, or when using advanced imaging technologies. This review aimed to explore how parent experience and prenatal attachment is impacted by antenatal imaging.

Method: Database searches were performed between September 2020 and April 2021 inclusion criteria were English language primary research studies published since 2000, describing or reporting measures of attachment after antenatal imaging in expectant parents. The Pillar Integration Process was used for integrative synthesis.

Findings: Twenty-three studies were included. Six pillar themes were developed: 1) the scan experience begins before the scan appointment; 2) the scan as a pregnancy ritual; 3) feeling actively involved in the scan; 4) parents' priorities for knowledge and understanding of the scan change during pregnancy; 5) the importance of the parent–sonographer partnership during scanning; and 6) scans help to create a social identity for the unborn baby.

Conclusion: Antenatal imaging can enhance prenatal attachment. Parents value working collaboratively with sonographers to be actively involved in the experience. Sonographers can help facilitate attachment by delivering parent-centred care tailored to parents' emotional and knowledge needs.

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Introduction

Prenatal attachment is described as the emotional connection parents form to their unborn child (Condon, 1993). It is important for healthy infant brain development (Glover, 2014), parental emotional well-being (Göbel et al., 2018) and represents a transformation during pregnancy whereby expectant parents start to reconceptualise their identity from self to care-giver (Walsh, 2010). The concept arose from Bowlby's early

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definitions of attachment theory (Bowlby, 1982); however, the term 'prenatal bonding' is often used interchangeably in literature to describe the parent-fetal relationship (Walsh, 2010). For clarity, the parent-fetal relationship is referred to as 'attachment' throughout this review to incorporate all constructs, although bonding is recognised as a synonym in this context, and therefore included as a key word to ensure all relevant records were captured during searches.

Routine medical ultrasound imaging during the antenatal period is generally regarded as a positive pregnancy experience which also facilitates the bonding process as it allows expectant parents to create a mental image of their unborn baby (Walsh, 2020). This image can be central to the developing attachment by providing a visual catalyst for parents to construct and fantasise about their 'imagined child' (Trombetta et al., 2021), to which they attribute personal characteristics to humanise the fetus and thus experience a deeper emotional tie towards the unborn baby (Condon, 1993). It is thought that prenatal attachment can predict the quality of the parent–child relationship after birth, thus antenatal imaging may provide a unique and early opportunity during pregnancy for parents to establish a positive emotional connection towards the fetus, or for health-care professionals to provide timely intervention and support to parents if required (Della Vedova & Burro, 2017). For most parents, scans are an enjoyable and reassuring experience (G.M. Thomas et al., 2017). However, there is evidence to suggest that the experience may also lead to increased anxiety and stress in parents, particularly those who are unable to interpret the image (National Institute for Health and Care Excellence, 2019), which may impact on the developing relationship.

Research in this field is warranted, especially with the increasing use of advanced fetal imaging techniques to complement routine ultrasound imaging, including three-dimensional (3D) and four-dimensional (4D) ultrasound and fetal magnetic resonance imaging (MRI). These modalities produce highly detailed images and videos of fetuses, yet the effect of seeing these images on the developing parent-fetal relationship is not well studied or reported (Van den Bergh & Simons, 2009), especially for pregnancies in which a fetal anomaly is suspected or has been diagnosed. For some parents, visualising the anomaly may aid their understanding of a diagnosis (Gonçalves et al., 2005; Leung et al., 2006; Sreejith et al., 2018), although for some it may increase distress, for example, if faced with a decision to continue the pregnancy (Mitchell, 2004). Furthermore, studies evaluating the effect of imaging on the paternal-fetal relationship are sparse (Walsh et al., 2017), even though quality prenatal attachment is associated with a positive effect on maternal emotional well-being and the maternal-foetal relationship (Borg Cunen et al., 2017; Lindgren, 2001).

This review aimed to explore the research question 'what is the effect of medical imaging in pregnancy on prenatal attachment?', to enhance current understanding of the impact antenatal imaging may have on the parent-fetal relationship and identify factors of the parent imaging experience that may affect attachment.

Materials and methods

The protocol for this review was registered on the PROSPERO database (CRD42020197259). No patients were involved in the development or conduct of this review. Funding was received from the College of Radiographers Doctoral Fellowship Award (DF017) and City, University of London.

Search strategy

The PRISMA statement (Page et al., 2021) was used to develop a search strategy from keywords identified using the PEO framework (Khan et al., 2003; Table 1). This was reviewed by a university librarian specialising in literature searches and piloted for efficacy. Identified keywords and synonyms were combined with Wildcard and Boolean operators to generate search queries (e.g. TI (mother* or maternal or mum*) AND TI (magnetic resonance imaging or MRI) OR TI (ultrasound or sonography or sonogram or ultrasonography) AND TI (bonding or attachment or relationship or behaviour or experience)) (Supplementary Material S1). During September 2020-April 2021, searches of 10 electronic databases were performed (MEDLINE, CINAHL, PsychNET, Academic Search Complete (via EBSCOhost), (Embase, MIDRIS (via OVID), The Cochrane Library, PubMed, Scopus and Web of Science) in addition to searches of grey literature (HMIC, OpenGrey, NICE, and TRIP) and doctoral dissertations (ProQuest Dissertations, Theses Global).

Eligibility criteria

Studies were eligible if they were primary research studies published in English describing or reporting measures of attachment in expectant adult (≥18 years old) parents in the context of medical imaging in pregnancy. To incorporate the impact of fetal imaging advances, studies published before 2000 were excluded. Only studies where the antenatal imaging examination was the research intervention (e.g. 2D/3D/4D ultrasound or fetal MRI) were considered for inclusion. There was no restriction on gestational age or fetal anomaly diagnosis. Studies measuring prenatal attachment after birth were excluded to reduce recall bias.

Table 1. PEO framework to identify keywords and develop search terms.

POPULATION	EXPOSURE (INTERVENTION)	OUTCOMES
mother/maternal	imaging/screening/assessment/modality	attachment/bonding/relationship/behaviour
father/paternal	ultrasound/sonography/US	experience
parent/parental	dimensional/2D/3D/ 4D	
f*etal/f*etus/antenatal/obstetric/pregnancy/prenatal/expectant/prepartum/antepartum	magnetic resonance/magnetic resonance imaging/MRI	
f*etal anomaly/abnormality/prenatal diagnosis	scan/examination	

Selection of papers

References were imported into review management software program, EPPI-Reviewer4 (Thomas et al., 2010). After removing duplicates, titles and abstracts were screened for relevance. Full texts of studies meeting the eligibility criteria were retrieved for further evaluation. Using the same keywords as the electronic databases, additional searches were performed on Google Scholar and using web-based literature searching platform, ResearchRabbit Beta3 (www.researchrabbit.ai). Reference lists of included studies were hand-searched for additional relevant studies. All references were reviewed by ES, with independent double-screening performed by RW on randomly allocated 10% of the total studies for both title/abstract and full-text screening. Discrepancies were discussed by the reviewers to reach consensus following each level of screencing.

Data extraction and quality appraisal

A database was developed for extraction of study characteristics including participant demographics, study design, and reported measure of attachment or qualitative insights. Included studies were quality appraised using Joanna Briggs Institute checklists (Lockwood et al., 2015; Moola et al., 2020; Tufanaru et al., 2020). These assist reviewers in evaluating the rigour and validity of published research, helping to identify flaws in reported study designs and methods through focused questions. Reviewers can respond with 'yes', 'no', 'unclear' or 'not applicable'. Whilst a scoring system is not embedded in these checklists, studies with a high proportion of 'no' or 'unclear' responses are suspected to be of lower quality.

Data synthesis

Owing to the heterogeneity of the studies, a research synthesis (Sandelowski et al., 2006) was more appropriate than the separate meta-analytical and meta-ethnographic approaches proposed in the protocol (Skelton et al., 2020). This method is becoming popular in health research as it enables extraction of categories and themes from quantitative and qualitative data pertaining to a research question, facilitates validation or triangulation of findings (Moon, 2019), and creates a more complete understanding of complex phenomena of interest (Stern et al., 2020). The Pillar Integration Process (Johnson et al., 2019) was used to integrate and synthesise quantitative and qualitative studies in a convergent approach, as it is flexible for use across study designs, yet provides a well-defined methodological approach to the analysis in keeping with the nature of a systematic review (Flanagan et al., 2020). After initial, separate analyses of quantitative and qualitative studies had been completed, the 4-stage (listing, matching, checking, Pillar building) Pillar Integration Process was used to build central, integrated themes. In the first stage, coded categories from quantitative studies and themes for qualitative studies were listed in the respective column on the joint display matrix. The data was then matched to the opposite quantitative or qualitative column and horizontally rearranged to reflect the corresponding content. The rows of matched data were then cross-checked for quality and completeness, before the Pillars were built in the central column to represent the integrated themes from each row (Johnson et al., 2019).

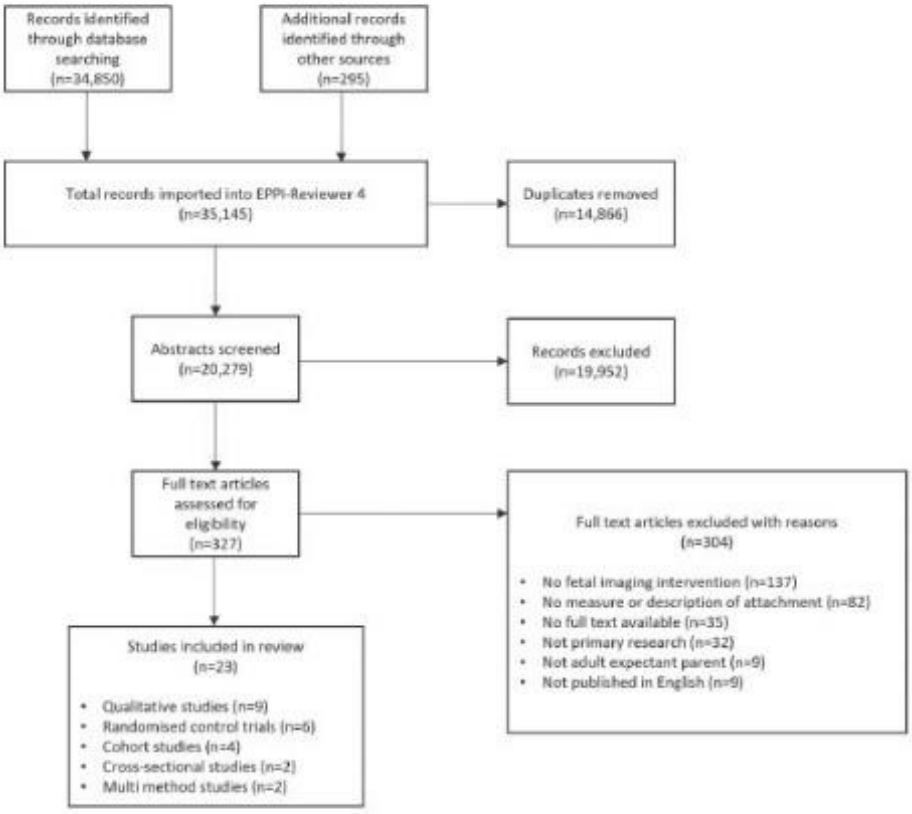

Figure 1. PRISMA diagram.

Results

Results of the searches are given in Figure 1. After removing duplicates, 20,279 references were screened by title and abstract. Of these, 19,952 did not meet the inclusion criteria and were excluded. After detailed review of 327 full-text references, 304 were excluded (see Supplementary Material S2). Twenty-three studies (13 quantitative and 10 qualitative/descriptive studies) were eligible for inclusion. Agreement between the two reviewers was 98% on title and abstract, and 91% on full-text screening.

Study characteristics

Study characteristics are presented in Supplementary Material S3 and S4. There were nine qualitative studies, (Cadogan et al., 2009; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Firth et al., 2011; Freeman, 2000; Øyen & Aune, 2016; Stephenson et al., 2016; Wadephul et al., 2015; Westerneng et al., 2019), 6 RCTs (Boukydis et al., 2006; De Jong-Pleij et al., 2013; Lapaire et al., 2007; Righetti et al., 2005; Rustico et al., 2005; Sedgmen et al., 2006), 4

cohort studies (Edwards et al., 2010; Lalor & Devane, 2007; Polizzi et al., 2017; Robak-Chołubek et al., 2015), 2 cross-sectional (Harpel & Barras, 2018; Sidi & Josheu, 2019), and 2 studies using a multi-method approach (Cristofalo et al., 2006; Murakami et al., 2012).

Most studies (n = 13) were conducted in European countries (Cadogan et al., 2009; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; De Jong-Pleij et al., 2013; Lalor & Devane, 2007; Lapaire et al., 2007; Øyen & Aune, 2016; Polizzi et al., 2017; Righetti et al., 2005; Robak-Chołubek et al., 2015; Rustico et al., 2005; Wadephul et al., 2015; Westerneng et al., 2019), followed by the USA (n = 5; Boukydis et al., 2006; Cristofalo et al., 2006; Edwards et al., 2010; Freeman, 2000; Harpel & Barras, 2018), Africa (n = 2; Firth et al., 2011; Sidi & Josheu, 2019), Australia (n = 2; Sedgmen et al., 2006; Stephenson et al., 2016), and Japan (n = 1; Murakami et al., 2012).

Seventeen studies featured maternal participants only (Boukydis et al., 2006; Cristofalo et al., 2006; Dykes & Stjernqvist, 2001; Edwards et al., 2010; Firth et al., 2011; De Jong-Pleij et al., 2013; Lalor & Devane, 2007; Murakami et al., 2012; Øyen & Aune, 2016; Polizzi et al., 2017; Robak-Chołubek et al., 2015; Rustico et al., 2005; Sedgmen et al., 2006; Sidi & Josheu, 2019; Stephenson et al., 2016; Wadephul et al., 2015; Westerneng et al., 2019), five included both parents (Cadogan et al., 2009; Ekelin et al., 2004; Harpel & Barras, 2018; Lapaire et al., 2007; Righetti et al., 2005), and one study only recruited fathers (Freeman, 2000). Studies with specific research foci included 3D/4D ultrasound (n = 8; Cadogan et al., 2009; Edwards et al., 2010; De Jong-Pleij et al., 2013; Lapaire et al., 2007; Righetti et al., 2005; Rustico et al., 2005; Sedgmen et al., 2006; Wadephul et al., 2015), scans in third trimester (n = 5; Edwards et al., 2010; De Jong-Pleij et al., 2013; Lapaire et al., 2007; Robak-Chołubek et al., 2015; Westerneng et al., 2019), known or high chance of foetal anomaly (n = 3; Cadogan et al., 2009; Cristofalo et al., 2006; Polizzi et al., 2017), first-time mothers (n = 2; Dykes & Stjernqvist, 2001; Sedgmen et al., 2006), and ethnic minorities (n = 2; Firth et al., 2011; Sidi & Josheu, 2019). No studies reporting fetal MRI as the imaging modality were included.

Increased prenatal attachment was measured or reported after scanning in 16 studies (Boukydis et al., 2006; Dykes & Stjernqvist, 2001; Edwards et al., 2010; Ekelin et al., 2004; Firth et al., 2011; Freeman, 2000; De Jong-Pleij et al., 2013; Lalor & Devane, 2007; Murakami et al., 2012; Øyen & Aune, 2016; Righetti et al., 2005; Robak-Chołubek et al., 2015; Rustico et al., 2005; Sedgmen et al., 2006; Sidi & Josheu, 2019; Stephenson et al., 2016), was unchanged in one study (Westerneng et al., 2019), and temporarily decreased after scanning in one study following diagnosis of foetal anomaly (Cristofalo et al., 2006). Four studies reported no difference in attachment between imaging modalities (De Jong-Pleij et al., 2013; Righetti et al., 2005; Rustico et al., 2005; Sedgmen et al., 2006); however, one study found a significant difference in prenatal attachment after 3D/4D compared to 2D ultrasound (Lapaire et al., 2007).

Quality appraisal

Critical appraisal indicated moderate level of quality across the studies. Quality was considered higher where studies used a pre- and post-scan comparative design (Boukydis et al., 2006; Cadogan et al., 2009; Dykes & Stjernqvist, 2001; De Jong-Pleij et al., 2013; Lalor & Devane, 2007; Øyen & Aune, 2016; Polizzi et al., 2017; Righetti et al., 2005; Sedgmen et al., 2006; Wadephul et al., 2015), chose a validated questionnaire for

quantitative data collection (Boukydis et al., 2006; De Jong-Pleij et al., 2013; Polizzi et al., 2017; Righetti et al., 2005; Rustico et al., 2005; Sedgmen et al., 2006), and fully described the analytical process (Cristofalo et al., 2006; Freeman, 2000; Øyen & Aune, 2016; Wadephul et al., 2015).

Elements of qualitative studies that were considered of lower quality were: not disclosing the relationship of the researchers to participants (e.g. to determine whether this relationship could have influenced data collection; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Stephenson et al., 2016; Wadephul et al., 2015; Westerneng et al., 2019), not describing the data collection environment in sufficient detail (Cristofalo et al., 2006; Ekelin et al., 2004; Øyen & Aune, 2016; Wadephul et al., 2015), and not reporting triangulation methods (Cristofalo et al., 2006; Dykes & Stjernqvist, 2001).

Elements of quantitative studies that were considered of lower quality were: using non-validated questionnaires (Edwards et al., 2010; Lalor & Devane, 2007; Lapaire et al., 2007; Murakami et al., 2012; Robak-Chołubek et al., 2015; Sidi & Josheu, 2019), unclear participant recruitment, or randomisation procedures (Boukydis et al., 2006; De Jong-Pleij et al., 2013; Righetti et al., 2005), and not providing details for the ultrasound scan protocol (Polizzi et al., 2017; Righetti et al., 2005; Robak-Chołubek et al., 2015; Sidi & Josheu, 2019).

Fourteen studies did not report ethical approval (Boukydis et al., 2006; Cadogan et al., 2009; Cristofalo et al., 2006; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Freeman, 2000; Harpel & Barras, 2018; De Jong-Pleij et al., 2013; Lapaire et al., 2007; Polizzi et al., 2017; Righetti et al., 2005; Robak-Chołubek et al., 2015; Rustico et al., 2005; Sedgmen et al., 2006).

Excluding lower-quality studies based on these considerations, however, would severely reduce the quantity of data available for use in this review, therefore it was decided they should still be included.

Convergent integrated Pillar data synthesis

Analysis of the included studies identified 58 codes related to prenatal attachment. Six central themes were then developed from the Pillar Integration Process (Table 2): 1) the scan experience begins before the scan appointment; 2) the scan as a pregnancy ritual; 3) feeling actively involved in the scan; 4) parents' priorities for knowledge and understanding of the scan change during pregnancy; 5) the importance of the parent–sonographer partnership during scanning; and 6) scans help to create a social identity for the unborn baby. For simplicity, the term sonographer is used throughout the paper to represent any health-care professional or ultrasound practitioner who performs pregnancy imaging. These themes are described below with illustrative quotes.

The scan experience begins before the scan appointment

This theme conceptualises pregnancy scans as experiences that are not confined to the scan room. Prior to the scan, expectant parents sought information from a range of sources, including leaflets provided by scan departments, the internet, and social interactions (Cristofalo et al., 2006; Ekelin et al., 2004; Firth et al., 2011; Øyen & Aune, 2016), which they used to develop individual expectations about the scan (Cristofalo et al., 2006; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Firth et al., 2011; Lalor & Devane, 2007;

Table 2. Adapted Pillar Integration process analysis (Johnson et al., 2019).

Coded data from quantitative studies	Quantitative categories	Pillar Theme	Qualitative themes	Qualitative codes
---------->		OUTCOME	<----------	
• First-time mothers have higher expectations of scan and quality of images (Lalor & Devane, 2007) • Parents create pre-conceptions of scan from gathered information and social interactions (Murakami et al., 2012)	Scan expectations	The scan experience begins before scan appointment	Anticipating the scan (the scan paradox)	• Pre-scan expectations (Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Cristofalo et al., 2006; Firth et al., 2011; Wadephul et al., 2015; Øyen & Aune, 2016) • Conflicting emotions (e.g. excited but apprehensive for unexpected news; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Firth et al., 2011; Øyen & Aune, 2016; Stephenson et al., 2016; Westerneng et al., 2019) • Dilemma of finding an anomaly (Ekelin et al., 2004; Firth et al., 2011; Stephenson et al., 2016; Westerneng et al., 2019) • Getting information about the scan (Ekelin et al., 2004; Cristofalo et al., 2006; Firth et al., 2011; Øyen & Aune, 2016)
• Parents enjoy scans (Murakami et al., 2012) • Parents show a preference for 3D/4D scans compared to 2D (Lapaire et al., 2007; Edwards et al., 2010) • 3D/4D scans are easier to recognise but do not significantly impact overall perception of fetus, satisfaction of scan or attachment (Righetti et al., 2005; Rustico et al., 2005; Sedgmen et al., 2006; Lapaire et al., 2007; Edwards et al., 2010; De Jong-Pleij et al., 2013) • Parent recognition of 3D/4D images dependent on scan quality (Sedgmen et al., 2006) • First-time mothers find it more difficult to recognise 2D images (Sedgmen et al., 2006)	Imaging technology	The scan as a pregnancy ritual	Seeing the baby (parent interaction with imaging)	• Confirmation of pregnancy (Ekelin et al., 2004; Firth et al., 2011; Øyen & Aune, 2016; Stephenson et al., 2016) • Visualisation of the fetus (Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Cadogan et al., 2009; Firth et al., 2011; Wadephul et al., 2015; Øyen & Aune, 2016; Stephenson et al., 2016; Westerneng et al., 2019) • Creation of fetal images (Stephenson et al., 2016) • Reaction to imaging/technology (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Cadogan et al., 2009; Firth et al., 2011; Øyen & Aune, 2016; Stephenson et al., 2016; Westerneng et al., 2019) • Comparison of imaging modalities (Ekelin et al., 2004; Wadephul et al., 2015; Stephenson et al., 2016) • Reaction to fetal anomalies (Dykes & Stjernqvist, 2001; Cristofalo et al., 2006; Cadogan et al., 2009; Stephenson et al., 2016)

(*Continued*)

Table 2. (Continued).

Coded data from quantitative studies	Quantitative categories	Pillar Theme	Qualitative themes	Qualitative codes
• Fathers attending scans feel closer to baby (Harpel & Barras, 2018) • Paternal-fetal attachment not affected by imaging modality (Righetti et al., 2005; Sedgmen et al., 2006) • Mothers more likely to want additional scans (Harpel & Barras, 2018) • It is important for partners to attend scans (Murakami et al., 2012)	Mums and Dads	Feeling actively involved in the scan	Feelings about the scan (parent reaction to imaging)	• Impact of scan (e.g. validation of parent ability to create life; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Øyen & Aune, 2016) • Feeling involved in scan experience (Ekelin et al., 2004; Stephenson et al., 2016) • Support of partner at scan (Ekelin et al., 2004; Øyen & Aune, 2016; Westerneng et al., 2019) • Negative feelings about the scan (Ekelin et al., 2004; Cadogan et al., 2009; Firth et al., 2011; Wadephul et al., 2015) • Positive feelings about the scan (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Cadogan et al., 2009; Firth et al., 2011; Wadephul et al., 2015; Øyen & Aune, 2016) • What parents value at scans (Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Wadephul et al., 2015; Øyen & Aune, 2016; Westerneng et al., 2019) • Scan is reassuring or a relief (Ekelin et al., 2004; Cristofalo et al., 2006; Cadogan et al., 2009; Wadephul et al., 2015; Øyen & Aune, 2016; Westerneng et al., 2019)

(*Continued*)

Table 2. (Continued).

Coded data from quantitative studies	Quantitative categories	Pillar Theme	Qualitative themes	Qualitative codes
• What parents need from the scan changes at different gestational ages (Murakami et al., 2012) • Parents want to know if there is a fetal anomaly, so they can prepare (Murakami et al., 2012) • Negative health behaviours associated with lower attachment but decrease after scan (Sedgmen et al., 2006) • Knowing the fetal sex helps some parents to prepare for having a baby but is not a priority for all parents, and the result is not always trusted (Murakami et al., 2012; Robak-Chołubek et al., 2015) • Contrary expected fetal sex and fetal presentation thought to affect attachment (Sidi & Josheu, 2019) • Asking questions helps parents to understand and feel better informed about the scan purpose and limitations (Murakami et al., 2012)	The fetus as an individual	Parents' priorities for knowledge and understanding of the scan change during pregnancy	Understanding the scan and becoming a parent (parenting behaviours after the scan)	• Safety concerns about scanning (Firth et al., 2011; Øyen & Aune, 2016; Westerneng et al., 2019) • Knowledge/acceptance of fetal anomalies or unexpected news (Ekelin et al., 2004; Cristofalo et al., 2006; Cadogan et al., 2009; Stephenson et al., 2016) • Positive pregnancy-related behaviours (Dykes & Stjernqvist, 2001; Cadogan et al., 2009; Øyen & Aune, 2016; Westerneng et al., 2019) • Different feelings at different gestational ages and parity (Wadephul et al., 2015; Øyen & Aune, 2016; Westerneng et al., 2019) • Reasons for having/wanting scans (Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Cadogan et al., 2009; Firth et al., 2011; Wadephul et al., 2015; Øyen & Aune, 2016; Stephenson et al., 2016; Westerneng et al., 2019) • Cultural differences (Firth et al., 2011) • Knowing the fetal sex (Freeman, 2000; Firth et al., 2011; Øyen & Aune, 2016)
• Interaction with sonographer during scan: ○ Enhances attachment (Boukydis et al., 2006) ○ Positively impacting perception of scan (Boukydis et al., 2006) ○ Significantly reduces anxiety after scan (Boukydis et al., 2006)	Sonographers	The importance of the parent-sonographer partnership during scanning	Communicating during the scan (how parents and sonographers interact)	• Humanising the fetus and sonographer language (Ekelin et al., 2004; Stephenson et al., 2016) • What parents value in the sonographer (Ekelin et al., 2004; Øyen & Aune, 2016; Stephenson et al., 2016) • Two-way interaction (Øyen & Aune, 2016) • Trust in the sonographer (Freeman, 2000; Firth et al., 2011) • Making enough time for the scan (Westerneng et al., 2019) • Knowledge and understanding of the scan procedure including limitations (Ekelin et al., 2004; Firth et al., 2011; Øyen & Aune, 2016; Westerneng et al., 2019)

(*Continued*)

Table 2. (Continued).

Coded data from quantitative studies	Quantitative categories	Pillar Theme	Qualitative themes	Qualitative codes
• Attachment occurs irrespective of scan (Righetti et al., 2005; De Jong-Pleij et al., 2013; Polizzi et al., 2017) but parents feel closer to their unborn babies after scans (Sidi & Josheu, 2019) • Attachment measures increase more in unplanned pregnancies, at earlier gestational ages or after first scan than later gestations or repeat scans (Sedgmen et al., 2006; Robak-Cholubek et al., 2015; Sidi & Josheu, 2019) • It is unclear how parity affects attachment (De Jong-Pleij et al., 2013; Harpel & Barras, 2018) • Parents talk about scan with family/friends (Sidi & Josheu, 2019) • Perception of social support is important for attachment (Polizzi et al., 2017) • Scan souvenirs represent baby in a physical presence that others can interact with socially (Murakami et al., 2012)	Attachment	Scans help to create a social identity for the unborn baby	Sharing and thinking (sharing the scan experience with family and friends, recognition of self as a parent)	• Using the scan and souvenirs to share pregnancy news (Ekelin et al., 2004; Cadogan et al, 2009; Wadephul et al., 2015) • Extended family attending scans (Westerneng et al., 2019) • Perception of attachment before scan (Freeman, 2000; Dykes & Stjernqvist, 2001) • Perceived impact of scan on attachment (Freeman, 2000; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Cristofalo et al., 2006; Cadogan et al., 2009; Firth et al., 2011; Øyen & Aune, 2016; Stephenson et al., 2016; Westerneng et al., 2019)

Murakami et al., 2012; Øyen & Aune, 2016; Wadephul et al., 2015). Parents looked forward to the scan, but were simultaneously apprehensive of the potential to receive unexpected news about their baby (Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Firth et al., 2011; Øyen & Aune, 2016; Stephenson et al., 2016; Westerneng et al., 2019), with a 'fear that something could be wrong' always present (Cadogan et al., 2009). This emotional conflict created a paradox, whereby in the excitement of visualising their unborn baby, parents also had to consider the possibility of the scan detecting a fetal anomaly and further antenatal care decisions that may have been needed (Cristofalo et al., 2006; Ekelin et al., 2004; Firth et al., 2011; Stephenson et al., 2016).

The scan as a pregnancy ritual

Parents regarded scans as a milestone event, which they expected, and wanted (Harpel & Barras, 2018):

> One of the first-time mothers even considered the ultrasound examination to be an initiation rite into pregnancy, making it obvious not only to herself but also to others that she really was expecting a baby (Ekelin et al., 2004).

Many parents had made the decision to attend the scan before receiving information about it, and were unaware that it is not obligatory in antenatal care (Ekelin et al., 2004). Parents viewed scans as an opportunity to see their baby (Cadogan et al., 2009; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Firth et al., 2011; Øyen & Aune, 2016; Stephenson et al., 2016; Wadephul et al., 2015; Westerneng et al., 2019) and to confirm the presence of a new life (Ekelin et al., 2004; Firth et al., 2011; Øyen & Aune, 2016; Stephenson et al., 2016). Guided by the sonographer's commentary, they used the scan images to create mental images of their baby (Stephenson et al., 2016). Whilst some parents showed a clear preference for advanced imaging techniques, such as 3D/4D ultrasound for ease of recognition (Sedgmen et al., 2006), particularly for first-time mothers (Rustico et al., 2005), scan type, did not seem to significantly impact on parents' perception of the fetus or attachment (Edwards et al., 2010; Lapaire et al., 2007; Righetti et al., 2005; Rustico et al., 2005; Sedgmen et al., 2006).

For some, novel modalities felt more exciting and therefore desirable; however, they also created uncertainty and feelings of disappointment in parents who have high expectations that may not be met (Cristofalo et al., 2006; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Firth et al., 2011; Øyen & Aune, 2016; Wadephul et al., 2015).

> All [parents] expected clear, detailed images of the baby, particularly the face, enabling them to see 'what the baby looks like' (Wadephul et al., 2015).

Pregnancy scans also enabled parents to engage with fetal anomalies by providing a visual image (Cadogan et al., 2009; Cristofalo et al., 2006; Dykes & Stjernqvist, 2001; Stephenson et al., 2016).

Feeling actively involved in the scan

This theme focuses on parents as active participants in the scan (Ekelin et al., 2004; Stephenson et al., 2016). Scans were generally felt to be reassuring or a relief (Cadogan et al., 2009; Cristofalo et al., 2006; Ekelin et al., 2004; Øyen & Aune, 2016; Wadephul et al., 2015; Westerneng et al., 2019), and parents reported positive feelings when the baby's health was confirmed (Ekelin et al., 2004). Parents enjoyed recognising personal characteristics in the baby (Boukydis et al., 2006; Ekelin et al., 2004), and this helped validate their role as creators of life (Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Øyen & Aune, 2016). The presence of fathers at scans was important (Ekelin et al., 2004; Øyen & Aune, 2016; Westerneng et al., 2019), not only for maternal support (Murakami et al., 2012), but also for enhanced attachment as fathers who attended scans felt closer to their unborn baby than those who had not (Harpel & Barras, 2018). Partner behaviour changed after the scan to be 'more understanding and gentle' towards mothers (Ekelin et al., 2004). As with mothers, the imaging modality did not seem to significantly impact paternal attachment (Lapaire et al., 2007; Righetti et al., 2005), rather it was being present and active in the real-time, dynamic scan experience which helped them to feel closer to their unborn baby:

> The women and their partners used the ultrasound examination in planning the pregnancy process leading towards birth and a new life with the baby (Cadogan et al., 2009).

