Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Reduced fetal movements in pregnancy: systematic reviews of the evidence and a case-control study of perinatal risk factors and outcomes

Lorraine Carroll

Thesis submitted in fulfilment of the requirement for the Degree of Doctor of Philosophy at the University of Dublin, Trinity College
2023

Declaration

I declare that this thesis has not been submitted as an exercise for a degree at this or any other university and it is entirely my own work.

I agree to deposit this thesis in the University's open access institutional repository or allow the Library to do so on my behalf, subject to Irish Copyright Legislation and Trinity College Library conditions of use and acknowledgement.

I consent to the examiner retaining a copy of the thesis beyond the examining period, should they so wish (EU GDPR May 2018).

Signed,

_____

Lorraine Carroll

Acknowledgements

There are many people that supported me through my PhD journey over the last six years and made this thesis possible.

Firstly, I particularly want to acknowledge the women and babies that the numbers and statistics presented within this thesis represent. I hope that I have given justice to raising awareness and knowledge of the perinatal risk factors for and outcomes associated with reduced fetal movements. My sincere thoughts are with the parents who experienced stillbirth during the period of this thesis.

I am hugely indebted to my PhD supervisors, Professor Valerie Smith and Dr Louise Gallagher. I was extremely fortunate to have you both as my supervisors. Both of you have played an integral role in my development as a researcher. Valerie, a special thanks for sharing your enthusiasm and desire for high quality systematic reviews and research. I am in awe of your dedication, attention to detail and infinite research knowledge. Louise, I am so grateful for your generous time, collaboration, wisdom and support associated with developing and supervising this thesis. I am eternally grateful to you both, not only for your academic and research guidance, feedback and wisdom, but also for your tremendous patience, friendly calm support at times when I felt overwhelmed and unsure, for keeping me focussed and pushing me forward to complete this thesis on time. I truly hope that we will continue to collaborate as educators and researchers for many years to come.

To Greg Sheaf, subject librarian in Trinity College Dublin, thank you for your generous time and support in teaching and demonstrating database searches and Endnote to me.

I would like to express my sincere gratitude to Gillian and Fionnuala, my study gatekeepers who gave of their precious clinical and MN-CMS knowledge, time and assistance throughout the study. Your motivation and commitment to keep the study going during the first National Covid-19 lockdown, when everything else was so uncertain, made completion of the study possible.

I could not imagine completing this PhD journey without the friends I have made along the way. The immense support, guidance and comradery at RSED and peer support days, and from our 'Researchers' WhatsApp group will be forever treasured. Ciara, in particular, you are a legend. The effort you go to and generous time you give to helping others is inspirational. Thank you also to Marie-Pierre Lavergne for your stellar administrative support.

Sincere gratitude to my wonderful midwifery and nursing colleagues at UCD School of Nursing, Midwifery and Health Systems and the National Maternity Hospital for your encouragement, friendship and immense support, especially over the last six months, giving me space and time to write and to complete this thesis. Best of luck Mary and Liz with completing your own PhD journeys. We collectively have shared the rollercoaster ride of PhD life, celebrating our 'little' achievements along the way. Regina, I am forever grateful for your endless words of wisdom, encouragement, and tough love!

I feel privileged to have been given the opportunity to undertake this programme of research over the past six years, and extremely grateful for the financial support of PhD fees from the School of Nursing, Midwifery and Health Systems, without which this thesis would not have been possible.

To my parents, Mary and Pat, who have supported me wholeheartedly in everything I do. To my brother Patrick, sister in-law Niamh and family for all your support and love. I know deep down you are very proud of my achievements. I will be forever grateful for the many cooked meals, house cleaning, garden maintenance and babysitting provided along the way.

Lastly, and importantly, I express my deepest thanks to my husband Gavin and to my daughters, Rachel, Aoibhinn, Kate, and Ciara, for their unconditional love, sacrifices, patience, understanding, support and encouragement over the last six years. You too have travelled this journey with me and made it possible. Love you!

Dedication

This thesis is dedicated to my wonderful Mam and Dad,
husband Gavin and beautiful daughters,
Rachel, Aoibhinn, Kate and Ciara.
Thank you for your love and support always.

Summary

Background: The presence of fetal movements (FMs) is regarded as an indicator of fetal wellbeing during pregnancy. Conversely, maternal perception of reduced fetal movements (RFM) is considered a potential sign of a fetus at risk of adverse perinatal outcomes, particularly stillbirth. Early detection of RFM is considered an opportunity for fetal health screening, thus current clinical guidance encourages women to contact the maternity hospital for any FM concerns. Preventing and reducing adverse outcomes can only be achieved through better detection and management of women with RFM. Pregnancy characteristics of women with RFM however vary across studies.

Aim: The thesis aim was to present an investigation of perinatal risk factors for, and pregnancy, birth and neonatal outcomes associated with RFM in pregnancy.

Methodology and Methods: A review of the existing literature was conducted to provide background information on FMs and RFM. A systematic review was also conducted to synthesise the evidence from non-randomised studies on perinatal risk factors for and pregnancy, birth and neonatal outcomes in women who presented with RFM. Subsequently, a case-control study, underpinned by a positivist philosophy, was chosen as the most appropriate research design to address the study aims and objectives in the context of maternity care in Ireland. Ethical approval was granted by the University and Hospital Research Ethics Committees. A prospective case-control study of women with a singleton pregnancy, presenting to the emergency department, of a large urban maternity hospital, with a primary complaint of RFM after 24 weeks' gestation (cases) between 1 January -30 September 2020 were compared with women who did not have RFM during pregnancy (controls). To provide up to date contemporary evidence on perinatal risk factors for and outcomes associated with RFM, the systematic review was updated to include the findings of the prospective case-control study.

Findings: The effectiveness of many strategies to raise awareness of FMs and improve detection of RFM remains inconclusive. Several maternal characteristics also impact on maternal perception of FMs, some of which can be classified as risk factors for RFM e.g., anterior placenta and obesity. Modifiable (smoking) and non-modifiable (ethnicity,

anterior placenta, and abnormalities of amniotic fluid) risk factors for RFM were identified in the systematic review. Variation in the reporting of risk factors deemed prominent in contemporary maternity care was emphasised. The association between RFM and stillbirth was almost 4-fold at increased risk, while babies born small for gestational age (SGA) were nearly two-fold. The case-control study compared 850 women who presented with RFM with 1743 women who did not present with RFM during the study period. The rate of women attending with RFM has nearly doubled in the last two decades. Women with RFM, were more likely to be younger than 35 years, nulliparous, have a higher mean body mass index and have an anterior positioned placenta. Women with a history of pregnancy after loss, specifically recurrent miscarriages or neonatal death were also more likely to attend with RFM during pregnancy. In contrast to the findings of the systematic review, RFM was not found to be associated with stillbirth, however, was associated with babies born SGA. Consistent with numerous studies, women with RFM were more likely to have induction of labour, although emergency caesarean section was not associated when other factors were included in the analysis. The updated systematic review identified risk factors for RFM as nulliparity, women with anterior placenta, assisted conception, a medical history of psychiatric illness and a previous history of neonatal death. African Black ethnic groups were less likely to attend for RFM than Asian/Chinese women, including women aged 35 years and over. The risk of stillbirth associated with RFM is declining, though potentially only in cases where women have increased awareness of FMs and RFM and is dependent on the timing of assessment for RFM and subsequent clinical management.

Conclusion: Knowledge of maternal characteristics associated with RFM could assist in identifying pregnancies at higher risk of adverse perinatal outcomes and aid decision making regarding need for further investigation when a woman presents with RFM during pregnancy. Contemporary evidence also signifies the groups of women that may require additional support through information and education on fetal movements. It also identifies that improvement in the detection of SGA during pregnancy is required.

Publications and Presentations Related to this Thesis

There have been several outputs from the research undertaken for this thesis to date, as listed below. These include oral and poster presentations at conferences both nationally and internationally and two peer-reviewed publications. I have published work aside from publications directly related to my PhD project, and these too are listed below.

Peer reviewed publications

Carroll L, Gallagher L, Smith V. (2022). Pregnancy, birth and neonatal outcomes associated with reduced fetal movements: A systematic review and meta-analysis of non-randomised studies. *Midwifery*, 116, 103524. doi:10.1016/j.midw.2022.103524

Carroll L, Gallagher L, Smith V. (2019) Risk factors for reduced fetal movements in pregnancy: A systematic review and meta-analysis.
European Journal Obstetrics & Gynaecology Reproductive Biology **243**,72-82. https://doi.org/10.1016/j.ejogrb.2019.09.028 0301-2115/

Presentations (Oral)

Carroll L, Byrne F, Canty G, Gallagher L, Smith V. (2022). A prospective case-control study of risk factors associated with reduced fetal movements during pregnancy. In *'Resilience, Rehabilitation and Reablement', Trinity Health and Education International Research Conference 2022 (THEconf2022)*. School of Nursing and Midwifery, Trinity College Dublin, 8-10 March 2022, Virtual.

Carroll L, Gallagher L, Smith V. (2020). A systematic review and meta-analysis of pregnancy, birth and neonatal outcomes associated with reduced fetal movements in pregnancy. In '*Integrated healthcare: developing person-centred health systems,' Trinity Health and Education International Research Conference 2020 (THEconf2020), '*School of Nursing and Midwifery, Trinity College Dublin, 4-5 March 2020.

Presentations (Posters)

Carroll L, Byrne F, Canty G, Gallagher L, Smith, V. (2022). The impact of COVID-19 on attendance for reduced fetal movements during pregnancy. In *'Resilience, Rehabilitation and Reablement', Trinity Health and Education International Research Conference 2022 (THEConf2022)*. School of Nursing and Midwifery, Trinity College Dublin, 8-10 March 2022, Virtual.

Carroll, L., Byrne, F., Canty, G., Gallagher, L., & Smith, V. (2022). Reduced fetal movements during pregnancy: an audit of pregnancy characteristics. *National Perinatal Epidemiology Centre Virtual Study Day,* 21 January 2022.

Carroll, L., Smith, V. & Gallagher., L. (2019). A systematic review and meta-analysis of risk factors for and outcomes associated with reduced fetal movements in pregnancy. *The International Stillbirth Alliance, Conference Proceedings of the 15th Annual Conference on Perinatal Mortality and Bereavement Care,* 5-6th October 2019, Madrid, Spain.

Carroll, L., Smith, V. and Gallagher, L. (2019) 'Risk factors associated with reduced fetal movements in pregnancy: A systematic review and meta-analysis'. *Trinity Health and Education International Research Conference (THEconf2019).* School of Nursing and Midwifery, Trinity College Dublin, 6-7 March 2019.

Additional non-thesis related publications published during my PhD

Carroll, L., Thompson, S., Coughlan, B., McCreery, T., Murphy, A., Doherty, J., O'Brien, D. (2022). 'Labour Hopscotch': Women's evaluation of using the steps during labor. *European Journal of Midwifery*, *6*(September), 1-10. doi:10.18332/ejm/152492

Kirwan, C., Szafranska, M., Coveney, K., Horton, S., & Carroll, L. (2022). Midwifery students' experiences of objective structured clinical examinations: A qualitative evidence synthesis. *Nurse Education Today*, *113*. doi:10.1016/j.nedt.2022.105381

O'Brien, D., Coughlan, B., Thompson, S., Carroll, L., Sheehy, L., Brosnan, M., Doherty, J. (2022). Exploring midwives' experiences of implementing the Labour Hopscotch Framework: A midwifery innovation. *European Journal of Midwifery*, 6, 18. doi:10.18332/ejm/146081

Curtin, M., Carroll, L., Szanfranska, M., & O'Brien, D. (2022). Embedding continuity of care into a midwifery curriculum in the Republic of Ireland: A historical context. *European Journal of Midwifery*, 6(April). doi:10.18332/ejm/146232

Carroll, L., Curtin, M., Greene, L. E., & O'Brien, D. (2021). Midwifery Lecturers' Reflections of Midwifery Education During Covid-19 in Ireland. *The Practising Midwife*, 24(7), 8-9.

Hardie, P., Darley, A., Carroll, L., Redmond, C., Campbell, A., & Jarvis, S. (2020). Nursing & Midwifery students' experience of immersive virtual reality storytelling: An evaluative study. *BMC Nursing*, *19*(1). doi:10.1186/s12912-020-00471-5

Carroll, L., Sheehy, L., Doherty, J., O'Brien, D., Brosnan, M., Cronin, M., Kirwan, C. (2020). Perineal management: Midwives' confidence and educational needs. *Midwifery*, *90*. doi:10.1016/j.midw.2020.102817

Table of Contents

List of Abbreviations

AFI	Amniotic Fluid Index
ANC	Antenatal Care
aOR	Adjusted odds ratio
APO	Adverse pregnancy outcome
BMI	Body mass index
CI	Confidence interval
CS	Caesarean Section
CTG	Cardiotocograph
EFW	Estimated fetal weight
FGR	Fetal growth restriction
FM	Fetal Movements
FMC	Fetal movement counting
Gest	Gestation
GROW	Gestation-related optimal weight
ICM	International Confederation of Midwives
LMP	Last menstrual period
MeSH	Medical Subject Headings
N/n	Number
NICE	National Institute of Clinical and Health Excellence
NICU	Neonatal intensive care unit
OR	Odds ratio
PhD	Doctor of Philosophy
PRISMA	Preferred Reporting Items for Systematic Review and Meta-Analyses
PTB	Preterm birth
RCOG	Royal College of Obstetricians and Gynaecologists
RCT	Randomised controlled trial

RFM	Reduced fetal movements
SB	Stillbirth
SFH	Symphysiofundal height
SGA	Small for gestational age
SVB	Spontaneous Vaginal Birth
UK	United Kingdom
USA	United States of America
USS	Ultrasound Scan
WHO	World Health Organisation

Glossary of Terms

Assisted conception	Use of fertility treatment to become pregnant
Birthweight	The first recorded weight of the baby following birth, usually performed in the first hour of birth.
Continuous variable	A variable that can take any value e.g., birthweight, BMI, age.
Dichotomous variable	A variable that can have two possible values e.g., yes/no, male/female
Estimated date of birth/delivery (EDD)	Estimated due date of the birth of the baby
Gestational age	Age of the pregnancy
Gravida	The number of times the woman has been pregnant regardless of outcome
Induction of labour	Use of artificial methods used to start labour
Meta-analysis	A statistical method used to merge findings of single independent studies to calculate an overall or absolute effect
Mode of birth	The method of which the baby was born -spontaneous vaginal birth, ventouse, forceps or caesarean section
Multiparous	A woman who has had at least one previous birth
Nulliparous	A woman who has not given birth to a live baby before
Odds ratio	A statistic that quantifies the strength of an association
Oligohydramnios	Decreased amniotic fluid volume for gestational age
Onset of labour	The method by which the process of labour began
Outcome	Study endpoints, measures chosen to assess the impact of the exposure (e.g., RFM)

Parity	The number of times a woman has given birth to a live neonate (any gestation) or at 24 weeks or more, regardless of whether the child was viable or non-viable (i.e., stillbirths).
Polyhydramnios	Increase of amniotic fluid volume during pregnancy
Pre-eclampsia	A hypertensive syndrome that occurs in pregnant women, most often after 20 weeks' gestation, which consists of new-onset, persistent hypertension with either proteinuria or evidence of systemic involvement.
Primiparous	A woman who has given birth once only
Risk factor	A risk factor is defined as any modifiable or non-modifiable characteristic that increases or decreases the likelihood of a woman experiencing RFM in pregnancy.
Systematic review	A systematic review of research which includes identifying, appraising and synthesising all of the empirical evidence that meets pre-specified eligibility criteria to answer specific research question
Trimester	a stage of pregnancy e.g., first trimester (conception to 12 completed weeks), second trimester (13 weeks to 27 weeks gestation), third trimester (28 weeks to birth of baby)

List of Figures

List of Tables

List of Appendices

Chapter 1 Introduction

1.1 Introduction to the topic

The purpose of antenatal care is to optimise maternal and fetal health by identifying factors that could potentially affect pregnancy outcome and plan care accordingly. This is achieved through the regular assessment and monitoring of maternal and fetal wellbeing during pregnancy. Assessing fetal movements (FMs) is one of the most commonly used methods to assess fetal wellbeing during pregnancy (Froen 2004). The presence of fetal activity is an indirect way of evaluating the integrity of the fetal musculoskeletal and central nervous system and has long been used as an indicator of fetal wellbeing (Berbey *et al.* 2001, Royal College of Obstetricians and Gynaecology 2011). A healthy and well fetus is usually active with physical movement when not in a period of rest or sleep. Fetal activity is one of the first signs of life perceived by pregnant women. Pregnant women are usually attentive of how their babies move in utero and serves as a reassuring sign for women and healthcare professionals (HCPs). FMs can be assessed subjectively by the mother or objectively using more formal assessment methods such as fetal movement counting (FMC), ultrasound and more recently advanced technological methods such as mobile applications and abdominal sensors recordings.