Parents' priorities for knowledge and understanding of the scan change during pregnancy

Interacting with, and understanding the visual images of babies during scan evoked positive pregnancy-related behaviours in parents, such as reducing alcohol/caffeine consumption and preparing the house for the baby's arrival (Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Øyen & Aune, 2016; Sedgmen et al., 2006; Westerneng et al., 2019).

These behaviours represented the developing attachment, and parents' transformation of themselves as a care-giver with 'feelings of responsibility and concern for fetal development' (Stephenson et al., 2016). The pattern to these behaviours was progressive, and as such, the need to inform parents with specific knowledge and understanding from scans changed with gestation (Cadogan et al., 2009; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Firth et al., 2011; Øyen & Aune, 2016; Stephenson et al., 2016; Wadephul et al., 2015; Westerneng et al., 2019). At earlier gestations, parents prioritised knowing that their pregnancy was viable (Murakami et al., 2012). At later gestations, it was important for parents to know about the presence of foetal anomalies (Murakami et al., 2012). Knowledge of the fetal sex was highlighted as an important insight for some parents in trying to learn more about their baby (Firth et al., 2011; Freeman, 2000; Øyen & Aune, 2016). However, limitations of fetal sex determination were understood by parents, with reports to suggest doubt, particularly if it did not align with their preferences (Murakami et al., 2012; Robak-Chołubek et al., 2015). This implied that fetal sex does not have a substantial impact on bonding, as parents seemed to value knowing the health of the baby as a priority (Freeman, 2000).

The importance of the parent–sonographer partnership during scanning

During scans, sonographers facilitated the connection between expectant parents and their babies (Firth et al., 2011), and contributed to parents' knowledge and understanding of the scan procedure (Ekelin et al., 2004; Firth et al., 2011; Øyen & Aune, 2016; Westerneng et al., 2019).

Certain aspects of the sonographer's practice-influenced parents' perceptions of their overall scan experience (Ekelin et al., 2004; Øyen & Aune, 2016; Stephenson et al., 2016), which impacted on attachment (Boukydis et al., 2006). Parents' confidence in their sonographer was linked with narration of the scan (Freeman, 2000), highlighting the importance of the role of the sonographer in partnership with parents:

> The women also stressed the importance of having had the picture on the screen thoroughly explained (Dykes & Stjernqvist, 2001).

Two studies noted the importance of language choices for sonographers (Ekelin et al., 2004; Stephenson et al., 2016). Limiting the use of non-medical terminology humanised the fetus, implied to parents that the sonographer recognised their unborn baby as an individual, and demonstrated professional investment in their care (Stephenson et al., 2016). Making parents feel like they had been given sufficient time during the scan to engage with the experience and ask questions (Øyen & Aune, 2016) helped to reduce parental anxiety and was also important to delivering parent-centred care (Westerneng et al., 2019):

> I wish there was more time for the ultrasound so that she could explain more and also go through what can and cannot be seen (Ekelin et al., 2004).

Scans help to create a social identity for the unborn baby

The final theme represents parents' ongoing scan experience and how they continued to reflect on it to enhance attachment. Many parents centred their news about pregnancies around a scan (Sidi & Josheu, 2019), using it as 'proof' of their unborn baby to others (Ekelin et al., 2004). Some parents waited until their first scan to tell friends and family about their pregnancies, sharing their pictures or videos (Cadogan et al., 2009; Ekelin et al., 2004; Wadephul et al., 2015). Scan mementos represented the baby in a physical presence that others could interact with, and this helped create a social identity before birth (Murakami et al., 2012). After birth, both the parents and the parents' social circle had a sense of 'knowing' the baby already (Cadogan et al., 2009; Cristofalo et al., 2006; Dykes & Stjernqvist, 2001; Ekelin et al., 2004; Firth et al., 2011; Freeman, 2000; Øyen & Aune, 2016; Stephenson et al., 2016; Westerneng et al., 2019).

The perception of social support was an important factor in the developing prenatal attachment (Polizzi et al., 2017) and some mothers chose to bring people other than their partner to scans:

> I took my mother in law and my father . . . so there are also involved a little bit more with the pregnancy (Westerneng et al., 2019).

Discussion

Main findings

This review explored how prenatal attachment is impacted by antenatal imaging. The objectives were to enhance current understanding of parents' experiences of pregnancy imaging, and to identify factors, which could impact on attachment. Six pillar themes were developed, each describing an element of the scan experience and how it impacts the developing attachment. The experience begins in advance of the scan with the creation of expectations, and continues by sharing pregnancy images and knowledge outside of the parental relationship.

Strengths and limitations

A strength of this review was in using the Pillar Integration Process, which enabled rigorous integration of results from quantitative and qualitative studies. It was chosen above other integration methods because the process is displayed clearly and therefore replicable by others (Johnson et al., 2019). An additional strength was the external support received from a subject expert librarian in developing the robust search strategy.

However, a few limitations need to be considered before drawing conclusions. First, the wide publication date range yielded many eligible studies but findings from earlier studies (particularly those involving 3D/4D ultrasound) may not be wholly generalisable to the current context given technological advancements and improvements in image quality (Pulliainen et al., 2019). Additionally, increasing availability of access to pregnancy imaging through private scan clinics may also have an impact on the parent experience, which may not be fully represented within older studies.

A meta-analysis of quantitative studies was not conducted due to heterogeneity of data. The richness of common themes across both qualitative and quantitative studies, however, highlighted the importance of using the Pillar Integration Process to ensure these key themes were strong and thematic saturation was achieved between all eligible studies while addressing the conceptual complexity of prenatal attachment and parental experiences in antenatal imaging.

Despite the high yield returned from the searches, a thorough screening process was enabled by use of the EPPI-Reviewer 4 software (Thomas et al., 2010). This facilitated management of the records across a shared platform and kept an electronic 'audit trail' of the reviewer's judgment against the defined inclusion criteria. Although partial double screening of the records may be considered a limitation of the study, high concordance between reviewers demonstrates the clarity of the inclusion criteria. Finally, to ensure breadth of knowledge in the review, some of the included studies were of low quality. Although it may be argued that this could limit the extent to which the findings can be transferred beyond the review, use of the Pillar Integration Process to synthesise qualitative and quantitative findings helps to mitigate conflicts by highlighting the commonalities across the studies. The need for more methodologically rigorous studies in future research is also emphasised.

Interpretation

Most studies in this review measured or reported increased attachment following scanning (Boukydis et al., 2006; Dykes & Stjernqvist, 2001; Edwards et al., 2010; Ekelin et al., 2004; Firth et al., 2011; Freeman, 2000; De Jong-Pleij et al., 2013; Lalor & Devane, 2007; Murakami et al., 2012; Øyen & Aune, 2016; Righetti et al., 2005; Robak-Chołubek et al., 2015; Rustico et al., 2005; Sedgmen et al., 2006; Sidi & Josheu, 2019; Stephenson et al., 2016). Fetal imaging provided a visual image of the unborn baby that enabled expectant parents to place them in their own familiar reality (Pedreira & Leal, 2015), thus promoting feelings of closeness. Scans gave visual confirmation of the pregnancy, and this reassurance of viability helped to enhance attachment. This is related to parents' pre-scan anxiety of receiving unexpected news, including that of a fetal anomaly (Brisch et al., 2002; Van der Zalm & Byrne, 2006). Rothman historically described the concept of the 'tentative pregnancy' (Rothman, 1987) where parents delay feelings towards the pregnancy until they are more confident the pregnancy is viable (Rowe et al., 2009). Similarly, some find it more difficult to develop an attachment to their baby when an anomaly is diagnosed (Boztepe et al., 2016). In this review, one study reported a temporary decrease in attachment after mothers were informed of a fetal brain anomaly (Cristofalo et al., 2006). Detection of a fetal anomaly may be particularly distressing beyond the first trimester, as previous unremarkable scans may create a false sense of assurance (Ekelin et al., 2008). Parents must address the uncertainty of the diagnosis on their emotional investment to the pregnancy, whilst simultaneously processing the loss of the baby they had initially begun to connect with (Ruschel et al., 2014).

Parent-centred care and implications for sonographers

Parent-centred care by sonographers was highlighted as an essential element of the scan experience to positively enhance attachment (Businelli et al., 2021). When parents feel actively involved, their overall perception of the scan improves (Ranji et al., 2012). A 'good' scan is determined by positive interaction with sonographers (Van der Zalm & Byrne, 2006), which helps to improve parents' recognition of images and strengthen their understanding of the examination (Masroor et al., 2008; J. Walsh, 2010). Parents are then more likely to feel satisfied that their expectations for the scan have been met, even if the overall image quality during the scan is limited (Whynes, 2002). The review supports this finding, as whilst novel imaging techniques (e.g. 3D/4D ultrasound) may be considered desirable, any perceived impact on attachment may be attributed by parents to the explanation given to help interpret the image rather than the image itself (Ranji et al., 2012). This emphasises the integral role of the sonographer during the scan, who personifies the interface between technology and parental knowledge and collaborates with expectant parents to help construct an identity for the fetus (Roberts, 2012). Whilst the medical purpose of the examination is paramount, viewing the scan more holistically to incorporate parent-centred care practices should also be considered in the provision of sonographic education and training (Walsh, 2020).

Making the scan a satisfactory experience for parents (Chudleigh, 1999) should also be considered in providing parent-centred care, with a focus on promoting open communication (Øyen & Aune, 2016). However, with the extensive clinical requirements of scans

placing heavy demand on sonographers (Masroor et al., 2008) it is not surprising parents may feel their expectations are not met (Ekelin et al., 2004). Emerging technologies using artificially intelligent algorithms to automate scan processes or provide clinical support for sonographers may help reduce demand (Baumgartner et al., 2018; Sinclair et al., 2018; Yaqub et al., 2019); however, further, large-scale prospective testing is required to evaluate the real-world clinical utility and impact on the delivery of parent-centred care (Drukker et al., 2020).

A cross-cutting theme was the importance of partners at scans. For fathers and non-pregnant partners, the lack of physical cues can make it difficult to accept the reality of the pregnancy, leading to distress, depression, and poor attachment (Fenwick et al., 2012). Scans help fathers and non-pregnant partners to engage with the pregnancy and get to know the baby through visual cues (Ekelin et al., 2008). The baby represents a project shared between a couple (Cristofalo et al., 2006; Pedreira & Leal, 2015) and the scan is a pregnancy-related event that both parents can experience simultaneously (Fenwick et al., 2012). Knowledge about the unborn baby is acquired together, and physical movements can be witnessed in real time during the scan, providing fathers and non-pregnant partners with a glimpse into the otherwise privileged access their partner has of the pregnancy (Harpel and Barras, 2018). The 'thrill' of being present cannot be fully felt through images shared afterwards (Firth et al., 2011), and the scan experience may further support the intrapsychic dynamics of the expectant parents by enabling an encounter with their imagined child (Walsh et al., 2017). When the coronavirus pandemic reached the UK in March 2020, many maternity departments placed temporary restrictions on those accompanying pregnant people to antenatal scans to minimise virus transmission. The impact of these restrictions on prenatal attachment is yet to be formally evaluated, however a recent report concludes there may be long-term implications for parents, babies and families including 'psychosocial functioning, early parenting and child developmental outcomes' (Lalor et al., 2021).

Implications for future research

This review identified the lack of published studies exploring the potential impact of fetal MRI on prenatal attachment. The searches identified two studies reporting the parent's perspective of foetal MRI (Lie et al., 2019; Reed et al., 2016); however, they were excluded because they did not specifically describe the impact on prenatal attachment. As fetal MRI becomes popular to complement conventional ultrasound, the acceptability of this modality to parents and its potential effect on attachment requires further evaluation to facilitate successful integration into clinical pathways. In addition, the studies in this review emphasise pregnancy scans as a visual experience. Advances in 3D printing help the scan experience to be more accommodating for expectant parents who are visually impaired, contributing to attachment (Coté et al., 2020; Werner et al., 2016). These studies were excluded from this review because the 3D print was the research intervention, however they highlight the importance for sonographers performing scans to consider the needs of parents with additional sensory requirements when delivering high-quality, parent-centred care.

Conclusion

This review highlights antenatal scans as an important pregnancy experience that can enhance prenatal attachment. As well as giving reassurance regarding the health of their unborn baby, scans also provide a visual image, which parents can engage with in real-time, and utilise for attachment by attributing physical and psychological characteristics, thus transforming the baby from a medical entity (fetus) to be recognised as an individual person. The success of this transformation is dependent on sonographers interpreting images in a way that becomes accessible to parents. Sonographers can help facilitate the attachment process by providing an interactive, parent-centred scan experience that is tailored to parents' individual emotional needs and requests of information and knowledge for the gestation of pregnancy.

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Protocol registration

The protocol for this review is registered on the PROSPERO database (CRD42020197259).

Contribution to authorship

ES, CM and SA developed the review protocol. ES performed searches, reviewed papers, undertook the analysis and drafted the paper. RW reviewed references for inclusion. ES, RW, MR, CM and SA revised the review for publication.

Details of ethical approval

Not required.

Data sharing

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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11.11 Appendix 11 - Published Article 2

Original Research

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UK obstetric sonographers' experiences of the COVID-19 pandemic: Burnout, role satisfaction and impact on clinical practice

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Abstract

Introduction: The COVID-19 pandemic placed additional demands and stressors on UK obstetric sonographers, who were required to balance parent safety and service quality, alongside staff safety. Increased pressure can negatively impact a healthcare worker's well-being and the provision of person-centred care. The aim of this study was to explore obstetric sonographers' experiences of performing pregnancy ultrasound scans during the pandemic and to assess the impact on burnout, role satisfaction and clinical practice.

Methods: An online, anonymous cross-sectional survey was created to capture sonographers' experience alongside using the Oldenburg Burnout Inventory to evaluate burnout and Clinical Outcomes in Routine Evaluation 10 (CORE-10) to measure psychological distress.

Results: Responses were received from 138 sonographers. Of those completing the Oldenburg Burnout Inventory (n = 89), 92.1% and 91.0% met the burnout thresholds for exhaustion and disengagement, respectively. Sonographers with a higher burnout score also perceived that COVID-19 had a greater, negative impact on their practice ($p < 0.05$). The mean CORE-10 score of 14.39 (standard deviation = 7.99) suggests mild psychological distress among respondents. A significant decrease in role satisfaction was reported from before to during the pandemic ($p < 0.001$), which was associated with higher scores for burnout and psychological distress ($p < 0.001$). Change in role satisfaction was correlated with sonographers' perception of safety while scanning during the pandemic ($R^2 = 0.148$, $p < 0.001$). Sixty-five sonographers (73.9%) reported they were considering leaving the profession, changing their area of practice or working hours within the next 5 years.

Conclusion: Job and context-specific interventions are required to mitigate burnout and its consequences on the workforce and service provision beyond the pandemic.

Keywords

Burnout, COVID-19, obstetrics, job satisfaction, sonographer, well-being

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Introduction

Occupational burnout syndrome is a psychological phenomenon defined as a 'prolonged response to chronic emotional and interpersonal stressors on the job'.[1] The development of burnout in obstetric sonographers can be explained using the job demands-resources model, which identifies two processes leading to the burnout domains of exhaustion and disengagement. In the 'job demands' process, exhaustion is a consequence of sustained physical and/or psychological work pressures (e.g. heavy workload, interpersonal interactions, sub-optimal work environment).[2] Demands specific to obstetric sonographers, which also contribute to the exhaustion domain, include unexpected news delivery in cases of fetal anomaly or miscarriage,[3] maintaining concentration while experiencing distractors in the scan room,[4] as well as

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the physical exertion of scanning a population with increasing body habitus.[5] Meeting these demands can be made more challenging by a lack of 'job resources', including support from supervisors, and opportunities for personal growth, which can lead to disengagement from work.[6]

High and rising levels of burnout in healthcare practitioners, including sonographers, have been previously acknowledged.[7,8] Additional stressors of the COVID-19 pandemic (e.g. lack of personal protective equipment (PPE), fear of contracting or transmitting the virus, or working under rapidly changing guidelines) may also have a negative psychological impact on healthcare workers;[9] thus, there is potential for the proportion of sonographers meeting the threshold for burnout post-pandemic to be even higher than previously reported. The consequences of burnout on healthcare professionals are well-known, with established associations between the syndrome, mental health, job performance and patient care.[10] During obstetric ultrasound scans, the parent–sonographer partnership is integral to support the delivery of parent-centred care; however, there is limited research into burnout in medical imaging professionals,[8] and even less regarding the specific impact of sonographer burnout on parental experiences of fetal ultrasound.[11]

An additional challenge faced by obstetric sonographers during the pandemic was that many clinical departments temporarily restricted the attendance of partners and support persons at scans in an attempt to minimise virus transmission.[12] In addition to the clinical requirements of the examination, fetal ultrasound scans are often regarded as a milestone event in pregnancy, which provide expectant parents with an opportunity to see their unborn baby. While most parents were understanding of these measures, the profession received critical media attention from expectant parents, other health care staff and parent advocacy groups,[13] which may have contributed to further stress in sonographers.

The aim of this study was to explore sonographers' experiences of performing obstetric ultrasound examinations in the UK during the COVID-19 pandemic to further understand the impact of the pandemic on sonographer burnout and psychological well-being, and consider the implications on the sonographic workforce.

Methods

A UK-wide, cross-sectional open survey design was used to collect data from an anonymous, online questionnaire, created using the secure Qualtrics XM™ survey platform (www.qualtrics.com). The Checklist for Reporting Results of Internet E-Surveys (CHERRIES) was used to guide the reporting of the survey methods and results.[14] This 30-item checklist helps to standardise the reporting of web-based surveys to enable readers to identify potential bias in the methods and establish their own conclusions about the validity of the findings. The questionnaire was divided into four sections: Part 1 captured sonographers' experiences of obstetric scanning during the COVID-19 pandemic, parts 2 and 3 used the validated Oldenburg Burnout Inventory (OLBI) and Clinical Outcomes in Routine Evaluation 10 (CORE-10) tools to evaluate and measure sonographer burnout and psychological distress, respectively, and part 4 recorded basic demographic information (e.g. age, geographical location and employment status). Where appropriate, open-ended questions were used (e.g. for participants to provide additional detail if they wished to). These free-text responses will be qualitatively analysed and included in a separate publication as part of the larger doctoral research project (www.blogs.city.ac.uk/afi-study). The questionnaire was piloted for usability with members of the Society of Radiographers Ultrasound Advisory Group. Their recommendations for minor changes to the wording and display of some questions were incorporated into the final version, prior to launch, for improved accessibility. Participants were prompted (but not forced) to answer all questions and were given the option to review and change answers using navigation buttons within the survey. As the survey contained a mixture of response types (e.g. single click vs free text), no restrictions were placed on the time allotted for completion. To ensure anonymity, no directly identifying participant information was collected. The survey was designed so that participants were prevented from attempting to complete it more than once.

The questionnaire was live for 8 weeks between 9 March and 6 May 2021. The recruitment strategy used snowball sampling via social media channels (Twitter, Facebook, LinkedIn) and word-of-mouth through professional networks to circulate a weblink to the questionnaire. Participants were required to meet all of the following inclusion criteria to be eligible to take part: (1) a qualified sonographer/ultrasound practitioner who has performed obstetric ultrasound scans in the UK since March 2020 (e.g. during the COVID-19 pandemic), (2) aged ≥21 years and (3) informed consent form completed. No incentives were offered to participants. The data collection period coincided with the UK's third national lockdown which began on 6 January 2021.[15]

Oldenburg Burnout Inventory

The OLBI comprises 16 items covering two dimensions: exhaustion (OLBI-E) and disengagement (OLBI-D) from work, which reflect the physical and cognitive aspects of occupational burnout. The highest burnout response to each item scores 4 points, and the lowest scores 1 point. The total burnout score was recorded, and the average scores for each dimension were calculated and compared against a threshold of ≥2.25 for exhaustion and ≥2.10 for disengagement, which have been previously used to determine burnout in other studies.[16–18]

CORE-10

The CORE-10 is a short, generic measure of psychological distress that includes 10 items addressing depression, anxiety, trauma, and physical problems. A score of ≥25 indicates severe psychological distress.[19]

Statistical analysis

Data were analysed using Microsoft Excel (version 2008, Microsoft Corporation, USA) and IBM SPSS Statistics (version 26, SPSS Inc, USA). Q-Q plots demonstrated normally distributed data for parametric statistical analysis to be performed. Where appropriate, analysis of variance (ANOVA) with post hoc testing was used to identify any differences between means of the OLBI, CORE-10 and COVID-19 experience sections of the questionnaire in different sociodemographic groups (e.g. education, geographical region, years of clinical experience and employment status). *T*-tests were used to further compare means, and the Pearson correlation coefficient was used to quantitively assess for any evidence of a linear relationship between variables. A value of $p < 0.05$ was used to determine statistical significance, and a value of $R^2 > 0.7$ was used to determine strong linear correlation. Standard deviation is reported in the results as SD.

Ethical considerations

This study received formal approval from City, University of London (reference: ETH2021-1240). Although all data were collected remotely and anonymously, participant wellbeing was considered with the provision of contact details for two UK-based mental health support groups where participants could self-refer and seek support. All participants confirmed their consent electronically via Qualtrics XM™ before they were able to proceed to the questionnaire. All data were managed as per university guidance.

Results

Participant characteristics

In total, 138 sonographers actively participated in this study. Of those, 63.6% ($n = 84$) completed part 1 in full, 67.4% ($n = 89$) completed parts 2 and 3, and 66.7% ($n = 88$) completed part 4 of the questionnaire. Not all participants answered every question, which resulted in some missing data; however, all recorded responses were still included in the analysis. The average completeness for the entire questionnaire was 81%. Of those who answered the participant information questions ($n = 89$), the largest proportion of respondents identified as female ($n = 86$, 96.6%), of White/British/Welsh/Scottish/Northern Irish/Gypsy or Irish Traveller ethnicity ($n = 77$, 86.5%), between the ages of 51 and 60 years ($n = 31$, 34.8%) and working in the South East region of England ($n = 20$, 22.5%). Full participant characteristics are reported in Table 1.

Sonographers' experiences of obstetric scanning during COVID-19

Of those answering the question ($n = 107$), most sonographers (97.2%, $n = 104$) reported using PPE (either employer provided or self-supplied) when scanning asymptomatic pregnant women or people. For symptomatic pregnant women or people, 97.6% ($n = 83$) of sonographers answering the question ($n = 85$) reported using PPE when scanning. There were 17 sonographers who reported they were not scanning symptomatic pregnant women or people at all. Sonographers' opinions were sought on a range of issues using scales where 0 = negative response/impact or portrayal and 10 = positive response/impact or portrayal. First, sonographers were asked how safe they felt performing pregnancy scans during the pandemic, giving a mean score of 4.25 (SD = 2.58). When asked to rate the impact of COVID-19 on their scanning practice, the mean score was 6.40 (SD = 2.68). The impact of COVID-19 on communication with expectant parents was rated at an average score of 4.03 (SD = 1.87). Sonographers' mean rating of the impact of COVID-19 on the overall parent experience of obstetric ultrasound was 3.27 (SD = 1.67).

Portrayal of the sonographic profession in the news during COVID-19

When asked how they felt the profession had been portrayed in the news (e.g. newspapers and online press articles) during the pandemic, the sonographers' mean score was 1.94 (SD = 1.74) (Figure 1). The lowest mean score was reported in the West Midlands (0.6, SD = 0.55) and the highest was in Wales (3.33, SD = 2.89) (Figure 2).

Portrayal of the sonographic profession on social media during COVID-19

The mean score for the portrayal of the sonographic profession on social media (e.g. Twitter, Facebook) was 1.70 (SD = 1.75) (Figure 1). The lowest mean score was again reported in the West Midlands (0.40, SD = 0.55) and the highest in Scotland (3.50, SD = 2.121). For portrayal of the profession in both the news and on social media, the mean scores by geographical region did not exceed 3.5 (Figure 2).

A paired *t*-test showed that the mean difference in sonographer portrayal in the news and on social media was not significant ($p = 0.110$), however, a moderate positive correlation was noted between the scores ($R^2 = 0.427$, $p < 0.001$). The perceived portrayal of sonographers in the news scored an average of 0.24 more positive than on social media (95% confidence interval (CI) (−0.055, 0.529)).

Table 1. Participant characteristics.

Age group	21–30, *n* = 12 (13.48%) 31–40, *n* = 20 (22.47%) 41–50, *n* = 24 (26.97%) 51–60, *n* = 31 (34.84%) 61+, *n* = 2 (2.25%)
Gender	Female, *n* = 86 (96.63%) Male, *n* = 2 (2.25%) Prefer not to say, *n* = 1 (1.12%)
Ethnicity	White / British / Welsh / Scottish / Northern Irish / Gypsy or Irish Traveller, *n* = 77 (86.52%) Asian / Asian British, *n* = 4 (4.49%) Mixed / Multiple ethnic, *n* = 2 (2.25%) Other, *n* = 2 (2.25%) Black / African / Caribbean / Black British, *n* = 1 (1.12%) Prefer not to say, *n* = 3 (3.37%)
Education	University degree (postgraduate), *n* = 79 (87.00%) Diploma in Medical Ultrasound, *n* = 5 (5.00%) University degree (undergraduate), *n* = 3 (3.00%) Prefer not to say, *n* = 3 (3.00%)
Years of experience	0–5, *n* = 19 (21.35%) 6–10, *n* = 13 (14.61%) 11–15, *n* = 18 (20.22%) 16–20, *n* = 13 (14.61%) 21–25, *n* = 9 (10.11%) 26 +, *n* = 17 (19.10%)
Professional memberships	Society of Radiographers, *n* = 79 British Medical Ultrasound Society, *n* = 40 Royal College of Midwives, *n* = 9 International Society of Ultrasound in Obstetrics and Gynecology, *n* = 2 Royal College of Nursing, *n* = 1 Other, *n* = 1 Prefer not to say, *n* = 1
Geographical location	England – South East, *n* = 20 (22.47%) England – North West, *n* = 13 (14.61%) England – South West, *n* = 13 (14.61%) England – East, *n* = 10 (11.24%) England – London, *n* = 9 (10.11%) England – East Midlands, *n* = 6 (6.74%) England – West Midlands, *n* = 5 (5.62%) England – Yorkshire and the Humber, *n* = 4 (4.49%) Wales, *n* = 3 (3.37%) Scotland, *n* = 2 (2.25%) Prefer not to say, *n* = 4 (4.49%)
Employment status	Full-time employment (NHS/public sector), *n* = 44 (49.44%) Part-time employment (NHS/public sector), *n* = 42 (47.19%) Part-time employment (private practice), *n* = 1 (1.12%) Other, *n* = 1 (1.12%) Prefer not to say, *n* = 1 (1.12%)

Reliability analysis

Cronbach's alpha showed good internal consistency of the OLBI for the eight items of the exhaustion dimension ($\alpha = 0.802$) and acceptable internal consistency for the eight items of the disengagement dimension ($\alpha = 0.777$). The reliability analysis performed on the 10 items of the CORE-10 showed good internal consistency ($\alpha = 0.881$).

Burnout (OLBI) and psychological distress (CORE-10)

Of a maximum 64 points, the mean total burnout (OLBI) score was 44.47 (SD = 7.60). The mean score for the exhaustion domain was 2.96 (SD = 0.49) and for the disengagement domain was 2.67 (SD = 0.48). The results showed 92.1% of sonographers ($n = 82$) met the burnout

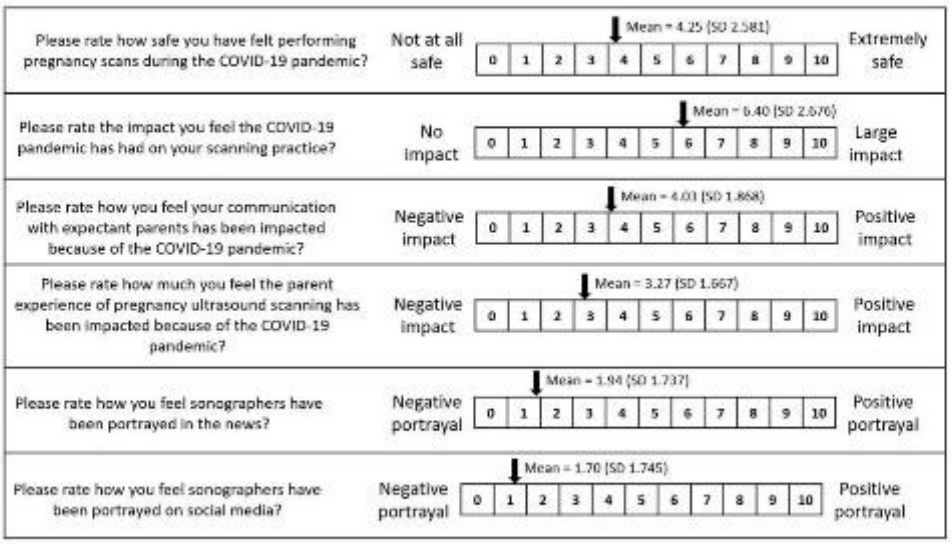

Figure 1. Impact of COVID-19 on sonographic practice.

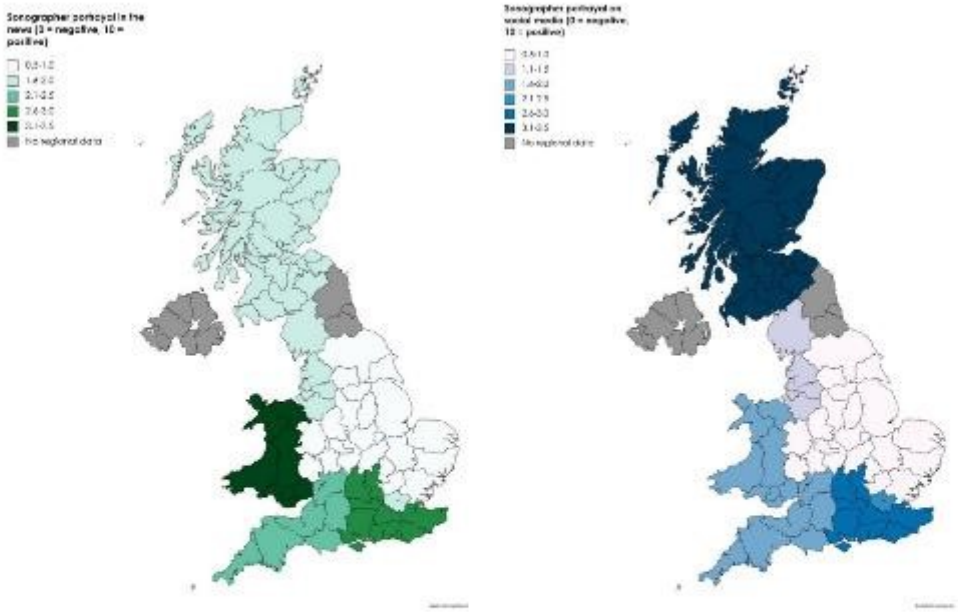

Figure 2. Geographical variation in perception of sonographer's portrayal in the media.