A report of reduction or sudden alteration in FMs is regarded as an 'alarming' clinical sign. Pregnant women intuitively interpret reduced fetal movements (RFM) as a worrying sign prompting them to seek further medical advice and/ or self-refer for assessment (Erlandsson *et al.* 2012, Smyth *et al.* 2016). Maternal perception of RFM has been reported in up to fifteen percent of pregnancies during the third trimester, leading to frequent unplanned hospital consultations (Tveit *et al.* 2009a). It is hypothesised that RFM is a fetal response to chronic oxygen consumption in an attempt to conserve energy (Lai *et al.* 2016). Associations have been found between RFM and adverse perinatal outcome such as stillbirth (Harrington *et al.* 1998, Tveit *et al.* 2009b). Other studies have found that that RFM is also linked with having a smaller baby at birth (small for gestational age-SGA) (Harrington *et al.* 1998, Sinha *et al.* 2007, Saastad *et al.* 2008, Stacey *et al.* 2011a), low Apgar scores at birth and neonatal intensive care unit admission

(Heazell & Froen 2008, Singh & Sidhu 2008). Early detection of RFM is therefore considered as an opportunity for fetal health screening.

1.2 Aim of thesis

The aim of this thesis is to present an investigation of perinatal risk factors for, and pregnancy, birth and neonatal outcomes associated with RFM in pregnancy. To achieve this aim, three discrete, yet complementary research activities were undertaken. These were:

1) a broad review of the literature on FMs and RFM in pregnancy.
2) systematic reviews to determine risks factors for and outcomes associated with RFM in pregnancy specifically, and
3) a case-control study to explore the risks factors for and outcomes associated with RFM in pregnancy in a cohort of women in Ireland.

1.3 Outline of thesis

This doctoral thesis, inclusive of this introductory chapter (Chapter 1), is organised into seven chapters. Chapter two examines the existing literature on FMs and RFM. Chapter three synthesises the evidence available, through systematic reviews, on risk factors for and pregnancy, birth and neonatal outcomes associated with RFM in pregnancy. In chapter four the methodological and philosophical underpinnings that were considered in planning and conducting this research study are presented. The chapter also describes the study's paradigm and design, including the rationale for choosing a quantitative case-control design. The study design and study methods are presented, and ethical considerations are described. Chapter five presents the findings of the case-control study. Chapter six is the discussion chapter. This chapter provides a synopsis of the key findings and explores these in the context of the case-control study's key findings with reference to existing literature. The chapter also incorporates an update of the systematic review and meta-analysis from Chapter three, to include the findings of the case-control study, and findings from additional studies published since undertaking the initial systematic review.

The strengths and limitations of the study are also acknowledged. Chapter seven presents the conclusion and recommendations arising from the research and summarises the contribution of the research in the broader context of maternity care, and care provision. A dissemination plan, a summary of my PhD journey and recommendations for further research and implications for education, professional practice and policy are provided.

1.4 Personal and Professional Motivation

Since qualifying as a midwife in 2000, I have gained 15 years' experience in the clinical setting, most of which was obtained on a labour and birthing unit in a large maternity hospital in Dublin, Ireland. I have additionally gained teaching and research experience, initially as a Clinical Tutor (2012), and subsequently as an Assistant Professor in Midwifery (2017) in a large Higher Education Institution in Dublin, Ireland. My interest in and motivation for my research studies on FMs stems from a real-life scenario which I encountered in my professional capacity. The scenario, outlined below (with pseudonyms used), is one I will likely never forget, and one which similarly may resonate with many other midwives engaged in clinical midwifery care:

> *Sally arrives with her partner Jeff to the labour ward. She is a primigravida, 41 weeks and 6 days gestation (I am gathering a pregnancy history). She had a scan done yesterday and all was well. She is delighted to be finally getting contractions and hopefully not have to be induced-she will finally meet her baby today. As part of orientating Sally to the ward and obtaining a pregnancy history, I ask her about her FMs-casually she says 'No, no movements today'…… My heart skips a beat… I walk faster with her to the labour room. I grab a fetal heart doptone. Sally doesn't seem to get onto the bed quick enough for me. I eventually find the baby's back upon abdominal palpation. I place the doptone over her abdomen….. no sound. I find another doptone, …again no sound. I know she can see the concerned look on my face. How will I tell Sally and Jeff that their baby has no heartbeat?*

As both a midwife and a mother of four daughters, each pregnancy was different in terms of 'feeling' fetal movements. My interest in the topic of fetal assessment, and especially fetal movements, has continued to grow since my Undergraduate days where I recall undertaking my BSc assignment on performing a cardiotocograph (CTG) on admission to the labour ward. Since taking up an Assistant Professor in Midwifery role in 2017, I have been encouraged, by senior colleagues, to pursue a Doctoral study, which I appreciated I would need to undertake part-time. Given my extensive interest on the topic of fetal assessment, I reached out to Professor Valerie Smith. Prof. Smith is a member (and now lead) of the School of Nursing and Midwifery, Trinity College Dublin's Maternal Health Research Theme, and I was aware she had undertaken studies in the area of fetal assessment, including FMs, previously. Thus began, in March 2017, my PhD journey. I feel privileged to have had the opportunity to undertake this programme of research over the past six years, the culmination of which is presented in this thesis.

Chapter 2 A review of the literature

2.1 Introduction

This chapter presents a review of the existing literature on FMs and RFM to provide background information on the topic of interest, the rationale for conducting a systematic review and the context in which the case-control study was designed.

2.2 A description of the literature review[1]

Sourcing existing literature began with a scoping search of publications by seminal authors, for example Froen and Heazell, and papers on FMs and RFM known to me, for example, publications by Grant *et al* (1989) and Mangesi *et al* (2015). This scoping search was completed using Google Scholar. These authors' names were also copied and pasted into the University Library search engine to find other publications by the same author and/co-authors. Initial reading of these retrieved articles provided familiarity with the language, text words and index terms commonly used in relation to my topic of interest. Alternative vocabulary and spellings were considered, and a thesaurus was used to identify synonyms for the key words, for example, fetal and foetal, movements and activity, decreased and reduced.

The search terms of *'fetal movement'* OR *'reduced fetal movement'* and their synonyms were then used to conduct a more thorough search in PubMED and CINAHL databases. Studies published in English were included and there were no limits on year of publication. To determine the informative relevance of the retrieved citations (approx. 2350 across all databases), the title and abstracts were first read, excluding those clearly not relevant. The full texts of the remaining records were then read, and those that appeared relevant to the literature review were saved in a dedicated folder. The reference lists of included papers were also searched for any additional potentially applicable studies. Dedicated folders were created in Google Drive and subsequently subfolders of topics and study design related to FM and RFM e.g., seminal articles,

[1] A search for relevant literature to inform this chapter (and consequently, my systematic review and research study) was initially undertaken in 2018. In preparation for completing this chapter and for purposes of Discussion (Chapter 6), I updated the search in Sept 2022.

maternal perception of FM, risk factors for and outcomes associated with RFM, case-control studies, RCTs. In addition, I created weekly alerts on key obstetric and midwifery journals to keep up to date, throughout the course of my PhD, with any new content or newly published studies on FMs or RFM. Overall, source information from 166 studies, reports, or guidelines, contributed to the review of the literature as presented in this chapter.

2.3 Identification and description of fetal movements

Women regard first FMs as one of the first signs of fetal life and pregnancy. Hippocrates (1923) as cited in Sadovsky (1981) believed that a fetus begins to move as early as 70-90 days after conception. Studies conducted in the 1970s, 80s and 90s using 2D ultrasound, describe and quantify the onset and development of FMs in the first trimester. Birnholz *et al.* (1978) and de Vries (1982, 1985) observed the onset of first fetal spontaneous FMs via ultrasound between 7.5 weeks to 10 weeks gestation. Fetal 'twitching', 'startles and hiccups' were observed between 8 to 10 weeks gestation, while independent limb (arm and leg) movements were observed from 10 weeks gestation. Various limbs, head, and torso movements were observed between 12- and 16-weeks' gestation (Birnholz *et al.* 1978). By 10 to 12 weeks, hand to face contact was observed along with fetal breathing movements, jaw opening and stretches. Fetal yawns and suck-swallow movements were observed between 12- and 15-weeks' gestation. Movements in the first trimester were described as frequent, jerky and chaotic with fetal inactivity lasting only between four and six minutes of a 60-minute ultrasound scan (de Vries *et al.* 1985, Kisilevsky & Low 1998).

In qualitative studies, different sentiments have been used by women to describe and express sensations of FMs during pregnancy at various stages of pregnancy. During the first trimester, early fetal sensations have been described by women as very soft, quick and repetitive movements*, 'flutters', 'butterflies', 'air', 'gas'* or *'bubbles popping'* (Raynes-Greenow *et al.* 2013, p. 3) or similar to a small *'knock', 'flick'* or *'jolt'* (Bradford & Maude 2018, p. e289).

The sensation of these early movements made the pregnancy '*seem real*' for women and initiated '*feelings of happiness*' (Bradford & Maude 2018, p. e289). FMs in early pregnancy were also described as infrequent and sporadic, with some women reporting long periods of not feeling movements following their initial recognition (Bradford & Maude 2018). This contrasts directly with ultrasound-based observations of FMs during the first trimester. However, this may be explained by the fact that the baby is so small at this point; there is not yet direct contact between fetal limbs and the maternal abdominal wall; therefore, the woman may not detect the FMs even if occurring, whereas ultrasound is a real-time visual assessment.

During the second trimester of pregnancy, ultrasound studies demonstrate that FMs change in terms of quantity and quality. Natale *et al.* (1985) reported a significant reduction ($p<0.05$) in the mean number of FMs, and the percentage of time the fetuses moved ($p<0.01$) between 24- and 32-weeks' gestation. Using 24-hour ultrasound, Nasello-Paterson *et al.* (1988) observed FMs in 10 women with normal pregnancies who were between 24- and 26-weeks' gestation and 10 women who were between 26 and 28 weeks' gestation. The percentage of time that the fetus spent moving in each group was similar, but the mean number of FMs per hour was significantly higher in the 24-to-26-week group compared to the 26-to-28-week group ($p<0.005$). Some studies report a plateau or decrease in the frequency of FMs during the second trimester (Natale *et al.* 1985, de Vries *et al.* 1988), while other studies do not (Patrick *et al.* 1982, Roodenburg *et al.* 1991). More recent studies using 4D ultrasound demonstrated that during the second trimester fetal activity increases, while in the third trimester, the number of FMs decline and periods of rest increase in frequency (Kurjak *et al.* 2005, Yigiter & Kavak 2006, Lebit & Vladareanu 2011, Sajapala *et al.* 2017).

Available evidence also provides conflicting information on the frequency of FMs in the third trimester. Some ultrasound studies report decreasing frequency of FMs in the third trimester. D'Elia *et al.* (2001) studied 15 women with normal pregnancies for 60 minutes, and observed a decrease in gross fetal body movements but an increase in the interval between the FMs. Roodenburg *et al.* (1991) also observed that the percentage of time that the fetus moved decreased with advancing age, from 24% at 20 weeks gestation to

11% at 36 weeks gestation, and the frequency of general movements decreased significantly between 20- and 36-weeks' gestation ($p<0.01$). In contrast, Roberts *et al.* (1980) recorded FMs using real time ultrasound in 100 normal pregnancies between 28 weeks' and term gestation, and reported that the mean number of fetal trunk movements per 30 minute observation period was inversely related to gestational age, whereas the mean duration of movements was seen to increase towards term gestation. Patrick *et al.* (1982) conducted 24-hour observations of FMs in 31 women in the last 10 weeks of pregnancy, 9 women at 30-31 weeks, 11 women at 34-35 weeks and 11 women at 38-39 weeks, also reporting that the mean number of gross FMs and the percentage of time the fetus moved did not vary between gestational age groups. Differences in findings could be due to several factors, such as the inability to visualise the entire fetus as the pregnancy advances and the fetus grows, with weaker FMs going undetected on observations, periods of fetal inactivity and rest and activity being prolonged as gestation advances, diurnal pattern, inter-intra individual variability and quality in ultrasound scanning or varying definitions by practitioners as to what constitutes a single fetal movement. The advent of using magnetic resonance imaging (MRI) has improved the detection of FM and contributed further information to the understanding of FMs at term gestations. Unlike ultrasound, MR imaging permits complete view of the whole fetus.

Hayat *et al.* (2011) measured volumes of fetal and free space occupied within the uterus, concluding that the ratio of fetal to free-uterine space doubled between 18- and 37-weeks' gestation. In a subset of 24 fetuses, a significant correlation was found also between decreased frequency of FM and increased volume of fetal occupancy of the uterus (r -0.703, $p=0.001$). This suggests that as space in the uterus becomes confined, FMs may be more constricted and therefore FM sensations change.

Fetal movement counting (FMC) studies conducted nearly 50 years ago also demonstrated that the frequency of FMs decreases towards term gestation. Sadovsky & Yaffe (1973) reported that daily FMs increase from 18 weeks gestation, reaching a maximum between 29 and 38 weeks of pregnancy, and then reduce before birth. Pearson & Weaver (1976) recorded the number of FMs occurring daily between

09.00am and 09.00pm in sixty-one women with uncomplicated pregnancies from 32 weeks' gestation until birth. A median of 90 FMs per 12 hours were recorded at 32 weeks' gestation while this number reduced to 50 per 12 hours by 40 weeks' gestation. Only 2.5% of these participants reported less than 10 movements in 12 hours. Rayburn (1990) suggests that the perceived decline in FMs in the third trimester is due to improved fetal coordination, reduced amniotic fluid volume and increased fetal size. Notably ultrasound, MRI and FMC studies are methods used to quantify the frequency of FMs rather than the quality or strength of FMs. Qualitative descriptions of maternal perception of FMs provide further information of the quality of FMs at term.

As the pregnancy advances into the third trimester, qualitative reports from women describe visible movement of their baby's limbs moving under the skin and feeling movements when their hands are placed on their abdomens (Bradford & Maude 2018). Women between 28-32 weeks' gestation described fetal activity as '*wriggling',' pressing', or 'tickling'*. Vigorous movements were described as '*rolling', 'kicking', 'flip-flopping', 'tumbling', 'turning', 'swooping', 'pumping'* and *'somersaulting'* (Bradford & Maude 2018, p. 288*).* A cross-sectional survey of 156 women at more than 28 weeks of pregnancy reported a progression of fetal movement quality with advancing gestation from '*gentle*' to '*strong*' and in actions from '*limb*' to '*whole body'* movements (Raynes-Greenow *et al.* 2013, p.4). In other qualitative studies, women described FMs as '*becoming stronger*', '*slower*' including '*whole body movements'* such as '*stretching*', '*wriggling*' and '*rolling*' (Radestad & Lindgren 2012, Malm *et al.* 2014, Bradford & Maude 2018). Furthermore, women were more likely to use the term '*movement*' rather than '*kick*' when describing FMs towards the end of pregnancy (Radestad & Lindgren 2012) indicating that although fewer '*kicks*' were experienced at term, an increase in FM strength and whole-body movements were felt (Radestad & Lindgren 2012, Raynes-Greenow *et al.* 2013, Bradford & Maude 2018). In this sense, these qualitative studies provide evidence that the pattern and quality of FMs experienced by women changes as pregnancy advances towards term gestation.

2.4 Reduced fetal movements

First descriptions and interest in RFM as an *alarm signal* for fetal risk began in the 1970's, with the publication of two papers. Sadovsky & Yaffe (1973) in a case series of six hospitalised women, observed in two women that FMs decreased or ceased before intrauterine fetal death. An observational study of 61 women, by Pearson & Weaver (1976) corroborated these findings and proposed that a '*movement alarm signal*' of fewer than 10 movements in 12 hours could be used to monitor higher risk pregnancies. A number of studies have since attempted to apply alarm limits for the minimum number of FMs perceived in a given time period; ranging from as many as 10 movements in two hours (Moore and Piacquadio, 1989) to as few as 12 movements in 24 hours (Pearson and Weaver, 1976; Sadovsky *et al.*, 1983) or absence of movements for 24 hours (Leader *et al.* 1981) (Table 2.1).

Table 2.1 Varying definitions of RFM in the literature

• RFM for < 2 consecutive hours
• A day of no FMs or 2 successive days in week
• < 3 FM per hour
• Total absence
• < 4 FM per hour
• ≤ 10 FM in 12hours
• at least 2 hours of RFM in the previous 12 hours
• <four movements/hr for 2 consecutive hrs
• < five FMs/day for 2 consecutive days

RFM is a common concern for pregnant women, causing anxiety that the baby is unwell or has died (Erlandsson *et al.* 2012, Smyth *et al.* 2016). Up to 40% of pregnant women express concern about FMs at least once during the pregnancy (Saastad *et al.* 2012). Failure to reach a consensus on the definition of RFM contributes to the confusion regarding pregnant women receiving appropriate antenatal advice for women regarding FMs (Heazell *et al.* 2008; Flenady *et al.* 2009) and may subsequently lead to women misunderstanding when to present with concerns for FMs. Consequently, this may affect the timing in which women could receive timely intervention or expedited birth in an effort to avoid an adverse outcome such as stillbirth.

2.4.1. Adverse consequences associated with reduced fetal movements

2.4.1.1. Stillbirth

RFM is associated with adverse fetal outcomes such as stillbirth. A stillbirth (SB) or stillborn infant is the death of a potentially viable baby before or during birth and born without signs of life. The definition of stillbirth varies between countries with gestation limits ranging from 20 weeks in the USA (Gregory *et al.* 2022) to 28 weeks by the World Health Organisation (WHO) (Lawn *et al.* 2016), and birth weight ranging from 500 grams to 1000 grams. In Ireland, the definition of a stillbirth is a baby born without signs of life at ≥24 weeks gestation or with a birthweight greater than 500 grams (Government of Ireland 1994). Although many researchers use the WHO definition of stillbirth, the lack of global agreement on the definition of stillbirth remains challenging, leading to discrepancies when comparing rates around the world.

Notwithstanding advances in maternity care, stillbirth rates vary worldwide. Globally, there are approximately 2.6 million stillbirths each year, from more than 40 per 1,000 births in low-income countries such Pakistan, Ethiopia and India, to less than 2 per 1,000 births in high income countries such as Iceland and Denmark (Hug *et al.* 2021). A Confidential Enquiry into Stillbirths and Deaths in Infancy conducted in the UK in 2017, indicated that 16% of all stillbirths were preceded by a maternal perception of RFMs (Heazell & Evans 2017). Of the 78 women who had an intrapartum related perinatal death, over a quarter of women (n=22) had attended with RFM, culminating in 17 stillbirths and five neonatal deaths. The management of RFM was notably substandard in a third of these cases (Heazell & Evans 2017). Maternity care around detection and management of women with RFM was highlighted in the report as one of the areas for improvement.

Ireland's stillbirth rate compares favourably when examined alongside 48 countries in a Lancet Series publication on stillbirth in high income countries (Flenady *et al.* 2016) and has one of the lowest stillbirth rates when compared with other European countries (Gissler *et al.* 2022). The most recent published statistics show that in 2020, of the 57,114 births in Ireland, there were 240 stillbirths (San Lazaro Campillo *et al.* 2022). This equates to a stillbirth rate of 4.2 per 1,000 with nearly a third of stillbirths occurring at term

gestation (San Lazaro Campillo *et al.* 2022). The causes of stillbirths in Ireland, identified retrospectively following post-mortem have remained constant over the past decade. Major congenital anomaly and specific placental conditions accounted for approximately 63% of all stillbirths in 2020. The remaining 37% were attributed to causes such as antepartum or intrapartum haemorrhage (5.4%), mechanical (7.9%), infection (4.2%), specific fetal conditions (5.4%), while for nearly 11% of stillbirths the cause of death was unexplained (San Lazaro Campillo *et al.* 2022). In Ireland, perinatal deaths are audited each year by the National Perinatal Epidemiology Centre (NPEC) (www.npec.ie), however the establishment of a national confidential review for stillbirth and neonatal deaths similar to that occurs in the UK (MBRRACE-UK Perinatal Mortality Surveillance Report)[2], could assist in identifying areas for improvement of maternity care locally and nationally (McNamara *et al.* 2018, San Lazaro Campillo *et al.* 2022).

The loss of any pregnancy through miscarriage, ectopic pregnancy, stillbirth, or neonatal death is a significant event for any woman or parent. Research has shown that the death and loss of a baby can not only have long-lasting physical and psychological impacts for bereaved parents but can also potentially have emotional and economic effects on healthcare professionals and wider society (Nuzum *et al.* 2014, Heazell *et al.* 2016, Nuzum *et al.* 2018b, Murphy *et al.* 2021). Pregnancies after loss are at increased risk of complications such as adverse maternal and perinatal outcomes including preeclampsia, operative birth, preterm birth and subsequent pregnancy loss (Bhattacharya *et al.* 2010, Lamont *et al.* 2022). The risk of subsequent stillbirth is estimated to increase nearly fivefold among women with a previous stillbirth, irrespective of the presence of risk factors (Lamont *et al.* 2015). A systematic review and meta-summary of 144 articles from 15 different countries demonstrates that pregnancy after stillbirth also presents the potential of psychological harm for women, partners and the wider family including increased rates of anxiety, depression, disenfranchised grief, social phobia and post-traumatic stress (Burden *et al.* 2016). A systematic review of 20 studies also found that the psychological and professional impact of stillbirth on healthcare professionals varied

[2] The MBRRACE-UK (Mothers and Babies Reducing Risk through Audit and Confidential Enquiries across the United Kingdom) conducts surveillance and confidential enquiries, whereby the causes of maternal deaths, stillbirths and infant deaths are independently examined by an expert panel of the care provided and a report is produced highlighting learning points.

from guilt, anger, blame, anxiety, sadness and blame to fear of litigation, disciplinary action and public humiliation (Heazell *et al.* 2016b). Gold *et al.* (2008) also reported that nearly 10% of obstetricians in the United States considered giving up their profession following the impact of stillbirth. Data on the impact of stillbirth to wider society is sparse and most economic analyses focus on the cost of stillbirth prevention (Heazell *et al.* 2016b). There are however direct (such as investigations into the cause of death, health-care costs in a subsequent pregnancy after stillbirth due to increase maternal and fetal surveillance) and indirect costs (such as funeral, associated reduced earnings from employment due to reduced working hours, medical costs of counselling) associated with stillbirth (Heazell *et al.* 2016b).

In 2011, in a Lancet Stillbirth series (https://www.thelancet.com/series/stillbirth), the detection and management of RFM was identified as one of the top 10 key research priorities for the prevention and management of stillbirth (Flenady *et al.* 2011b). RFM or the absence of movements has long been regarded as a potential sign of impending fetal compromise or fetal death. The Auckland Stillbirth Study, for example, found that women who had experienced a stillbirth were twice as likely to report a reduction in the strength and frequency of FMs in the weeks preceding than women with ongoing pregnancies (Stacey *et al.* 2011a). Inversely, in the same study increased strength of movements was reported by 36% of women with ongoing pregnancies compared to 14.6% of women who had experienced a late stillbirth (Stacey *et al.* 2011a). Similar associations between RFM in the final two weeks of pregnancy and stillbirth were also found in three other large case-control studies conducted internationally (40% stillbirths vs 8.4% controls, aOR 14.1, 95% CI 7.27-27.45, $p<0.0001$), in New Zealand (aOR 0.20, 95% CI 0.12-0.35) (Bradford *et al.* 2018a) and the UK (aOR 4.51, 95% CI 2.38-8.55) (Heazell *et al.* 2018b).

Qualitative studies (or qualitative data collected as part of surveys) describe instances where parents suspected that the baby was not well before being told their baby had died. In an online survey of 614 Swedish women who had experienced stillbirth, nearly half of the women (n=393) described having premonitions and intuitively '*just knowing*' that their '*unborn baby might be unwell*' following discerning changes in fetal activity

(Erlandsson *et al.* 2012, p. 31). Warland *et al.* (2018, p. 173) in an international internet survey involving over 1700 women who experienced late stillbirth, also reported that the majority of women perceived changes in FMs and described a '*gut instinct*' or an intensive feeling and suspicion that something was wrong. In addition, Malm *et al.* (2010) conducted interviews with 26 women who gave birth to a stillborn baby in Sweden. Women in this study described strong emotions of not feeling in touch with their baby, worry, and having strong suspicions that something was wrong and that their baby had died. These retrospective qualitative and quantitative accounts of women who have experienced a stillbirth are a source of information for developing an understanding of the changes in FMs that may occur prior to stillbirth and signify that any change in maternal perception of the FM pattern (strength and frequency) or premonition/instinct that something is wrong could be an important clinical marker for an impending adverse outcome.

2.4.1.2. Small for gestational age

Perinatal audits identify non detection of small for gestational age (SGA) as a substandard care factor involved in stillbirths (O'Farrell *et al.* 2021, San Lazaro Campillo *et al.* 2022). Numerous studies also demonstrate that pregnancies with undetected SGA during pregnancy have a higher risk of stillbirth when compared with pregnancies where SGA was detected antenatally (Stacey *et al.* 2012, Verlijsdonk *et al.* 2012, Gardosi *et al.* 2013, Aviram *et al.* 2015, Sterpu *et al.* 2020). Identifying pregnancies at risk of SGA has thus become a leading strategy to reduce the incidence of stillbirth (Flenady *et al.* 2011). SGA at birth refers to babies born smaller in size than normal for their gestational age, most commonly defined as a birthweight below the 10th percentile for gestational age (Royal College of Obstetricians and Gynaecologists 2014). It is widely reported however that only 10% to 36% of pregnancies with infants born SGA, have SGA detected antenatally (Fratelli *et al.* 2013, Aviram *et al.* 2015).

SGA detected antenatally is commonly described and defined using interchangeable terms such as SGA and fetal growth restriction (FGR). FGR however is not synonymous with SGA (Bullough *et al.* 2021). About two thirds of fetuses may be constitutionally small where fetal growth is relative to maternal size and ethnicity and will usually have

good neonatal outcomes. During pregnancy these fetuses are commonly referred to as SGA, defined as estimated fetal weight (EFW) or birth weight below the 10th centile (Lees *et al.* 2020, Bullough *et al.* 2021). The other third of fetuses may however be pathologically growth restricted, described as FGR, intrauterine growth restriction (IUGR) or severe SGA and at increased risk of poor neonatal outcomes. FGR is defined as EFW less than the 3rd centile (Lees *et al.* 2020, Bullough *et al.* 2021). While EFW can be calculated by ultrasound, using biometric measurements of fetal head circumference (HC), abdominal circumference (AC) and femur length (FL), fetal growth can only be determined using sequential ultrasound scans. Studies consistently report that women who attend with RFM during pregnancy are at increased risk of SGA at birth.

In a retrospective descriptive study of 92 women presenting with RFM during pregnancy, Heazell *et al.* (2005) reported that nearly one third (29.1%) of babies of these pregnancies were SGA at birth. Similar findings were found by Daly *et al.* (2011) in an Irish study. Caution is required, however, in interpreting these findings due to small sample sizes and the retrospective non-comparative research methods used in these studies. Findings from prospective cohort studies comparing women with RFM with women without RFM however concur. Valentin & Marsal (1987) in a prospective fetal movement counting cohort study of 1914 women in Sweden found that babies of women who presented with RFM were significantly more likely to be SGA at birth (3.8% v 1.4%, $p<0.05$). Holm Tveit *et al.* (2009) also prospectively studied 2374 women with RFM and 614 women without RFM and found an increased risk of SGA associated with RFM (aOR 1.6 95% CI 1.1-2.2, p=0.01). O'Sullivan *et al.* (2009) and Scala *et al.* (2015) also report increased proportions of SGA babies born to women who had multiple episodes of RFM during pregnancy. Binder *et al.* (2018) found that RFM was associated with SGA but there was no proportional difference in the incidence of SGA between pregnancies with single or recurrent episodes of RFM. It is suggested that the link between RFM, SGA/FGR and stillbirth is placental insufficiency, where ongoing decreased placental function leads to a deficiency in oxygen and nutrients resulting in reduced fetal growth, RFM and subsequent intrauterine death (Warrander *et al.* 2012). To date though, ultrasound observational studies have not fully clarified that FGR is associated with RFM.

Some ultrasound studies have shown that growth restricted fetuses move less than appropriately grown fetuses (Mor-Yosef *et al.* 1983, Bekedam *et al.* 1985).

In contrast D'Elia *et al.* (1998) and Sival *et al.* (1992) reported no quantitative differences in gross movements when FGR fetuses were compared with normal-sized fetuses. Differences in findings could be attributed to the length of observation used in studies. The majority of studies observed fetuses for one hour. The fetus usually has a rest-activity cycle therefore, counting the number of FMs could lead to inaccuracies if the length of observation time is insufficient. Nevertheless, listening and responding to maternal concern of RFM could provide a window of opportunity for clinicians to identify and detect a SGA fetus, timely manage and reduce the risk of stillbirth. Research has shown though that women sometimes delay presenting to the maternity hospital or to a healthcare professional with RFM.