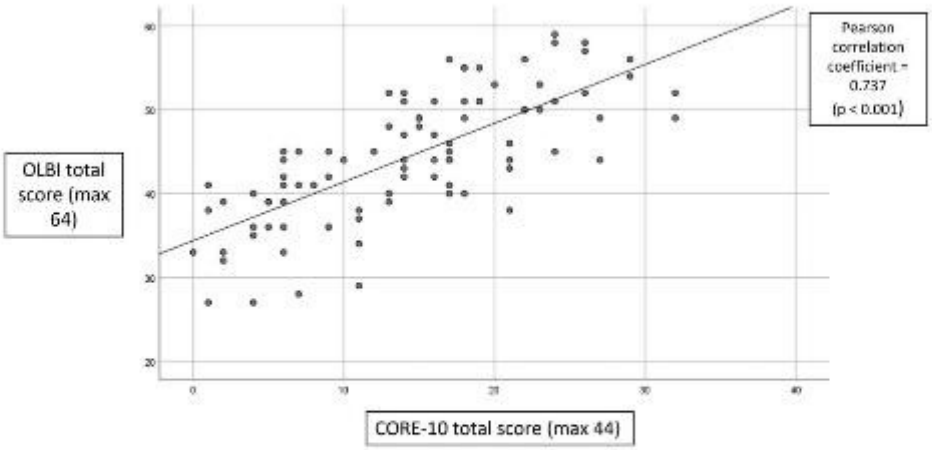

Figure 3. Correlation between OLBI and CORE-10 score.

threshold for exhaustion (≥2.25) and 91.0% ($n=81$) met the burnout threshold for disengagement (≥2.10). Geographical region, education, years of experience and employment status (e.g. full-time or part-time) did not appear to influence burnout scores in this study.

The mean CORE-10 score was 14.39/40 (SD = 7.99). This equates to mild psychological distress. No significant differences were identified between grouped participant characteristics and CORE-10 score.

The Pearson correlation coefficient demonstrated a statistically significant linear relationship between total burnout (OLBI) score and psychological distress (CORE-10) score ($R^2=0.543$, $p<0.001$). The magnitude of the association was moderate. This shows a positive trend between sonographers with a higher burnout score and higher levels of psychological distress (Figure 3).

Sonographers' experiences, burnout and psychological distress

The Pearson correlation coefficient was calculated to assess the association between different aspects of sonographer experience factors and the total burnout (OLBI) or distress (CORE-10) score. Statistically significant negative linear relationships were demonstrated between sonographers' perception of safety and total burnout score ($R^2=0.198$, $p<0.001$) and distress score ($R^2=0.079$, $p=0.008$). A positive trend was observed between the sonographers' perceived impact of COVID-19 on obstetric scanning practice and total burnout score ($R^2=0.044$, $p=0.048$). No other statistically significant associations were demonstrated.

Impact of COVID-19 pandemic on sonographer satisfaction in role

Where 0 = not at all satisfied and 10 = very satisfied, the mean satisfaction in the sonographer role prior to the COVID-19 pandemic was 6.99 (SD = 2.01). Role satisfaction before the COVID-19 pandemic scored on average 2.87 points higher than during the pandemic (SD = 2.58, 95% CI (2.35, 3.39), resulting in a significant change in sonographer role satisfaction from before to during the pandemic ($t_{97}=10.988$, $p<0.001$). A significant, positive correlation between sonographers' individual before and during pandemic role satisfaction scores was demonstrated ($R^2=0.145$, $p<0.001$). No differences were seen in role satisfaction between grouped participant characteristics using analysis of variance (ANOVA); however, statistically significant linear relationships were demonstrated between the change in satisfaction and total burnout ($R^2=0.157$, $p<0.001$), and psychological distress scores ($R^2=0.095$, $p=0.003$). In addition, statistically significant negative correlations were also demonstrated between respondents' change in role satisfaction and sonographers' portrayal in the media ($R^2=0.050$, $p=0.028$), portrayal on social media ($R^2=0.066$, $p=0.011$) and perception of safety ($R^2=0.148$, $p<0.001$).

Impact of COVID-19 on working practice

Of the 88 sonographers who answered the question 'Are you thinking about leaving the profession, changing your area of practice or working hours within the next 5 years?',

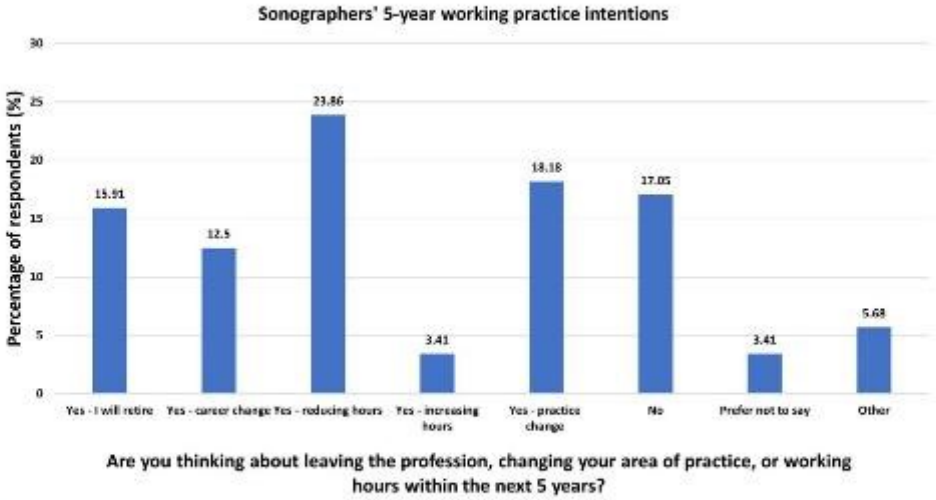

Figure 4. Sonographers' 5-year working practice intentions.

73.9% ($n=65$) responded 'yes' (Figure 4). Of these, 67.1% ($n=47$) of sonographers said that their practice change would happen sooner than planned because of the COVID-19 pandemic. Nearly a quarter of sonographers (24.6%, $n=16$) reported their intention to change their practice by no longer performing obstetric ultrasound examinations. Change of practice was weakly, positively correlated with psychological distress (CORE-10) score ($R^2=1.359E-4$) and difference in role satisfaction before and during the pandemic ($R^2=0.012$); however, neither were significant associations. Change of practice was weakly, negatively correlated with total burnout (OLBI) score ($R^2=0.010$), although this was not significant either.

Discussion

This study aimed to explore the impact of the COVID-19 pandemic on sonographers performing obstetric ultrasound examinations in the UK. Over 90% of sonographers in this sample who completed the OLBI met the burnout thresholds for exhaustion or disengagement. The findings of this study suggest a greater incidence of burnout among the sonographic workforce compared to similar studies using the OLBI to evaluate COVID-19-related burnout in healthcare professionals. For example, Denning et al.[20] identified 67% of healthcare workers from across the UK, Poland and Singapore as being at high risk of burnout. Tan et al.[18] reported 75.3% and 79.7% of healthcare workers meeting the threshold for exhaustion and disengagement, respectively. In both studies, healthcare workers were identified as doctors, nurses, allied health professionals and non-clinical/administrative staff. Higher burnout score was associated with being in a clinical role and redeployment to a new clinical area;[18,20] however, the site of work (e.g. hospital, community, home-based) was not.[18]

Tan et al.[18] also found that those who scored higher for burnout were also more likely to score higher for psychological distress, as demonstrated by a significant, positive correlation. This finding is supported by Chigwedere et al.'s[9] systemic review, which observed a predictive relationship between high anxiety scores and burnout. In this study, a higher total burnout score was also significantly associated with a negative perception of the impact of COVID-19 on scanning practice. It was also demonstrated that sonographers who reported a large, negative change in role satisfaction before and during the pandemic were more likely to have higher total burnout and distress scores. This implies that reduced job satisfaction contributes to burnout and psychological well-being for sonographers. A similar relationship between job satisfaction and psychological distress in primary healthcare nurses was reported by Stefanovska-Petkovska et al.,[21] who also noted a statistically significant association between negative job satisfaction and resignation. However, in this study, no significant association was demonstrated between change in role satisfaction post-pandemic and planned changes to practice. Statistically significant relationships (albeit weak) were observed between sonographers' perceptions of feeling safe while scanning and total burnout and distress scores. A recent study reported elevated psychological distress in Israeli dentists and dental hygienists who were fearful of

contracting COVID-19,[22] which suggests this may have been an important moderator.[9]

Impact of burnout on the sonographic workforce

In addition to the negative impact on individuals' well-being,[6,9] high levels of burnout within the workforce have several important implications for sonographic practice. An association between practitioners who score higher for occupational burnout and absenteeism has been reported.[16,33] With the sonographic workforce vacancy rate at 12.6%[24] and increased sickness rates from COVID-19 and through precautionary measures of self-isolation,[25] additional absenteeism because of burnout is likely to further heighten the workload and subsequent job demands of other obstetric sonographers. This in turn may contribute to their increased exhaustion. Indirectly, burnout may also affect the sonographic team through its influence on working conditions, leading to dissatisfaction and disengagement with the work, and reduced organisational commitment.[6] In this study, a significant decrease in sonographer role satisfaction (compared with perceived satisfaction pre-pandemic) was noted during the pandemic. One highly debated response to employee dissatisfaction is that of the Exit-Voice-Loyalty-Neglect (EVLN) typology, whereby in reacting to a problematic event, a worker may resign (exit), attempt to improve the situation (voice), wait to see whether the issue will be resolved (loyalty) or passively obstruct potential improvements, for example, through lack of interest (neglect).[26] Of those answering the question in this study, over 70% of sonographers stated they were considering leaving or changing their practice within the next 5 years. As this was not found to be significantly associated with burnout, psychological distress or role satisfaction, this typology further highlights the negative impact of the pandemic on the workforce by the high proportion of sonographers with the intention to remove themselves from the clinical situation completely (exit) over other responses (e.g. voice or loyalty).

Potential impact of burnout on provision of parent-centred care

Despite concerns regarding the physical barrier of PPE as a hindrance to effective patient practitioner interaction,[27] sonographers rated the impact of COVID-19 on their communication with parents as mildly negative to none in this study. Although this study was unable to directly assess the impact of burnout on parent care and outcomes, Freudenberger reported that regardless of the effort, burnout will affect how efficiently an individual can perform.[28] High levels of burnout are associated with poor patient safety outcomes, including increased likelihood of errors,[29] as well as low-quality patient interaction and care experiences.[19] In this study, sonographers indicated that the pandemic had a moderate impact on their scanning practice and perceived a mildly negative impact on the parents' experience of the ultrasound scan. The parents' experience of obstetric ultrasound may be enhanced when they are actively involved in the scan;[30] however, it is suggested that exhausted healthcare professionals may be more likely to view patient requests for interactivity as demanding.[31] Repeated interactions that evoke feelings of cynicism over time can cause practitioners to withdraw and disengage in an attempt to conserve their emotional resources.[31] This explanation is based on theories of social equity and reciprocity applied to healthcare settings, whereby a perceived imbalance in the patient practitioner relationship (e.g. the caregiver feels their investment in the relationship is significantly greater than is reciprocated by the patient) actively contributes to burnout syndrome,[31] further impacting care delivery.

Reciprocity and role satisfaction

Reciprocation from patients through expression of gratitude has been shown to reduce burnout in nurses.[32] In this study, a negative correlation was demonstrated between how respondents felt the sonographic profession had been portrayed in the news and on social media during the pandemic, and their change in role satisfaction during the pandemic. Interestingly, significant differences were also found between geographical regions and the sonographer's media portrayal, suggesting there may have been areas in the UK where the media attention was more concentrated. During the pandemic, other healthcare professionals also received a lot of public attention; however, much of it was in praise of 'heroic' frontline workers (e.g. #clapforheroes). This narrative has been questioned for its potential adverse psychological effects on staff, causing stress through increased moral responsibility,[33] as well as implying that reciprocal social obligations are unrequired.[34] In addition, persistent unrealistic expectations about the interpersonal relationship between staff and their patients can also cause imbalance of reciprocity when they are not met, leading to burnout of the individual. This can affect the whole team via the socially induced model of burnout transmission.[35] Sonographic teams are typically small and work closely together; thus, there is a greater chance of being directly exposed to and mirroring a colleague's symptoms of exhaustion or disengagement, or reaching burnout because of a change in work conditions initiated by a colleague with burnout.[35] Many burnout interventions suggested in the published literature focus on promoting individual well-being and resiliency, with limited evidence of efficacy demonstrated.[33] Therefore, interventions that address occupation-specific factors contributing to burnout may be more successful in easing exhaustion and disengagement.

As per Demerouti et al.[2] these should aim to reduce job demands (e.g. improving the physical working environment or varying tasks to balance the physical workload) while providing greater job resources (e.g. personal support from supervisors, opportunities for career development). This model suggests that significant action at organisational level may now be required to alleviate pandemic-induced burnout.

Strengths and limitations of study

A strength of this study was the use of the validated OLBI and CORE-10 tools. These demonstrated good reliability within the study and have clearly defined thresholds which were used to aid interpretation of results. The sample size may be considered relatively small and not representative of the UK obstetric sonographer population; however, it was comparable with other UK sonographer studies.[3,16] While the results focus on, as needed, the peak of the COVID-19 pandemic, the cross-sectional design of this study limits conclusions of causality.[17] The self-selected and self-reported participation may skew the results towards those motivated to share negative personal experiences. In addition, the results are susceptible to common method bias (a known limitation of questionnaire design where the same tools are used to collect all data), which can result in artefactual estimates of the relationships between constructs.[18] While the homogeneity of participant characteristics for gender and ethnic identity improves confidence that the findings accurately represent the study sample, the results cannot be generalised to a wider, more heterogeneous population and are therefore limited beyond this specific demographic.[19]

Future research

A follow-up survey to compare sonographer well-being and role satisfaction after the pandemic would be beneficial to determine whether self-reported burnout scores reduce when the additional stressors of COVID-19 are diminished. This may also help to identify any limitations in the study data incurred through over-reporting of negative personal experiences during the pandemic. Considering an alternative method of data collection, for example, using impartial assessors to determine burnout, may also be more accurate than using self-reported scores. Qualitative analysis of free-text responses collected as part of this questionnaire may provide deeper insight into sonographers' experiences of performing obstetric ultrasound scans during the COVID-19 pandemic to help further inform the quantitative observations. Further research could also consider the impact of individuals' differences (e.g. personality traits, home demands) on burnout and psychological well-being.[6]

Conclusion

Most respondents in this study met burnout thresholds for exhaustion and disengagement. Sonographers with a higher burnout score also demonstrated higher levels of psychological distress and negative changes in role satisfaction, which has implications for the delivery of parent-centred care. Sonographers perceived the pandemic to have had a moderate impact on their immediate scanning practice; however, the findings of this study suggest that the long-term impact on the workforce is yet to be fully realised as demonstrated in the high proportion of respondents considering a change in their clinical practice within the next 5 years. Urgent interventions are therefore required to mitigate the consequences of burnout within the profession, such as those to reduce job demands and increase resources, improve sonographer role satisfaction, and enhance and promote positive relationships between sonographers and expectant parents in the scan room.

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Author contributions

ES and CM conceptualised the study. The study design was developed by ES, GH, SA and CM. ES analysed the data and drafted the paper. All authors revised the paper for publication.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethics approval

Ethical approval was granted by the School of Health Sciences Research Ethics Committee (City, University of London). Reference: ETH2021-1240 (date of approval: 9 March 2021).

Data availability

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data are not available.

Guarantor

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11.12 Appendix 12 - Published Article 3

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"It has been the most difficult time in my career": A qualitative exploration of UK obstetric sonographers' experiences during the COVID-19 pandemic

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ABSTRACT

Introduction: Substantial changes were made to the provision of pregnancy ultrasound services during the COVID-19 pandemic with the intention of minimising virus transmission and maintaining service continuity. Published literature describing the impact of the pandemic on obstetric sonographers is predominantly quantitative in nature, however statistics cannot fully convey sonographers' voices. This study aimed to gain a deeper understanding of the lived experiences of UK obstetric sonographers performing pregnancy ultrasound scans during the pandemic.

Methods: A UK-wide, online, anonymous cross-sectional survey on Qualtrics XM™ was open to responses between 8th March and 6th May 2021. Whilst this survey contained some quantitative elements, open questions were included to capture additional qualitative detail from respondents about their perceptions and experiences of scanning during the pandemic. Key themes were generated from free text responses using thematic analysis.

Results: : Written responses were received from 111/138 sonographers participating in the survey. Five themes were generated, depicting the impact of the pandemic on obstetric sonographers: 1) continuity in a crisis; 2) decisions about me, without me; 3) battle scars – the lasting damage of COVID-19; 4) what people think I do vs. what I really do; and 5) the human touch. A cross-cutting theme was sonographers' feelings of disconnection from senior figures and expectant parents which created a sense of abandonment and distrust.

Conclusion: Survey respondents' self-reported experiences of ineffective leadership and management, and perceived lack of understanding of the complexity of the sonographer role are potential contributory factors in the high levels of moral injury and occupational burnout reported within the workforce during the pandemic.

Introduction

During the COVID-19 pandemic, healthcare services made substantial changes to balance continuity of care with safety of service users, members of the public and staff.[1] Recommended changes to the provision of obstetric ultrasound included reprioritisation of fetal scans because of reduced departmental capacity,[2] risk assessments,[3] and temporary restrictions on additional people attending scans.[4,5] Early published literature exploring the experiences of healthcare professionals reported immediate considerations for services, including the supply (or lack) of personal protective equipment (PPE),[6] telehealth in place of in-person appointments,[7] and screening initiatives to reduce virus transmission in hospitals.[8] However, as staff adapted to new working practices,

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research foci shifted to explore the longer-term psychological impact of the pandemic on workers.[9]

Moral injury and burnout in COVID-19

The negative psychological impact of the COVID-19 pandemic on healthcare professionals is well documented.[10] This has been described in relation to occupational burnout, and attributed to factors such as fear of contracting or transmitting the virus, being redeployed to unfamiliar clinical areas, and increased workloads because of staff shortages.[11] However, it has been suggested that research exploring occupational burnout in healthcare professionals often fails to give appropriate recognition to the prevalence and influence of moral injury as a precursor to burnout.[12]

Moral injury is often described in the military context, whereby individuals experience guilt or shame as a result of their own actions (or lack of), which conflict with their moral values.[13] However, it is also experienced through the recurrent violation of normative expectations, or betrayal of trust, by a person in authority.[14] Normative expectations are broadly defined as "beliefs about what people *should* do combined with predictions about what they *will* do".[15] When they are felt to be breached, individuals may experience a strong affective response including feelings of cynicism, disengagement resentment, and withdrawal of trust[16] causing a moral injury.[17] It is important to make the distinction between occupational burnout and moral injury, as without full appreciation of the underlying cause of an individual's psychological distress, appropriate support and initiatives for recovery cannot be actioned.[18]

The impact of COVID-19 on sonographers

There is a growing body of literature reporting the impact of the COVID-19 pandemic on obstetric sonographers working in the UK,[19–21] Australasia[22–24] and other countries.[25] As with other healthcare professionals, the lack of adequate and available PPE for sonographers was a common finding,[19,21,23] with concerns raised by 71.9% of sonographers across 124 countries.[25] Substantial modifications to scanning practices were noted; including reducing the number of scans[22] and length of appointments,[23] restricting the number of people permitted to attend,[21,23] and making changes to public waiting areas following risk assessments,[20] although these varied between countries. Additionally, increased workloads from rigorous cleaning and infection control procedures,[23,24] rapidly changing guidance perceived as ambiguous[21] and unhelpful,[23] and concerns over personal safety because of aggressive and abusive behaviour towards sonographers from expectant parents and the public are also reported.[21]

Although studies reporting the psychological impact of the pandemic on sonographers are fewer, fear of contracting or transmitting the virus is highlighted as a contributing negative factor on sonographers' well-being,[21,24] exacerbated by the inability to physically distance whilst scanning.[21] In UK obstetric sonographers, high levels of occupational burnout were reported, with over 90% of respondents meeting thresholds for emotional exhaustion and disengagment.[19] In addition, 73.9% of respondents were considering leaving the profession completely, or changing their area of clinical practice within the next five years,[19] which would have a significant impact on the already stretched UK sonographic workforce.[26]

With one exception,[21] published literature regarding sonographers' experiences of scanning during the COVID-19 pandemic is largely based on numerical data and statistics which cannot fully capture individual voices and reflections. The aim of this paper, therefore, was to qualitatively explore UK obstetric sonographers experiences of performing pregnancy ultrasound scans during the COVID-19 pandemic, and to provide additional, psychosocial context to previously reported quantitative findings[15,20] which may be used to underpin workforce recovery strategies in the aftermath of the pandemic.

Methods

Reporting of the study is guided by the Journal Article Reporting Standards for All Qualitative Research Designs (JARS-Qual).[27] An online, anonymous questionnaire was developed using the QualtricsXM™ platform,[28] and the weblink was shared within the UK sonographic community using a snowball sampling technique via social media and professional networking channels (e.g. Twitter, Facebook, LinkedIn). Departmental managers were also approached by the research team to share the weblink with staff who were not active on social media. This approach was used to facilitate rapid collection of a large dataset for the quantitative components of the survey during a period of national lockdown,[29] and to adhere to additional restrictions on conducting research activity which were in place during the COVID-19 pandemic.[30] The survey was reviewed by volunteers from the Society of Radiographers' Ultrasound Advisory Group who gave feedback on readability of questions and usability of the QualtricsXM™ platform, resulting in minor changes to the wording of questions for improved clarity. No data was collected during this review phase, and volunteers could still take part in the main study if they wished to. The questionnaire was composed of four sections: 1) sonographer experiences of performing obstetric ultrasound examinations during the COVID-19 pandemic (Supplementary Appendix 1); 2) Oldenburg burnout inventory[31] to evaluate self-reported levels of occupational burnout; 3) CORE-10 tool[32] to assess psychological distress in respondents; and 4) participant demographics. Section one featured multiple choice questions and provided the option for respondents to share further insight into their experiences through free text responses. Further details about the study design and the quantitative results for sections 1-3 have been previously published.[15,20] This paper presents the qualitative analysis of sonographers' free text survey responses from section one.

Eligibility and informed consent

Sonographers could participate if they were 21 years old or over and had performed obstetric ultrasound examinations during the COVID-19 pandemic (i.e., since March 2020). Exclusion criteria were trainee and non-obstetric sonographers to keep alignment with the research focus. Prior to accessing the questionnaire, respondents were required to read the accompanying information sheet, confirm their eligibility to participate, and complete an electronic declaration of informed consent. Participants were prompted to answer all questions, although they were free to leave blank responses if they wished.

Qualitative analysis

Data were downloaded into Microsoft Excel (version 2008)[33] from the QualtricsXM™ platform[28] after the questionnaire was closed to responses on 6th May 2021. Qualitative data were extracted and imported into NVivo (version 12)[34] for thematic analysis. This method was chosen for its flexibility to facilitate a thorough analysis of the large and heterogeneous qualitative dataset acquired through the online questionnaire.[35] An inductive approach was taken following the 6-step framework described by Braun and Clarke.[36,37] Following familiarisation with the dataset, the free-text responses for individual questions were coded. Codes

were reviewed collectively for further exploration of patterns of meaning across the dataset. During this process, similar codes were combined, and new codes were generated to represent the groups. The groups were reviewed against the full dataset, and overarching themes were developed and subsequently refined to reflect the individual codes. Finally, core themes were reviewed during the writing up process, and illustrative quotations were selected from the dataset to provide supportive examples. Prior to submission, a near-final version of the manuscript was reviewed by two sonographers who volunteered to provide feedback on the findings.[38] This was an important process to validate the findings. These volunteers had not completed the survey themselves, but confirmed the developed themes were reflective of their clinical experiences, therefore no changes were made to the reporting.

Ethical considerations

This study was reviewed and granted ethical approval by the School of Health and Psychological Sciences at City, University of London (reference: ETH2021-1240, date of approval 09 March 2021). Due to the sensitive nature of the research topic and timing of data collection, there was a possibility that sonographers' participation may have led to psychological distress in recalling and relaying their experiences. Therefore, contact details for UK-based mental health organisations were provided to all respondents on completion of the questionnaire.

Results

In total, 138 sonographers actively participated in the questionnaire with a completion rate of 81.0%. Free-text responses were provided by 111 sonographers across 15 questions. Most participants were female (96.6%), of white ethnicity (86.5%) and working in full-time clinical roles within the NHS during the COVID-19 pandemic (49.4%) (Table 1). Despite the potential risk of distress, many sonographers expressed gratitude through their responses at the opportunity to take part in this study and share their perspectives.

Findings

Five themes were generated: 1) continuity in a crisis; 2) decisions about me, without me; 3) battle scars – the lasting damage of COVID-19; 4) what people think I do vs. what I really do; and 5) the human touch (Table 2). Themes and illustrative quotations are provided below.

Continuity in a crisis

Continuity of obstetric ultrasound services during the pandemic was primarily facilitated by sonographers' immense professional pride and duty of care to expectant parents. Despite concerns around contracting the virus because of working in physical closeness to parents, they did not let this stand in the way of them providing high-quality care.

> *"I am professional and will care for women and their partners as usual."*
>
> (Full-time sonographer, aged 51–60)

Efforts required to keep the screening service going were also driven by feelings of satisfaction and accomplishment in the role, particularly when drawing on specialist knowledge to contribute to care management pathways. In contrast, risk mitigation strategies and new guidance issued by professional organisations to assist the safe running of imaging services were not highly regarded, because of their perceived lack of direct benefit to sonographers and ambiguity leading to variation in implementation.

> *"I feel that the guidelines have been as a result of public pressure as opposed to being actually supportive of sonographers."*
>
> (Full-time sonographer, aged 21–30)

The focus from leadership and management personnel on preservation of the parental experience during scans above the well-being of sonographers, led to solidarity in their shared sense of abandonment from senior figures, and sonographers seeking compassion from other members of the immediate ultrasound team to keep them going.

> *"Fellow sonographers have been vital emotional support during a truly difficult professional time."*
>
> (Part-time sonographer, aged 31–40)

Decisions about me, without me

Sonographers felt excluded from discussions at both local and national levels, about their own working practices, creating a sense of isolation.

> *"We as sonographers feel as if we were forgotten during the pandemic."*
>
> (Part-time sonographer, aged 31–40)

They described indignation at how decisions to reintroduce partners and support persons to scans, as national lockdown restrictions lifted, had been made by non-sonographer colleagues, whilst restrictions and/or virtual appointments remained for other antenatal care consultations. This evoked a feeling of distrust, which was further exacerbated by contradictory risk assessments and mitigation strategies which failed to reassure them of the safety of their working environments.

> *"The risk assessments were initially done on a generic basis and were found to be lacking. They have since been redone and there is some disagreement between the staff actually working in the environments and what the health and safety advisor and management assessments state ..."*
>
> (Employment status not shared, aged 31–40)

In addition, sonographers were frequently made to feel like troublemakers for raising concerns over their safety, particularly after the restrictions around partner attendance at scans were lifted around the end of 2020, and described encounters where they had been berated by senior management for speaking out. These events served to reinforce a shared belief that sonographers were expendable workers whose safety needs could be compromised to avoid confrontation and facilitate "business as usual".

> *"Obstetric ultrasound was the sacrifice given to protect other staff providing antenatal care. The scan was promoted by the Trust as a gift to pregnant women and partners so they wouldn't complain about the reduced antenatal checks without partners."*

Table 1
Participant characteristics.

Age Group	21–30, n = 12 (13.48%) 31–40, n = 20 (22.47%) 41–50, n = 24 (26.97%) 51–60, n = 31 (34.84%) 61+, n = 2 (2.25%)
Gender	Female, n = 86 (96.63%) Male, n = 2 (2.25%) Prefer not to say, n = 1 (1.12%)
Ethnicity	White/British/Welsh/Scottish/Northern Irish/Gypsy or Irish Traveller, n = 77 (86.52%) Asian/Asian British, n = 4 (4.49%) Mixed/Multiple ethnic, n = 2 (2.25%) Other, n = 2 (2.25%) Black/African/Caribbean/Black British, n = 1 (1.12%) Prefer not to say, n = 3 (3.37%)
Education	University degree (postgraduate), n = 79 (87.00%) Diploma in Medical Ultrasound (DMU), n = 5 (5.00%) University degree (undergraduate), n = 3 (3.00%) Prefer not to say, n = 3 (3.00%)
Years of experience	0-5, n = 19 (21.35%) 6-10, n = 13 (14.61%) 11-15, n = 18 (20.22%) 16-20, n = 13 (14.61%) 21-25, n = 9 (10.11%) 26+, n = 17 (19.10%)
Professional memberships	Society of Radiographers, n = 79 British Medical Ultrasound Society, n = 40 Royal College of Midwives, n = 9 International Society of Ultrasound in Obstetrics and Gynecology, n = 2 Royal College of Nursing, n = 1 Other, n = 1 Prefer not to say, n = 1
Geographical location	England – South East, n = 20 (22.47%) England–North West, n = 13 (14.61%) England – South West, n = 13 (14.61%) England – East, n = 10 (11.24%) England–London, n = 9 (10.11%) England – East Midlands, n = 6 (6.74%) England – West Midlands, n = 5 (5.62%) England – Yorkshire and the Humber, n = 4 (4.49%) Wales, n = 3 (3.37%) Scotland, n = 2 (2.25%) Prefer not to say, n = 4 (4.49%)
Employment status	Full-time employment (NHS/public sector), n = 44 (49.44%) Part-time employment (NHS/public sector), n = 42 (47.19%) Part-time employment (private practice), n = 1 (1.12%) Other, n = 1 (1.12%) Prefer not to say, n = 1 (1.12%)

(Part-time sonographer, aged 51–60)

Battle scars – the lasting damage of COVID-19

Most sonographers described how the pandemic had a considerable, and long-standing negative impact on their psychological and mental health. In the early stages, they experienced significant distress at being *"sat cuddled up to patients"* for extended periods of time whilst scanning, or felt upset after giving unexpected news to pregnant mothers and people who had been scanned without a support person. Later, increasing numbers of parental complaints and episodes of aggression prompted sonographers to withdraw because of emotional exhaustion and burnout. Complaints received were often not considered valid (*"you have ruined my gender reveal scan"*), and sonographers felt personally attacked for encouraging mask-wearing and physical distancing in scan rooms. They were also deeply distressed by abuse received from parents via unmoderated social media platforms, some of which was individually targeted. A heightened perception of public disrespect for sonographers was further reinforced by the stark contrast of praise and recognition given to other healthcare services.

"I felt the population clapped for the NHS but sonographers were abused verbally at work and on social media."

(Full-time sonographer, aged 51–60)

Lack of support from senior staff who failed to respond adequately to online comments further increased anxiety levels in sonographers. This caused sonographers to question their trust in their employers, as well as their future careers, with many actively seeking to leave obstetric ultrasound or sonography as a result.