2.4.2. Reporting reduced fetal movements

Tveit et al (2009), in their case control study involving 2374 pregnant women, found that 25% of women who perceived an absence of FMs waited more than 24 hours before consulting their maternity care provider, while 54% of women with RFMs waited longer than 48 hours. O'Sullivan *et al.* (2009) also found that the duration of perceived RFM ranged from 12 hours to >72 hours, with concerningly, 35% waiting > 72 hours before presentation. A population study conducted in Japan of 66 stillbirths also found that only 11% presented with RFM within 24 hours, 23% between 24–48 hours and 17% between 48–72 hours. This study also noted that 8% visited more than 72 hours after their perception of RFM (Koshida *et al.* 2017). Ominously, only 54% of 304 women in a Canadian study reported that they would seek advice if they perceived a reduction in FMs (Berndl *et al.* 2013). Prompt reporting of perceived RFM can prevent, through timely intervention or expedited birth, adverse consequences, including stillbirth. To address this, an understanding of why women delay in reporting RFMs or in seeking advice is required.

2.4.2.1. Factors associated with delay in presenting with RFM

There are multiple reasons reported in the literature for why women perceiving RFMs delay in presenting for assessment to hospital. These include receiving misleading information or even no information about FM's during pregnancy, or sourcing incorrect information from family, friends or the internet (Smyth *et al.* 2016). One such example of misinformation is that it is normal for FMs to become reduced at the end of pregnancy or at the onset of labour (Radestad 2010, Berndl *et al.* 2013). Up to 20 internet sites were also found informing women that reduced FMs after 28 weeks' gestation is normal (Farrant & Heazell 2016). Other reasons for not presenting or for delayed presentation with RFM, as explained by women include not wanting to burden or waste health professionals time unnecessarily, fear of being perceived as excessively worried, not being taken seriously, receiving a negative response, or fears that their baby has died (Erlandsson *et al.* 2012, Georgsson *et al.* 2016, Linde *et al.* 2017b, Pollock *et al.* 2020). The lack of consensus on a RFM definition amongst international guidelines may contribute to why women often receive conflicting advice or inadequate information. It is also reported that some women avoid reporting RFM to avoid interventions such as induction of labour that could prevent a desired physiological birth (Smyth *et al.* 2016). Contrary to this though, clinicians have expressed suspicion that some women report FM concerns when they have none with the aim of accessing an ultrasound scan or induction of labour (Heazell *et al.* 2008, Walker & Thornton 2018, Chan *et al.* 2021, Clark 2021).

When concerned about FMs women often consult a range of sources for information about FMs including family and friends, the internet and written sources (McArdle *et al.* 2015, Smyth *et al.* 2016, Pollock *et al.* 2020). Smyth *et al* (2016) interviewed 21 women who had experienced RFM. All women reported observing their FMs and associated them with fetal well-being. Any unusual changes in FMs were associated with concern for their baby's wellbeing. In contrast, a minority of women in Pollock *et al.* (2020) study reported that it was 'normal that babies slow down or run out of room at the end of pregnancy' (n = 21). Concerningly, a 'reduction' of FMs was thought to be 'normal' and perhaps even ignored. Several studies also report that, prior to seeking professional help, women use a range of methods to stimulate and prompt FMs such as drinking cold,

caffeinated or sugary drinks, light and noise or lightly stroking or prodding the abdomen (Raynes-Greenow *et al.* 2013, Linde *et al.* 2016, Smyth *et al.* 2016, Pollock *et al.* 2020). When women did contact with a healthcare professional with FM concerns, women often received inappropriate advice. Warland & Glover (2017) reported that over a third of midwives (39%) advised women with RFM to drink a cold or sugary drink before requesting them to present to the hospital for assessment, despite an evidence-base to the contrary (Druzin & Foodim 1986, McCarthy & Narrigan 1995, Michaan *et al.* 2016). This clearly demonstrates that inconsistent advice and information is being provided to pregnant women by healthcare professionals worldwide, another possible factor in why women delay reporting RFM.

In addition to misleading or inaccurate advice, studies have also found that between 30-60% of women do not recall receiving information about FM during their pregnancy from their maternity care provider (Saastad *et al.* 2008, Berndl *et al.* 2013, McArdle *et al.* 2015). This contravenes evidence that women want to be more informed about FMs from their first pregnancy appointment and wish to receive further specific questioning about their baby's movements from their healthcare provider (McArdle *et al.* 2015, Pollock *et al.* 2020). A contributory issue here could be the wide variation in knowledge, information sharing and practice amongst midwives and obstetricians relating to women with RFM. Five surveys (summarised in Table 2.2), that elucidated information on midwives and obstetricians' knowledge, and practices for the detection and management of women with RFM, were identified.

Four out of the five surveys unanimously reported that midwives and obstetricians considered enquiry about FMs to be part of routine antenatal care. It is unclear however as to the extent of the information and advice provided routinely to women about FMs, as this question was not explicitly asked within the surveys.

Midwives were more likely to enquire about FMs at earlier gestations such as 28-32 weeks' gestation (Heazell *et al.* 2008) while both midwives and obstetricians certainly enquired about FMs at term gestations (Heazell *et al.* 2008, Flenady *et al.* 2009). Despite FMC not being supported by high quality evidence, midwives and obstetricians in the UK, Australia and New Zealand still described RFM with time limits as either maternal

perception of RFM for 12-24 hours (Heazell *et al.* 2008, Flenady *et al.* 2009, Warland & Glover 2017) or <10 movements over a 12 hour period for two days (Peacock *et al.* 2013) whereas midwives and obstetricians in Ireland tended to rely on <10 movements in 12 hours (Smith *et al.* 2014b). Even within countries, in different regions and maternity units, different alarm limits and definitions of RFM are used.

Table 2.2 Studies reporting on HCPs detection and management of RFM

Lead Author	Year	Country	Participants	n	Data Collection Method
Heazell	2008	UK	Midwives & Obstetricians	223 (94 midwives & 124 obstetricians)	Postal survey
Flenady	2009	Australia & New Zealand	Obstetricians	805	Postal survey
Peacock	2009	Australia & New Zealand	Midwives	206	Web-based survey
Smith	2014b	Ireland	Midwives & Obstetricians	midwives n=57 obstetricians n=136	Postal survey
Warland	2017	South Australia	Midwives	85	Paper survey

Not only is this confusing for women, (Raynes-Greenow *et al.* 2013, Smyth *et al.* 2016, Warland & Glover 2017), but also for maternity HCPs who might be mobile between maternity units within countries or move to different countries to practice.

2.5 Methods for assessing fetal movements

Methods for assessing FMs in pregnancy are varied and include subjective maternal perception of FMs, as well as alternative methods which use a variety of objective approaches (e.g., fetal movement charts) for more formal recording, monitoring and increasing awareness of FMs and RFM.

2.5.1. Maternal perception of fetal movements

Maternal perception of FMs refers to the sensation of movements that a pregnant woman feels during pregnancy. It is one of the oldest and most widely used method for monitoring fetal wellbeing. It does not require specialised equipment and can be performed at any time of the day by the mother in any setting. In qualitative studies, the majority of women expressed positive emotional responses to the experience of FMs describing them as '*a good thing*', '*enjoying them*', '*a way of bonding*' (Raynes-Greenow *et al.* 2013, Bradford & Maude 2018), although in contrast some women expressed FMs as '*irritating*' especially if the baby was moving continuously (Raynes-Greenow *et al.* 2013). In cross sectional surveys conducted in Norway and Canada, 99% of women considered FMs to be indicative of fetal well-being (Saastad *et al.* 2008), found it easy to feel FMs and that it was important to feel FMs (Berndl *et al.* 2013). Malm *et al.* (2016), in a prospective population-based survey of 456 women in Sweden, also found that those who perceived frequent FMs on several occasions had higher scores of prenatal attachment.

Studies that have investigated the correlation between maternal perception of FMs and fetal movements simultaneously identified on ultrasound scans, show wide variation. Some studies report a correlation of between 33% and 66% agreement (Hertogs *et al.* 1979, Hijazi *et al.* 2010); while some women perceived more than 80% of movements and others as few as 2% (Brown *et al.* 2016). This indicates that FMs are complex; stronger movements may be easier to feel, while other factors may influence maternal perception (Brown *et al.* 2016).

2.5.1.1. Factors influencing maternal perception of fetal movements

Research suggests that maternal perception of FMs may be influenced by physical, pregnancy and social factors. These include, although not necessarily limited to gestational age, parity, time of day, hunger, mealtimes, maternal position, external stimuli and obesity. This section will tease out some of the physical, pregnancy and social factors that may influence maternal perception of FMs.

2.5.1.1.1. Gestational age and parity

The relationship between gestational age, parity and FMs has been investigated over the last forty years with varying conclusions. A cross sectional survey of 156 pregnant women conducted in Australia found that the mean gestation for women to first perceive FMs was 19 weeks (Raynes-Greenow *et al.* 2013). This was confirmed in a more recent online survey of 428 women by Pollock *et al.* (2020). In an earlier study of 112 women, Gillieson *et al.* (1984) found that parous women could identify FMs earlier than nulliparous women (mean 17 weeks versus 19 weeks), however the authors also found that other factors such as placental location can influence the timing of when women first feel FMs.

Studies comparing nulliparous to multiparous women's maternal perception of fetal activity using real-time ultrasound have contrasting results. Schmidt *et al.* (1984) observed 31 nulliparous women and 19 multiparous women between 31- and 40-weeks' gestation and found that multiparous women perceived a higher rate of FMs than nulliparas women ($p < 0.001$). Conversely, a number of other ultrasound studies have reported no association between parity and maternal perception of FMs (Hertogs *et al.* 1979, Neldam 1982, Brown *et al.* 2016). Although multiparous women seem to be able to perceive FMs earlier in pregnancy than nulliparous women, there is no further evidence available that parity impacts maternal perception of FM later in pregnancy.

2.5.1.1.2. Time of day

Findings are consistent in the literature that FMs tend to have a circadian pattern. There is considerable evidence from ultrasound studies conducted in the 1970's and 1980's that FMs were greater in the evening than in the morning time (Spellacy *et al.* 1977, Wood *et al.* 1977). For example, Roberts and colleagues (1979) and Patrick *et al.* (1982) recorded FMs in 21 and 31 women respectively, between 28- and 39-weeks' gestation continuously over a 24-hour period, with each study reporting a peak in fetal trunk movements between 22:00 and 01:00 hours. Ehrström (1984) also evaluated the frequency of perceived FMs during the day and at night in 116 women with healthy pregnancies between 31- and 40-weeks' gestation. A distinct diurnal pattern of FMs with maximum fetal activity in the evening between the hours of 9pm and 10pm and minimal

activity between 1am and 5am was observed. More recent international qualitative and cross-sectional studies also confirm that most pregnant women perceive stronger or moderate FMs in the evening and night-time (Fisher 1999, Raynes-Greenow *et al.* 2013, Malm *et al.* 2016, Bradford & Maude 2018, Bradford *et al.* 2019).

Interviews conducted at two time points, at early (28–32 weeks) and late (37–41 weeks) gestations, with 19 women who had an uncomplicated first pregnancy in New Zealand, concluded that all participants reported increased FMs in the afternoon or evening (Bradford & Maude 2018). A cross sectional survey of 274 women across seven regions in New Zealand also found a clear diurnal pattern with women reporting an increasing likelihood of strong FMs as the day advanced. Twenty two percent of women reported strong movements upon wakening in the morning, which increased to 74.5% by night-time (Bradford *et al.* 2019). Raynes-Greenhow et al (2013) in a cross-sectional survey of 156 women in Australia found that there was an upward trend of FM perception throughout the day, however this peaked in the evening and during the night. In a survey of 78 women attending antenatal care in the UK, 73% of women reported that greatest activity occurred during 'nocturnal' periods of the evening, bedtime and early morning, with only 27% reporting greatest activity during the daytime (Fisher 1999). Notably more than half or all participants in each of these studies were primigravida and more than half in each study were in employment. It could be assumed that women are maybe more attentive therefore to FMs in the evening time than during the day because they are busy with other activities such as work or other children. Minors & Waterhouse (1979) reported that FM perception was correlated with maternal sitting or lying position, with most FMs occurring in the evening, and when the mother was in a sitting position. The intention of these studies was to provide descriptive accounts of FMs perceived by women during pregnancy, therefore it is also probable that these descriptions are true for some women but maybe not all as each woman and baby are different.

Importantly however, studies have found that fetal quiescence in the evening time is associated with adverse perinatal outcomes. A before-and-after study that evaluated focused fetal movement counting (FMC) in the evenings between 7pm and 11pm whilst

women were resting on their left side found a significant reduction in stillbirths from 44 to 10 per 1000 (Moore & Piacquadio 1989). Inversely, a multi- centre case-control study of 733 participants in New Zealand found a more than threefold increase in stillbirth in women who reported RFM in the evening time (aOR3.41, 95% CI 1.34-8.72) (Bradford & Maude 2018). Diurnal perceptions of FMs, and changes in these, may therefore play an important role in assessing the health of a fetus, or importantly, may provide an indicator of potential impending compromise.

2.5.1.1.3. Food and Nutrition

When a person eats food, it is digested by the stomach and small intestine and absorbed into the bloodstream as glucose. In qualitative and cross-sectional studies, women have described and reported experiencing increased fetal activity before, during and after mealtimes (Raynes-Greenow *et al.* 2013, Bradford & Maude 2018, Bradford *et al.* 2019), and associating this with hunger (Bradford & Maude 2014). The authors offer a possible explanation that it may be a baby's way of communicating a need for food or an appreciation after eating (Bradford & Maude 2014). A cross-sectional survey of 156 women found that 12% of women associated consumption of food, especially an evening meal or feeling hungry with a perceived increase in FMs (Raynes-Greenow *et al.* 2013). Bradford *et al.* (2019, p.7) reported that '*quiet*' FMs were commonly perceived by women before and after meals. However, compared to '*before meals'* there was an increase in the strength of FMs '*within fifteen minutes of eating'* ($p<0.001$) and '*an hour after eating*' ($p<0.001$). Quantitative studies examining the influence of maternal glucose on fetal activity have reported conflicting results. Small quantitative studies (n=20 and 21 respectively) conducted between 1970s and 1990s (Miller *et al.* 1978, Eller *et al.* 1992) using either ultrasound or cardiotocography to monitor FMs and fetal heart rate (FHR), conclude that there is a correlation between increased FMs and the mother receiving either intravenous or oral glucose. Others refute this (Patrick *et al.* 1982, Bocking *et al.* 1984), reporting either no increase in FMs or that the opposite was true, increased FMs was associated with hypoglycaemia (Holden *et al.* 1984). A Cochrane review (Tan & Sabapathy 2012) also concludes that there is no concrete evidence that glucose or orange juice administered to a woman increases FMs, although only two RCTs with high risk of bias were included in this meta-analysis. Differences in gestational age,

length of observation, and amount of glucose provided to the participants may account for the discrepancies among studies. Findings from earlier studies suggest an inverse relationship between maternal glucose levels and fetal activity, which also corresponds with the pattern of FMs described by participants in qualitative studies. Therefore, the issue remains unresolved.

2.5.1.1.4. Maternal position and external stimuli

A limited number of quantitative and qualitative studies indicate that maternal perception of FMs can be influenced by maternal position and external stimuli such as music therapy and maternal touch. In a study by Bradford & Maude (2018), women described in interviews being reassured by the familiar response of feeling increased bouts of FMs when seated or lying down. In a cross-sectional survey of 156 women, nearly 20% (n=26) of women also perceived increased movements when either sitting, ''*lying down on the side*'' or resting with ''*feet up*'' (Raynes-Greenow *et al.* 2013, p. 5), most likely because other distractions were minimised. Only one quantitative study was found that examined the effect of maternal position on perception of FMs (Sheikh *et al.* 2014). In this prospective cohort study, 729 women were asked to count their FMs for one hour three times a day in a position of their choice. RFM was perceived more often in women who lay in a supine position (p=0.001) (Sheikh *et al.* 2014). Studies using magnetic resonance imaging (MRI) have shown that as the pregnancy advances and the fetus grows, the gravid uterus causes increased compression, resulting in decreased utero-placental and feto placental blood flow and oxygenation (Rossi *et al.* 2011, Humphries *et al.* 2019, Couper *et al.* 2021). This may explain why women may perceive less movements when in the supine position and increased frequency of movements while in a seated or lying on side position. Case-control studies have also found that women who sleep in a supine position at later gestations have a 2- to 3-fold increased risk of stillbirth, compared to women who went to sleep on their left side, further suggesting that an underlying pathophysiological process is involved (Stacey *et al.* 2011b, Gordon *et al.* 2015, Heazell *et al.* 2018a).

The effect of music therapy on FMs is unclear. Individual small, randomised studies indicate that there is a positive correlation between listening to music and perceived

increase in the frequency of FMs. For example, Kafalİ *et al.* (2011), Gebuza *et al.* (2018) and Toker & KÖMÜRcÜ (2016), who randomised 201, 33 and 70 pregnant women respectively to listening to music or not listening to music, all found that the frequency of FMs was significantly increased in the music groups ($p<0.001$, $p=0.02$, $p=0.02$ respectively). A recent systematic review of eight RCTs, of which three contributed data to the effect of music therapy versus no music therapy on FMs found that music therapy did not alter the number of FMs (mean difference [95 % CI]: 0.50 [-0.79–1.78] time/min, P = 0.45) (He *et al.* 2021) . Caution is required in interpreting these findings though as all studies were assessed as having a high risk of bias, used different music therapy strategies, and for varying lengths of time.

Pregnant women are often seen 'rubbing and stroking' their abdomen during pregnancy. Data is sparse on the effect of maternal touch on FMs. Using 3D ultrasound, Marx & Nagy (2015) explored the response of 23 fetuses to maternal touch, reporting that there was a significant increase in fetal activity after maternal 'stroking and rubbing' of the abdomen. Rolland Souza *et al.* (2019) also in a pre and post clinical trial of 28 low-risk pregnant women that assessed fetal cardiotocography patterns after maternal touch of the abdomen, found that while fetal heart rate patterns did not change, FMs were significantly increased (p=0.04). Qualitative reports from women also described visible movement of their baby's limbs moving under the skin when their hands were placed on their abdomens (Bradford & Maude 2018). It is possible that the tactile motions by a mother or partner are likely to exert gentle pressure onto the abdomen causing the fetus to respond to the stimulation. This supports earlier observations made by obstetricians Valman & Pearson (1980), that later in pregnancy, the fetus moves towards any sensory or motor stimulation.

2.5.1.1.5. Obesity

Evidence that maternal perception of FMs is influenced by body weight is conflicting. Tuffnell *et al.* (1991) investigated the incidence of maternal overweight in 180 women with no previous pregnancy complication, presentation with RFM, and subsequent birth outcome. In comparison to the general population, women who weighed >80kgs and >90kgs were respectively, nearly twice (OR 1.81, 95% CI 1.20-2.93) and three times more

likely to present with RFM. Tuffnell *et al.* (1991) concluded without further investigation that maternal obesity inhibits maternal perception of FMs due to excess abdominal fat acting as a barrier to the woman in detecting any stimulation of the abdominal wall by fetal kicks or movement. Available data from small low quality observational studies comparing FMs detected by ultrasound and maternal perception of FMs do not support this view, reporting that maternal perception of FMs was not inhibited in women with obesity or increased maternal weight (Gettinger *et al.* 1978, Hertogs *et al.* 1979, Schmidt *et al.* 1984, Valentin *et al.* 1986). Brown *et al.* (2016) compared 14 women with increased body mass index (BMI) (i.e., ≥25 kg/m²) and seven women with healthy BMI (<25kg/m²) and found no significant relationship between the ability to perceive FMs and maternal BMI. However, in a larger cohort study of 1786 women, Winje *et al.* (2011) evaluated maternal characteristics and the time taken to count ten FMs. They reported that women with pre-pregnancy BMI ≥28 kg/m² more often took longer to count to ten movements than women who had a BMI <28 kg/m². Bradford and colleagues also refute the view that perception of FMs in women with obesity is impaired (Bradford *et al.* 2020). Using an interviewer-administered questionnaire with questions on perceived FMs in the previous two weeks, they compared women with a BMI ≥30 kg/m² (n=233) with 149 women with BMI <25 kg/m². They reported that the strength and frequency of FMs were similar in women with obesity when compared with women with normal BMI (Bradford *et al.* 2020).

Numerous studies have however reported on the association between increased maternal size and presentation with RFM, although findings are similarly conflicting. In a systematic review of ten studies, Bradford *et al.* (2018b) found that of the four studies reporting BMI as a continuous variable, no significant association was found between BMI and presentation with RFM. In case-control studies, Warrander *et al.* (2012) and Binder *et al.* (2017) reported that median [range] BMI was not significantly different between women with RFM and women without RFM, while in contrast Pagani *et al.* (2014b) reported that women presenting with RFM had a significantly higher median BMI than women without RFM (n=16907, 24.2 [21.8-28.3] vs. 23.5 [21.2-26.7] kg/m2, p=<0.001). A meta-analysis of five low quality studies however found a positive association between increased maternal body size and presentation with RFM, (OR 1.56,

95% CI 1.27-1.92 for two cohort studies and OR 1.32, 95% CI 1.12-154 for three case-control studies) (Bradford *et al.* 2018b). No studies were found that examined RFM in women with BMI > 35 kg/m². While individual studies as discussed in Chapter 2, albeit of various designs, do not seem to support an association between obesity and impaired maternal perception of FMs, higher level evidence through systematic review suggests that a raised BMI is associated with women attending hospital with RFM during pregnancy (Bradford *et al.* 2018b). These conflicting findings could be explained by several factors. For example, BMI categories varied among studies, some studies were of varying quality, and some were not sufficiently powered to investigate further the associations between RFM, obesity and adverse pregnancy outcomes. Notably, some studies were performed thirty to forty years ago, and it is known that the prevalence of obesity in women of reproductive age has changed globally over this time. Uncertainty therefore remains as to the clinical significance of RFM in women with raised BMI.

2.5.1.1.6. Anterior placenta

An anterior placenta is a placenta that is located and positioned at the front of the uterus. Some studies have linked anterior placenta to the time at which FMs are first perceived. Gillieson et al (1984) reported that anterior placental location delays 'quickening' by approximately one week. Neldam (1982) compared maternally perceived FMs with ultrasound in 284 women between 20- and 42-weeks' gestation. Women of earlier gestation, 20 to 27 weeks with an anterior placenta perceived significantly less movements than those observed on ultrasound when compared to women with posterior placental position, although no difference was found in women from 28 weeks' gestation (Neldam 1982). Forty years later, a prospective cohort study including 2009 singleton pregnancies in Northern Greece supported Gillieson and Neldam's findings. This study (Tsakiridis *et al.* 2022) concluded that the mean gestational age at the onset of perception of FM was more advanced, at 19.3 weeks (±1.5), in women with an anterior placenta, while it was 18.8 weeks (±1.4) for women with a non-anterior placenta (MD −0.505; 95% CI −0.635 to −0.375; p<0.001).

In a qualitative study of nineteen primigravidae, interviewed at 28 to 32 weeks' gestation, women generally described being able to feel movements when their hands

were on their abdomen. Two participants however with anterior placentae reported that while sensations of FMs were strong and frequent, they were not able to feel the movements with their hands (Bradford & Maude 2018). An anterior placenta acts as a barrier, hindering direct contact between the fetus and the uterus or abdominal wall, thus reducing the ability to recognise FMs. Notably, the associations between placental location and perception of FMs, from the perspectives of women, are not well studied.

Quantitative studies have also assessed the associations of placental site and the perception of RFM but with conflicting results. For example, a case control study, conducted in Israel, of 399 women with RFM and 4493 women without RFM, anterior placenta was significantly associated with RFM (55.9% versus 50.5%, OR = 1.44, $p = 0.042$) (Mohr Sasson *et al.* 2016). A UK study of 182 women also found that an anterior placenta reduced the perception of FMs and women with an anterior placenta were twice as likely to present with RFM (OR 2.10, 95% CI 1.51-2.92) (Tuffnell *et al.* 1991). In contrast, Sheikh *et al.* (2014) found no significant association between the perception of FM with placental location (OR 1.04). These conflicting results are mainly due to the small study sample sizes, different gestational ages studied and inconsistent definitions of RFM used across studies. Further research is needed to determine the effect of placental location on the perception of FM. Due to a dearth of research, uncertainty also exists of the clinical significance of anterior placenta and RFM. There is currently no research available that has investigated the clinical significance of RFM with anterior placenta and subsequent neonatal outcomes, therefore further studies are required.

2.5.1.1.7. Amniotic fluid volume

Amniotic fluid is the liquid that surrounds the fetus within the uterus, initially developed from the membrane plasma by the development of the fetus. It is mainly composed of water and solids and acts as a protective cushion to the growing fetus. Its inherent antibacterial properties protect the fetus from infection. Amniotic fluid volume (AFV) generally increases with the growth of the fetus, reaching a peak in the middle of the third trimester (Brace 1997), thus distending the uterus, enabling the growth and normal development of the fetus. Sival and colleagues studied the effect of reduced AFV on FMs

in 19 women with pregnancies complicated by premature rupture of membranes. They reported that the frequency of FMs was not altered, however the speed and amplitude of movements was reduced, suggesting that low amniotic fluid levels may have a mechanical effect on FMs by restricting freedom of movement of the fetus (Sival *et al.* 1990).

Studies with conflicting results have assessed the association between maternal perception of RFM and abnormalities AFV. Whitty *et al.* (1991) examined 292 women with low-risk pregnancies and a primary complaint of RFM, of which only six women had oligohydramnios (low amniotic fluid volume). Yogev *et al.* (2003) also studied a group of 115 women who were admitted for induction of labour at term due to persistent RFMs and found that 15.6% (n=18) had oligohydramnios. Other studies however have reported that reduced amniotic fluid is associated with RFM. In a study of 352 women with uncomplicated pregnancies at less than 32 weeks' gestation, Sherer *et al.* (1996) found a significant correlation between decreased AFV and RFM ($P<0.001$). A large retrospective cohort study conducted in Israel between 2008 and 2013, involving 825 women with RFM compared to 37,031 women with no RFM, found that RFM was associated with oligohydramnios regardless of parity ($p<0.01$) (Aviram *et al.* 2016). Several factors can account for these differences in findings, including gestational age at examination, small sample sizes and the low numbers of women with abnormal AFV in some of the studies.

Aside from subjective maternal perception, there are several alternative methods and interventions that have been tried, used and tested in practice for assessing and improving awareness about FMs. These include, for example, the use of fetal movement counting (FMC) or 'kick' charts, the provision of information via written leaflets (Norman *et al.* 2018, Wackers *et al.* 2019, Akselsson *et al.* 2020), websites (Akselsson *et al.* 2020), and social media campaigns (Chan *et al.* 2021, NHMRC Centre for Research Excellence in Stillbirth 2021, Tommy's 2021), the practice of mindfetalness or use of mobile phone applications (Flenady *et al.* 2022). Fetal movement monitoring devices, known as accelerometers, are also emerging as a means to monitor FMs using wearable

technology that alerts the woman or her healthcare providers when FMs appear to be reduced (Ryo *et al.* 2012, Lai *et al.* 2018).

2.5.2. Alternative methods for assessing fetal movements in pregnancy

2.5.2.1. Fetal movement Counting and 'Kick Charts'

Fetal movement counting (FMC) is a method used by women to systematically quantify and formally document on a chart (usually paper based) their perceptions of fetal activity. FMC, which has been used in antenatal care for more than fifty years, is predicated on the notion that by recording FMs with alarm limits set for RFM, a woman would be alerted to report perceived RFM to a healthcare provider, who in turn, could initiate further investigation and monitoring to prevent perinatal morbidity and mortality.

There are several descriptions in the literature of FMC methods, although collectively, the methods involve either recording the time it takes to observe a specified number of FMs or recording the number of FMs within a specified time-period (Malm *et al.* 2014). Table 2.3 presents commonly known FMC methods that have been/are used currently in clinical practice. The first formal FMC method was developed by Sadovsky in 1973. Sadovsky observed that a reduction or cessation of FMs, but with an audible fetal heart rate, was followed by fetal demise within 12 to 48 hours (Sadovsky & Yaffe 1973). Subsequently, Sadovsky developed a protocol for FMC where a woman counts FMs for 30 to 60 minutes, three times a day in the morning, afternoon, and again in the evening. A count of at least four FMs at each time-point was noted as reassuring for normal fetal activity. If less than four movements were perceived, counting continued for 1, 2 or more hours. Less than ten FMs in six hours was a signal for the woman to seek medical attention from her health care provider (Sadovsky, Rabinowitz and Yaffe 1981).

Table 2.3 Methods of formal fetal movement counting

Name	Method
Cardiff Method/'Count to Ten'	the woman counts FMs up to 10, and records the time period in which she reached the number (Freda *et al.* 1993)
Modified Cardiff Method	a woman records the time taken to feel 10 FMs on a modified Cardiff 'count-to 10' chart (A chart to record the number of times and the times her baby moved) (Grant *et al.* 1989)
Sadovsky Method	the woman counts the first 4 movements after each meal, indicates each movement with an X on the fetal movement chart and stop counting (Sadovsky & Yaffe 1973, Freda *et al.* 1993)
CLAP Method	the woman records FMs four times per day, for 30 minutes after each meal and at bedtime. Ten or more FMs per day are considered reassuring (Gómez *et al.* 2007)

Pearson (1977) developed a different method of recording FMs known as the Cardiff 'Count to Ten' chart. With this method, the woman starts counting the number of FMs from 09.00am and continues in half hour blocks until the 10th movement is felt. The time taken to record ten FMs is recorded on a chart. Less than ten FMs in 12 hours are an indication to notify a healthcare provider. The time taken to count 10 FMs varies however depending on the woman's activity. When using this method of counting, Valentin *et al.* (1984) found that it took 20 minutes if the woman was relaxed and focused on counting, while Grant *et al.* (1989) found that it took up to 162 minutes during a woman's normal daily routine.

In 1989, Moore and Piaquadio proposed evening FMC, a time more convenient for pregnant women. During a pilot study of 100 women, they found that it took women while lying on their left side during the evening, a mean time of 20.9 ±18.1 minutes to count ten movements. An alarm limit of two hours or less to achieve 10 FMs was set. Women who did not achieve ten movements in two hours were prompted to present to the hospital. During the study, there was a significant reduction in the rate of stillbirths from 8.7/1000 to 2.1/1000.