What people think I do vs. what I really do

This theme captures the perceived disconnect between the way sonographers understand their role, and how they considered others to. They expressed disappointment and frustration with the portrayal of scans as entertainment for expectant parents, their families, and friends.

"Feel as though the medical element of ultrasound is no longer important and that patients are obsessed with ultrasound as an entertainment scan and gender scan."

Table 2
Key themes and codes.

Theme	Definition	Codes	Illustrative quotations
Continuity in a crisis	The professional and personal values of obstetric sonographers is what really facilitated service continuity during the pandemic	• Actions taken to mitigate risk • Variation in interpretation and implementation of guidance • Parents are the priority • COVID-19 impact on workload • Making a difference • Working in a team	*"... the department has done an incredible job implementing what they can. Keeping the service afloat has been a monumental effort."* *"We were very aware of making the scan as good of an experience as possible ..."*
Decisions about me, without me	Feeling excluded and let down by professional colleagues	• What about us? • Distrust in risk assessment procedures • Feeling underrepresented and unsupported • Job demands and (lack of) resources • Sonographers are expendable	*"They [senior management] often changed things without including our opinion or allowing us to discuss them."* *"They [senior management] did not support sonographers when we highlighted that it is not possible to socially distance in some of our smaller scan rooms. The discussion was just shut down and we were told to get on with it."*
Battle scars – the lasting damage of COVID-19	Occupational burnout and psychological distress in the aftermath of the pandemic	• Moral injury • Pouring from an empty cup • Safety in the scan room • Unsocial media • The future of obstetric ultrasound is uncertain	*"I fear that many people will have already made their minds up to walk away from obstetric scanning."* *"The social media campaigns have been demoralising, inane and disgusting towards our profession. This will undoubtabley affect sonographers and the future of obstetric ultrasound."*
What people think I do vs. what I really do	Obstetric sonographers' frustration in the public lack of understanding and acknowledgement for the profession	• Scanning is multifaceted • Lack of recognition and understanding of the profession • Public perception of sonographers • The entertainment factor	*"We are not an entertainment industry but skilled medical professionals who deserve appropriate recognition."* *"... many see the scans as a social event and not a diagnostic test with a purpose."*
The human touch	Finding satisfaction in quality interpersonal connections with expectant parents	• Sonographers as support • Positive sonographer experiences • Communication is key to role satisfaction • Feeling valued and important	*"... I felt that I made a real difference ..."* *"I still enjoy my job and find it rewarding and that I am important in the role that I do."*

(Part-time sonographer, aged 31–40)

In these scenarios, sonographers felt their clinical expertise was being undermined. An inferred emphasis on the parent experience placed them in an uncomfortable position where they felt the pressure of balancing the potential risk of failing to detect an unexpected fetal condition with that of receiving criticism from parents.

"Constant worry about missing pathology because you are too busy trying to make experience nice for patient [...] because you are worried about getting a complaint."

(Full-time sonographer, aged 41–50)

Some sonographers described how parents' use of private ultrasound clinics (both prior and during the pandemic) contributed to the disparity between medical and social elements of scans by setting unrealistic expectations for parents and conflating ultrasound screening and diagnosis with the promise of a fun, family experience. Respondents called for initiatives to improve public and professional understanding of the role following the pandemic.

"It is imperative we are not seen as entertaining clowns but an essential part for the medical profession."

(Full-time sonographer, aged 41–50)

The human touch

Despite its challenges, the pandemic presented an opportunity for some sonographers to return to their core professional values in providing high quality parent-centred care. They were emotionally responsive to expectant parents' needs and desires to share the scan with a fellow human, and whilst attendance restrictions were in place, they extended their roles to act as default companions, offering temporary social support during the scan appointment. This working relationship was gratifying for sonographers who described feeling more engaged and appreciated in their role through the enhanced connection.

"Many [mothers] interacted with me in a way that they wouldn't if their partner was there."

(Full-time sonographer, aged 51–60)

Without additional attendees, sonographers felt better able to focus their attention on the individual they were scanning. They described how this facilitated a richer, more personal scan experience that was more aligned to the purpose of the scan and created a safe and trusting environment in the scan room. As a result, many observed increased disclosure of additional issues such as domestic violence. These positive interactions helped sonographers to feel valued and satisfied in their roles, despite the challenges of working during the pandemic.

"[I] ... did consider leaving the NHS at the beginning but felt that I do love my job and I do feel that I have been important to the women I've scanned."

(Part-time sonographer, aged 31–40)

Discussion

The themes generated depict UK obstetric sonographers' experiences of facilitating the continuity of obstetric ultrasound services during the COVID-19 pandemic. Sonographers relied on their strong professional values and sense of duty to overcome challenges in the interpretation and implementation of new guidance and avoid disruption to antenatal care provision. However, their

efforts were not felt to be fully appreciated or supported, resulting in reduced trust and increased disengagement from leadership and management figures. The themes reflect the occurrence of moral injury amongst sonographers, who, despite this, continued to engage with their role, finding satisfaction in team-working, deeper connections with pregnant women and people, and the application of their specialist ultrasound knowledge and skills.

Occupational moral injury

In addition to concerns around the risk of contracting COVID-19 and personal safety within the scan room, disconnect from senior professional colleagues was identified in this analysis as a longer-term influence on the psychological well-being of obstetric sonographers. Feelings of disappointment were consistent across all but one of the themes generated ("the human touch"), and were evoked in response to sonographers' perception that their normative expectations of senior management, professional organisations, and the general public had been violated. Sonographers felt let down by senior management and professional organisations because of the perceived inadequacy and lack of visible leadership, which may have been interpreted as contradictory to recommendations emphasising the importance of authoritative figures being present during a time of crisis for staff support.[35] Sonographers also felt dismissed when concerns shared over safety in the scan room were not taken seriously. This finding was not unique to this analysis, with failures in PPE provision reported as a major cause of distress in UK healthcare professionals.[40] A study of Australasian workers also reported feeling shamed and victimised when asking for higher-grade PPE.[41] Dismissal of concerns by senior managers can be perceived as a lack of care, and causes staff to question their position as a valued team member or dispensable object,[42] in this case, merely an extension of the ultrasound machine.

Occupational moral injury and parent-centred care

Occupational moral injury in healthcare professionals has been dubbed as the "hidden pandemic" of COVID-19,[41] however it was not just ineffective leadership that was identified as morally injurious in this study. Obstetric sonographers also felt let down by expectant parents and the public who displayed threatening behaviour and directed abuse towards them, most often regarding the restrictions around partner attendance. As sonographers identified themselves as the victims in this situation, expectant parents also experienced feelings of disappointment; that these restrictions were not in their best interests,[43] resulting in a mutual withdrawal of trust.

Trust is integral to parent-centred care, as it underpins the relationship between the sonographer and the expectant parent.[44] Trust in healthcare professionals develops from both an understanding and appreciation of clinical skills, as well as demonstration of "humaneness" through compassion and care.[45] The parent-sonographer relationship is acknowledged as complex,[16] and development of trust can be challenging in the obstetric setting. As highlighted in this analysis, it was hindered by the COVID-19 pandemic. Survey responses suggested that lack of public recognition and awareness for obstetric sonographers' clinical role could be explained by the absence of statutory regulation for the workforce. This failure to acknowledge sonography as a distinct occupation creates ambiguity around the role, and as such lowers the public profile of sonographers and recognition of specialist clinical skills.[47] This can be further confused by the rise in popularity of private scanning clinics which promote more social aspects of obstetric ultrasound.[48] In addition, it may be considered that guidance recommending shorter scan times and the restriction of partners and supporting persons at scans during the pandemic[4] were not conducive to developing the trusting parent-sonographer relationship and the subsequent perception of high-quality care.[49] However, obstetric sonographers did not consider these as significantly impactful on their communication with expectant parents during scans.[16] Instead, efforts to enhance interactions with parents during the peak of the pandemic restrictions, as described in the final theme, suggest incidences of psychological growth in response to the situational trauma,[50] whereby sonographers made positive changes to their practice to ensure the provision of parent-centred care.

Moral repair and recovery

Recovery following moral injury is essential to prevent progression to burnout[17] and the development of deeper psychological trauma.[14] The context-driven nature of moral injury and burnout suggests that initiatives at the individual level (e.g. practising mindfulness, resiliency training) are likely to be ineffective in the longer term.[51,52] Therefore, structural reform is urgently required to support post-pandemic recovery of the workforce. However, unlike mitigation for occupational burnout which may attempt to reduce job demands and increase resources for workers,[51] moral repair requires that the "moral equilibrium" between the perpetrator and the victim is re-established, such that trust can be restored.[54]

Shale describes a 7-point framework for moral repair that places the notion of acknowledgement firmly at the centre of trust restoration.[13] This includes acknowledgement that moral injury has occurred, acknowledgement of responsibility for causing harm, acknowledging the feelings of those who have been injured, and acknowledging what is required to rectify the wrong. These are fundamental components of an apology, which is used as the first step to facilitate resolution between two parties after a moral violation.[55] Apologies are moral acts, integral to the practice of ethical leadership, as they provide an opportunity for individuals to publicise their values and present themselves as figures of integrity who are worthy of trust and respect.[56]

In the first instance, the findings of this analysis call for effective and ethical leadership in the aftermath of the COVID-19 pandemic, whereby individuals are seen to demonstrate and promote normatively appropriate conduct to their followers.[57] This leadership approach has been associated with increased job satisfaction and staff morale, and reduces burnout by encouraging positive working environments[58] because of its focus on two-way communication, reinforcement of common moral values, and practice of shared decision-making.[55] Interprofessional teamwork in collaboration with Maternity Voices Partnerships is also needed to rebuild trust between sonographers, parents and professional groups, as highlighted in recent reports reviewing maternity services in England[59,60] and Wales.[61]

Strengths and limitations

The study findings provide qualitative context which help to explain previously reported high levels of occupational burnout in obstetric sonographers.[39] Although limitations inherent in the sampling strategy are acknowledged,[62] survey responses were received from sonographers who were working across all regions of the UK during the COVID-19 pandemic, which has enabled good geographical representation of obstetric ultrasound departments. The sample size was comparable with another recent study involving UK sonographers.[63] Respondents were predominantly female and white, which is reflective of the current workforce,[64] and advantageous from the qualitative perspective because the sample is relatively homogeneous.[65] However, it must be

recognised that the experiences of male or ethnic minority sonographers may be different. Due to the cross-sectional nature of the survey, self-selecting population and timing of data collection, findings may not be transferable outside of the study setting,[66] and follow-up research may be beneficial. The theoretical principles of thematic analysis preclude the use of established quality practices (e.g. member checking) to determine credibility of the findings.[67] An alternative practice (member reflection) was utilised,[38] whereby sonographers reviewed a near-final draft of this manuscript to confirm the developed themes were consistent with their experiences.

Conclusion

This analysis provides qualitative context to previous research findings of occupational burnout within the workforce, highlighting sonographers' moral injury through perceptions of ineffective and invisible leadership and management during the pandemic as a key contributing factor. Failure to urgently acknowledge and appropriately repair the harm experienced by obstetric sonographers is likely to exacerbate occupational burnout at the detriment of staff well-being and high-quality parent-centred care. Senior figures must work in collaboration with sonographers to rebuild trust and recreate supportive working environments. Additionally, whilst positive interactions with expectant parents in the scan room were identified as integral to role satisfaction, this is often undermined by a lack of understanding of the clinical aspect of pregnancy ultrasound, and future efforts should be made to raise awareness of the sonographer's role amongst service users and the public.

Declaration of competing interest

CH is the Professional Officer for Ultrasound at the Society and College of Radiographers.

Author contributions

ES and CM conceptualised the study. All authors developed the study design. ES analysed the data and drafted the paper. All authors revised the paper for publication.

Ethical approval

This study was granted approval from the School of Health and Psychological Sciences Research Ethics Committee at City, University of London (reference: ETH2021-1240, approval date: 09 March 2021). All participants gave their informed consent prior to accessing the online survey, which included giving their permission to use anonymised quotations for research presentation and publication.

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Data availability

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available for distribution.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2023.03.007.

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11.13 Appendix 13 - Published Article 4

PLOS ONE

RESEARCH ARTICLE

The effect of the COVID-19 pandemic on UK parent experiences of pregnancy ultrasound scans and parent-fetal bonding: A mixed methods analysis

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Abstract

Introduction

Companionship in antenatal care is important for facilitating positive parental experiences. During the COVID-19 pandemic, restrictions on partner attendance at fetal ultrasound scans were introduced nationally to minimise transmission of the virus. This study aimed to explore the effect of these restrictions on maternal and paternal experiences of pregnancy scans and evaluate their potential effect on parent-fetal bonding.

Methods

A UK-wide, anonymous cross-sectional survey was completed by new and expectant parents (n = 714) who had, or were awaiting a pregnancy scan during the COVID-19 pandemic. The CORE-10 and an adapted version of the Prenatal Attachment Inventory were used to evaluate psychological distress and prenatal bonding. Additional survey questions captured parental experiences of scans. Separate statistical and thematic analyses of the data were undertaken. A joint display matrix was used to facilitate integration of quantitative and qualitative claims to generate a comprehensive interpretation of study findings.

Findings

When fathers did not attend the scan, feelings of excitement and satisfaction were significantly reduced ($p<0.001$) and feelings of anxiety increased ($p<0.001$) in both parents. Mothers were concerned about receiving unexpected news alone and fathers felt excluded from the scan. Mean paternal bonding (36.22, SD 10.73) was significantly lower compared to mothers (47.01, SD 7.67) although no difference was demonstrated between those who had attended the scan and those who had not. CORE-10 scores suggested low-to-mild levels of psychological distress, although the mean difference between mothers and fathers was not significant. Key themes described both parents' sense of loss for their desired

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pregnancy scan experience and reflected on sonographers' central role in providing parent-centred care during scans.

Conclusion

Restrictions on partner attendance at scans during the COVID-19 pandemic had a negative effect on parental experiences of antenatal imaging. Provision of parent-centred care, which is inclusive of partners, is essential for improved parental experiences.

Introduction

During the COVID-19 pandemic, significant changes were made to the provision of antenatal and intrapartum care to incorporate guidance for physical distancing and minimise virus transmission [1]. These recommendations prioritised the safety of the general population and healthcare staff, and aimed to reduce their risk of contracting the virus [2]. In addition, restrictions on partner attendance at ultrasound scans were advised by professional organisations [3,4]. However, inconsistent communication around guidelines, which were constantly updated in response to emerging (and often contradicting) knowledge about the virus and public health advice, resulted in confusion and ambiguity in how they were used [1]. Concerns were also raised about increasing variation in practice between clinical centres [5]. When UK lockdown restrictions began to ease, many partners were still unable to attend pregnancy scans due to reasons such as varying interpretation of guidelines, differing estates and local risk assessment. Parent advocacy groups considered the on-going restriction of partners at scans to be disproportionate in the response to COVID-19, calling for the guidance to be reviewed, and risks of virus transmission to be re-evaluated against the psychosocial risks in expectant parents [6]. The risk of psychological harm was especially concerning in parents whose scans demonstrated an unexpected physical fetal condition or fetal loss, as many pregnant women and people received this news alone [1]. Research exploring how the pandemic further impacted women who had experienced pregnancy loss suggests that feelings of grief, trauma and anxiety were exacerbated because of inadequate social support [7], thus highlighting the value of companionship during antenatal care.

Parent-fetal bonding during COVID-19

The maternal prenatal bond is a complex entity thought to be influenced by various contextual and psychosocial factors including support [8], physical health [9] and the strength of the parental relationship [10]. Maternal anxiety during pregnancy is also considered to have a negative effect on the developing prenatal bond, albeit small [11]. Pregnancy is a transformational life event during which individuals must make significant changes to adjust to their new circumstances [12]. As a result, there is a high risk of new onset or recurrence of mental illness, including depression and anxiety [13]. The COVID-19 pandemic presented further stressors in addition to those already experienced by expectant parents, with studies reporting increasing levels of depression [14,15] and anxiety [16] in pregnant women compared to pre-pandemic levels. Prenatal maternal distress has been associated with impaired fetal neurological development and increased risk of mental health problems in later life [17]. It is also thought that anxiety during the pandemic may have been further increased in mothers of high-risk pregnancies [18], with a resultant negative impact on prenatal bonding demonstrated [19].

Study rationale and aim

However, research studies exploring the effect of the COVID-19 pandemic on prenatal bonding have focussed predominantly on mothers and are generalised to consider the whole pregnancy experience, including labour and childbirth [20–22]. Whilst some do acknowledge antenatal ultrasound as part of the wider analysis, drawing more specific conclusions around the effect of ultrasound scanning during the pandemic on bonding is challenging because of the additional and external moderators. Focused research in this area is therefore warranted to gain a deeper understanding of how the changes to pregnancy imaging services have affected psychological and social domains of antenatal care [23]. The aim of this study was to gain insight from parents who had accessed pregnancy ultrasound scans during the COVID-19 pandemic, compare the experiences of mothers and fathers or partners, and to evaluate prenatal bonding during this time.

Materials and methods

The study methods and results are reported as per the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [24]. Although a formal framework for reporting mixed methods research has yet to be published, the Checklist of Elements to Include in a Mixed Methods Manuscript has been used to guide the presentation of the methods and results [25].

An online, anonymous questionnaire was created using the secure Qualtrics XM ™ survey platform (www.qualtrics.com). This was reviewed by parent volunteers and representatives from UK-based antenatal support charity, Antenatal Results and Choices (ARC). In response to their feedback, minimal amendments were made to the phrasing of questions and overall survey structure to improve readability and usability. To improve overall completeness, the survey prompted participants to respond to all questions, however they could choose not to answer if preferred. Participants could also use navigation options within the Qualtrics XM™ platform to move between questions and change their answers if desired. To ensure adequate time was given for all respondents to complete the survey, no restrictions for duration were enforced. For their convenience, participants also had the option to save their progress and return to complete the survey later. However, the "ballot-box stuffing" option was enabled in the platform to prevent multiple attempts at the survey.

The survey contained four sections. Part 1 contained questions regarding scan expectations or experiences. Part 2 included an adapted version of the Prenatal Attachment Inventory (PAI) to assess parent-fetal bonding, and the CORE-10 tool was used in part 3 to evaluate psychological distress. Participants were asked to provide basic demographic information (e.g. geographical location, ethnicity, education status) in part 4.

Circulation of the survey's weblink to prospective participants was achieved through snowball sampling via social media platforms (e.g. Twitter, Facebook, LinkedIn) and word-of-mouth sharing. To be eligible for participation, the inclusion criteria required respondents to be an expectant or new parent aged 18 years or over, and either waiting for, or had attended a pregnancy ultrasound scan in the UK during the COVID-19 pandemic. The survey was open to respondents between 9th March-25th April 2021. During this 6-week data collection period, the UK was in its 3rd national lockdown, which began on 6th January 2021 [26].

A power calculation to determine sample size for this survey was based on estimates from studies using the maternal antenatal attachment scale [27] to compare change in bonding after ultrasound [28,29]. Using these studies to assume that prenatal bonding may be increased after fetal imaging by an approximate average of 3-points on the scale, an alpha of 0.05 and power of 80%, it was estimated that a minimum sample size of 39 participants was required in each scan group (e.g. waiting for scan vs. had scan) to avoid error in comparative analyses. A target

sample size of 500 parent participants was set to absorb anticipated incomplete questionnaires, with the intention for this quota to be divided between the two groups, although this could not be controlled because of the sampling method.

Parent expectations and experiences

This part of the survey captured parent expectations and experiences of pregnancy scans during the COVID-19 pandemic. Topics explored through these questions included searching for information about the scan, what might or did happen during the scan, and thoughts about the scan. A mixture of question types was used, with open-ended questions included to compliment the closed questions so that participants could further elaborate on their answers if they wanted to. Objective parental experience was quantitatively evaluated through closed-questions (e.g. "did you see images of the baby?"). Subjective parental experience was captured in the free-text responses which generated qualitative data. Participants were also asked to report their feelings of anxiety, excitement and satisfaction regarding their scan using a rating scale.

Prenatal attachment inventory (PAI)

The original version of the prenatal attachment inventory (PAI) contains 21-items which measure the maternal-fetal relationship on a 4-point Likert scale from "Almost never" to "Almost always" [30]. As noted in a previous study [31], the PAI was modified for use by both parents in this survey by removing or rephrasing gendered items (e.g. "I try imaging what the baby is doing in there" becomes "I try to imagine what the baby does inside the womb"). The modified PAI contained 16-items and was reviewed by a group of maternal and paternal advisors to evaluate content validity. The response to each item in the PAI receives a score between 1–4, and these are combined to generate the total score. It is often considered that higher scores reflect a more developed bond, although it must be noted that no optimal score has been reported in the literature [32]. For the 16-item adapted PAI, the maximum possible score was 64.

It should also be noted that the relationship between expectant parents and their unborn babies is complex and definitions have evolved over time to reflect the growing body of research into this topic. Within the literature, studies refer to prenatal "attachment" and "bonding" interchangeably, however it has been suggested that the term attachment is less accurate as this implies a reciprocal relationship between the parent and the baby which is limited during the fetal period [33]. For simplicity, in this paper, the parent-fetal relationship is described as the prenatal bond throughout, although literature referring to attachment is also acknowledged and included.

CORE-10

This generic measure of psychological distress contains 10-items related to well-being and general functioning. Participants are required to choose from one of five Likert responses ("Not at all," "Only occasionally," Sometimes," "Often," and "Most or all of the time") which best reflects how often they have experienced symptoms in the past 7 days [34]. The highest distress response to each item scores 4-points, and the lowest scores 0-points. The maximum possible score is 40. The CORE-10 is validated for use in the perinatal population and commended for its brevity [35], as well as being simple to interpret with total scores less than 10 considered non-clinical at one end of the scale, and total scores of 25 or above corresponding with severe psychological distress at the other [36].

Data analysis

A mixed methods approach was used for data analysis so that rich quantitative and qualitative insights could be extracted and developed from the data initially, and then combined to generate a more comprehensive perspective to address the research aim [25].

Quantitative data analysis

The gendered terms "mother" and "father" are used throughout this paper as no non-binary parents completed part 4 of the questionnaire.

First, quantitative data were analysed in Microsoft Excel (version 2008, Microsoft Corporation, USA) and IBM SPSS Statistics (version 28, SPSS Inc, USA). In addition to descriptive statistics, parametric statistical analyses were performed as Q-Q plots demonstrated normally distributed data. Cronbach's alpha was calculated to determine the reliability of the CORE-10 and adapted PAI tools in this study. Pearson and point bi-serial correlation coefficients were calculated to explore possible associations between variables [32]. Due to differences in group sizes, Welch's t-test of unequal variances was used to compare means between parents who were waiting for a scan and those who already had been scanned, as well as between maternal and paternal participants. Further analyses of quantitative data from parents who had been scanned were performed to identify differences between maternal and paternal responses. As no fathers who were waiting for a scan took part in the survey, maternal vs paternal comparisons could not be made for this group of parents. To identify any variations between the means of the post-scan PAI, CORE-10 and scan anxiety, excitement and satisfaction scores by timing of scan in relation to COVID-19 restrictions, analysis of variance (ANOVA) was used [37]. For this, parents were allocated to one of four groups which reflected the national COVID-19 restrictions depending on the timing of the scan [26]. Post-hoc testing was performed to further identify differences between groups that reached statistical significance on ANOVA. Statistical significance was determined using a value of $p<0.05$.

Qualitative data analysis

Free-text responses to survey questions were collated and managed using NVivo qualitative data analysis software (version 12, QSR International). An inductive, thematic analysis was chosen to further explore parent experiences, primarily because it is well-suited to the study's large and heterogeneous dataset. The flexibility of this approach also facilitated a thorough analysis of the qualitative responses because they could be coded at question or dataset level. The analysis sought to explore the research question 'what was the parent experience of pregnancy ultrasound scans during the COVID-19 pandemic?'. After initial familiarisation with the dataset, the free-text survey responses were coded at the surface level for each individual question, and four core concepts around parent experiences of scans, partner attendance, parent-centred care and COVID-19 were generated. These codes were grouped into key concepts and combined with notes made during familiarisation to generate basic descriptive summaries which provided a general overview of the data. A second phase of coding was then undertaken on the whole dataset and provisional themes were developed and refined. During a final review of the data, the codes and provisional themes were then checked against the dataset for alignment and further refined as needed before being finalised as five core themes [38].

Convergence of data

Key quantitative findings and qualitative codes were then recorded into a joint display matrix [39] and triangulated. Connections between the data were assessed to identify where findings

could be confirmed or integrated with other findings to provide explanations in the case of contradictions. These were grouped around the core domains of: 1) anxiety; 2) excitement; 3) satisfaction; and 4) bonding, which were based on the structure of the survey questions. This process produced several integrated claims (IC) which could then be further developed or combined to generate a new claim if deeper understanding was required. To help provide a rich perspective on the full dataset, a final meta-inference, or "conclusion that connects or integrates various claims" [40] was developed using the integrated claims.

Ethical considerations

Ethical approval for the study was received from the School of Health and Psychological Sciences at City, University of London (reference ETH2021-1240). Prior to accessing the survey, prospective participants were required to read the study information sheet which explained the purpose of the study, eligibility criteria and instructions for navigating the online platform. After reading the information, participants were then required to confirm their consent to take part in the study by marking a digital checkbox built into the survey platform [41]. Due to the potential for sensitive issues to be raised by the questionnaire, the psychological well-being of participants was fully considered in the study design. As all responses were anonymous, individual support could not be offered. However, a link to a collection of further online resources where participants could self-refer for UK-based perinatal mental health support was built into the Qualtrics XM™ platform. Data management and research governance procedures were followed as per university guidance.

Reflexivity statement

All authors are female and from a range of clinical academic backgrounds including medical imaging, midwifery and psychology. The first author is a registered diagnostic radiographer with specialist ultrasound training, and over 10 years' experience of performing obstetric ultrasound examinations. During the COVID-19 pandemic, the first author was working in a full-time research role in a UK higher education institution. All authors believe that inclusive person-centred care is integral for the provision of pregnancy imaging, to facilitate a supportive experience for parents, birth partners and healthcare professionals alike. They also acknowledge the unique challenges raised by the pandemic, and that these impacted the lives of healthcare professionals as well as healthcare service provision.

Public engagement

Seven parents (four mothers and three fathers) who had pregnancy ultrasound scans during the COVID-19 pandemic volunteered to review the preliminary findings and manuscript prior to journal submission. These parents responded to an invitation to review which was posted on social media. An infographic summary of the research was prepared and circulated to the parents, who were asked to comment on how well the findings reflected their personal experiences during this time. All parents providing feedback were entered into a prize draw for a gift voucher in recognition of their time and contributions. Their suggestions were collated and addressed in the final manuscript submission.

Results

To minimise the potential for unforeseen psychological distress in responding to this survey, participants were free to answer the questions they felt comfortable with. Therefore, some responses are missing from the full dataset. All percentages have been calculated and reported

to reflect the number of participants responding to the specific question, therefore these figures will vary.

Participant characteristics

The target sample size was exceeded, as 714 new and expectant parents consented to take part in the online survey. Of these, 96.4% (n = 688) reported they had attended a pregnancy ultrasound scan since March 2020 (Fig 1).

The remaining 3.6% (n = 26) were awaiting a scan at the time of completing the questionnaire. Across both groups of parents, the average completeness for the questionnaire was 79.8%. Most participants who answered the question (96.3%, n = 474) were the mother of the baby who was being, or had been scanned, and of white/British/Welsh/Scottish/Northern Irish/Gypsy or Irish Traveller ethnicity (94.1%, n = 461). In section four of the questionnaire, only 14 respondents answered that they were a father although it is believed that several others did not complete this part of the survey, which likely increases the actual total of fathers represented in the data. Most parents reported the setting for the scan was an NHS or public hospital (98.1%, n = 576). At the time of completing the survey, 47.4% of parents (n = 223) reported the pregnancy was on-going. For other parents, the baby had either been born (n = 220) or the pregnancy had ended (n = 28). Full participant characteristics are reported in Table 1.

Most parents reported scans during the first (46.9%, n = 271) and second (36.0%, n = 213) trimesters of pregnancy, which coincide with the routine fetal screening examinations offered in the UK as part of the NHS Fetal Anomaly Screening Programme between gestational ages of 11^{+2}–14^{+1} weeks in the first trimester, and 18^{+0}–20^{+6} weeks in the second trimester. For pregnant mothers who had been scanned (n = 565), more than half reported they had been alone during the examination (65.5%, n = 370). Most fathers and partners taking the survey (59.0%, n = 13) had not attended the scan. Eighty-five respondents (12.6%) described partner attendance at some routine scans and non-attendance at others. This seemed to vary between departments with some only allowing partner attendance at the first trimester scan (n = 12), and others only allowing partner attendance during the second trimester (n = 34). Non-

Fig 1. Timing of respondents' pregnancy scan appointments during the pandemic.

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Table 1. Participant characteristics.

		Waiting for scan	Had scan	TOTAL RESPONSES
	Consent to survey	26	688	714
	Survey completeness	75.04%	84.90%	Average = 79.77%
Relationship to baby	Mother	17	457	474
	Father	0	14†	14
	Other	0	4	4
Previous scans	Yes	17	555	572
	No	3	178	181
Ethnicity	White	13	448	461
	Asian	2	4	6
	Black	0	3	3
	Mixed	0	7	7
	Prefer not to say	1	1	2
	Other	1	10	11
Education	Secondary	1	28	29
	College	3	115	118
	UG	7	151	158
	PG	5	131	136
	Doctorate	0	20	20
	Prefer not to say	0	2	2
	Other	0	6	6
Employment	Full time	7	309	316
	Part time	4	108	112
	Unemployed	2	25	27
	Student	0	3	3
	Other	2	23	25
Parental disclosure of physical health condition	Yes	1	92	93
	No	12	371	383
Parental disclosure of mental health condition	Yes	6	165	171
	No	10	301	311
Parental disclosure of currently prescribed medication	Yes	5	136	141
	No	11	331	342

†Of these, n = 2 fathers attended the scan and n = 2 did not attend the scan.

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routine examinations (e.g. scans in early pregnancy and third trimester) were most reported to have restrictions on partner attendance (n = 48) (Table 2).

Pregnancy ultrasound scanning during the COVID-19 pandemic

Searching for information. The majority of parents waiting for scan (60.0%, n = 12) reported that they had searched for information in advance of the scan, with the most frequently accessed source (75.0%, n = 9) being internet information (e.g. local hospital or NHS webpage). The most searched for information was related to who could attend the scan (91.6%, n = 11). In comparison, only 35.7% (n = 191) of parents who had been scanned stated they had searched for additional information after the examination. Again, the most frequently accessed post-scan resource was internet information (91.1%, n = 174). Following the scan, the most searched for information was regarding the results of the scan (84.2%, n = 160). There

Table 2. Respondents' scan information.

		Waiting for scan	Had scan	TOTAL RESPONSES
Geographical location for scan	North East	0	15	15
	North West	3	96	99
	West Midlands	2	27	29
	East Midlands	3	76	79
	Yorkshire	3	15	18
	East	0	73	73
	London	1	57	58
	South East	4	59	63
	South West	3	127	130
	Wales	1	10	11
	Scotland	0	15	15
	NI	0	2	2
Scan setting	NHS/public hospital	19	557	576
	Private	1	10	11
Timing of scan	Early pregnancy (≤10w)	2	23	25
	1st Trimester	6	265	271
	2nd Trimester	3	210	213
	3rd Trimester	9	73	82
Timing of survey	Currently pregnant		223	
	No longer pregnant		212	
	Other		4	

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were 22 parents who indicated they had searched for other information related to fetal growth, placental position and unexpected physical conditions. Most parents (89.5%, n = 171) felt that they had found all the information they were looking for (Table 3).

Expectations for the scan appointment. Most parents who were waiting for a scan expected that they would see images of their baby (85.0%, n = 17), that the sonographer would explain the images during the examination (70.0%, n = 14), and that they would be given a scan picture (65.0%, n = 13) (Table 4). The majority (73.7%, n = 11) stated they wanted a scan picture and reported that they would likely keep it as a memento for themselves (88.2%, n = 15).

Experiences of the scan appointment. For parents who had been scanned (n = 502), most saw images of the baby (97.0%, n = 487), saw the baby move (89.8%, n = 451) and had the scan images explained to them (86.3%, n = 433) (Table 4). A small proportion of respondents (2.4%, n = 10) reported that they had additional imaging performed, although no further details were provided about the type of imaging. Most parents (80.0%, n = 433) indicated they would be having, or did have other scans in the pregnancy, with several respondents to this question answering that they had either had, or were planning to book private scans (15.7%, n = 68) in addition to those offered by the NHS.

Pre and post scan anxiety, excitement and satisfaction. The mean anxiety score of parents waiting for scans was 6.40 (SD 2.62). For parents who had been scanned, the mean anxiety score was lower at 4.70 (SD 3.29). Mean excitement was 6.15 (SD 3.09) for parents awaiting scans and 7.25 (SD 2.67) for parents who had been scanned. No significant differences between pre- and post-scan anxiety, or pre and post-scan excitement were demonstrated (Table 5). No statistically significant correlation between pre-anxiety and pre-scan excitement levels was observed (Table 6).

Table 3. Parents' self reported information searching behaviours .

		Waiting for scan (n, %)		Had scan (n, %)	
1. Searched for information about the scan?	Yes	12 (60.0%)		191 (35.7%)	
	No	8 (40.0%)		344 (64.3%)	
2. Source of information searched?	Internet information page	9 (75.0%)		174 (91.1%)	
	Internet forum	3 (25.0%)		88 (46.1%)	
	Family/friends	3 (25.0%)		84 (44.0%)	
	Social media	3 (25.0%)		67 (35.1%)	
	Healthcare professional	3 (20.0%)		55 (29.0%)	
	Someone who attended the hospital	2 (16.0%)		20 (10.5%)	
3. Information searched?		Who can come to the scan	11 (91.6%)	Scan results	160 (84.2%)
		What the scan is for	5 (41.6%)	How baby looked on scan	47 (24.6%)
		What would happen during the scan	3 (25.0%)	What happened during the scan	44 (23.0%)
		What the baby will look like	3 (25.0%)	How I felt after the scan	34 (17.8%)
		Getting results	3 (25.0%)		
		How to prepare for the scan	3 (25.0%)		
4. Found all information required?		Yes, fully	7 (58.3%)	Yes	171 (89.5%)
		Partially	5 (41.6%)	No	20 (11.0%)

[1]In Table 3, n denotes the number of participants selecting the question response. The total number of respondents to each of the questions in this table ranges between 12–20 for those waiting for scan, and 191–536 for those who had been scanned. For questions 2&3 in this table, participants could select multiple responses.

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Negative ($p<0.001$) correlations were noted between post-scan anxiety and excitement ($R = -0.36$), and post-scan anxiety and satisfaction scores ($R = -0.46$). Parents who were more satisfied with their scan also scored more highly for excitement ($R = 0.49$, $p<0.001$). No association was demonstrated between pre scan anxiety scores and searching for information. however, a higher post-scan anxiety score was correlated ($p<0.001$) with searching for information ($R = -0.34$).

Table 4. Expectations and experiences of the scan appointment[1].

	Scan expectations–what will happen during the scan?	Scan experiences–what did happen during the scan?
	Waiting for scan (n, %)	Had scan (n, %)
See images of the baby?	17 (85.0%)	487 (97.0%)
Get a picture?	13 (65.0%)	493 (98.2%)
See baby move?	15 (75.0%)	451 (89.8%)
Sonographer explains images?	14 (70.0%)	433 (86.3%)
Opportunity to ask questions?	15 (75.0%)	369 (73.5%)

[1]In Table 4, n denotes the number of participants selecting the question response. The total number of respondents to each of the questions is 20 for those waiting for scan, and 502 for those who had been scanned.

https://doi.org/10.1371/journal.pone.0286578.t004

Table 5. Pre and post scan comparisons of anxiety, excitement, bonding and psychological distress (Welch's t test).

	Waiting for scan	Had scan	Mean difference	t	Significance
Anxiety (pre or post scan)	6.40 (SD 2.62)	4.70 (SD 3.29)	-1.70	2.81	0.10
Excitement (pre or post scan)	6.45 (SD 3.09)	7.25 (SD 2.67)	0.80	-1.14	0.27
PAI* (pre or post scan)	46.76 (SD 9.79)	46.77 (SD 8.16)	0.01	0.00	1.00
CORE-10 (pre or post scan)	10.88 (SD 5.96)	11.42 (SD 7.11)	0.54	-0.36	0.72

*Only parents whose pregnancy was on-going at the time of taking part in this study were eligible to complete the PAI. There were 17 mothers waiting for scan and 233 parents who had been scanned and gave responses to the PAI.

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Parents who had been scanned rated their overall satisfaction of the experience at an average of 8.46 (SD 2.75) (where 0 = not at all satisfied and 10 = extremely satisfied). A lower post-scan satisfaction score was associated ($p<0.001$) with information searching ($R = 0.22$).

Reliability analysis

A reliability analysis using Cronbach's alpha showed good internal consistency of the modified PAI ($\alpha = 0.885$) and CORE-10 ($\alpha = 0.847$).

Pre and post-scan bonding (PAI) and psychological distress (CORE-10)

No significant difference in mean PAI score was seen between parents who were waiting for a scan (46.76, SD 9.79) and parents who had been scanned (46.77, SD 8.16). Pre-scan PAI score was not associated with pre-scan anxiety or excitement (Table 6). PAI score was positively

Table 6. Pre and post-scan correlations between bonding (PAI), psychological distress (CORE-10) and feelings about the scan (anxiety, excitement, satisfaction and information searching).

Variables	Pearson (R)	R^2	p-value*
PAI and searching for information	-0.05	0.00	0.44
PAI and pre-scan anxiety	0.21	0.05	0.36
PAI and pre scan excitement	0.03	0.00	0.83
PAI and post-scan anxiety	0.05	0.00	0.42
PAI and post-scan excitement	0.25	0.06	<0.001**
PAI and post-scan satisfaction	0.09	0.01	0.167
PAI and CORE-10	-0.13	0.02	0.10
CORE-10 and searching for information	-0.25	0.06	<0.001**
Pre scan anxiety and searching for information	0.05	0.00	0.84
Post scan anxiety and searching for information	0.36	0.12	<0.001**
Pre-scan anxiety and excitement	-0.28	0.08	0.23
Post-scan anxiety and excitement	-0.36	0.13	<0.001**
Post-scan anxiety and satisfaction	-0.46	0.21	<0.001**
Post-scan satisfaction and excitement	0.49	0.24	<0.001**
Post-scan satisfaction and searching for information	0.22	0.05	<0.001**

*In Table 6, values marked with
** are significant at the level of $p<0.05$.

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correlated ($p<0.001$) with post-scan excitement ($R = 0.25$), although no association was demonstrated between PAI score and post-scan anxiety or satisfaction.

The average CORE-10 scores equate to mild-low level psychological distress within the group of respondents. No significant difference was seen between parents waiting for a scan and parents who had been scanned (Table 5). The mean CORE-10 score was higher ($p<0.001$) in parents who also reported a previous mental health condition compared to those with no history of mental health issues. For all parents, the total CORE-10 score was higher ($p<0.001$) in those who searched for more information about their scan ($R = -0.25$). No correlation between total PAI and CORE-10 score was demonstrated.

Comparison of maternal and paternal post-scan bonding and feelings about scan. All maternal participants reported they were the birthing parent, and all fathers reported they were the non-birthing parent, therefore no analyses of same-sex couples could be performed.

Post-scan bonding was significantly higher ($p<0.05$) in mothers (47.01, SD 7.97) compared to fathers (38.22, SD 10.73). Although paternal-fetal bonding was lower, there was no significant difference demonstrated between those who had attended scans and those who had not (Table 7). Partner attendance did not significantly affect maternal-fetal bonding either, with a mean PAI score in mothers whose partner had attended the scan of 47.60 (SD 7.41) compared to 46.72 (SD 8.87) of those whose partner had not.

Table 7. Comparison of maternal and paternal feelings following pregnancy scan (Welch's t-test) [a].

	Group maternal mean (n = 512)	Group paternal mean (n = 13)	Mean difference	t	Significance
Post scan anxiety	3.67 (3.036)	3.67 (3.905)	0.00	0.00	0.99
Post scan excitement	7.48 (2.12)	6.22 (3.60)	1.25	0.98	0.35
Post scan satisfaction	7.16 (2.45)	6.67 (3.94)	0.49	0.57	0.72
Post scan PAI	47.01 (7.97)	38.22 (10.73)	8.79	2.43	0.04**
Post scan CORE-10	11.21 (6.51)	9.00 (6.35)	2.21	0.98	0.36
Mothers only	Scanned with partner mean (n = 155)	Scanned alone mean (n = 305)	Mean difference	t	Significance
Post scan anxiety	3.23 (2.86)	5.44 (3.25)	-2.21	-7.49	<0.001**
Post scan excitement	8.00 (2.06)	6.80 (2.85)	1.20	4.73	<0.001**
Post scan satisfaction	7.94 (1.84)	5.66 (2.62)	2.28	10.38	<0.001**
Post scan PAI	47.60 (7.41)	45.72 (8.87)	1.88	1.55	0.12
Post scan CORE-10	10.72 (6.63)	11.90 (7.43)	-1.19	-1.66	0.10
Fathers only	At scan mean (n = 7)	Not at scan mean (n = 7)	Mean difference	t	Significance
Post scan anxiety	2.86 (2.41)	7.14 (3.44)	-4.29	-2.70	0.02**
Post scan excitement	8.29 (1.11)	3.57 (3.05)	4.7	3.85	0.005**
Post scan satisfaction	8.43 (1.40)	3.00 (2.16)	5.43	4.13	0.003**
Post scan PAI	38.00 (9.92)	38.67 (14.64)	0.67	0.07	0.948
Post scan CORE-10	9.83 (8.06)	9.29 (5.88)	0.53	0.11	0.885

[a]In Table 7, n denotes the number of participants answering the question. Note that only parents whose pregnancy was on-going at the time of taking part in this study were eligible to complete the PAI–this was 226 mothers and 9 fathers. The scores are reported in the table as mean (standard deviation). Values marked with ** are significant at the level of $p<0.05$.

https://doi.org/10.1371/journal.pone.0286578.t007

Table 8. Post scan anxiety, excitement, satisfaction, bonding and psychological distress by parental experience of scans (Welch's t-test)[1].

	No previous scan experience mean	Previous scan experience mean	Mean difference	t	Significance
Anxiety	4.57 (3.33)	4.78 (3.20)	0.111	0.307	0.214
Excitement	7.04 (2.72)	7.67 (2.52)	0.529	2.607	0.005**
Satisfaction	6.51 (2.75)	6.37 (2.74)	-0.137	-0.556	0.592
PAI	46.91 (8.26)	46.60 (8.39)	-0.414	-0.377	0.707
CORE-10	11.78 (7.35)	10.69 (6.30)	-1.092	-1.688	0.092

[1]In Tab. 8, the number of participants answering the questions ranged from 170–172 for parents with previous scan experience and 318–353 without. Note that only parents whose pregnancy was on-going at the time of taking part in this study were eligible to complete the PAI- this was 80 with previous scan experience and 162 without. The scores are reported in the table as mean(standard deviation). Values marked with ** are significant at the level of p < 0.05.

https://doi.org/10.1371/journal.pone.0268578.t008

There was no significant difference ($p = 0.36$) in psychological distress (CORE-10) demonstrated between mothers and fathers. CORE-10 score was also not significantly affected for either parent by partner attendance at the scan.

When comparing parental mean scores for anxiety, excitement and satisfaction, no significant differences were noted between mothers and fathers generally. However, anxiety was significantly higher ($p<0.05$) in fathers who had not attended scans (7.14, SD 3.441) compared to those who had (2.86, SD 2.41). Paternal excitement and satisfaction was significantly higher ($p<0.05$) in those who had been present at the scan than those who had not. For mothers who had been scanned with their partners, there were significantly ($p<0.001$) lower levels of anxiety, and higher reported levels of excitement and satisfaction compared to those who had been scanned alone (Table 7).

Mean scores were also compared between parents who had prior experience of pregnancy ultrasound scans (either earlier in the current pregnancy or in a previous pregnancy) and those who had not. No significant differences were observed in post-scan anxiety, satisfaction, bonding or psychological distress (Table 8). However, parents with prior scan experience scored significantly higher ($p<0.05$) for excitement (7.67, SD 2.52) than those without (7.04, SD 2.72).

Post-scan bonding and feelings about scan by timing of scan

ANOVA testing demonstrated that, in general, as the pandemic progressed, parental anxiety scores decreased while satisfaction scores increased (Table 9). However, two exceptions to this were observed. Firstly, there was no significant difference in anxiety score between parents scanned during November 2020 –February 2021 (3.73, SD 3.06) and March –May 2021 (3.26, SD 3.19). No significant difference in satisfaction was demonstrated between parents scanned during July–October 2020 (6.53, SD 2.81) and November 2020 –February 2021 (6.95, SD 2.50). Post-scan excitement, bonding and psychological distress scores did not significantly differ with the timing of the pregnancy ultrasound scan during the COVID-19 pandemic.

Qualitative findings

Five core themes were developed in relation to parental experiences of pregnancy ultrasound scans during the pandemic: 1) the pandemonium of pandemic pregnancy scans; 2) fathers as the forgotten parent; 3) a pregnancy in isolation; 4) sonographers as the gatekeepers to the information about the fetus; and 5) remote connections: missed opportunities for bonding. These themes and their corresponding codes are presented in Fig 2. Illustrative quotations are used to underpin each theme's description below.

Table 9. Post-hoc analysis of post-scan anxiety and satisfaction by timing of scan during the COVID-19 pandemic (Welch's t-test) [1].

	Scanned March 2020—June 2020 (1st UK lockdown) (n = 139)	Scanned July 2020 –October 2020 (Local restrictions) (n = 167)	Scanned November 2020 -February 2021 (2nd/3rd UK lockdown) (n = 153)	Scanned March 2021—May 2021 (Local restrictions) (n = 43)	Mean difference	t	Significance
Anxiety	3.70 (3.15)	5.00 (3.29)			0.7	1.97	0.05**
Satisfaction	5.52 (2.80)	6.53 (2.81)			-1.008	-3.33	<0.001**
Anxiety	3.70 (3.15)		3.73 (3.06)		1.975	5.622	<0.001**
Satisfaction	5.52 (2.80)		6.95 (2.50)		1.428	4.741	<0.001**
Anxiety	3.70 (3.15)			3.26 (3.19)	2.444	4.469	<0.001**
Satisfaction	5.52 (2.80)			7.95 (2.00)	-2.435	-6.447	<0.001**
Anxiety		5.00 (3.29)	3.73 (3.06)		1.273	3.598	<0.001**
Satisfaction		6.53 (2.81)	6.95 (2.50)		0.420	1.430	0.160
Anxiety		5.00 (3.29)		3.26 (3.19)	1.744	3.177	0.002**
Satisfaction		6.53 (2.81)		7.95 (2.00)	1.426	3.902	<0.001**
Anxiety			3.73 (3.06)	3.26 (3.19)	0.470	0.860	0.388
Satisfaction			6.95 (2.50)	7.95 (2.00)	-1.006	-2.748	0.007**

[1]In Table 9, n denotes the average number of participants answering the question. The scores are reported in the table as mean(standard deviation). Values marked with ** are significant at the level of $p<0.05$.

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The pandemonium of pandemic pregnancy scans

This theme captured expectant parents' perceptions of how the COVID-19 pandemic had impacted on their pregnancy scans, creating uncertainty and stress, specifically in relation to restrictions on partner attendance. Parents were understanding of the measures initially, but as lockdown restrictions began to ease around the country, the rationale for not reinstating partner attendance became a point of contention:

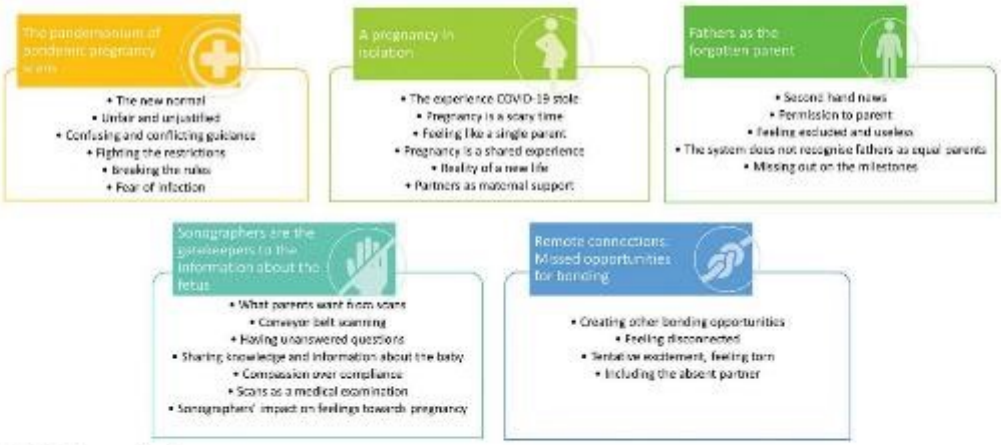

Fig 2. Key themes and codes.

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"I understand why these are the way things are but think a priority for our society should be getting scans back to normal first instead of allowing pubs and restaurants and socialising. . ."

Parents' scepticism of the restrictions was further intensified by perceived inconsistencies in their enforcement, alongside other COVID-19 safety measures.

"People were walking around the hospital with no masks including hospital staff. COVID rules were not adhered to at the hospital but yet my partner was not allowed to attend. . ."

Examples of "double-standards" were often described, with parents receiving mixed messages from clinical departments about partner attendance. Some parents had received written confirmation that partners would be allowed into the scan room, only to be told on arrival at the hospital that this was not the case. This ambiguity raised questions of credibility, and parents rejected previous justifications for partner restrictions based on attempts to minimise virus transmission, claiming it was "based on rubbish." Parents who were co-habiting found the restrictions particularly exasperating:

"If you live in the same household, what difference does it make?"

Despite the guidance being issued nationally, this sense of unfairness was so profound that some parents felt compelled to actively contest the restrictions, seeking support for their efforts from legal and governmental sources. Challenging the right to have a partner attend the scan became a battle against the healthcare system with anger that was often projected onto the sonographers as they were the first point of in-person contact for parents. The overall perception of lack of transparency around the restrictions created contempt and frustration, and parents felt their best interests had not been fully considered.

"Whilst I appreciate the need to keep staff safe, I really feel that the impact on parents due to the changes made to Maternity services as a whole and in particular ultrasound scans have not been thought through properly during the pandemic."

Fathers as the forgotten parent

Measures introduced in response to COVID-19 served as a reflection of how partners are viewed by the healthcare system as an adjunct to pregnancy rather than an equal parent with their own rights.

". . .he was discriminated against for not being the one physically carrying the baby, despite it being just as much his child as mine."

Both mothers and fathers perceived that guidance unfairly favoured healthcare professionals' needs over their own, criticising ill-thought-out actions that served to further emphasise how partners had been seen as a low priority.

"I wasn't allowed in due to COVID but a student was. Really couldn't make it up."

Parents largely described partner attendance or non-attendance at scans by using terms such as "allowed" or "not allowed" which implied antipathy at the prospect of needing permission from the system in order to be a part of the experience. Non-attendance at scans led to

fathers feeling excluded from the pregnancy experience and undermined as a parent. The feeling of "missing out" on both the scan event and what it symbolised in the on-going pregnancy was evident. Scans can be an opportunity for fathers to acquire new knowledge about the pregnancy and their baby at the same time as their pregnant partner, temporarily placing them into a privileged position they do not otherwise have access to. Having to learn about their unborn baby and the scan from their partner meant that fathers were completely reliant on their partner to relay details, which often failed to satisfy their individual needs for information:

"I was still very nervous in case my wife missed telling me something."

Having restricted access to information about the pregnancy emphasised the disconnect experienced by many partners who could not attend the scan, and instead were required to wait outside of the hospital building. The feeling of being excluded, however, was not just limited to those who did not attend the scan. Partners also felt excluded within the scan room as they sat behind screens and were not acknowledged by sonographers.

"…the person doing the scan did not include him / talk to him."

A pregnancy in isolation

Due to changes in service provision, parents were required to adjust their expectations for scanning and as a result were resentful towards the pandemic for denying them the opportunity to share the scan experience with their partner. They described feeling as if something irreplaceable had been taken away, and how this had affected their overall attitude towards their pregnancy.

"It was not having my partner there that made the whole experience completely different and not what I wanted, expected or ever [want] to go through again."

Fathers overwhelmingly described how they had wanted to attend the scan to provide support for their pregnant partner. In their first act of parenting, they saw their primary role as protector and advocate for their future family, wanting to take some of the responsibility of antenatal care from their partner.

"It was a high-risk pregnancy, our first, and my wife needed support during scans and appointments which I could not give to her. There were times when the medical professionals were not listening to her and her needs, and I needed to be there advocate for her when she felt helpless and alone."

In attending their scans and other antenatal appointments alone, mothers saw themselves as single parents, highlighting the impact that being separated from their partners had on the perception of their family as a whole. This placed the onus of pregnancy exclusively on them, further exacerbating worries about potential complications and having to relay information to their partners.

"Pregnant women … need the support of their partners during all scans and appointments. I have felt so anxious and stressed prior to and during scans that I have not been able to hear and process the important medical information provided."

Parents also spoke of their concerns regarding the potential impact that the additional stress of partner restrictions may have had on the pregnancy:

"All the extra stress of having to go through this alone, scans and other appointments, isn't good for mum or baby."

Anxiety surrounding the scan was described by almost all parents but was more evident in those who had experienced pregnancy-related complications and were being followed-up by clinical teams. Instead of alleviating maternal apprehension, scans often seemed to exacerbate it.

"... I was actually made to feel like a nuisance and was brought to tears once I left as the experience was so awful."

Sonographers as the gatekeepers to the information about the fetus

Parents often attended for their appointment with the fundamental expectation that the scan would provide a chance to receive additional knowledge about their baby. The level of information about the baby that parents could access was perceived to be governed by the sonographer performing the scan. When sonographers openly shared information about the baby, parents described a more positive experience.

"The lady doing it made me feel at ease. She would let me know what she was doing. She'd show me the baby and what he [the baby] was up to. . .pointing out body parts."

However, this was not the case for all parents, and some felt as if they had been actively kept in the dark about what had happened during the scan and the results. For mothers particularly, this placed them in an uncomfortably passive role during the scan process, where the scan was largely done to them without their involvement and resulted in a lack of knowledge afterwards.

"I couldn't see the screen to know what was going on. Most of the scan was done in silence and I was handed the photographs at the end without even being sure everything was okay."

Many of those who felt uninformed following the scan later went on to search for further information, particularly after additional or unexpected findings were identified and not fully discussed, which often did not provide the reassurance that had been hoped for:

"I wasn't told what it would mean [my daughter having a small head] so ended up Googling it and ended up increasing my anxiety."

When sonographers narrated and explained the scan appearances, parents felt more included in the process and felt that they had received a higher quality scan and a more personal care experience. Conversely, the concept of "conveyor belt scanning" was alluded to by the parents who had been given little in the way of information about the scan and their baby and were left with the impression that they had been a waste of the sonographers' time. This impacted negatively on parents' overall perception of the scan experience and feelings towards their pregnancy:

"She [the sonographer] completely took away any excitement I could have felt because of the way she was."

Not all parents shared this view, however, highlighting the need to improve parental awareness of the medical rationale behind pregnancy ultrasound examinations, and manage expectations around the more social elements of scanning.

"Whilst it's nice for the sonographer to explain and take questions and have a good bedside manner, all that really needs to be done is the health screening and it would help if more women realised this."

Remote connections: Missed opportunities for bonding

Pregnancy scans were generally considered to be a positive event, whereby expectant parents could see and connect with their unborn babies in "real-time". Although most parents were given pictures from the scan as a memento, this was not seen as an adequate substitute for the live experience. For partners who could not attend the scan, this was perceived as having had a considerable impact on their developing bond with the baby and how they then processed the reality of the pregnancy.

"He felt disconnected from the pregnancy and not as involved as he could be."

This disengagement of partners also affected mothers, who described feelings of guilt for having enjoyed the scan and time with their unborn baby in the absence of their partner. To mitigate this personal conflict, they would purposely downplay their scan experience when relaying it back to their partners:

"I didn't want to appear over excited (even though I was) as I could see the heartbreak in his face missing out on such a special moment for us. . ."

Many parents described how they created their own opportunities for bonding by booking non-medical scans at private clinics, although this was recognised as a privilege.

"We were lucky that we were in a position to be able to pay for a private scan but not everyone can."

During these scans parents could experience three and four-dimensional imaging of their baby, something which is not routinely offered by the public health services. Parents felt these scans would enable them to "properly see" their babies in a way that they had not been able to in hospital departments. At later gestations, the timing of these was carefully considered to complement the clinical scans and "check-in with baby". However, in light of the partner restrictions many parents also chose to be scanned in very early pregnancy to avoid the possibility of receiving unexpected news without partner support:

"I absolutely couldn't face finding out if the pregnancy had failed on my own which was my concern."

Parents commented on the use of digital alternatives such as video-calling or taking short recordings of the scan that could be shared with partners to overcome the challenge of not being physically present. However, parents reported inconsistencies in this practice, which created a further source of confusion for parents alongside partner restrictions, and was considered to be unjust:

"I felt I could have easily called my partner or taken a video so that he could have been part of such a special moment. I can't see why this would have been a problem which was the most frustrating thing."

Integration of quantitative and qualitative data

Integration of key quantitative and qualitative data through the joint display matrix facilitated triangulation to offer insight and further clarity on the findings. These were largely explanatory and centred around partner attendance at scans during the COVID-19 pandemic (Table 10). The integrated claims were further explored using other claims generated through the matrix to try to provide a comprehensive, overarching meta-inference. The interwoven nature of the survey domains, quantitative claims and qualitative codes is demonstrated in Fig 3.

The following meta-inference was developed from the study data:

During the COVID-19 pandemic, maternal anxiety was significantly increased when mothers were scanned without their partner because they were fearful of receiving unexpected news alone. Paternal anxiety was significantly increased when they did not attend the scan because they felt uninformed about the pregnancy and wanted to support their pregnant partners during the scan. Excitement for the pregnancy was reduced in both mothers and fathers when the partner did not attend the scan. This is because mothers who were scanned alone felt guilty for enjoying the experience without their partner, and scans make the pregnancy seem more real for fathers. In addition, mothers and fathers felt more satisfied with their scan experience when partners had attended because those who had not attended the scan felt excluded and parents viewed scans as a pregnancy-related event that should be experienced together. Although bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not, and paternal bonding did not significantly differ irrespective of scan attendance, excitement for the pregnancy increased in both mothers and fathers when they experienced the scan together, and parents who were more excited about the pregnancy scored more highly for bonding.

Discussion

The findings from this study demonstrate how pandemic-related changes with regards to partner attendance at pregnancy ultrasound scans created further anxiety for partners in addition to their general concerns around fetal health and wellbeing. This had a significant effect on scan satisfaction and overall excitement for the pregnancy. For mothers, this also resulted in a perceived negative effect on their emotional connection to their unborn baby. Partner attendance at the scan was highlighted in four of the five key themes developed from the survey responses. Many parents also commented how this was a central factor in determining the scores they gave for anxiety, excitement and satisfaction. In keeping with these findings, Schaal et al reported that the greatest worry for pregnant women during the pandemic, was that their partners would not be present during birth or that they would not be visited whilst in hospital [21]. This highlights the importance of partners for maternal support and companionship throughout the pregnancy.

COVID-19 effect on prenatal bonding

Several tools to assess prenatal bonding are used in research literature, although the most common are variations of the PAI, Maternal Antenatal Attachment Scale (MAAS) and Maternal-Fetal Attachment Scale (MFAS) [27,30,42]. Despite these objective measures, determining an

Table 10. Display matrix for development of the meta-inference.