Studies evaluating compliance with the use of FMC are also conflicting. Gómez *et al.* (2007) found that compliance was better with the count to ten FMC method rather than the CLAP method with women reporting that the count to ten method did not interfere with daily activities and required completion of one chart. Contrastingly, Mikhail *et al.* (1991) found no statistically significant difference in non-compliance between the Cardiff count to ten group or the Sadovsky FMC group.

Formal FMC or 'kick counting' continued as part of routine antenatal care up until the 1980s. Variations of these methods have been developed over the years, using either a 'fixed time' or 'fixed number' approach, however standardisation of practice has not been achieved and no consensus has been reached on the best FMC method or alarm limit to use. Consequently, although current guidelines recommend a reliance on maternal perception rather than formal FMC (see below for further discussion), different FMC methods continue to be used in some clinical maternity settings today.

In the 1970s and 1980s several observational studies identified that the use of FMC could predict impending stillbirth. A systematic review by Frøen (2004) evaluated 24 studies published between 1976 and 1997. Nine studies involved high risk pregnancies using the count to ten FMC method, eight involved low risk pregnancies using the count to ten FMC method and seven studies involved low-risk pregnancies using subjective evaluation of FMs. Use of FMC significantly reduced the rate of stillbirth in the high-risk pregnancy population (OR 0.56, 95% CI 0.40-0.78) but not in the low-risk group (OR 0.74, 95% CI 0.51-1.07) when compared to maternal perception. Grant *et al.* (1989), conducted one of the largest multicentre clustered randomised controlled trials across five countries involving 68 654 women between 28-32 weeks' gestation. In this study,

the use of formal FMC was compared with control group in which FMC was not routinely discussed. No significant reduction in the rates of stillbirth for women using the 'kick chart' were found and subsequently the usefulness of formal FMC in pregnancy was questioned. Several methodological issues have since been identified with the study that have raised questions about the findings. Significant contamination between the study and control groups is suspected as pregnant women in the same community/hospital were either asked to perform FMC or informed in writing about their inclusion in the FMC study and instructed not to perform FMC. The FMC 'alarm limit' to contact health professionals was absence of FM for one day or less than 10 FMs in two consecutive days. Only 60% of women in the study 'counting' group were compliant with FMC and fewer than half of women with a 'counting alarm' presented for assessment. Furthermore, there was no protocol for the management of women who presented with RFM, and 17 fetuses that were alive on admission to hospital subsequently died due to false reassurance from fetal testing (cardiotocography), and clinical error. While no difference was shown in the stillbirth rate across the study groups, the overall late gestation stillbirth rate fell during the study period from 4/1000 to 2.8/1000 (Grant *et al.* 1989). Leading experts on RFM hypothesise that this reduction could have been attributed to 'a Hawthorn effect' of increased knowledge and awareness of RFM (Frøen *et al.* 2008). Involvement in a fetal movement study has the potential to increase awareness of FMs among pregnant women and healthcare professionals irrespective of the group or treatment allocated to e.g., counting or not counting, intervention or no intervention.

The effectiveness of kick counting, specifically the 'count to ten' approach has since been challenged in two systematic reviews which both found that FMC does not lead to improved birth outcomes (Mangesi *et al.* 2015, Bellussi *et al.* 2020). The Cochrane Review of RCTs published in 2015, included 71,458 women and compared two FMC methods; FMC versus hormonal analysis and FMC compared with standard antenatal care. Only one study (Thomsen *et al.* 1990) evaluated the modified Cardiff FMC method versus hormone analysis. The outcome stillbirth was not reported in this study. Of the two RCTs comparing routine FMC with mixed or undefined FMC, no difference in stillbirth, caesarean sections or birth weight less than 10th centile were found. When

different types of FMC methods were compared (FMC once a day versus FMC more than once a day after meals), there was no difference in incidence of caesarean section was found; perinatal death was not reported. In the most recent systematic review and meta-analysis (Bellussi *et al.* 2020), the inclusion criteria for study selection were different to the Cochrane meta-analysis. Bellussi *et al.* (2020) compared women who were given instructions on FMC with women who were not given any instructions. Five RCTs that compared perinatal outcomes in women who were instructed to formally count their FMs (n=262,059) with women who received standard antenatal care (n=196,542) were included, three studies of which were published since the publication of Mangesi's review. Despite the addition of three more recent studies, and additional data based on 386,836 babies, no evidence of effect for FMC was found.

Consequently, in keeping with current evidence, formal FMC is not routinely recommended in contemporary UK, Australian and New Zealand maternity care guidelines. Guidelines currently recommend that maternity healthcare providers should advise pregnant women to be aware of their baby's individual pattern of movements, observe only for changes in the pattern of their FMs and contact their maternity care provider if they perceive reduced or cessation of FMs (Perinatal Society of Australia and New Zealand and Centre of Research Excellence Stillbirth 2019, National Institute for Health and Care Excellence (NICE) 2021). Previous surveys (as discussed in section 2.4.2.1) have demonstrated that midwives and obstetricians rarely use formal kick charts for healthy uncomplicated pregnancies and reserve their use only in high-risk pregnancies (Heazell *et al.* 2008, Flenady *et al.* 2009, Smith *et al.* 2014b). These surveys also highlighted wide variations in clinical practice with regard to FMC and the management of women presenting with RFM. Notably some of these studies were conducted up to 15 years ago now. Nonetheless, when Pollock *et al.* (2020) surveyed 428 women in Southern Australia, many women quantified FMs by counting kicks when asked to describe '*what is normal movements for an unborn baby*?' suggesting that some women appear to still rely on counting FMs. A contemporary understanding of current practice regarding fetal surveillance and management of RFM is therefore required.

2.5.2.2. Fetal movement accelerometers

A fetal movement accelerometer (FMA) is a small recording device that the pregnant woman can use at home to record FMs by attaching two small sensors using adhesive tape, one to the abdomen (to detect fetal movements) and another sensor to the thigh (to detect maternal leg movements) (Ryo *et al.* 2012). The FM sensor detects oscillation of the woman's abdominal wall caused by FMs (Ryo *et al.* 2018). Several studies have been conducted to test the performance of various types of FMA devices (Mesbah *et al.* 2011, Ryo *et al.* 2012, Nishihara *et al.* 2015, Ryo *et al.* 2018, Sazali & Al-Ashwal 2018), however to date, these small studies, ranging from 4-64 participants, have been conducted only on pregnant women with no medical or pregnancy complications, with limited recording times of either 30 minutes or four hours duration, and at night-time when the woman is not moving or asleep. It is known that FM patterns can vary significantly between individuals, and factors such as gestational age, maternal position, obesity, anterior placenta and time of day can impact on the quality of FMs (section 2.5.1.1). Correlation of FM detected by FMA compared to real time ultrasound has been reported (Ryo *et al.* 2012), suggesting that FMA devices can only assess quantitative movements of the fetus. The utility of these devices has therefore yet to be determined as there is currently no agreement or definition on normal reference values for FMs. Further research is therefore required to develop reliable FMA devises to accurately detect fetuses whose FMs are deviating from the norm.

2.6 Methods for raising awareness about fetal movements

2.6.1. Information brochures

Benefits have been found when information brochures on FM and RFM have been used to increase awareness. In a pre and post small intervention study (n=140) conducted in the Netherlands, Wackers *et al.* (2019) found that the proportion of women who delayed contacting a healthcare professional for concerns of RFM significantly reduced from 78.2% to 55.1% ($p=0.02$). Women who read the information brochure also had significantly more knowledge about FMs ($p<0.001$). This is consistent with findings from a previous large before and after prospective study conducted in Norway (Tveit *et al.*

2009a, Saastad *et al.* 2010), which in addition also found that the intervention was associated with reducing the stillbirth rate. In particular, the incidence of stillbirth in primiparous women presenting with RFM was almost halved, from 4.2% to 2.4%. The Maternity and Children Quality Collaborative (MCQIC) in Scotland introduced a requirement in 2012 that all HCPs should have a discussion with women between 18-24 weeks about the importance of FMs; by 2015 stillbirth rates had reduced by nearly 15% (Harley *et al.* 2016).

2.6.2. Social media campaigns

Chan *et al.* (2021) conducted a before and after study in 2018 of the '*Movements Matter*' social media campaign in Australia that targeted raising FM awareness among pregnant women. The campaign overall led to an increase in women's awareness and knowledge about normal FMs and to contact their healthcare provider if they perceived RFM, however the ability to recall the information provided was low among women aged <25 years, prompting that further work with this age group is required.

2.6.3. E-learning education and intervention package

The Promoting **A**wareness of **F**etal Movements and **F**ocusing **I**nterventions **R**educe Fetal **M**ortality study (The AFFIRM Study) was a stepped wedge cluster randomised trial performed in 33 maternity hospitals and maternity units in the UK and Ireland. AFFIRM tested the hypothesis that rates of stillbirth would be reduced by providing an e-learning education package for all clinical staff in participating hospitals. A standardised antenatal package of care consisting of strategies to increase pregnant women's awareness of the need for prompt reporting of RFMs, followed by a management plan for identification of placental insufficiency with timely birth in confirmed cases (Norman *et al.* 2018). The management plan for identification and planned birth of babies at high risk included cardiotocography, ultrasound to measure liquor volume, estimate fetal weight and umbilical artery Doppler if available. Planned birth was recommended at or after 37 weeks' gestation for women when there were concerns related to fetal growth, abnormal liquor volume, abnormal cardiotocography, or recurrent RFM.

Stillbirth rates were lower during the intervention period (4.06 per 1000 births) compared to the control group (4.40 per 1000 births), but not significantly so (aOR 0·90, 95% CI 0·75–1·07; p=0.23). The incidence of SGA babies being born at term was reduced in the intervention period when compared with the control group, suggesting that it was possible that higher risk pregnancies were identified earlier, had timely birth, preventing stillbirths that may have otherwise occurred. The frequency of secondary outcomes, induction of labour, caesarean section and neonatal admission were however increased during the intervention period indicating that an awareness programme may have unintended consequences for women (Norman *et al.* 2018).

2.6.4. Mindfetalness

Mindfetalness was developed by a Swedish midwife as an alternative method of self-assessing the character, strength and frequency of FMs (Rådestad 2012, Radestad 2017). The woman devotes 15 minutes per day lying down on her side, focusing on the intensity and variation of all movements.

Akselsson *et al.* (2020) conducted a large cluster randomised trial (n=39,865 women) in Sweden investigating the use of promoting daily self-monitoring of FMs (Mindfetalness). Women in the intervention group (Mindfetalness) were provided with a leaflet instructing them from 28 weeks' gestation to lie down on their side for 15 minutes per day to monitor the character, strength and frequency of each movement but not count each movement and to seek care if they had any concern for their baby's wellbeing. Using this method, the hypothesis is that a woman becomes more familiar with her baby's unique pattern of movements (Akselsson *et al.* 2020). Unlike the AFFIRM trial, this study did not involve management recommendations for healthcare professionals. The primary endpoint was to detect a difference in Apgar score (< 7 at 5 minutes of age). No difference was found between the intervention and control groups for the rate of perinatal death (2 versus 5 deaths respectively, p=0.27) or in Apgar score. Notably though the trial was not powered to identify a reduction in stillbirth. In contrast to the AFFIRM trial, women in the mindfetalness intervention group had higher rates of spontaneous birth (71% v 69.6%, RR 1.02,95% CI 1.01–1.03, p=0.002) and lower rates of

induction of labour (19.1% v 19.8, RR 0.96, 95% CI 0.92-1.00, p=0.006) which are likely to have influenced the lower rate of caesarean section (19% v 20%, RR 0.95, 95% CI 0.91-0.99, p=0.02). Similar to the AFFIRM study fewer small for gestational age babies (10.2% v 10.7%, RR 0.95, 95% CI 0.90-1.00, p= 0.07) in the mindfetalness group could be attributed to the intervention; repeated exposure of women lying on their side, inadvertently increasing maternal cardiac output, increasing uterine artery blood flow and subsequently increasing placental perfusion and fetal growth.

2.6.5. Mobile applications

Flenady *et al.* (2022) conducted a stepped-wedge cluster-randomised trial in Australia and New Zealand, including 27 maternity services to evaluate the effectiveness of a 'My Baby's Movements' package of interventions to increase awareness of RFM for clinicians and pregnant women, in reducing the incidence of third trimester stillbirth in singleton pregnancies. The package of interventions included in-service education on the management of women with RFM, consisting of posters and leaflets, pens and an eLearning programme for maternity care staff and a mobile phone application (app) for women. Women were encouraged to monitor their baby's movements daily and present promptly to the hospital if they had any concerns about FMs. Unlike the AFFIRM study, this trial did not demonstrate a significant increase in the rates of intervention, although different management protocols were used. A less prescriptive, individualised approach for early planned birth was taken versus prescribed 37 weeks in the AFFIRM trial for women identified with FGR, recurrent RFM or abnormal cardiotocograph. The incidence of stillbirth was lower in the intervention group 2.2/1000 versus 2.4/1000 but not statistically significantly different (aOR 1.18, 95% CI 0.93-1.50, p=0.18). There was no overall change in the proportion of women presenting with RFM, however it was found that delayed reporting of RFM for 24 hours or more was significantly lower in the intervention period. Like other studies, Flenady *et al.* (2022) study supports the premise that improving awareness about FM and RFM is effective in women minimising delay in contacting healthcare professionals.

Formal FMC or promoting fetal movement awareness trials have created further debate on the clinical usefulness of FM awareness to prevent adverse perinatal outcomes. Although studies clinically suggest some benefits for increasing awareness in counteracting stillbirth, no fetal awareness method, to date, has demonstrated significant effect in reducing adverse events such as stillbirths. There thus remains uncertainty as to whether the reductions in stillbirth rates were due to increased maternal awareness of FMs or as a result of other components of clinical management or both. Research is ongoing and an individual participant data (IPD) meta-analysis combining data from all fetal movement awareness studies (PROSPERO CRD42021222997) is underway and could inform us further about the role of FM awareness and interventions to prevent stillbirths.

2.7 Chapter summary

RFM is a relatively common occurrence in pregnancy (up to 15%) and an established precursor to fetal demise. Early detection of RFM is therefore considered an opportunity for fetal health screening. The literature is abounded with research on the clinical management of RFM as well as trials on detection methods and raising awareness of RFM. Yet, evidence of conclusive effectiveness for many strategies currently remains lacking. Women will experience FMs uniquely, although several maternal characteristics that may impact on maternal perception of FMs were identified, some of which could equally be classified as risk factors for RFM, for example, gestational age, parity, anterior placenta and obesity. Similarly, outcomes associated with RFM have been extensively studied, with several associated outcomes, including stillbirth and SGA being reported. The findings across studies are inconsistent, however, and the study dates span many years. In this regard, a comprehensive systematic review to provide higher level evidence on risk factors for and outcomes associated with RFM is warranted.

Systematic reviews conducted to date on RFM in pregnancy have focused on methods for FMC, management of reported RFM and interventions to enhance maternal awareness of RFM (Hofmeyr & Novikova 2012, Mangesi *et al.* 2015 , Winje *et al.* 2016). No published systematic reviews and meta-analyses that synthesised the evidence from

non-randomised studies (NRS) on the potential risk factors and adverse pregnancy, labour and neonatal outcomes associated with RFM were identified. Collating the empirical evidence in a systematic way, minimises bias and can thus provide more reliable findings and conclusions. Given that identification of RFMs is a key component of international stillbirth prevention strategies, it is imperative that all of the existing evidence is brought together and evaluated. For these reasons, a systematic review to identify risk factors for RFM in pregnancy and to assess pregnancy, labour, birth and neonatal outcomes following RFM was performed. Early identification by healthcare professionals of risk factors, both modifiable and non-modifiable, and possible outcomes associated with RFM could contribute to the prevention and reduction of adverse pregnancy, birth, fetal and neonatal outcomes, and informatively aid clinicians and policymakers in clinical decision-making and clinical care. Chapter 3 presents the conduct and findings of this systematic review.

Chapter 3 Risk factors for and outcomes associated with reduced fetal movements in pregnancy: a systematic review and meta-analysis

3.1 Introduction

This chapter presents the aim and objectives, the methods used and the findings of a systematic review of studies on risk factors for and pregnancy, birth and neonatal outcomes associated with RFM. The conduct and reporting of this review was guided by MOOSE (Meta-analysis of Observational Studies in Epidemiology) guidelines (Stroup *et al.* 2000) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page *et al.* 2021a). The review protocol was registered with PROSPERO (http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42017082685). Versions of the review have also been published, with future updates planned[3].

3.2 Aims and objectives of the systematic review

1) To identify risk factors for RFM in pregnancy.
2) To identify the pregnancy, birth, fetal and neonatal outcomes associated with RFM in pregnancy.

3.3 Review questions

The review questions were:

1) What risk factors are significantly associated with RFM in pregnancy?
2) What outcomes (pregnancy, birth, fetal and neonatal) are significantly associated with RFM in pregnancy?

---

[3] Carroll L, Gallagher L, Smith V. (2022). Pregnancy, birth and neonatal outcomes associated with reduced fetal movements: A systematic review and meta-analysis of non-randomised studies. *Midwifery*, 116, 103524. doi:10.1016/j.midw.2022.103524

Carroll L, Gallagher L, Smith V. (2019) Risk factors for reduced fetal movements in pregnancy: A systematic review and meta-analysis. *European Journal Obstetrics & Gynaecology Reproductive Biology* 243, 72-82. https://doi.org/10.1016/j.ejogrb.2019.09.028 0301-2115/

3.4 Study selection

3.4.1. Criteria for inclusion of studies

3.4.1.1. Study design

A systematic review that aims to examine aetiology and risk, prediction and prognosis or the frequency of outcomes or complications following exposure to a condition are usually best answered by data from observational studies (Glasziou *et al.* 2001, Riley *et al.* 2013). Thus, to address the review aim, non-randomised, two-group observational prospective and retrospective studies (i.e., case-control or cohort) only, were eligible for inclusion in this review.

3.4.1.2. Type of participants

Studies were included in the review if they reported on pregnant women of at least 24 weeks' gestation or having achieved a gestational age of fetal viability as defined in the study setting up to twenty-eight days post birth.

3.4.1.3. Type of exposure

The exposed cohort must have experienced at least one episode of RFM, as a primary complaint, at ≥ 24 weeks gestation. For comparator analyses, reported data for non-exposed participants (that is, women without RFM) was required. As definitions of RFM are not consistent in the literature (e.g., self-reported, <10 movements/12hrs), the definitions described by the included studies' authors were accepted.

3.4.1.4. Type of outcomes

Risk Factor(s)

A risk factor is defined as any modifiable or non-modifiable characteristic that increases or decreases the likelihood of a woman experiencing RFM in pregnancy. To provide a clinically meaningful scope to investigating risk factors, risk factors were not pre-specified, rather risk factors for RFM that were reported in two or more eligible studies were reported in this review. Where a study reported on a risk factor, but no other included study reported on the same risk factor, this study was excluded.

Pregnancy/Birth/Neonatal Outcome Measures

The primary outcomes were:

1. Stillbirth (defined as a baby born with no signs of life at or after 28 weeks' gestation (World Health Organisation 2017b), or as described by the authors of the included study
2. Preterm Birth (defined as a baby born alive before 37 completed weeks of pregnancy (World Health Organisation 2017a)). Preterm birth was further sub-grouped as:
    a. extremely preterm (<28 weeks)
    b. very preterm (28 to <32 weeks)
    c. moderate to late preterm (32 to <37 weeks)
3. Small for Gestational Age (defined as an baby born with a birth weight less than the 10th centile (Royal College of Obstetricians and Gynaecologists 2014) or as defined by the study author(s).
4. Neonatal Death (up to 28 days postpartum)

The secondary outcomes were:

1. Onset of labour
    a. Induction of Labour
2. Mode of Birth
    a. Emergency Caesarean Section
    b. Instrumental vaginal birth (Ventouse and Forceps)
3. Birthweight (kgs)
4. Apgar score < 7 at 5 minutes following birth
5. Incidence of meconium-stained liquor
6. Metabolic acidosis (defined as lactate > 10 mmol/l or arterial umbilical cord pH < 7.05 with base deficit >12mmols/l) or as defined by study author(s)
7. Rates of admission to neonatal intensive care units (NICU) or special care baby units (SCBU)

In addition, baseline characteristics such as parity, infant gender and gestational age at birth for exposed and non-exposed cohorts, were extracted and recorded.

3.5 Methods

3.5.1. Search strategy

A comprehensive search of the following databases from inception to 23rd March 2018 (updated to 2022 in Chapter 6) was conducted: PubMed, EMBASE, CINAHL, Maternity and Infant Care, PsycINFO, Science Citation Index (1945-present). Searches were performed using a combination of free text and indexed/controlled vocabulary terms (e.g., MeSH in PubMed which were then adapted as appropriate across the other databases). Given the scope of the review (i.e., use of observational study designs which can be described in variable ways), and following trial and error scoping searches, a decision was taken to focus the search on the Exposure criterion only; that is, use of terms related to fetal movements and reduced fetal movements only combining these terms using the Boolean operators of 'OR' and 'AND' (Box 1). Truncation *was used to expand the terms to capture the singular and the plural as well as present and past tenses (e.g., reduc* to capture reduce or reduced). The complete search strategy, including the key terms, subject terms and number of citations retrieved for each database are presented in Appendix 1.

Box 1: Search terms

fetal movement OR fetal movement* OR foetal movement* OR fetal activit* OR foetal activit* AND reduc* OR decreas*

To identify all potential studies for inclusion, the search strategy was not filtered or limited by study design type, language or year of publication. Although studies reported in English and Spanish only were included, due to the unavailability of funding to translate into other languages, by searching all languages the numbers of potentially relevant studies not included due to language could be identified and any potential for language bias highlighted.

Grey literature online sources (www.opengrey.org) and conference proceedings of the International Confederation of Midwives (ICM) Triennial Conference (2017 and 2021) were also searched to identify any further potential studies of relevance to the review.

A manual search of the reference lists of included articles was also performed to identify any additional studies not captured by the electronic search. The results of the search were imported into a reference management software (EndNote) and duplicate references removed. Following de-duplication, the remaining citations were imported into Covidence (http://www.covidence.org) for screening and eligibility assessments.

3.5.2. Study selection strategy

Citations were screened initially on title and abstract against the review's inclusion/exclusion criteria by myself and at least one of my PhD supervisors, that is, all records were screened by at least two people independently (LC & VS and LC & LG). Potentially eligible studies were forwarded for full text review. Where uncertainty or disagreements existed about whether a study met the eligibility criteria at title and abstract screening, caution was applied, and the study was forwarded and screened at full text level. Full text papers were similarly assessed independently by two people (LC & VS and LC & LG) against the review's eligibility criteria, and agreement on studies for inclusion and exclusion was reached. Any conflicts during the selection process were resolved by discussion and consensus. Single studies reported across two or more publications were counted as one study in the review. Where an abstract and paper reported on the same study, the abstract was included only if there were additional data reported; otherwise abstracts of studies reported in full text were excluded.

3.5.3. Data extraction

A pre-specified data extraction form (Appendix 2) was developed to extract the relevant data. The data extraction form was first piloted on ten of the included studies to ensure that it was appropriate and useful (Higgins and Deeks, 2009). The form was further refined after this pilot, by adding additional columns for aim of study, definitions of outcomes reported, type of risk estimate used and unadjusted/adjusted risk estimate. The following information was extracted from each included study, where available, by two reviewers independently (LC & VS and LC & LG) and checked for accuracy. If any data were missing, attempts were made to contact authors for additional information.

a) Author(s)
b) Year of publication
c) Country where study was conducted
d) Setting where study was conducted
e) Time study was conducted
f) Study design
g) Data collection methods
h) Participant's inclusion and exclusion criteria
i) Number of participants enrolled, and number of participants included in analysis
j) Characteristics of the cohort
k) Description of exposure (e.g., definition of RFM)
l) Examined risk factor(s) and/or the review's pre-specified outcomes of interest, including definition(s) and method of assessment if described
m) Number of participants with and without the risk factor who did and did not experience RFM
n) Number of participants with and without RFM who did and did not develop the review's pre-specified outcome(s)
o) Unadjusted and adjusted effect measures, including details of the variables/confounders that were adjusted for, and other statistical results as presented in the included paper (e.g. sensitivity, specificity, and positive and negative predictive values).

3.5.4. Quality assessment of studies

Critical appraisal of included studies aims to identify the methodological quality of the literature. This is an important component of a systematic review to assess and identify potential biases. Numerous tools are available for evaluation of methodological quality of observational epidemiological studies and non-randomised studies.

In planning for the quality assessment of included studies phase, the following study appraisal tools were considered: Newcastle-Ottawa Scale (NOS) (http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp), Quality in Prognosis Studies (QUIPS) (Hayden *et al.* 2013) and A Cochrane Risk Of Bias Assessment Tool for Non-Randomized Studies (ACROBAT-NRS) tool (Stearne *et al.* 2014).

The Newcastle-Ottawa scale (NOS), developed by the Universities of Newcastle, Australia and Ottawa, Canada is a tool developed for the meta-analysis of observational studies and was first endorsed in 2009 for use in systematic reviews of NRS by the Cochrane Collaboration (Reeves *et al.* 2008). It contains eight items, categorised into three domains; selection, comparability and exposure (case-control studies) or outcomes (cohort studies). A star rating system is used whereby each criterion, in each domain, receives a single star if the appropriate methods have been reported. A maximum of nine stars can be awarded over the three domains. The kappa statistic (*κ)* is frequently used to test interrater reliability, that is the extent of agreement among reviewers. A value of kappa of 0.80 or higher is considered ' strong' agreement, 0.60-0.80 as 'moderate' agreement, while lower than 0.40 indicates 'poor/weak' agreement (McHugh 2012). Evaluation of the use of the NOS has shown wide variation in the degree of inter-rater agreement across the three assessment domains. For example, the inter-rater reliability varied from substantial for *length of follow-up* (κ = 0.68, 95% confidence interval [CI] = 0.47, 0.89) to poor for *selection of the nonexposed cohort* and *demonstration that the outcome was not present at the outset of the study* (κ = −0.03, 95% CI = −0.06, 0.00; κ = −0.06, 95% CI = −0.20, 0.07), and the reliability for the overall scale score was rated as fair (κ = 0.29, 95% CI = 0.10, 0.47) (Hartling *et al.* 2012, Hartling *et al.* 2013). I was therefore unconvinced that the NOS was the most appropriate choice of quality appraisal tool for the review, and other tools were thus considered.

The ACROBAT-NRS is a Cochrane Risk of Bias assessment tool, however it was specifically designed for non-randomised studies that compare the effects of two or more interventions. This tool was therefore not deemed appropriate for this systematic review.

The QUIPS tool was developed and refined by an international expert working group consisting of epidemiologists, statisticians and clinicians to assess risk of bias in studies examining prognostic factors (Hayden *et al.* 2006), but has also been used to assess risk of bias in studies examining risk factors (Pace *et al.* 2014). Six domains of research validity and bias are evaluated. These are study participation, study attrition, prognostic/risk factor measurement, confounding measurement and account, outcome measurement and analysis and reporting (Hayden *et al.* 2013). For each domain, specific guidance and prompts are given on how to rate the adequacy of reporting by a study as yes, partial or no. Each of the six potential bias domains are subsequently rated as having high, moderate or low risk of bias, making it easy for a novice reviewer to use and interpret. Interrater agreement of between 70-89.5% (median 83.5%) has been reported while the Kappa statistic for independent rating of QUIPS items ranges from 0.56 to 0.82 (median 0.75) (Hayden *et al.* 2013, Grooten *et al.* 2019). The QUIPS tool was thus chosen over the NOS and ACROBAT-NRS based on its suitability, reliability, and ease of use. The QUIPS tool, and modifications, used in this systematic review is described in Appendix 3. To enhance the robustness and transparency of the quality assessments each included study was assessed by two reviewers independently (LC and VS or LC and LG), with recourse to discussion and consensus, if required.

3.5.5. Data synthesis

Statistical analyses were performed using Review Manager Software (RevMan 2014). Meta-analyses were conducted where appropriate for each risk factor and outcome, where two or more studies reported on the same risk factor/outcome. Dichotomous data were summarised using odds ratio (OR) and 95% confidence intervals (CI). Continuous data were respectively summarised using mean difference (MD) or standardised MD, with 95% CI, when the same risk factors/outcomes were measured in the studies in the same way or measured using different methods. If meta-analysis was not possible, a narrative summary of study results was provided. For meta-analyses, results were presented statistically as well as graphically on a Forest Plot and interpreted. An example of a Forest Plot and how it is interpreted is illustrated in Figure 3.1.

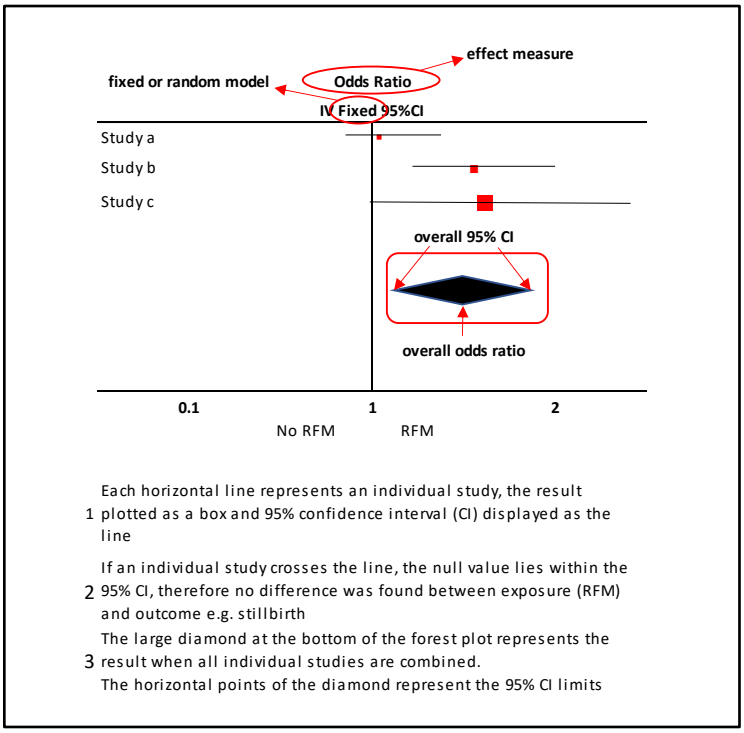


Figure 3.1 Interpretation of a forest plot. Adapted from Cantley (2016)

https://s4be.cochrane.org/blog/2016/07/11/tutorial-read-forest-plot/

3.5.6. Heterogeneity

It is possible that many studies collated together in a systematic review will have differing characteristics. This variability is known as heterogeneity. Different types of heterogeneity exist. These include clinical heterogeneity, methodological heterogeneity and statistical heterogeneity. Clinical heterogeneity relates to the variations found in study characteristics such as participants, definitions of exposure (e.g., RFM) and definition of risk factors or outcomes (Deeks *et al.* 2022).