Domain	Quantitative claim	Qualitative code(s)	Integrated claims	Connection between quantitative claim and qualitative data	Illustrative quotation
Anxiety	Maternal anxiety was significantly increased when mothers were scanned without their partner	Feeling like a single parent Scans as a medical examination	[IC1.] Maternal anxiety was significantly increased when mothers were scanned without their partner because mothers were fearful of receiving unexpected news alone	Explanation	*"I was extremely anxious about anything being wrong and being on my own with my husband not allowed to attend"*
	Paternal anxiety was significantly increased when fathers did not attend the scan	Partners as maternal support Second hand news	[IC2] Paternal anxiety was significantly increased when they did not attend the scan because they felt uninformed about the pregnancy and wanted to support their pregnant partners during the scan	Explanation	*"My wife needed support during scans [. . .] which I could not give to her [. . .] I needed to be there to advocate for her when she felt helpless and alone"*
Excitement	Excitement for the pregnancy was reduced in both mothers and fathers when the partner did not attend the scan	The experience COVID-19 style Missing out on the milestones Reality of a new life	[IC3] Excitement for the pregnancy was reduced in both mothers and fathers when the partner did not attend the scan because mothers who were scanned alone felt guilty for enjoying the experience without their partner, and scans make the pregnancy seem more real for fathers	Explanation	*"I didn't want to appear over excited (even though I was) as I could see the heartbreak in his face missing out on such a special moment for us"*
Satisfaction	Mothers and fathers felt more satisfied with their scan experience when partners had attended	Feeling excluded and useless Unfair and unjustified Pregnancy is a shared experience What parents want from scans	[IC4] Mothers and fathers felt more satisfied with their scan experience when partners had attended because fathers who had not attended the scan felt excluded because of unfair and unjustified restrictions and parents viewed pregnancy as a shared project and scans as an event that should be experienced together	Explanation	*"It led to anxiety from not being present rather than the joy of seeing our baby"*
Bonding	Bonding was not significantly changed between mothers waiting for scans and those who had been scanned	Tentative excitement, fading term Scans as a medical examination	[IC5.†] Bonding was not significantly changed between mothers waiting for scans and those who had been scans because after the scan, mothers maintain some emotional distance from the baby in case of an unexpected outcome	Explanation	*"Still has a long way to go until a safe delivery of a baby"*
Bonding	Bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not	Feeling disconnected	[IC6.] Bonding was not significantly different between mothers whose partners attended the scan and those whose partner did not but mothers whose partners did not attend the scan perceived their emotional connection to the baby was reduced	Contradiction	*"I just felt I was going through the motions and couldn't be excited as my partner had missed out"*
Bonding	Paternal bonding did not significantly differ irrespective of scan attendance	The system does not recognise fathers as equal parents Missing out on the milestones	[IC7.†] Paternal bonding did not significantly differ irrespective of scan attendance, but mothers perceived that not attending the scan had been detrimental to their partner's bonding	Contradiction	*"One of the only ways he could bond with the baby during pregnancy had been taken away from him"*

(Continued)

Table 10. (Continued)

Domain	Quantitative claim	Qualitative code(s)	Integrated claims	Connection between quantitative claim and qualitative data	Illustrative quotation
Bonding	Bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not	Scan as a medical examination Sharing knowledge and information about the baby	[IC8] Bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not, and paternal bonding did not significantly differ irrespective of scan attendance, however excitement for the pregnancy increased in both mothers and fathers when they experienced the scan together, and parents who were more excited about the scan scored more highly for bonding	Juxtaposition	*"Sharing the experience was amazing, got us even more excited about the baby"*
Bonding	Paternal bonding did not significantly differ irrespective of scan attendance	Partners as maternal support			
Excitement	Excitement for the pregnancy increased in both mothers and fathers when they experienced the scan together	Pregnancy is a shared experience			
Excitement	Parents who were more excited about the scan scored more highly for bonding	Reality of a new life			

Integrated Claims	Meta-inference	Illustrative quotation
[IC1] Maternal anxiety was significantly increased when mothers were scanned without their partner because mothers were fearful of receiving unexpected news alone	Maternal anxiety was significantly increased when mothers were scanned without their partner because they were fearful of receiving unexpected news alone. Paternal anxiety was significantly increased when they did not attend the scan because they felt uninformed about the pregnancy and wanted to support their pregnant partners during the scan. Excitement for the pregnancy was reduced in both mothers and fathers when the partner did not attend the scan. This is because mothers who were scanned alone felt guilty for enjoying the experience without their partner, and scans make the pregnancy seem more real for fathers. In addition, mothers and fathers felt more satisfied with their scan experience when partners had attended because fathers who had not attended the scan felt excluded and parents viewed scans as a pregnancy-related event that should be experienced together. Although bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not, and paternal bonding did not significantly differ irrespective of scan attendance, excitement for the pregnancy increased in both mothers and fathers when they experienced the scan together, and parents who were more excited about the pregnancy scored more highly for bonding.	*"Having a partner there would have completely changed the experience"*
[IC2] Paternal anxiety was significantly increased when they did not attend the scan because they felt uninformed about the pregnancy and wanted to support their pregnant partners during the scan		
[IC3] Excitement for the pregnancy was reduced in both mothers and fathers when the partner did not attend the scan because mothers who were scanned alone felt guilty for enjoying the experience without their partner, and scans make the pregnancy seem more real for fathers		
[IC4] Mothers and fathers felt more satisfied with their scan experience when partners had attended because fathers who had not attended the scan felt excluded and parents viewed scans as a pregnancy-related event that should be experienced together		
[IC8] Bonding was not significantly different between mothers regardless of whether their partner had attended the scan or not, and paternal bonding did not significantly differ irrespective of scan attendance, however excitement for the pregnancy increased in both mothers and fathers when they experienced the scan together, and parents who were more excited about the pregnancy scored more highly for bonding		

†In table 8, integrated claims 1–7 have been further developed to generate integrated claim 8 for use in the meta-inference.

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optimal bonding score is challenging because whilst a score may be statistically significant within an analysis, this may not represent clinical significance [32]. Previous studies using the MAAS define a threshold of 80% of the global score to differentiate between low and high bonding [9,20]. Using this definition, the average scores of parents completing the modified PAI in this study would be classified as low bonding. However, these findings are more comparable with those of Albaytak *et al* who reported mean bonding scores using the Turkish version of the PAI of 75.8% and 70.8% in mothers with low and high anxiety and obsession around COVID-19 respectively [22].

As no significant difference in bonding was demonstrated between mothers in this study regardless of scan status (e.g. waiting for scan, scanned alone or scanned with partner), this

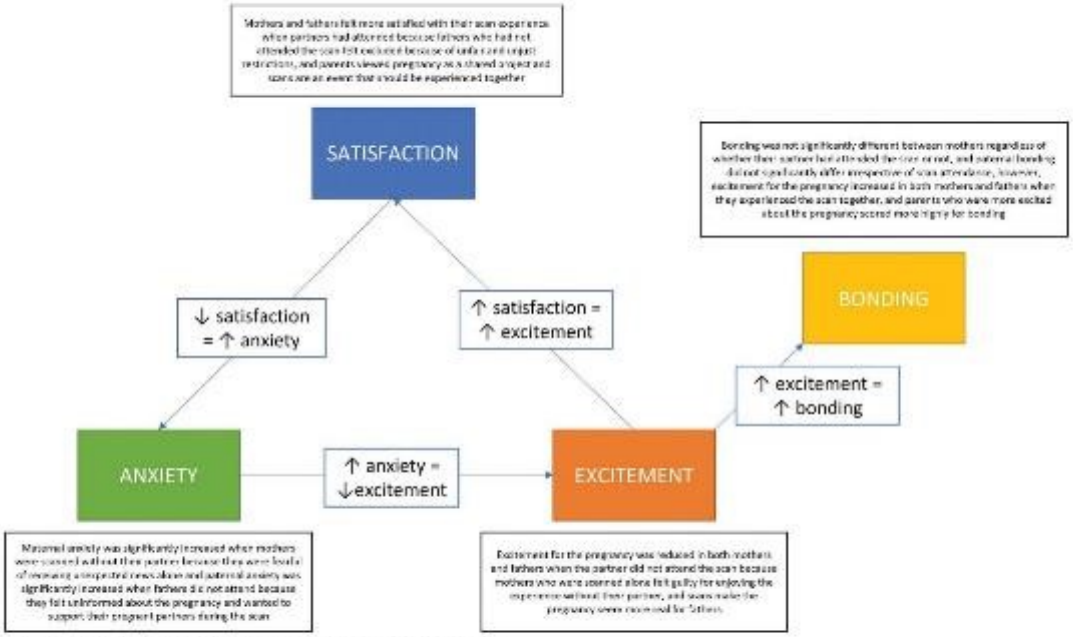

Fig 3. Visual representation of integrated claims developed for each domain.

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may suggest that any interpretation of low bonding in this sample is more likely to be related to the wider impact of the pandemic on levels of maternal anxiety [22] rather than directly attributable to the changes to the provision of pregnancy ultrasound scans performed during this time. Anxiety during pregnancy has been previously associated with decreased prenatal bonding [8]. This is thought to be because mothers who are preoccupied with other stressors may be distracted from thinking about their pregnancy, resulting in a decrease in emotional connection towards their unborn baby [43]. This explanation may reflect findings from the thematic analysis of the free-text parental responses which described mothers' feelings of reduced bonding, even though the PAI scores were unaffected. Alternatively, some parents may not have been comfortable to reveal their true feelings in this survey, and therefore may have modified their responses to the PAI. The reluctance to disclose information that could leave parents feeling vulnerable to negative judgement by others (including healthcare professionals) is not uncommon in the perinatal setting, and has been identified as a barrier to parents seeking further support [44].

In this study, bonding was significantly lower in fathers and partners than in mothers. However, no significant difference in bonding score was demonstrated between those who had attended the scan and those who had not. This implies that amongst this survey's respondents, the scans did not influence bonding. The finding of lower paternal and partner bonding is consistent with other studies that report lower levels of bonding compared to mothers [27,45,46]. The development of the prenatal bond is thought to be an ongoing process which intensifies during pregnancy as parents engage more on an emotional level with their unborn

baby. For this reason, it could be hypothesised that the maternal prenatal bond is accelerated as a result of their privileged embodied knowledge of the pregnancy [47]. In relation to scanning, it has been suggested that changes to paternal bonding may be dependent on the timing of the scan during the pregnancy [28], with earlier scans which confirm the viability of the pregnancy and the subsequent reality of impending parenthood, appearing to be more influential [10]. Fathers' response to pregnancy ultrasound is thought to be a predictor for prenatal bonding [10], and this has potentially significant implications considering the further association between paternal support, maternal bonding and postnatal attachment [48].

COVID-19 effect on scan experiences

Many parents described a sense of loss for their imagined pregnancy scan experience which had been taken away by COVID-19. This finding was also evident in recent studies evaluating the wider pregnancy and birthing experience and reflects how parents have felt their expectations for care have not been met [49–51]. Managing parental expectations of imaging in pregnancy became more challenging as sonographers attempted to balance parent-centred care and the social restrictions imposed by COVID-19. Pregnancy is generally considered to be a social event [52] and scans provide an opportunity for parents and their wider support networks to "meet" and get to know the baby before birth [53]. The prospect of a personalised care experience that can be shared and enjoyed with others is often how private providers promote their scan packages [54], which can include additional extras not offered during clinical examinations such as 4-dimensional imaging, high-quality prints and recordings of the fetal heartbeat.

In this survey, 18 parents mentioned they had booked or were planning to book a private scan in addition to those offered as part of their antenatal care pathway. Nearly all explained that this was so both parents could experience the scan together. Sharing the scan experience was important to parents for two reasons, firstly, for support in the event of unexpected news, and secondly for fathers and partners to feel involved with the pregnancy. As fathers lack embodied knowledge of the pregnancy, scans provide an opportunity for both parents to acquire new insights about their unborn baby simultaneously [47]. Sharing the scan experience can also create a sense of "togetherness" which helps to provide pregnant people with security and reassurance of their partner's investment in, and commitment to the pregnancy and postnatal emotional and practical support [55]. Goyal *et al* report that mothers felt detached from their partners when they had not attended antenatal appointments [51]. A key finding from this survey was how mothers perceived the absence of their partner at the scan to have had a negative effect on bonding. Although this was not confirmed by the PAI scores which remained unchanged, this finding has been previously acknowledged by Göhel *et al*, who reported that increased maternal anxiety may lead to mothers' perception of reduced emotional proximity to their baby [43]. It may also be suggested that mothers were also concerned about the possible negative effect of the restrictions on their relationship with their partner [55], which may have further influenced their feelings towards their baby. Our findings demonstrated that parents who were scanned at a later timepoint during the COVID-19 pandemic had significantly lower anxiety. This may be explained by a combination of increased information and understanding of the pandemic over time, as well as the removal of restrictions on partner attendance at scans towards the end of 2020 [56].

The role of the sonographer during the COVID-19 pandemic

Despite their frustration about the restrictions, parents recognised the distress that adhering to guidance around partner attendance at scans had caused for sonographers, particularly where

unexpected or difficult findings had been identified during the examination. A sub-theme of "compassion over compliance" was developed from the survey responses to capture parents' reflections of how sonographers had demonstrated empathy for those whose scan experiences had been affected by the restrictions by giving printed scan photos at no charge and "sneaking" partners into the scan room to be given unexpected news as a couple. Other studies have reported that parents appreciated when healthcare professionals validated their feelings of disappointment with the situation [51], and used technology to facilitate inclusion of partners from outside of the scan room [50]. Whilst this was no substitute for having been physically present, it was considered better than missing out completely and so when video-calling options were not available, this became a further source of anxiety and stress in parents who felt like they were being given inconsistent and ambiguous guidance [57].

Pregnancy companionship

"Fathers as the forgotten parent" was a key theme developed, and further supports the previously acknowledged lack of a family-centric approach to antenatal care [58]. During the pandemic, changes were made to care provision which prioritised infection control above psychological stress, and ultimately conceptualised partners as visitors rather than as parents and birth companions [52]. The concept of companionship in antenatal care is often described in relation to labour and childbirth, and it is considered by the World Health Organisation as integral to facilitating a positive parental experience [59]. Companionship may be provided by fathers and partners, family members, friends and healthcare professionals who give information support, advocacy, practical support and emotional support to pregnant women and people [60]. The benefits of companionship on infant outcomes and parental mental health are also acknowledged; associations between maternal health behaviours in pregnancy (e.g. cessation of smoking and consumption of alcohol) [61] and improved pre and postnatal bonding [62] have been reported when mothers feel adequately supported during pregnancy.

In restricting partner attendances during the COVID-19 pandemic, partners not only missed out on seeing their unborn baby during the ultrasound scan, but the potential to access to mental health services. For example, opportunities for sonographers to check-in with partners' well-being and facilitate support interventions in a timely manner may have been lost, and this has been shown previously within the wider antenatal care pathway to have serious negative implications on maternal and fetal/infant outcomes [63]. The importance of adopting a parent-centred approach to care has also been previously identified as essential to a satisfactory scan experience, with the role of the sonographer considered integral to co-constructing parental knowledge and understanding about their unborn baby through their interpretation and narration of ultrasound images [53]. In this study, parental satisfaction increased as the COVID-19 pandemic progressed and lockdown restrictions were lifted. Satisfaction of experience may be a significant moderator for perinatal mental health, indeed, dissatisfaction with the birth process from inadequate partner support has been previously associated with postpartum depression [64].

Strengths and limitations

As this was a UK-wide survey of parents, the responses provided are not limited to a single healthcare facility. In addition, the CORE-10 and modified PA1 tools used demonstrated high reliability with Cronbach's alpha. The convenience of the online and anonymous survey made it easier for parents to express their thoughts freely, which increases confidence that the findings are reflective of the experiences during this time. Separate quantitative and qualitative analyses not only produced rich findings, but new insights were generated because of the

integration process [39]. This process also demonstrated trustworthiness as the quantitative and qualitative findings were largely complementary.

A limitation associated with cross-sectional surveys is that they only capture a single moment in time, and results can be exaggerated by extreme responses from those who are more motivated to take part [65]. In addition, despite recruitment flyers explicitly stating that all parents were eligible to complete the survey, the proportion of parents waiting for scans and the number of fathers and partners was low. No non-binary parents took part in this study. When the survey was live, the intention was to have comparable numbers of respondents within the parent groups, however the final totals were skewed towards mothers who had been scanned. This could make statistical interpretation or generalisation more challenging as the results are not as powerful as if the optimal sample sizes had been achieved. Low uptake of fathers and partners is not uncommon in antenatal research and indeed antenatal care more holistically. Partners are often underrepresented, perceiving that, as they are not pregnant themselves, their perspectives are not relevant [66]. Similarly, there was limited variation in the ethnicity of parents completing this survey. At the time the survey was live, many other researchers were utilising online questionnaires whilst face to face data collection methods were restricted. This could have led to some prospective participants feeling over-researched and thus deciding not to take part in this study. Homogeneity within the population may also have occurred if the snowball sampling did not effectively reach underrepresented groups of parents. The lack of diversity in COVID-19 related antenatal research has been acknowledged [20,51] and highlights the need for more inclusive practices in research design and recruitment to gain a deeper understanding of all parents' experiences during this time. Furthermore, other information could be collected in future studies to provide deeper insight and explanation to the findings. For example, postnatal data may be useful to explore potential associations between parental anxiety and pregnancy outcome. In addition, this survey did not ask participants to provide in-depth information about their obstetric history or personal life, which may be important factors to consider when interpreting data around parental anxiety [67].

Recommendations for practice

This study has highlighted the immediate effect of the restrictions on partner attendance at scans during the pandemic on parent experiences of antenatal imaging and prenatal bonding, although the longer-term implications for parents and their infants may not be fully understood for several years. However, some recommendations for future practice can be developed from the literature.

1. Unexpected changes to the pregnancy and birthing experience because of COVID-19 have been associated with symptoms of anxiety and post-traumatic stress disorder [68], therefore parents who experienced antenatal care during the pandemic may benefit from additional follow-up and mental health interventions in the post-pandemic era. Opportunities for parents to access perinatal mental health services could be extended and made more inclusive of partners [69], and specialist training for healthcare professionals by psychological therapy teams may facilitate screening during pregnancy to improve early identification of parents in need of support [70]. In their parent-facing role, sonographers may be ideally positioned to recognise parents experiencing mental health difficulties and introduce resources, however this additional responsibility must be carefully balanced alongside existing clinical duties so as not to further increase workload and job demands within the profession [71].

2. Similarly, initiatives to promote staff wellbeing during the pandemic should be continued to alleviate burnout [72] and help to mitigate high sonographer attrition from obstetric services specifically of the NHS workforce in general in response to the pandemic [71]. As sonographers are central to parental experiences of pregnancy scans, promoting, offering training about, and practicing parent-centred care that is inclusive of fathers and partners as birth companions rather than visitors [52] may also contribute to improved satisfaction and perception of care, and enhanced prenatal bonding in the future.
3. More formalised, publicly available and versatile (in terms of content and format) information about what service users could expect from antenatal scans might be useful [73], as some parents in this study indicated they still had unanswered questions despite searching for additional information either prior to the scan, or after the appointment. Sonographers could be key in working with parents to co-develop that resource. Enhanced training for sonographers on key concepts and practices of parent-centred care would be vital to ensure they are equipped and empowered to address service user queries and manage expectations.

Conclusion

Restrictions on partner attendance at scans were introduced with the intention of minimising virus transmission during the COVID-19 pandemic. Significant differences in parental feelings of anxiety, excitement and satisfaction between parents were correlated with partner attendance at the scan. Partner attendance was important to parent satisfaction, which was increased when both parents were present at the scan. When partners did not attend the scan, parental anxiety was higher, thus parents who had pregnancy scans during the COVID-19 pandemic may benefit from additional mental health support in early parenthood. Although no demonstrable change in prenatal bonding because of the restrictions was recorded in this study, the findings of this UK-wide survey demonstrated that bonding was lower in fathers compared to mothers. Data triangulation suggested maternal guilt in enjoying the scan without their partner, and paternal frustration at being excluded from the scan and being unable to provide support to their pregnant partner. Parental feelings of excitement about the pregnancy were positively correlated with increased prenatal bonding, highlighting the power of antenatal ultrasound scans as an opportunity for expectant parents to engage with their unborn babies, and the integral role of sonographers in providing individualised, parent-centred care to support this.

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RESEARCH

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The influence of antenatal imaging on prenatal bonding in uncomplicated pregnancies: a mixed methods analysis

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Abstract

Background Prenatal bonding describes the emotional connection expectant parents form to their unborn child. Research acknowledges the association between antenatal imaging and enhanced bonding, but the influencing factors are not well understood, particularly for fathers or when using advanced techniques like fetal magnetic resonance imaging (MRI). This study aimed to identify variables which may predict increased bonding after imaging.

Methods First-time expectant parents (mothers = 58, fathers = 18) completed a two-part questionnaire (Qualtrics-sXM™) about their expectations and experiences of ultrasound ($n = 64$) or fetal MRI ($n = 12$) scans in uncomplicated pregnancies. A modified version of the Prenatal Attachment Inventory (PAI) was used to measure bonding. Qualitative data were collected through open-ended questions. Multivariate linear regression models were used to identify significant parent and imaging predictors for bonding. Qualitative content analysis of free-text responses was conducted to further understand the predictors' influences.

Results Bonding scores were significantly increased after imaging for mothers and fathers ($p < 0.05$). MRI-parents reported significantly higher bonding than ultrasound-parents ($p = 0.02$). In the first regression model of parent factors (adjusted $R^2 = 0.17$, $F = 2.88$, $p < 0.01$), employment status ($\beta = -0.38$, $p < 0.05$) was a significant predictor for bonding post-imaging. The second model of imaging factors (adjusted $R^2 = 0.19$, $F = 3.85$, $p < 0.01$) showed imaging modality ($\beta = -0.53$), imaging experience ($\beta = 0.42$) and parental excitement after the scan ($\beta = 0.29$) were significantly ($p < 0.05$) associated with increased bonding. Seventeen coded themes were generated from the qualitative content analysis, describing how scans offered reassurance about fetal wellbeing and the opportunity to connect with the baby through quality interactions with imaging professionals. A positive scan experience helped parents to feel excited about parenthood. Fetal MRI was considered a superior modality to ultrasound.

Conclusions Antenatal imaging provides reassurance of fetal development which affirms parents' emotional investment in the pregnancy and supports the growing connection. Imaging professionals are uniquely positioned to provide parent-centred experiences which may enhance parental excitement and facilitate bonding.

Keywords Attachment, Bonding, Fetal, Imaging, MRI, Parent, Ultrasound

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Background

Ultrasound is used to evaluate fetal viability, development and well-being, and to identify occasions where medical intervention during pregnancy or shortly after birth may improve post-natal outcomes [1]. Yet, its efficacy as an imaging tool can be compromised by inherent limitations including fetal lie, maternal body habitus and operator technique [2]. As scan acquisition methods advance, fetal magnetic resonance imaging (MRI) has become popular to complement ultrasound in prenatal diagnosis because it provides increased anatomical detail for some physical conditions [3]. However, the imaging procedure is markedly different, and pregnant women and people may experience anxiety because of loud MRI machine noises, claustrophobia whilst in the MRI scanner, and discomfort in lying still for an extended period of time [4]. Compared to ultrasound examinations which do not usually exceed 30-min in duration, fetal MRI appointments may be scheduled for 60-min (although not all of this time is devoted to image acquisition) [5].

In addition to medical value, psychological benefits of fetal imaging are reported for expectant parents in providing an opportunity to see and connect with their unborn baby before birth [6]. For the non-pregnant parent, scans are also an opportunity to engage with the pregnancy and provide companionship and support to partners [7]. Broadly, parent-fetal bonding refers to the emotional connection that expectant parents feel towards their unborn babies during pregnancy [8]. This definition acknowledges the unidirectional nature of the parent-to-fetal relationship and considers the construct of bonding as theoretically distinct from original conceptualisations of attachment which are characterised by a system of care-seeking and care-giving behaviours after birth [9]. Quality prenatal bonding is associated with parental wellbeing and positive behaviours during pregnancy (e.g., smoking cessation) that subsequently contribute to healthy infant brain and neurological development [10]. Prenatal bonding is also thought to predict postnatal attachment [11], and further links between parent-fetal bonding (particularly the paternal-fetal relationship) and the child's cognitive and socio-economic development also highlight the importance of studying this construct [12]. However, terminology of bonding and attachment are often used interchangeably to reflect varying definitions in the literature and as such, different approaches are utilised in attempts to evaluate not only the strength of the bond itself [9], but also the effect of interventions designed to facilitate its development [13]. Subsequently, inconsistent methodological approaches and varying quality in existing research studies have produced conflicting findings [14].

Fetal ultrasound images are thought to facilitate parents' connection to the baby by providing visual knowledge that can be used to further enhance mental representations of the imagined child [11]. A recent literature review including 23 studies concluded that parent-fetal bonding was enhanced following antenatal imaging [6]. In particular, the role of the sonographer (a healthcare professional who performs ultrasound scans) in creating a parent-centred scan experience was highlighted as an important factor to facilitate bonding. Expectant parents rely on sonographers not only to assess fetal health, but also to transform the medical entity captured within the acquired images into relatable individuals who they can interact with, and place in their own realities [15]. MRI images, like ultrasound, are also dependent on expert clinical interpretation [16], however, they are less familiar to expectant parents than ultrasound, and there is little understanding of how parents respond to these highly detailed anatomical visualisations of their unborn baby [6].

MRI is not currently part of the routine fetal screening pathway in England [17], but is used for more complex clinical investigations where ultrasound is inconclusive, or in research studies aiming to improve understanding of human development. Although the images produced are considered higher quality because they are not affected by the previously described limitations associated with ultrasound, it is unlikely that it will replace it due to increased financial cost and limited availability of specialist fetal MR imaging services [16]. This means that many studies reporting expectant parents' experiences and perceptions of MRI are set in the context of a prenatal diagnosis where increased parental anxiety and distress may be a moderator of bonding [4, 18]. They are also retrospective, therefore many variables or confounding factors are missing, or cannot be controlled for. Prospective research is required to further understand parental experiences and the potential influence of MRI on bonding. Additionally, research exploring the paternal-fetal bond is limited compared to maternal studies [19]. As fathers and partners are now increasingly involved in pregnancy [7], it is important to better understand their perceptions, experiences and individual needs around accessing antenatal care in order for services to be inclusive and supportive [20].

Based on other literature exploring bonding and scan experiences in pregnancy [6], it was hypothesised that parent-fetal bonding scores would increase after imaging. Therefore, this study aimed to further identify parental and scan variables which may be associated with enhanced parent-fetal bonding after ultrasound or MRI, and qualitatively explore how they may facilitate the developing connection.

Methods

The STROBE checklist was used to guide reporting [21]. A two-part questionnaire was developed for data collection, hosted on the Qualtrics XM™ platform (www.qualtrics.com).

Recruitment ran between October 2021-December 2022. First-time expectant parents (≥18 years) attending a London hospital for fetal imaging (routine ultrasound or research MRI) between 18–36 weeks gestation in uncomplicated pregnancies were eligible to participate. Convenience sampling was used; ultrasound-parents were identified by clinical staff following completion of their routine first trimester screening scan between 11^{+2}–14^{+1}weeks of pregnancy [17], and MRI-parents were identified by perinatal imaging researchers when booking their research MRI scan. An introductory email was sent to prospective parents containing links to the participant information video and electronic informed consent form, which was designed according to good practice recommendations [22]. Once recruited, participants were allocated a unique identification number which they used to access the questionnaire. Two weeks before the imaging appointment, the weblink to part one of the questionnaire (pre-imaging) was shared. The link to part two (post-imaging) was shared one week after the scan (Fig. 1). Reminders to complete the relevant parts of the questionnaire were sent at 7 and 14 days after they were initially shared.

Measures

Part one of the questionnaire contained four sections, and part two was composed of three (Fig. 2). Demographic information was only collected in the first part.

Prenatal attachment inventory (PAI)

A modified version of the Prenatal Attachment Inventory (PAI) [8] was used to measure parent-fetal bonding. Gendered items were removed or rephrased so that both mothers and fathers could respond to the same questions (e.g. "I tell others what the baby does inside me" became "I tell others what the baby does inside the womb"). For each item, parents were asked to select a Likert-response of "Almost Never," "Sometimes," "Often," or "Almost Always." A value between 1–4 was allocated to each

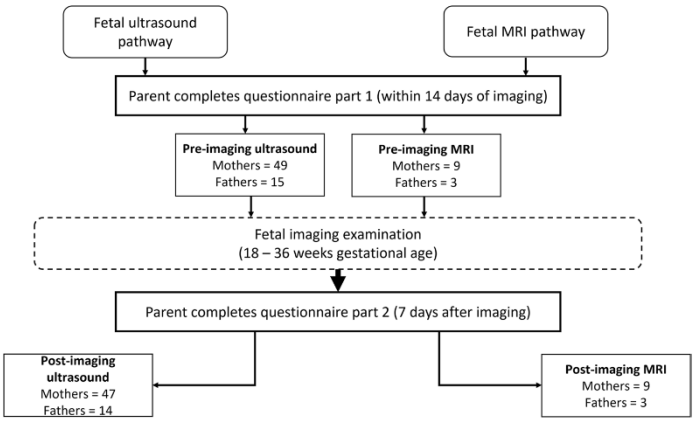

Fig. 1 Schedule of participation

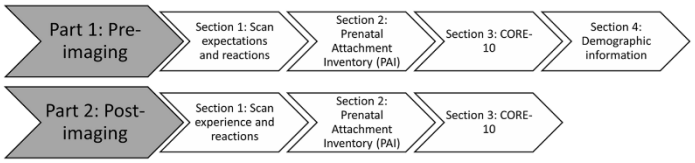

Fig. 2 Questionnaire structure

response, and the total PAI score was calculated. Higher scores are associated with a more developed bond [23], and in this 16-item PAI, the maximum possible score was 64. Good reliability of the modified PAI is previously established [24, 25]. In this study, Cronbach's alpha (α) was 0.90, indicating excellent internal consistency.

CORE-10

Psychological distress in participants was evaluated using the CORE-10 [26], which has been validated for use in the perinatal population [27]. Participants were asked to respond to 10-items using one of five Likert-responses ranging from "Not at all," to "Most or all of the time" based on their experiences during the preceding week. Responses were allocated a value between 0–4 and combined. Total scores of ≥ 25 are associated with severe psychological distress [28]. Cronbach's alpha (α) for the CORE-10 was 0.84.

Parental expectations, experience and reactions to antenatal imaging

Exisiting measures of parental expectations and experiences of antenatal imaging [29] were not suitable for the current study's focus on bonding so a measure was specifically developed for use based on prior literature findings and research studies [6, 25]. For statistical comparison, expectation and experience factors were matched (Fig. 3). An overall score was calculated from the total number of factors (maximum 5 score).

Rating scales (where 0 = not at all and 10 = extremely) were utilised for participants to report their reactions to imaging (anxiety and excitement prior to imaging, and anxiety, excitement, and satisfaction after imaging). Open-questions (e.g., What are you least looking forward to about your scan? What did you most enjoy about your scan?) were also included to further capture parental perspectives.

Representatives from UK-based support charities, Antenatal Results and Choices (ARC) and Fathers Reaching Out were invited to review the questionnaire and provide feedback regarding readability and usability. This resulted in minor amendments to the presentation (e.g., change of rating scale slider) for ease of use on a mobile device. Prior to launch, the questionnaire was piloted by parent volunteers ($n = 7$). The QualtricsXM™ platform contained instructions for navigating the questionnaire, including the use of directional tools to move between sections for editing. Participants could complete the questionnaire with no time limit enforced. The option to save and return to an incomplete questionnaire at a different time was also available.

Data analysis

Sample size for paired analysis was informed by a power calculation based on previous studies evaluating the change in maternal–fetal bonding after antenatal ultrasound [30, 31]. From these, it was assumed that bonding scores may be increased by an average of 3-points. Using an alpha level of 0.05 and power of 80%, the minimum sample size required for this study was estimated as $n = 70$. Sample size for regression analysis was guided by published literature suggesting the number of subjects per independent variable should lie between 5–20 [32]. Therefore, it was aimed to include 10 subjects per variable in each model.

Quantitative data were analysed using Microsoft Excel (version 2008) and IBM SPSS Statistics (version 29). Frequencies and descriptive statistics including average scores for imaging expectations and experience, PAI and CORE-10 scores were calculated for each parent group. Kolmogorov–Smirnov tests indicated normally distributed data, therefore parametric statistical analyses were performed [33]. Independent and paired t-tests (assuming unequal variances where Levene's statistic was significant) were used to compare means. Hedge's g statistic (g) determined effect size. Cases were excluded from some analyses where paired data was unavailable. Two multivariate linear regression analyses were run to identify predictors significantly associated with enhanced bonding after imaging. Parent variables (e.g., parent demographics and social factors) were entered into the first model and scan variables (e.g., imaging modality, experience, and parental reactions) were entered into the second. Categorical variables were converted to

Part 1: What you do you think will happen during the scan? (pre-imaging expectations)	**Part 2:** What happened during the scan? (imaging experience)
❑ I will see images of my baby	❑ I saw images of my baby
❑ I will see my baby move	❑ I saw my baby move
❑ I will hear my baby's heartbeat	❑ I heard my baby's heartbeat
❑ The radiographer/sonographer will explain the images of my baby to me	❑ The radiographer/sonographer explained the images of my baby to me
❑ I will have an opportunity to ask questions	❑ I had an opportunity to ask questions

Fig. 3 Matched questions to evaluate pre-imaging expectations and imaging experience

binary-coded dummy variables (e.g., ethnicity became majority/white or minority/non-white) to enable their inclusion in the regression analysis whilst minimising the potential for overfitting in the models [34]. Statistical significance was determined at $p < 0.05$.

Qualitative content analysis of free-text responses was undertaken to help explain findings of the regression models. This was chosen over more interpretative methods because the brevity of responses was not conducive to deep analysis [35]. A deductive coding system was developed ES (a sonographer with 12 years' experience in obstetric ultrasound) using the significant predictors identified in the regression models as coding clusters [36]. Responses were first organised into clusters and abstracted into units of meaning. Identified units were recontextualised and grouped into initial coded themes and reviewed against the original data. Coded themes were refined before being checked against the coding clusters to ensure their appropriate classification [37]. To evaluate reliability of the coding system, re-coding of a randomised 10% of the qualitative responses was independently performed by DC (a paediatrician and clinical research fellow with 5 years' experience of fetal MRI). Following this, minor changes to the coding descriptors were made for improved clarity. Inter-coder agreement on 10% of the content was 96% following resolution of discrepancies.

Ethics

Ethical approval was received by the West of Scotland REC 3 (REC reference: 20/WS/0132, date of approval 12th November 2020) and School of Health and Psychological Sciences REC at City, University of London (REC reference: ETH1920-1680, date of approval 30th November 2020). Due to the sensitive nature of this research, only participants who were committed to continuing their pregnancy were approached to participate. The potential risk of parental anxiety caused by taking part was low, however a contact list of perinatal mental health support resources was shared after completing part one of the questionnaire. An emergency referral pathway was developed in conjunction with the local perinatal mental health team to provide urgent support for parents who scored highly for psychological distress although its use was never required.

Results

All parents stated they were either the mother or father of the baby. A total of 76 expectant parents (58 mothers, 18 fathers) completed part one of the questionnaire. Of these, 64 had ultrasound and 12 had fetal MRI. Sixteen sets of parents were in a couple. Three parents did not respond to the invitation to complete part two, resulting in paired data for 73 parents (56 mothers, 17 fathers).

Mean maternal age was 32 (range = 23–39), and mean paternal age was 34 (range = 28–41). Most parents were educated to postgraduate degree level ($n = 39$, 51.3%), of white ethnicity ($n = 57$, 75.0%) and in full-time employment ($n = 64$, 84.2%). Sixteen parents (21.1%) disclosed a pre-existing physical health condition, and twenty (26.3%) reported receiving a previous diagnosis of, or support for a mental health condition (Table 1).

Fetal imaging was performed between October 2021-December 2022. Mean gestational age (GA) in weeks and days at the time of the scan was 21^{+1} (range: 18^{+6}–33^{+2}) for ultrasound and 27^{+1} (range: 18^{+4}–35^{+4}) for MRI.

Parent-fetal bonding (PAI)

Bonding was significantly increased in mothers ($p < 0.001$) and fathers ($p = 0.04$) after imaging. Mean increase was larger in mothers (4.71, g = -0.81) than fathers (3.06, g = -0.53). No significant differences in mean scores were observed between mothers and fathers pre or post-imaging (Table 2). MRI-parents had significantly higher bonding scores than ultrasound-parents, both before and after imaging. The pre-imaging mean difference in PAI was 7.25 ($p = 0.01$, g = -0.85). Post-imaging, the mean difference was 6.46 ($p = 0.02$, g = -0.74).

Predictors of bonding after imaging

Eight parent variables were entered into the first multivariate regression model (Table 3). This model was significant (adjusted $R^2 = 0.17$, $F = 2.88$, $p < 0.01$) and showed that employment status was significantly predictive of parent-fetal bonding after imaging ($\beta = -0.38$, $p < 0.05$), with unemployed and part-time working parents scoring higher on the PAI than those in full-time work.

The second model was also significant (adjusted $R^2 = 0.19$, $F = 3.85$, $p < 0.01$). Three of the six imaging variables (Table 4) were significantly predictive of bonding. These were imaging modality type ($\beta = -0.53$, $p < 0.05$), imaging experience ($\beta = 0.42$, $p < 0.05$), and parental excitement after imaging ($\beta = 0.29$, $p = 0.02$). Issues of multicollinearity were not indicated as variance inflation factors in the models were between 1.12–2.33 (tolerance = 0.54–0.87).

Parental expectations, experience, psychological distress and reactions to imaging

Pre vs. post-imaging

Average CORE-10 scores in all parents (including those with a prior mental health condition) were < 10 which indicated low-level psychological distress (not of clinical concern). Mothers' pre and post-scan CORE-10

Table 1 Participant characteristics

	Ultrasound-Mothers	Ultrasound-Fathers	MRI-Mothers	MRI-Fathers
Questionnaire part 1	*n* = 49	*n* = 15	*n* = 9	*n* = 3
Questionnaire part 2	*n* = 47	*n* = 14	*n* = 9	*n* = 3
Mean age	32.22 (SD = 3.15)	34.40 (SD = 3.76)	32.22 (SD = 3.96)	32.67 (SD = 2.89)
Ethnicity				
White	*n* = 34 (69.39%)	*n* = 13 (86.67%)	*n* = 8 (88.89%)	*n* = 2 (66.67%)
Mixed	*n* = 4 (8.16%)	*n* = 1 (6.67%)	*n* = 0	*n* = 1 (33.33%)
Black	*n* = 3 (6.12%)	*n* = 0	*n* = 0	*n* = 0
Asian	*n* = 5 (10.20%)	*n* = 0	*n* = 0	*n* = 0
Other	*n* = 3 (6.12%)	*n* = 1 (6.67%)	*n* = 1 (11.11%)	*n* = 0
Education level				
College (A-Levels)	*n* = 3 (6.12%)	*n* = 2 (13.33%)	*n* = 0	*n* = 0
Undergraduate degree	*n* = 15 (30.61%)	*n* = 6 (40.00%	*n* = 5 (55.56%)	*n* = 2 (66.67%)
Postgraduate degree	*n* = 29 (59.18%)	*n* = 5 (30.33%)	*n* = 4 (44.4%)	*n* = 1 (33.33%)
Doctorate	*n* = 2 (4.08%)	*n* = 2 (13.33%)	*n* = 0	*n* = 0
Employment status				
Full-time	*n* = 41 (83.67%)	*n* = 13 (86.67%)	*n* = 7 (77.78%)	*n* = 3 (100%)
Part-time	*n* = 4 (8.16%)	*n* = 2 (13.33%)	*n* = 0	*n* = 0
Student	*n* = 1 (2.04%)	*n* = 0	*n* = 0	*n* = 0
Unemployed	*n* = 2 (4.08%)	*n* = 0	*n* = 1 (11.11%)	*n* = 0
Other	*n* = 1 (2.04%)	*n* = 0	*n* = 1 (11.11%)	*n* = 0
Mental health condition				
Yes	*n* = 17 (34.69%)	*n* = 1 (6.67%)	*n* = 2 (22.22%)	*n* = 0
No	*n* = 30 (61.22%)	*n* = 14 (93.33%)	*n* = 6 (66.67%)	*n* = 3 (100%)
Prefer not to say	*n* = 2 (4.08%)	*n* = 0	*n* = 1 (11.11%)	*n* = 0
Physical health condition				
Yes	*n* = 12 (24.49%)	*n* = 1 (6.67%)	*n* = 3 (33.33%)	*n* = 0
No	*n* = 37 (75.51%)	*n* = 14 (93.33%)	*n* = 6 (66.67%)	*n* = 3 (100%)

Table 2 Parent-fetal bonding (PAI pre and post-imaging (t-tests)

	Pre-imaging PAI	Post-imaging PAI	Mean difference	t	Effect size (Hedge's g)
All-mothers (paired data for *n* = 56)[a]	38.02 (SD 8.47)	42.73 (SD 8.90)	4.71	-6.11**	-0.81
All-fathers (paired data for *n* = 17)[a]	35.53 (SD 8.45)	38.59 (SD 8.26)	3.06	-2.29*	-0.53
Mothers vs. Fathers	**All-mothers**	**All-fathers**	**Mean difference**	**t**	**Effect size (Hedge's g)**
Pre-imaging PAI	38.19 (SD 8.41)	36.94 (SD 10.16)	-1.25	0.52	0.14
Post-imaging PAI	42.73 (SD 8.90)	38.59 (SD 8.26)	-4.14	1.71	0.47
Ultrasound vs. MRI	**All-ultrasound**	**All-MRI**	**Mean difference**	**t**	**Effect size (Hedge's g)**
Pre-imaging PAI	36.75 (SD 8.77)	44.00 (SD 6.21)	7.25	-2.73*	-0.85
Post-imaging PAI	40.70 (SD 8.86)	47.14 (SD 7.04)	6.46	-2.38*	-0.74

* Significant at $p < 0.05$

** Significant at $p < 0.001$

[a] Participants with unmatched data were excluded from these analyses

scores were similar, however fathers' scores were significantly decreased after imaging ($p < 0.001$). Anxiety significantly decreased after imaging in mothers ($p < 0.001$) and fathers ($p = 0.01$). Fathers' post-imaging excitement was significantly higher ($p = 0.01$), although this increase was not observed in mothers. No significant difference between pre-scan expectation and post-scan experience score was noted for mothers or fathers (Table 5).

Table 3 Multivariate linear regression model for parent variables predicting post-imaging bonding

Independent variable	Standardised coefficient (β)
Step 1: demographics	
Parent type (mother or father)	0.17
Parent age	-0.06
Ethnicity (majority or minority)	0.20
Step 2: social factors	
Education (school or higher education)	0.02
Employment status (full-time or not)	-0.38*
Step 3: physical and mental health	
Mental health condition	0.08
Physical health condition	-0.24
Post-imaging CORE-10	-0.01
Model summary	$F = 2.88$ ($p < 0.01$) Adjusted $R^2 = 0.17$

* Significant at $p < 0.05$

Table 4 Multivariate linear regression model for scan variables predicting post-imaging bonding

Independent variable	Standardised coefficient (β)
Step 1: ultrasound or MRI	
Imaging modality	-0.53*
Step 2: scan factors	
GA at scan	-0.06
Step 3: experience	
Imaging experience	0.42*
Step 4: post-imaging reactions	
Excitement	0.29*
Anxiety	0.09
Satisfaction	-0.15
Model summary	$F = 3.85$ ($p < 0.01$) Adjusted $R^2 = 0.19$

* Significant at $p < 0.05$

Mothers vs. fathers

Although mean values suggest low anxiety in both parents, it was still significantly ($p < 0.001$) higher in mothers (4.21, SD = 2.45) compared to fathers (2.39, SD = 1.29) pre-imaging. Post-imaging, the mean difference between fathers' (9.12, SD = 1.05) and mothers' excitement (7.63, SD = 2.29) was also significant ($p < 0.001$). Fathers' post-imaging satisfaction (9.12, SD = 1.05) was also significantly higher than mothers' (8.36, SD = 1.78) although the effect size was small ($p = 0.04$, g = 0.46). A final significant difference ($p = 0.02$) was noted between mothers' and fathers' post-imaging CORE-10 scores, with mothers scoring higher (8.38, SD = 5.94) than fathers (4.82, SD = 3.09). No significant differences in pre-imaging excitement, pre-imaging CORE-10 or post-imaging anxiety were observed between mothers and fathers (Table 6).

Ultrasound vs. MRI

There were very few differences between parents who had ultrasound or MRI. Ultrasound-parents had significantly higher pre-imaging expectation scores than MRI-parents ($p = 0.01$). Imaging experience scores between the modalities were also significantly different ($p = 0.01$), with ultrasound-parents scoring higher (4.75, SD = 0.47) than MRI-parents (3.75, SD = 1.14). No significant differences were observed between mean scores for anxiety, excitement, post-imaging satisfaction or CORE-10 in ultrasound-parents compared to MRI-parents.

Qualitative findings

Of the four statistically significant predictors, qualitative data relating to parental employment were not collected, therefore this was not included as a coding cluster in the content analysis. A fourth category (parent type) was developed to further explore perspectives of mothers and fathers. Seventeen coded themes were generated (Table 7), representing 78.05% of the content. Coded

Table 5 Parental expectations, experience, psychological distress and reactions to imaging

All mothers (paired data for $n = 56$)	**Pre-imaging**	**Post-imaging**	**Mean difference**	**t**	**Effect size (Hedge's g)**
Anxiety	4.30 (SD 2.42)	2.14 (SD 2.34)	-2.16	7.17**	0.95
Excitement	7.38 (SD 2.01)	7.63 (SD 2.29)	0.25	-0.78	-0.10
CORE-10	8.86 (SD 5.00)	8.38 (SD 5.94)	0.48	0.94	0.12
Expectations (pre-imaging) or experience (post-imaging)	4.54 (SD 0.87)	4.61 (SD 0.62)	0.07	-0.66	-0.09
All fathers (paired data for $n = 17$)	**Pre-imaging**	**Post-imaging**	**Mean difference**	**t**	**Effect size (Hedge's g)**
Anxiety	2.41 (SD 1.33)	1.47 (SD 0.94)	-0.94	2.89*	0.67
Excitement	7.47 (SD 2.50)	9.12 (SD 1.05)	1.65	-2.75*	-0.63
CORE-10	6.88 (SD 3.74)	4.82 (SD 3.01)	2.06	4.15**	0.96
Expectations (pre-imaging) or experience (post-imaging)	4.65 (SD 0.70)	4.53 (SD 1.01)	0.12	0.46	0.11

* Significant at $p < 0.05$

** Significant at the level $p < 0.001$, parental satisfaction was only rated post-imaging

Table 6 Parental expectations, experience, psychological distress and reactions to imaging

	All mothers	All fathers	Mean difference	t	Effect size (Hedge's g)
Pre-imaging:					
Anxiety[a]	4.21 (SD 2.45)	2.39 (SD 1.29)	-1.82	4.11**	0.81
Excitement	7.38 (SD 2.03)	7.50 (SD 2.43)	0.12	-0.21	-0.60
CORE-10	8.64 (SD 5.07)	7.17 (SD 3.82)	-1.47	1.13	0.30
Expectations	4.55 (SD 0.86)	4.56 (SD 0.78)	0.01	-0.02	-0.00
Post-imaging:					
Anxiety[a]	2.14 (SD 2.34)	1.47 (SD 0.94)	0.67	1.74	0.32
Excitement[a]	7.63 (SD 2.29)	9.12 (SD 1.05)	1.49	-3.74**	-0.71
Satisfaction[a]	8.36 (SD 1.78)	9.12 (SD 1.05)	0.76	-2.18*	-0.46
CORE-10	8.38 (SD 5.94)	4.82 (SD 3.09)	-3.55	2.36*	0.65
Imaging experience	4.61 (SD 0.62)	4.53 (SD 1.01)	-0.08	0.39	0.11

* Significant at $p < 0.05$

** Significant at $p < 0.001$

[a] Equal variances not assumed, parental satisfaction only rated post-imaging

themes are presented by statistical importance as per the regression analyses.

Imaging modality

MRI-parents perceived the imaging technique as superior to ultrasound, however, in contrast to its importance in the regression analysis, it was not a high frequency theme in their open-text responses ($n = 13$, 1.04%).

Imaging experience

Parents regarded imaging as a tool to provide reassurance about fetal health ($n = 174$, 12.94%), although they were simultaneously anxious of the potential to receive unexpected news about a fetal anomaly or pregnancy complication ($n = 111$, 8.12%). Satisfaction in the experience was reported by parents who had their expectations for care adequately met ($n = 84$, 6.19%), which included feeling informed about the scan procedure. This was facilitated by positive interactions with radiographers and sonographers ($n = 67$, 4.40%), although the rushed "conveyor belt" experience was also described by some parents and identified as an area to address for improved provision of parent-centred care ($n = 65$, 4.63%). Discomfort in the scan procedure was reported for both modalities ($n = 37$, 2.92%). Ultrasound-mothers were uncomfortable because of transducer pressure on their abdomen, particularly if the fetal lie was unfavourable, and being scanned with a full bladder. MRI-mothers noted feelings of claustrophobia, loud scanner noises, and lying still for an extended period as causes of discomfort. Parental dissatisfaction was expressed in relation to hospital waiting times and COVID-19 infection control measures which were unsupportive of partner attendance ($n = 37$, 2.47%), as well as a lack of information about the scan ($n = 19$, 1.15%). Increased options for imaging extras including choosing souvenir photos, recording video clips, having 3-Dimensional ultrasound offered as standard, and receiving MRI images immediately after the scan were suggested as further means to improve experiences ($n = 25$, 1.63%).

Parent excitement

References to "seeing baby" were most frequently observed in the free-text responses ($n = 197$, 13.43%). Parents enjoyed visualising fetal movement and cardiac activity during scans as it provided reassurance. Images helped parents to personify the fetus, creating a sense of familiarity that could be further intensified by learning the fetal sex ($n = 78$, 3.77%). For some parents, the scan marked a pivotal moment to accept the reality of pregnancy and embrace the transition to parenthood ($n = 66$, 4.77%). The scan experience was perceived by both parents as beneficial, particularly for fathers in enhancing their emotional connection with the baby, and strengthening the partner relationship ($n = 31$, 1.84%).

Parent type

Many parents reported that in the absence of any physical experience of pregnancy, imaging provided a unique and exciting opportunity for fathers' engagement ($n = 62$, 4.78%). Mothers reported greater apprehension prior to scans due to the possibility of an unexpected finding, and actively supressed excitement until receiving confirmation of fetal health ($n = 41$, 3.05%). Mothers' anxiety was

Table 7 Final clusters and coding themes

Coding cluster	Coded theme	Description	Quotations	Frequency of occurrence (n)	Percentage of free-text content (%)
Imaging modality	MRI as an advanced fetal imaging modality	Parents viewed fetal MRI as superior to US	*"We'd had ultrasound scans before, but I wasn't prepared for how amazingly detailed the MRI would be."*	13	1.04%
Imaging experience	Scans for confirmation of fetal health	Pregnancy scans considered a tool for reassurance about the pregnancy	*"I'm most looking forward to the confirmation that the pregnancy remains low risk and that all is as expected."*	174	12.94%
	The potential for unexpected news	Parents felt anxious about the possibility of receiving unexpected news from the scan	*"I'm just worried that something is wrong with the baby and I get bad news."*	111	8.12%
	Satisfaction with the scan experience	Parents felt satisfied with their scan experience when their expectations for care were adequately met	*"I do not think there are any improvements to be made. I was kept informed, well prepared and made comfortable."*	84	6.19%
	Interaction with healthcare professionals	Parental experiences were supported by good communication during the scan to alleviate anxiety	*"The sonographer was professional but warm, sharing her expertise in an accessible and calm-inducing way. She talked through every step of the scan, the image, and also what might take a bit longer to see (but that didn't mean there was a problem with the fetus) – i.e. managing our anxiety pre-emptively."*	67	4.40%
	Facilitating improved care experiences	Parent-centred care requires sufficient time to experience the scan and ask questions	*"Unfortunately, they made it feel rushed and it's such a huge moment for us that it felt like we were another tick off the list."*	65	4.63%
	Uncomfortable scans	Despite some maternal discomfort, both scan procedures were tolerated because of their potential benefits	*"It was quite uncomfortable [in the MRI scanner], but of course I would get all necessary scans if there any concerns about my baby's health."* *"It was a little bit uncomfortable at one point when the baby's head was very low down and the sonographer was trying to get the right angle to see the face clearly."*	37	2.92%
	Attending hospital during a pandemic	Infection control measures were stressful for parents, especially as they were not supportive of partners' attendance	*"It made everything harder to wait outside the hospital [. . .] it made the entire process far more stressful and unpleasant. Pregnancy is not just for women – partners need to be involved at all times."*	37	2.47%
	Scan extras	Some parents wanted more from their scans than can be offered in practice	*"I would love to have seen everything in 3D."*	25	1.63%
	The unknowns of pregnancy scanning	Some parents did not feel fully prepared for scans	*"It took a long time and I wasn't aware upfront exactly how long [it would take]."*	19	1.15%

Table 7 (continued)

Coding cluster	Coded theme	Description	Quotations	Frequency of occurrence (n)	Percentage of free-text content (%)
Parent excitement	Seeing baby for oneself	Parents reassured by seeing their babies and enjoy the visual interaction	*"It was a lovely period of time to get to spend looking at the baby and seeing how they're growing. It reassured me that everything was progressing as it should be"*	197	13.43%
	Knowing baby's sex	Parents excited to learn the fetal sex as it helped to personify their baby	*"I would have welcomed a girl or boy equally, but finding out the gender helps me visualise the reality of the baby coming into our lives…"*	78	3.77%
	Becoming a parent for the first time	The scan as a catalyst for the transition to parenthood	*"The scan completely changed how I felt about my baby…I definitely prioritised my baby more – my prior concerns about my career just don't seem as pressing now"*	66	4.77%
	Scans for bonding	The scan experience helped parents to feel more connected to their babies and each other	*"This scan really helped us to be in a better place mentally and to bond with our baby"*	31	1.84%
Parent type	Fathers' excitement to be involved	Scans provided an opportunity for fathers to be involved in the pregnancy	*"Being a Dad-to-be in this process, the scan is the only time I get to see the baby and interact with it"*	62	4.78%
	Tentative motherhood	Mothers withheld excitement until they felt reassured by their scans	*"Having confirmation that the baby was growing as normal allowed me to be more excited and start to believe properly that the baby would be born without complications…"*	41	3.05%
	Mothers' responsibility for scans	Mothers felt a greater sense of responsibility for the scan outcome	*"The baby wouldn't move […] this was stressful as I felt I needed to do something about it […] but was unable to make him move. I felt like I'd done something wrong"*	13	0.92%

also created by assuming greater responsibility for the scan or pregnancy outcome ($n=13$, 0.92%), for example fetal sex or position.

Discussion

In this study, parent-fetal bonding scores were significantly increased following imaging in both parents which is consistent with existing literature [6]. However, in contrast to other studies [25, 38–40], bonding scores were not observed to be significantly different between mothers and fathers. Four variables were identified as significant predictors of parent-fetal bonding after imaging: scores were significantly higher in parents who had MRI, who scored their imaging experience and excitement levels higher, and who were not in full-time employment. Parental excitement in visualising their baby and the positive experience of receiving confirmation of fetal health were the most frequent references in the qualitative content analysis.

Interpretation

Many parents regarded imaging as a tool for reassurance of fetal development and wellbeing, and, mothers in particular, described how they attempted to supress excitement about the pregnancy until receiving confirmation of fetal health [41]. Whilst it has been suggested that conceptualisations of the "tentative pregnancy" may indicate detachment from the fetus in parents' reluctance to embrace the developing bond [42], it has been argued that this response (often perceived as anxiety or worry about a possible unexpected physical condition or pregnancy loss) actually demonstrates the presence of this connection as fear that the imagined baby may not become reality [14].

The high frequency of references made to 'seeing baby' shows how scans provided powerful visual evidence used by parents to further validate assurances of fetal health offered by healthcare professionals [43]. However, in addition to reassurance, the images could be regarded as a source of uncertainty, creating anxiety if parents are not guided in how to interpret them [1]. Further uncertainty may also be created by communication around the limitations of prenatal screening [44], particularly if acquired images are low-quality [2]. Anxiety was significantly decreased for both parents after imaging, suggesting scans helped to mitigate this reaction. Additionally, some parents may not identify as anxious before the scan, however, expressing relief post-imaging may imply suppressed anxiety [29]. It has been suggested that the need for reassurance arises from anxiety created by the scan itself and uncertainties in fetal screening [45]. This may partly explain why parents perceived MRI as superior, due to its reputation as a more objective, diagnostic modality [46]. The wider field-of-view also enables parents to visualise the whole fetus instead of a series of 2-Dimensional cross-sectional images. However, as with ultrasound, MRI images require skilful interpretation, which is dependent on a clinician's specialist knowledge and experience [16], therefore it may not actually be considered completely objective.

Other explanations may be offered to further understand the association between MRI and higher bonding scores. First, it could be argued that as these scans occurred at a more advanced GA (and these parents would have already received reassurance about fetal health from routine ultrasound screening scans) their emotional connection was more developed [47]. However, although higher MRI bonding scores were consistently noted compared to ultrasound, GA was not found to be a significant predictor in the regression analysis. Secondly, it must be acknowledged that unlike ultrasound, MRI scans were performed for research purposes. Parents may volunteer for pregnancy research because of its perceived benefits to the fetus [48], which suggests emotional investment through demonstration of responsible parenting [49]. Alternatively, parents experiencing a deeper connection may have been more motivated at the opportunity to see their baby again [50].

The findings also suggest how parental excitement is increased after imaging, and why this may help to enhance bonding. Parents reported feeling excited to 'see the baby' and 'hear the heartbeat'. Visual and audial scan cues may substantiate fetal presence, and facilitate growing tangibility of the baby [14]. After scanning, some parents remarked how the pregnancy felt more 'real' and expressed excitement imagining the baby in their lives. This may highlight scans as a'trigger moment' where the bond is initiated or intensified [19], and parents are prompted to engage with their new caregiving role [51]. For some, the scan was an opportunity to learn the fetal sex, which further contributed to feelings of closeness to the baby and excitement. Yet, it has been argued that knowing the fetal sex may actually be problematic for bonding [14], particularly if it does not align to parental preferences, or is inaccurate, as this mismatch in expectations requires parents to adjust their existing mental depictions [52].

Regardless of imaging modality, fathers' excitement was noted to be consistently and significantly higher than mothers. Whilst some free-text responses alluded to fathers lack of awareness or anxiety for unexpected news to explain this [53], it may also be considered that fathers were increasingly excited about the opportunity to be involved in an aspect of antenatal care [7]. Fathers and partners are more likely to attend ultrasound scans than other antenatal checks [54]. Nevertheless, being

present does not guarantee a positive experience for either parent, especially if healthcare professionals fail to fully acknowledge the partner's role [55]. Pregnancy is regarded as a psychologically demanding time for fathers transitioning into their parental role [56], and conflicting emotions experienced during this time may be associated with feelings of chaos or loss of control [57].

It has been suggested that healthcare professionals are not adequately trained to engage with partners [58] which leads to their exclusion from care interactions [59, 60] and further contributes to feelings of confusion and isolation [61]. In this study, COVID-19 infection control measures in the ultrasound department requiring fathers to wait in a separate area of the hospital to their partners created stress for both parents. This reflects findings reported in relation to the COVID-19 pandemic when partners were temporarily restricted from attending scans [25]. As they do not physically experience pregnancy, providing support through companionship is thought to be a key aspect of how expectant fathers conceptualise their role during the prenatal period [19]. Being unable to fulfil this role reinforces feelings of inadequacy, which can negatively affect the sense of connection to the pregnancy [62]. Partner inclusion is important for prenatal bonding and to support maternal emotional wellbeing [63], therefore, healthcare professionals should make efforts to involve partners by acknowledging the importance of their presence [57], providing father-focused information [20], and directing conversation to both parents [64]. 'Interactions with healthcare professionals' was developed to highlight the integral role of the imaging professional in facilitating good communication, which contributed to positive parental experiences and reduced anxiety. Thoroughly explaining the scanning process and images, being open to questions and not rushing through the appointment were identified as central to parent-centred care. Indeed, previous literature has reported improved satisfaction in the scan experience associated with increased feedback from healthcare professionals [29, 65]. However, recent research suggests that moral injury and occupational burnout experienced by UK obstetric sonographers because of the COVID-19 pandemic may present substantial challenges to the provision of parent-centred care [66, 67].

Whilst the influence of parental employment (e.g., unemployed or part-time working) to enhance bonding was not further qualified, it may be that parents in full-time employment have reduced cognitive capacity to engage in imaginative practices which are essential to facilitate the developing bond, as they may be preoccupied with procedural and operational aspects of their work [68]. A similar explanation relating to cognitive capacity was proffered pertaining to the negative effect of anxiety related to COVID-19 pandemic on parent-fetal bonding [69], where it was argued that increasing preoccupation with pandemic-related anxiety in mothers decreased their capability to think about the baby [70].

Clinical implications

Although various scales attempt to quantify parent-fetal bonding [71], the clinical use of this metric is uncertain. Whilst higher scores are typically considered to reflect a more developed bond, no optimal value has been reported [23]. A positive correlation between bonding and GA has been previously observed [72], and supports the theory of key 'trigger moments' throughout pregnancy to intensify the bond [19]. However, this implies that bonding is a linear process, which may not be reflective of all parents' experiences. Instead, it has been suggested that even if 'low' bonding scores are recorded by parents earlier in the pregnancy, their developing connection is likely to be comparable with other parents at the end of the pregnancy [14]. As such, it is possible to inaccurately label a prenatal bond as dysfunctional, which may cause expectant parents to feel inadequate, and thus have substantial implications, not only for the developing bond, but postnatal infant attachment [73]. In addition, it may be argued that the development of an optimal value based on self-reported scores would not adequately reflect the theoretical complexity of the prenatal bonding construct, and therefore should not be considered in isolation to guide the provision of enhanced support for expectant parents. Thus, it is recommended in the first instance that a parent-centred approach to care which recognises and meets the individual needs of expectant parents is adopted within fetal imaging services to facilitate supportive experiences that may, in turn, promote enhanced parent-fetal bonding. Indeed, studies reporting the positive effect of healthcare consultations on prenatal bonding further reflect the findings of this study [74, 75], and suggest that the care interaction experienced during fetal imaging may be an important moderator to consider in the antenatal setting [76].

Strengths and limitations

Prospective data collection facilitated engagement with different parent groups and modalities to enable focused comparisons to be made. Additionally, many studies evaluating parent-fetal bonding after imaging are purely quantitative; in this study, free-text responses provided qualitative context to extend the statistical findings [77]. A further strength was the use of validated instruments for data collection in all parents which permitted direct comparisons to be made between parent groups. However, self-reported bonding scores may be limited by social desirability bias [78]. In this context, parents

completing the questionnaire may have altered their responses to achieve a higher score [73]. It has also been suggested that fathers may not disclose negative feelings if they think doing so may detract professional care and attention from their partner, or if they do not believe they are entitled to [79]. Another limitation was the predominance of ultrasound-mothers in the sample. Lack of fathers' engagement in pregnancy research is acknowledged [80], and despite targeted efforts to recruit fathers into this study, numbers are low, reflecting the need to further improve approaches. In addition, recruitment of eligible MRI-parents was affected by continued disruption of research studies after the peak of the COVID-19 pandemic [81]. Although the pre-determined target sample size of $n=70$ was achieved, it is likely that a greater number of participants would provide further power in the quantitative findings [82]. However, it should be noted that in addition to the challenges experienced in recruiting fathers into antenatal research, as a relatively new imaging modality in pregnancy, the provision of fetal MRI in the UK is limited. Thus, these initial findings serve to provide preliminary insight into expectant parents' experiences of this technology and future work should seek to build on this. Enlarging the dataset and extending the sample population would also be beneficial to include greater representation of parents (including same-sex couples or non-binary parents), ethnicities and educational level.

Conclusions

A detailed understanding of the influence of antenatal imaging on the developing parent-fetal bond is essential to ensure the provision of supportive and inclusive care for expectant parents accessing imaging services. This work extends existing knowledge by directly comparing mothers and fathers, and introduces new insights related to the use of fetal MRI in uncomplicated pregnancies. Bonding scores were significantly increased in both parents after imaging, however no differences between mothers and fathers were observed. Bonding was greater in parents after MRI compared to ultrasound although this may reflect the more developed emotional connection at later GAs. Parental excitement and experience were also identified as important variables, and qualitative analysis suggested they may be influenced by the professional conduct of imaging professionals during the scan. Effective communication helped parents to interpret scan images and offered reassurance of fetal wellbeing, contributing to a positive experience. Visualisation of the fetus provided evidence of its presence, which intensified parents' sense of connection to the baby and increased excitement in imagining future parenthood. Imaging professionals should therefore adopt an informed, parent-centred approach to care to best support expectant parents.

Abbreviations

GA Gestational age
MRI Magnetic resonance imaging
PAI Prenatal attachment inventory

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Authors' contributions

ES: Conceptualisation, Methodology, Formal analysis, Investigation, Writing – Original draft, Writing – Review & Editing, Funding acquisition, Project administration; DC: Resources, Validation, Writing – Review & Editing; AS: Resources, Writing – Review & Editing; GH: Writing – Review & Editing; MR: Resources, Writing – Review & Editing, Supervision; CM: Conceptualisation, Methodology, Writing – Review & Editing, Funding acquisition, Supervision; SA: Conceptualisation, Methodology, Writing – Review & Editing, Supervision. All authors reviewed and approved the final manuscript.

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Availability of data and materials

There are ethical restrictions on public sharing of this study's dataset because of limited anonymity. However, a minimum dataset will be made available on reasonable request to the lead author (emily.skelton@city.ac.uk) and institutional research ethics committee (researchethics@city.ac.uk).

Declarations

Ethics approval and consent to participate

This study was granted approval from the NHS West of Scotland REC 3 (reference: 20/WS/0132, approval date 12th November 2020) and School of Health and Psychological Sciences REC at City, University of London (reference: ETH1920-1680, approval date: 30th November 2020).
All participants gave electronic informed consent prior to accessing the questionnaire, which included permission to use anonymised quotations for research presentation and publication.

Competing interests

The authors declare no competing interests.

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"It's not just the medical aspects that are important": A qualitative exploration of first-time parents' experiences of antenatal imaging and their influence on parent-fetal bonding

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ABSTRACT

Introduction: Antenatal imaging provides clinical information regarding fetal growth and development. The additional benefit afforded by imaging for expectant parents in developing an emotional connection (bond) to the unborn baby is also acknowledged. However, the relationship between imaging and bonding is not fully understood, particularly where there are differing parental and pregnancy circumstances, for example use of advanced imaging techniques or the prenatal diagnosis of a congenital fetal condition. This study aimed to explore the role of antenatal imaging in enhancing the developing parent-fetal bond in first-time parents.

Methods: A descriptive, qualitative methodology was used. Semi-structured telephone interviews were conducted with first-time expectant parents attending a London hospital for clinical ultrasound (n 20) or research MRI (n 8) imaging during pregnancy. The sample included parents receiving specialist antenatal care for a diagnosed fetal cardiac condition (n 8). Thematic analysis was conducted.

Results: The analysis generated three themes: 1) Our baby, our scan too; 2) Destination parenthood; and 3) Being in the dark, then finding the light. These themes highlight the important, but transient role of antenatal imaging in enhancing parent-fetal bonding, as well as the differing care needs of expectant parents. The integral role of healthcare professionals in providing a personalised, supportive, imaging experience to facilitate bonding is also reflected.

Conclusion: Adopting parent-centred care approaches which involve expectant parents in fetal imaging influences bonding by helping parents to consider the reality of their impending parenthood. Knowledge acquired during scans is used to create an identity for the unborn baby, which parents can develop an emotional connection to.

Implications for practice: To optimise the potential for enhanced parent-fetal bonding, care provision in fetal imaging should be tailored to the individual needs of expectant parents.

Introduction

Imaging is integral to antenatal care, providing insights into fetal development to inform clinical management pathways.[1] B-mode ultrasound is most frequently used, however technological advances enable application of additional techniques like 3 and 4-dimensional ultrasound, and fetal magnetic resonance imaging (MRI). Although fetal MRI is not routine in pregnancy, its value in acquiring highly detailed anatomical information to compliment ultrasound is acknowledged.[2–4]

The psychosocial benefits of antenatal imaging for expectant parents are also reported, and current literature explores the association between imaging and enhanced parent-fetal bonding.[5] The

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emotional connection which parents feel towards their unborn child is associated with fetal development[6] and parental well-being.[7] Establishing a quality bond involves developing a new parental identity and building an emotional relationship with the fetus.[8] Fetal imaging is thought to support bonding as it transforms pregnancy from an abstract concept into a reality by providing visual evidence of fetal personhood.[9] Some parents may use fetal imaging to validate and document their new identity in social settings, a behaviour which has been linked to enhanced bonding.[10] It is believed sharing scan images with family and friends involves others in the pregnancy, contributes to the development of a fetal identity, and helps to establish a social network for supporting the new family unit.[11]

The biopsychosocial model of healthcare acknowledges the importance of imaging for providing medical information (biological), facilitating parent-fetal bonding (psychological) and supporting parents' unique experiences of pregnancy (social). This model may be applied to antenatal imaging when considering the interplay between biological, psychological and social factors of scanning, and how these may influence expectant parents' experiences of pregnancy scans.[12] However, it has been criticised for its integration difficulties within healthcare.[13] More complex scan protocols, workforce shortages and high levels of occupational burnout in healthcare professionals (HCPs) makes finding a balance between the biological and psychosocial domains of fetal imaging challenging, especially following the COVID-19 pandemic.[14] Inadequate acknowledgement by HCPs of parents' psychological needs and expectations during fetal imaging can lead to parents' perception of a medico-centric approach to care and subsequent feelings of disempowerment and indifference in the process which may be detrimental to the developing parent-fetal bond.[15] An alternative to the biopsychosocial model is the concept of person-centred care. This shares some similarities in promoting a humanistic approach to involve individuals in their care.[16] Yet, in pregnancy, it must be further adapted to recognise the unique and additional needs of the expectant parent and incorporate the wider family unit.[17]

Parent-centred care is important for improved parental satisfaction and pregnancy outcomes,[18] and its positive influence on parent-fetal bonding. Greater role satisfaction and mitigation of occupational burnout in obstetric sonographers is also reported.[19] However, care may be hindered by organisational challenges and, additionally, there is currently no accepted definition or model in fetal imaging or obstetrics, although recent work seeks to address this.[20] This may be partly due to gaps in knowledge; research into fathers' experiences of antenatal care is limited, despite their increasing involvement in pregnancy and childcare.[21] Furthermore, expectant parents requirements may differ depending on their previous experiences of care. For example, scans in pregnancies following an unexpected outcome may trigger distressing flashbacks for parents,[22] with stress and anxiety noted to be particularly high at the same gestational age to the initial diagnosis.[23] Finally, the effect of new and advancing technologies (e.g., fetal MRI) on parent experiences are yet to be fully evaluated. Imaging acquisition processes of fetal MRI are different to ultrasound, and it has been suggested that expectant parents may not be prepared for loud scanner noises, feelings of claustrophobia, and discomfort when lying still for an extended period.[24] Additional considerations surround parental responses to seeing highly detailed fetal images, particularly if a congenital condition has been diagnosed in the baby.[5]

This study aimed to explore the research question, how does antenatal imaging influence prenatal bonding in first-time expectant parents? A qualitative approach is used to extend current knowledge by providing deeper insight into the role of pregnancy imaging in supporting the developing parent-fetal connection, and further understanding of how this may change with differing parental circumstances and pregnancy outcomes.

Methods

A descriptive, qualitative methodology was used in this study, located within a pragmatist paradigm. The flexibility of this approach allows the researcher to choose the most appropriate method to address the research question.[25] Semi-structured interviews were conducted to enable in-depth exploration of parental experiences and perceptions of antenatal imaging. Data were analysed using reflexive thematic analysis.[26] The JARS-Qual checklist[27] was used to guide reporting of this study.

Participants

Convenience sampling was utilised. First-time expectant parents (≥18 years) were approached by HCPs during clinical or research imaging appointments at a London hospital. All parents had attended for fetal imaging (clinical ultrasound or research MRI) between 18 and 36 weeks gestation of pregnancy. For some parents, scans were offered as part of the antenatal care pathway in uncomplicated pregnancies.[28] Some parents were receiving specialist care following a fetal diagnosis of congenital heart disease (CHD). These parents were only approached if they were committed to the pregnancy, willing to support research, and their care team believed participation would not be distressing. An information video and written information further detailing the purpose of the study, participation schedule and options for withdrawal were shared with parents who expressed their interest to be involved. Parents were given time to ask questions and consider their participation before providing consent and permission for illustrative quotations to be included in publications through an electronic informed consent form.[29] Based on feedback received during public involvement activities undertaken to inform the methods, no incentives were offered to parents.

Data collection

Individual interviews were arranged within four weeks of the fetal imaging examination. All were conducted by the lead author via telephone between October 2021–December 2022 because of restrictions around face-to-face research activity during the COVID-19 pandemic.[30] As all interviews were remote, participants could choose the environment they felt most comfortable to talk in, most being at home. No participants were previously known to the research team. A semi-structured interview guide (Supplementary Material 1) was developed to address the research question based on findings from a systematic review of published literature,[5] and reviewed by parent volunteers and project collaborators (Antenatal Results and Choices, Fathers Reaching Out). The interview guide was piloted with three parent volunteers, resulting in some changes to the question phrasing for improved response clarity (e.g., 'tell me about your experience of the scan' became 'tell me what happened during your scan appointment?'). The interview guide empowered participants to lead the conversation with occasional prompts by the interviewer to maintain alignment with the research question. Sample size was guided by a model of information power.[31] This model identifies five items (aim, specificity, theory, dialogue and analysis) which may inform sample size considerations. For example, the broad aim and exploratory nature of the study to capture experiences across differing case scenarios (including parent type, imaging modality used, routine or specialist antenatal care pathway) suggests a larger sample size is required for adequate information power. Therefore, we aimed to interview approximately 10 parents per scenario.

Member reflections were utilised during the interview (e.g., repeating phrases and checking understanding) and analysis (e.g., review and feedback on themes). This helped to ensure accurate

interpretation and portrayal of participant responses in the final report.[32] Interviews were recorded using an encrypted Dictaphone and transcribed verbatim for qualitative analysis by a professional service. Contracts were in place to conform to data compliance regulations. All transcripts were reviewed for accuracy prior to analysis, and identifying information (e.g., names or specific personal details) was edited to preserve participant anonymity.

Analysis

Transcribed interviews were imported into NVivo for analysis (v14, QSR International Pty LTD). A 6-step framework was followed utilising a reflexive, inductive approach so that codes and themes could be developed from the data whilst also acknowledging the researcher's reflexivity in generating meaning.[26,33] Following a period of familiarisation with the data, each transcript was individually coded. The initial codes were reviewed collectively and further developed through combining similar codes and generating new codes. The codes were grouped into core themes and named. In keeping with the principles of reflexive thematic analysis, all analyses were conducted by the lead author and only discussed with other authors at the point of finalisation. Further details of the analytical process are provided in Supplementary Material 2.

Ethics

Ethical approval was given by the NHS West of Scotland REC 3 (REC reference: 20/WS/0132, date of approval: 12th November 2020) and School of Health and Psychological Sciences REC at City, University of London (REC reference: ETH1920-1680, date of approval: 30th November 2020). Due to the nature of the research, the lead author attended an external training session on sensitive interviewing practices prior to starting data collection. This built on their existing communication skills and professional experience of conducting difficult conversations in the clinical setting. Opportunities to provide further care and support to parents during their participation in the study were also considered in the study design; debriefing was offered immediately following the interview, and an information leaflet with contacts for further support was also shared with all parents by email after the interview. The lead author also had access to psychological support and debriefing provided by senior members of the research team.

Positionality

The lead author is a sonographer with over 12-years clinical experience of obstetric ultrasound, and four years experience of conducting and publishing research in the topic area. The wider authorship team are composed of male and female clinical and academic professionals with substantial experience across domains including medical imaging, midwifery, paediatrics and psychology. All recognise the potential implications and influence of their positions on the research.

Findings

Twenty-eight parents were interviewed (18 mothers, 10 fathers). Of these, eight parents attended for fetal MRI. There were eight pregnancies with a known fetal cardiac condition: six had ultrasound and two had fetal MRI (Table 1). The average interview length was 55 min (range: 39–76 min). Of all parents who gave their consent to be interviewed, none requested withdrawal from the study.

Three themes were developed: 1) Our baby, our scan too; 2) Destination parenthood; and 3) Being in the dark, then finding the light (Table 2). Collectively, these themes placed fetal imaging as pivotal for expectant parents in developing the emotional connection to their unborn baby, transitioning into new caregiving roles and establishing their new family unit. All parent names used in direct quotations below are pseudonyms that preserve anonymity but maintain authenticity of the process and the human-centric focus of this research.

Our baby, our scan too

The duality of antenatal imaging is represented in this theme, highlighting the importance of adopting a parent-centred approach to scans. Expectant parents welcomed the medical focus of scans for providing assurance of fetal development, but also craved the opportunity to engage with their unborn baby on a deeper emotional

Table 1
Participant characteristics – grouped to provide participant information whilst preserving individuals' anonymity.

	Mothers-1 (n = 8)	Mothers-2 (n = 4)	Mothers-3 (n = 4)	Mothers-4 (n = 2)	Fathers-1 (n = 6)	Fathers-2 (n = 2)	Fathers-3 (n = 2)
Modality	Ultrasound	Ultrasound	MRI	MRI	Ultrasound	Ultrasound	MRI
Fetal cardiac condition?	No	Yes	No	Yes	No	Yes	Yes = 1 No = 1
Average GA at scan	20 w 2 d	25 w 4 d	26 w 3 d	33 w 6 d	22 w 1 d	20 w 4 d	31 w 1 d
Average GA at interview	23 w 3 d	29 w 1 d	29 w 4 d	35 w 1 d	26 w 4 d	27 w 1 d	33 w 5 d
Average parental age	32	29	34	25	27	35	31
Ethnicity (self-reported)	White British = 5 Asian British = 1 Latin American = 1 White Jewish = 1	White British = 3 Black Caribbean = 1	White British = 3 European = 1	White British = 2	White British = 5 Mixed ethnic = 1	White British = 2	White British = 2
Education	Undergraduate degree = 3 Postgraduate degree = 5	College = 2 Undergraduate degree = 2	Undergraduate degree = 2 Postgraduate degree = 2	College = 1 Undergraduate degree = 1	College = 2 Undergraduate degree = 2 Postgraduate degree = 2	College = 1 Postgraduate degree = 1	College = 1 Undergraduate degree = 1
Employment status	Full-time = 8	Full-time = 4	Full-time = 4	Full-time = 2	Full-time = 6	Full-time = 2	Full-time = 2
Pseudonyms assigned	Sara Elizabeth Jennifer Stephanie Jessica Alisha Nicole Kayla	Rachel Leah Mia Rebecca	Amanda Lauren Danielle Megan	Abigail Caitlin	Joshua Ryan Andrew Nicholas Rob Christopher	Matthew William	Joseph David

Table 2
Key themes and codes.

Theme	Definition	Codes	Illustrative quotations
Our baby, our scan too	The importance of parent-centred care to balance the medical and psychosocial aspects of fetal imaging	• Active participants, not observers • Checking in with baby • Dual-purpose imaging • Feeling cared for • Important moments for imaging • Making it through the MRI scan • More than a diagnosis • Understanding images	*"As [I am] not the parent carrying the child … this additional visualisation helps you feel even closer to it." [Ryan]* *"When they showed me all the pictures, they were showing a parent-to-be their baby for the first time." [Danielle]* *"I feel like from the NHS' point of view, they're taking it very much from a very pragmatic, biological, practical side. And it's like well that's all well and good but actually there's a huge emotional side to all of this as well." [Stephanie]* *"It's nice to feel that someone cares about you as well. Because of course they're there for the baby and everything else, they're also very much making sure that you're okay as well." [Rebecca]* *"She started explaining what she was doing and kept up almost a commentary the whole way through. I feel like I had an understanding of what she was doing." [Joshua]* *"My natural instinct is to just try and get out of the [MRI] machine … I tried to remember logically why I was doing it … having someone reassuring you and knowing that someone's there with you, knowing that perhaps you're gonna have that picture or video at the end, knowing that you're gonna help, it's definitely worth it." [Abigail]* *"You're not just looking at it like a case study of a condition, that is your baby, you are looking at your baby." [Abigail]*
Destination parenthood	Fetal imaging as a milestone and influence in the transition to parenthood	• Accepting new roles and responsibilities • Building a village • Getting to know you • Keeping a distance • Meeting the milestones • Power of the physical connection	*"When you see it on the scan, it just brings it all home and if makes you confront the reality." [Rob]* *"Close family and friends they have really journeyed with us, over the last two to three years, we have shared it [scan photo] with them." [Alisha]* *"… even sort of seeing that detail of like little fingers and things like that it really started to feel like a baby, rather than just a sort of idea … It started to make me feel that the baby had a bit of personality." [Elizabeth]* *"Just to see your little boy before he's actually here, I think that's a beautiful thing." [Joseph]* *"I feel like I kind of held back a little bit sometimes […] kind of want to make sure they are actually here before you throw yourself into it 100%, but you already are in it anyway regardless as to what you tell yourself." [Rachel]* *"I don't think a day has gone by where we haven't talked about something to do with the baby […] whereas I think before the twenty week scan it possibly wasn't something that came up every single day because it didn't seem like there was that much to talk about at that point." [Elizabeth]* *"Seeing the blood kind of going through the placenta and into the baby […] seeing that connection and then realising, actually, there is a physical bit where I and baby meet […] the baby is separate but it's also very much part of me as well." [Stephanie]*
Being in the dark, then finding the light	The role of fetal imaging in navigating the uncertainties of pregnancy	• Against all odds and expectations • Changing expectations • Making the best of the situation • "Normal for us" • Preparing for the worst, hoping for the best • Scanxiety is real • Taking control • The journey ahead • Trusting the professionals • Unknowns of fetal imaging • Vicarious experiences • When the unexpected happens	*"If we're talking about numbers, it's the fact that [the baby] has come about against tremendous odds." [Nicholas]* *"It's quite hard to process having a cardiac baby … you have an idea of what having a baby should be like to the have your world kinda spun upside down." [Abigail]* *"Everyone always wanted to tell you a story about somebody that something bad has happened to, but if you actually think about it, all the people that you know, that have gone through a healthy pregnancy, have given birth at the end to a healthy baby." [Leah]* *"Relief … it's not the right way of saying it, but it was a relieving moment […] it very much, sort of, it solidified things, and it made me feel much more relaxed within the pregnancy period." [Andrew]* *"I was really reassured by what [the HCP] said around the development of the baby […] I'm a big worrier on these things and my concern was that we were gonna get the scan and there was gonna be something slightly suboptimal or abnormal and that we were gonna worry." [David]* *"We've both got the mentality of, we can't change it so let's just get on with it. We're in the best hands possible, the care plan's in place, we're lucky cos it's been picked up … I actually think I've had a really positive outlook." [Leah]* *"I wanted to make sure that I was there with my husband to kind of both get the information because I feel like sometimes when you get that information you don't really process it until afterwards and you both take different information from it." [Rachel]*

level. Parents also expressed their desire to be actively involved in scans. Those who were involved, perceived a better overall experience. This was particularly evident for fathers who experienced challenges in navigating their role as a non-pregnant parent.

> *"I think sometimes as a partner when you go to a scan and all the conversation is directed at the pregnant woman then you sometimes feel like a bit of a spare part and, like, you're not particularly useful in the whole thing." [David]*

Fathers appreciated being welcomed into the clinical space and being included in conversations with HCPs. Feeling looked after and working with HCPs to understand and interpret fetal images were also important for supporting and including both parents during

scans. They felt empowered when the importance of their new parenting role was acknowledged, experienced joy in seeing the baby, and felt reassured by listening to and watching the fetal heartbeat. This was symbolic of on-going life, even for parents of babies with a cardiac condition. Being made to feel comfortable, receiving a clear explanation of scan findings and having the opportunity to ask questions were characteristics of good care. Fetal MRI scanning was highlighted to be a greater challenge for parents than ultrasound, both physically and psychologically. Mothers developed strategies to help them through the scan, including reminding themselves of the health benefits and counting down the remaining acquisition time with HCPs. Both parents also acknowledged feelings of isolation during fetal MRI; mothers felt alone in the scan room and fathers felt separated from the experience and their partner as they waited in another room. In both modalities, imbalances in parent-centred care delivery were perceived when the parents' needs were overshadowed by hcps' medical focus of the scan.

> *"If you tell a patient 'Oh you may have gestational diabetes', unfortunately that this is going to be their take-home message […] Everything else has been normal, that's what you need to take away from the scan." [Alisha]*

Parents receiving specialist care also appreciated when HCPs did not solely focus on the condition but took time to acknowledge the baby too. This was especially important for parents participating in clinical imaging research projects where a physical condition was being studied. Finding a balance between the medical and psychosocial aspects of scans was crucial to facilitate positive parental experiences of care.

> *"When you're put in a big machine and it's all very technical and just research, research, research […] I'm not a lab rat, my baby's not a lab rat, so it's quite nice to just bring the human side of it, you know, they understand you're still a parent…" [Abigail]*

Destination parenthood

Fetal imaging represented a milestone in the pregnancy journey and transition to parenthood. Scans provided expectant parents with a metaphorical compass to provide future direction for the pregnancy, and prompted many new caregiving behaviours. Collectively, these behaviours reflected individuals' acceptance of, and adjustment to their new parental roles, varying from recognisable "nesting" traits (e.g., buying things) to more subtle psychological tasks such as sharing news of the pregnancy with family and friends and building a social support network. Parents described delaying these behaviours until after the scan, wanting to feel fully reassured of the continuing pregnancy before fully committing.

> *"I was really hesitant with telling people […] because I was like you know, anything can happen. Maybe we'll have the second scan and maybe it won't be okay?" [Danielle]*

However, the influence of fetal imaging on the creation of a new parental identity and simultaneously developing parent-fetal bond was transient and time-sensitive. Scan images provided early proof of fetal presence in the absence of later-manifesting physical cues like a visible pregnancy bump. Many parents felt closer to their baby following scans, although were not always able to articulate exactly why this was. Some referred to a greater sense of "knowing baby", attributed to the recognition of personal or familial characteristics identified on scan images. However, parents' connection was not to the images themselves, but to the individual they were creating in their minds based on knowledge acquired from scans. Following scans, parents' visions of their baby rapidly shifted from a generic entity existing in the womb to their imagined child. At later gestations though, the superior influence of fetal imaging on bonding was replaced by a greater sense of connection through fetal movements.

> *"I literally feel everything all the time. I feel like that really connects me with the baby more than seeing the images." [Lauren]*

Being in the dark, then finding the light

Fetal imaging was transformational for first-time expectant parents as it provided an opportunity to resolve uncertainties they had encountered during pregnancy. Scans facilitated a shift from the unknown to the known, helping to inform parents about the progression of the pregnancy. Much of the uncertainty was centred around parents' fear of receiving unexpected news from the scan. This "scanxiety" was felt by all parents in the sense that pregnancy is never guaranteed, though was experienced most strongly in those influenced by previous complicated pregnancies or vicarious experience of pregnancy complications shared by family and friends.

> *"One of my sisters had a really bad experience […] and so that has kind of coloured my expectations of how difficult it can be and what can go wrong…" [Rob]*

In moments of uncertainty, parents sought to exert some control over the situation. For some, this meant actively searching for and arming themselves with information. For others, it meant simply deciding to put their faith in the HCPs and *"go with the flow"*. Parents who received a fetal cardiac diagnosis experienced an additional transformation; one which required them to rapidly adjust their expectations of pregnancy and parenthood and adapt to a new reality. After receiving news of a diagnosis, parents described initial reactions of shock, confusion and grief for the previously imagined child. With the support of their HCPs, they described a move from uncertainty to empowerment and acceptance of their baby's diagnosis. This was achieved by adopting a positive mindset and embracing the further opportunities afforded by specialist clinical care, including learning more about their baby through fetal MRI.

> *"As strange as it is to say, it's quite lucky in a way to be able to have seen that. It's such an incredible view of your baby and it's just quite an incredible experience." [Joseph]*

Discussion

Consistent with previous literature,[5] antenatal imaging was perceived by this group of parents to have a positive effect on bonding. The findings from this study suggest that first-time expectant parents utilised fetal imaging examinations to support two important processes for bonding; establishing a new parental identity and developing a connection to the unborn baby.[8] Both were informed by knowledge created and acquired during scans, although the superior influence of fetal imaging over other pregnancy milestones was time-sensitive.

Parents' use of fetal imaging to validate and explore their changing identities was observed, although fathers felt more uncertain in their role. Traditional and anthropological views of parenting associate caregiving tasks with mothers and play-based, interactional learning with fathers,[34,35] and whilst acts of maternal caregiving may begin during (and even before) pregnancy, the paternal role may be less well-defined until the baby's birth.[36] Pregnancy is a psychologically challenging time for fathers who, in the absence of any physical cues, experience pregnancy through their partner.[37] Consequently, many consider their primary role is in providing support and companionship for their pregnant partner,[38] which may draw focus away from developing their emotional

connection to the fetus. This may explain previously observed differences in measured bonding scores between mothers and fathers.[39 41] Research highlights fathers' participation in the scan experience and visualising fetal movement as more impactful than viewing images,[42] and fathers' exclusion from antenatal care and subsequent negative impact on their parental role has been previously discussed.[43] However, consistent with existing literature,[44 46] fathers in this study identified how HCPs created opportunities for involvement. As fathers may experience greater challenges in adjusting to their new parental identity than mothers, early involvement helps support their transition and prevent disengagement from the pregnancy.[47]

Whilst many expectant parents consider fetal imaging to be a source of reassurance for fetal health, it also caused parental anxiety.[48] In this analysis, many parents spoke of their concerns of receiving unexpected news about fetal development prior to the scan, regardless of whether they had previous experience of pregnancy complications or not. Indeed, research suggests that anxiety levels in parents peak immediately before fetal imaging.[49] Historically, it was believed that strong pre-occupation with concerns about fetal health may impair development of the parent-fetal bond as less time is spent fantasising about the future child.[50] For some parents, previous experience of loss may make it more difficult to navigate feelings of closeness to a new baby whilst grieving for the first baby.[51] The importance of identifying previous psychological trauma in expectant parents to inform sensitive care delivery is therefore highlighted.[22]

Although parents of babies diagnosed with a cardiac condition acknowledged their altered experience of pregnancy imaging compared to others, this did not seem to affect their feelings of connection to their baby. Whilst research is limited in this field, studies have attempted to observe quantifiable differences in measures of parent-fetal bonding between pregnancies with a fetal condition and uncomplicated pregnancies. However, the findings are often conflicting and vary depending on the type and severity of the anomaly.[52] Fetal imaging offers parents the opportunity to visualise a physical condition, which may be beneficial to support clinical explanations and parents' understanding of a diagnosis.[53] A study exploring fetal MRI in suspected brain conditions reported parents found these images empowering in enhancing their own conceptualisations of the fetal identity, and helpful in challenging an often negative, medicalised view of the pregnancy.[54] Rather than the fetal condition itself being a predictor for bonding, it may be argued that the potentially detrimental impact of the condition on the parental pregnancy experience may be more influential. For example, if multiple specialist care appointments are perceived as burdensome, this may contribute to a negative experience of pregnancy.[55] Interactions with HCPs may also affect how parents cope with unexpected news, with experiences of poor communication contributing to increased psychological distress.[56] Expectant parents therefore need clear, empathetic and consistent communication to feel adequately supported and satisfied with their care experience.[15]

Implications for practice

The findings from this study suggest that in fetal imaging, there is no "one size fits all" approach to parent-centred care. In supporting psychosocial factors of imaging, the dual role of HCPs as skilled professionals and communicators is acknowledged.[57] Literature reports the positive effect of an "imaging consultation" for reduced maternal anxiety and enhanced bonding.[58,59] This approach focuses on quality communication between HCPs and parents to improve clinical knowledge of the scan procedure, and promote parent-fetal interaction during the examination to assist with recognition and understanding of the fetus.[60] The importance of good communication to support parents is of particular importance in prenatal diagnosis.[56] Additional recommendations for parent-centred care in fetal imaging developed from the study findings are also informed by literature[5] and models of person-centred care in antenatal domains.[20] These include: providing adequate and accessible information to support decision-making; respecting parent choices and autonomy; responding to parental psychological and emotional needs; acknowledging the importance of social relationships during pregnancy; and establishing a collaborative alliance between HCPs and parents for best outcomes.

Trustworthiness of this study is supported in several ways.[61] Triangulation of field notes and analytical memos aided theme development by adding depth to interview transcripts.[62] Member reflections from participants were also utilised to improve confirmability.[32] As reflexive thematic analysis is conducted independently, the personal influence of the researcher over the findings is acknowledged. Practising reflexivity and including a detailed report of the analytical process provided transparency for others to understand the researcher's position in the analysis.[63] Still, this study is not without limitations. The broad scope of the research question did not facilitate in-depth exploration of the experiences of different parent groups included in the sample (e.g., fathers, specialist care, fetal MRI). Whilst principles of information power were adopted to inform the sample size,[31] it may be argued that the dataset would benefit from expansion, particularly for fathers and parents who had fetal MRI, as recruitment of these participants was limited by ongoing disruption in the aftermath of the COVID-19 pandemic. Purposive sampling may also be advantageous to include better representation of minority sociodemographic characteristics.

Conclusion

As fetal imaging is fundamental to antenatal care, it is critical for HCPs to understand the psychological importance it holds for expectant parents in connecting with their unborn baby. This study suggests it is not only fetal images which parents value for bonding, but the interactions with HCPs during the examination that help to shape fetal personhood, validate new parental identities, and provide reassurance of parents' emotional investment in the pregnancy. The provision of parent-centred care to address parents' differing psychosocial needs is essential for improved experiences of care and bonding. Whilst this study provides some recommendations for practice, further research is required to better understand imaging experiences in various parent groups (e.g., other ethnicities, same-sex couples, different fetal conditions) and develop a comprehensive framework for care, inclusive of all parents and their needs beyond the clinical aspect of fetal imaging.

Authors' contributions

ES: Conceptualisation, Methodology, Formal analysis, Investigation, Writing – Original draft, Writing – Review & Editing, Funding acquisition, Project administration; **DC:** Resources, Validation, Writing – Review & Editing; **AS:** Resources, Writing – Review & Editing; **MvP:** Resources, Writing – Review & Editing; **CMo:** Resources, Writing – Review & Editing; **GH:** Writing – Review & Editing; **MR:** Resources, Writing – Review & Editing, Supervision; **CMa:** Conceptualisation, Methodology, Writing – Review & Editing, Funding acquisition, Supervision; **SA:** Conceptualisation, Methodology, Writing – Review & Editing, Supervision.

Ethics approval

This study was granted approval from the NHS West of Scotland REC 3 (reference: 20/WS/0132, approval date 12th November 2020) and School of Health and Psychological Sciences REC at City, University of London (reference: ETH1920-1680, approval date: 30th November 2020). All participants gave informed consent prior to their interview, which included permission to use anonymised quotations for research presentation and publication.

Data availability

There are ethical restrictions on public sharing of this study's dataset because of limited anonymity. However, a minimum dataset will be made available on reasonable request to the institutional research ethics committee (researchethics@city.ac.uk).

Competing interests

None.

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Appendix A. Supplementary data

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