Clinical heterogeneity between studies was assessed by examining the characteristics of the included studies (see Section 3.6.2, Table 3.1). Methodological heterogeneity describes differences in study design and risk of bias (Deeks *et al.* 2022). Statistical heterogeneity is usually only evident after meta-analysis, whereby there is variation across the results of individual studies greater than one would be expect due to chance

(random error) alone. Statistical heterogeneity can be a consequence of clinical or methodological diversity, or both, among the studies (Deeks *et al.* 2022). The I^2 statistic is used to determine statistical heterogeneity. Heterogeneity is considered moderate if I^2=≥30%-60%, substantial if I^2=≥50%-90%, and considerable if I^2 is 75%-100% (Deeks *et al.* 2022). The level of heterogeneity can therefore influence how confident we can be in the results of a meta-analysis, or whether caution should be advised in translating the results to recommendations for clinical practice. For this review, data were pooled using the fixed effects model. Exploring substantial or considerable heterogeneity, where it exists, helps to understand the factors that may be influencing the results. In this review, for identified statistical heterogeneity, a random effects model, which assumes that the underlying true effects differ across the included studies, was subsequently applied to the affected meta-analysis. To explore methodological and clinical heterogeneity, sensitivity and subgroup analyses were respectively performed.

3.5.7. Sensitivity analysis

Meta-analyses of observational studies present particular challenges because of inherent biases and differences in study designs. Sensitivity analyses provide a means of further assessing the robustness of the results (Egger *et al.* 2022, Higgins & Thomas 2022). Sensitivity analyses were therefore performed for the review's primary outcomes based on i) study design whereby separate meta-analyses were performed using the available data from prospective and retrospective studies, and ii) risk of bias by excluding those studies with overall high risk of bias from the analyses.

3.5.8. Subgroup analysis

Subgroup analyses in a systematic review can be helpful for assessing potential differences in outcomes based on, for example, population characteristics (e.g., male versus females) or study settings (e.g., by geographical location) (Higgins and Thomas 2022). In this review, subgroup analyses for parity (primiparous versus multiparous women) and gestation of first presentation with RFM for the primary outcome data were planned *a priori*. These subgroup analyses, however, could not be performed due to a lack of reported data, by subgroup, in the included studies.

3.5.9. Publication bias

Publication bias can arise when the publication or non-publication of a research study is influenced by the strength and direction of study findings (Higgins & Thomas 2022). Publication bias can be visually evaluated using a funnel plot. A funnel plot is 'a scatter plot of the effect estimates from individual studies against some measure of each study's size or precision' (Sterne *et al.* 2011, p. 1). The x-axis (horizontal axis) shows the results of the study, expressed as an odds or risk ratio or a percent difference, while the y-axis (vertical axis) displays the sample size or an index of precision. The larger and most powerful studies are plotted towards the top of the triangle while studies with low precision or effect estimates are scattered more widely on both sides of the bottom, creating a funnel shaped distribution (Sterne *et al.* 2011) (Figure 3.2). Asymmetry in the funnel plot may be indicative of publication bias (Page *et al.* 2021b). As recommended by Sterne *et al.* (2011), publication bias for this review was evaluated where ten or more studies contributed data to the meta-analysis.

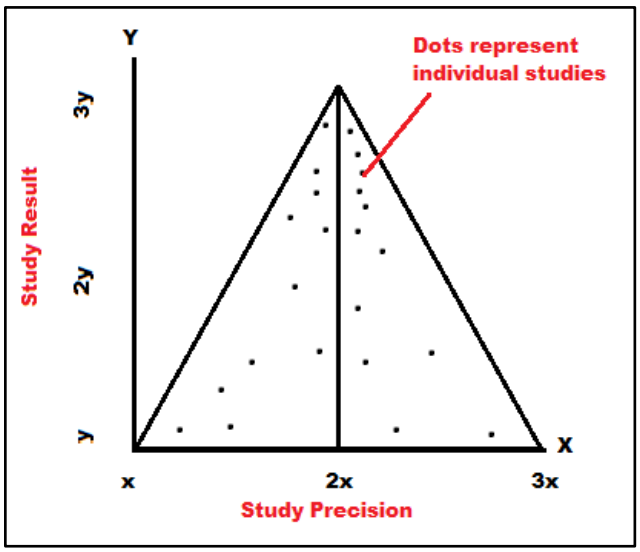


Figure 3.2 Interpretation of a funnel plot[4]

[4] Downloaded from Glen S "Funnel Plot: Definition, Examples" https://www.statisticshowto.com/funnel-plot/

3.6 Results

3.6.1. Search and selection

The search yielded a total of 4540 citations (4539 from databases and one from other sources[5]), of which 1390 were duplicates and removed. This resulted in 3150 records being downloaded to Covidence for screening. Of the 3150 records screened by title and abstract, 3001 were excluded as they clearly did not meet the review's eligibility criteria, and a further five were identified as duplicate publications. This resulted in full-text screening 144 records, of which 106 were subsequently excluded (see Appendix 4 for reasons). The remaining 38 records, which reported on 34 studies, met the review's eligibility criteria and were included. For one included study, both the abstract and paper were included as one study (McCarthy *et al.* 2015, 2016) because they reported additional data to each other. Two records reported on the same study (Pagani *et al.* 2014a, Pagani *et al.* 2014b) and two abstracts reported the same study (Sage & Fretts 2012a, 2012b). On closer review of another study (Jovic *et al.* 2015) it was found that no relevant data to the review was reported, and it was thus excluded. This resulted in forwarding 34 studies for data extraction and analyses. Of the 34 included studies, four studies examined risk factors only, seven examined the reviews' pregnancy/birth/neonatal pre-specified outcomes only, and 23 studies reported on both risk factors and outcomes. A review of the reference lists of retrieved papers and grey literature searching did not identify any further studies for inclusion. Figure 3.3 illustrates the search and selection process.

3.6.2. Characteristics of included studies

Table 3.1 presents the summary characteristics of the 34 included studies, listed alphabetically. The included studies were published between 1974 and 2018, with the majority (n=22) published in the previous ten years, highlighting renewed interest in the topic of FMs. Most studies were from Europe (16 studies), followed by Asia (9 studies),

[5] One further study, conducted by my PhD supervisor (VS) Smith V., Begley C., Clarke M. & Devane D. (2014a) Decreased fetal movements (DFM) in pregnancy: a retrospective cohort study. 30th International Confederation of Midwives (ICM) Triennial Conference, Prague., which was available in abstract format only was eligible for inclusion also, with additional data to that in the abstract provided.

Australia and New Zealand (3 studies), United States (3 studies), Western and Southern Africa (2). An international study was also included, involving participants from among others, the UK, USA and Canada. Of the 34 studies, 12 were retrospective studies, 10 were prospective, and in 12 studies the design was not clearly specified. Various definitions of RFM exposure were used. These included, maternal perception of RFM, self-reported RFM, <10 FM in 12 hours, less than four FM in one hour, <3 movements/half hour, RFM of at least 2 hours in the previous 12 hours, <4 movements/hour for 2 consecutive hours, and any maternal concern leading to hospital examination. Cut-off minimum gestational age from which RFM was reported in the 34 studies began at 24 weeks in eight studies, 28 weeks in eight studies and from 36 weeks in nine studies. For seven studies the minimum cut-off was not explicit, and in two studies this was described as in the second half of pregnancy and in the third trimester, respectively. The method of data collection in studies also varied. In the majority of studies (n=19) data were collated from either medical records or hospital electronic databases, however, in some studies it was also collected via questionnaire (n=3) or interviews (n=1). The data collection method was not specified or was unclear for eleven studies.

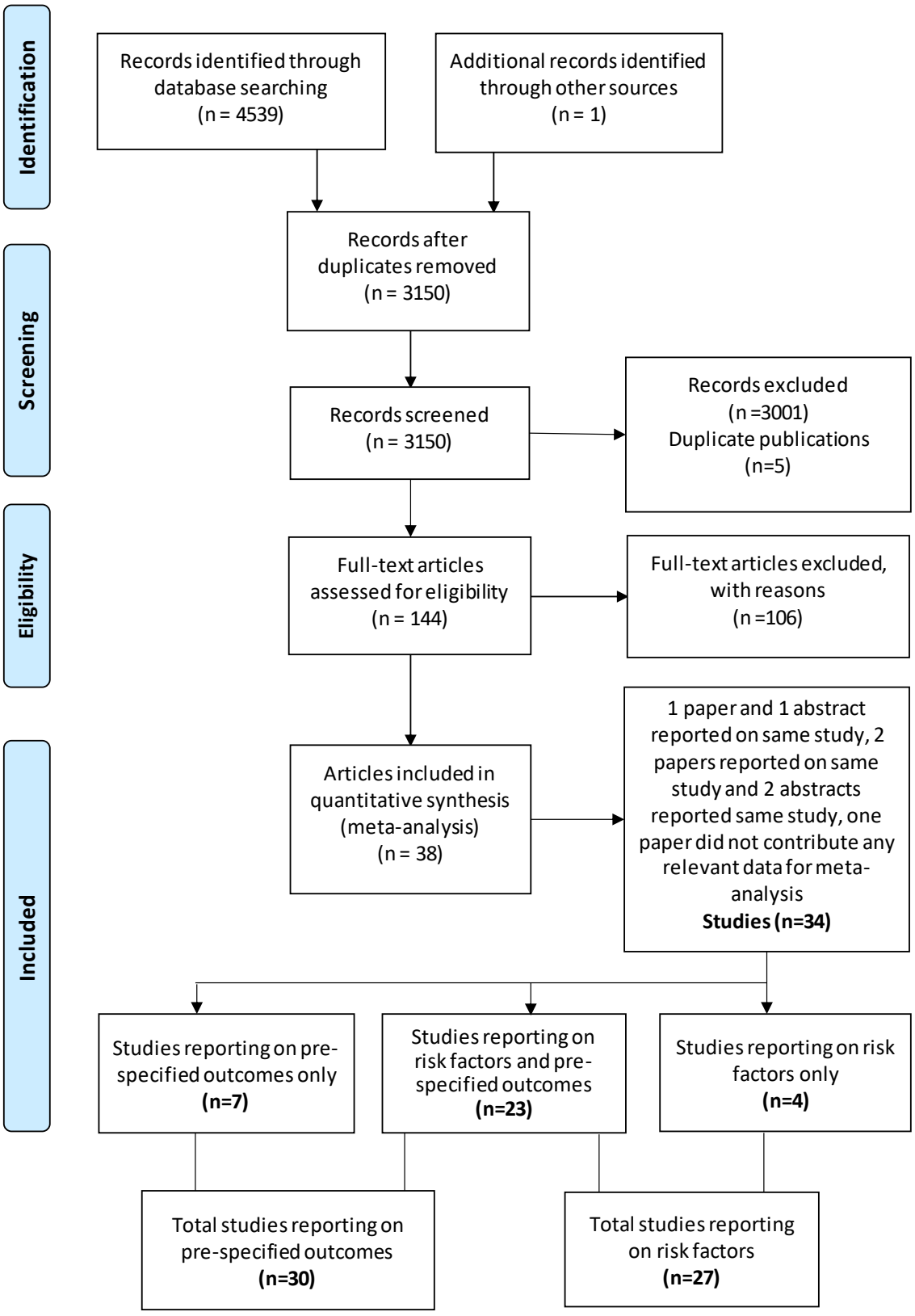


Figure 3.3 Prisma Study Selection Flow Chart

Table 3.1 Characteristics of Included Studies

Lead Author & Year	Setting (Country)	Study Design	Study Period	Inclusion Criteria	Definition of RFM	Gestational age of RFM reporting	RFM (n)	No RFM (N)
Aviram 2016 [RF, O]	Israel	Retrospective	2008-2013	Singleton pregnancy admitted to delivery ward with spontaneous onset of labour, or for labour induction excluding pregnancies with known structural or chromosomal anomalies.	< 2 consecutive hours or a marked subjective complaint of movements pattern change	37 - 42 weeks'	825	37031
Binder 2018 [RF, O]	UK	Retrospective	Jan 2008 - Oct 2015	Singleton pregnancy excluding multiple pregnancies congenital anomaly or aneuploidy	Each visit to the fetal medicine unit was considered a RFM episode	≥ 36 weeks'	4500	1527
Daly 2011 [RF, O]	Ireland	Retrospective	Not specified	Singleton pregnancy	Maternal perception	28-42+[2] weeks'	524	7,338
Eng 2016 [O]	Australia	Retrospective	Jan 2007 - Dec 2011	Case-Stillbirth, Control- live birth after 34 weeks' gestation excluding Women in labour < 34 weeks	Not explicit	2 weeks prior to stillbirth	35	129
Harrington 1998 [O]	UK	Not specified	20-month period	Women who presented to the FAU with a primary complaint of RFM	Not explicit	Not explicit	435	6793
Heazell 2017 [O]	International	Case-Control	Sep 2012 - Aug 2014	Cases -women ≥ 18 years, fluent in reading and writing English, delivered a singleton stillborn baby with no evidence of congenital anomaly at ≥ 28 weeks gestation. Controls-pregnant (≥ 28 weeks) or had recently delivered a living baby less than 30 days before they completed the survey. Multiple pregnancies, neonatal death, or fetal loss /live birth < 28 weeks gestation were excluded.	Maternal perception	>28 weeks'	88	545

LeadAuthor & Year	Setting (Country)	Study Design	Study Period	Inclusion Criteria	Definition of RFM	Gestational age of RFM reporting	RFM (n)	No RFM (N)
Ho 2017 RF, O	Australia	Prospective Matched	Mar 2015-Nov 2015	Uncomplicated third-trimester pregnancies excluding pregnancies with known fetal anomaly	Maternal perception/self-reported FMs	26-40 weeks'	50	50
Holm Tveit 2009 RF, O	Norway	Prospective Case-Control	Jun 2004-Oct 2005	Singleton pregnancy excluding Stillbirths not initially identified by RFM	Self-reported perception of RFM	≥ 28 weeks'	2374	614
Leader 1981 RF, O	South Africa	Prospective Case-Control	Not specified	Not explicit	A day of no FMs or 2 successive days in week before birth of FM <10/day	26-42	23	138
Linde 2017 RF, O, A	Sweden	Not specified	2014	All women with simplex pregnancy	Not explicit	Not explicit	2683	26041
McCarthy 2016 RF, O	Ireland	Prospective	Apr 2013-Oct 2013	All women presenting with RFM excluding multiple pregnancy and congenital anomalies	Not explicit	> 28 weeks'	275	265
Mohr Sasson 2016 RF, O	Israel	Retrospective	2011–2013	All women that visited the ER due to RFM. Control group-women who presented for different causes	Not explicit	24-42 weeks'	399	4493
Naz 2010 RF	India	Descriptive Case Series	Jan 2009 - Sept 2009	Women who were unbooked with a duration of pregnancy 42 weeks or more excluding women with IUD or pregnancy complications	Not explicit	≥42 weeks'	30	30
Olagbuji 2011 RF, O	Nigeria	Case-Control Matched	Jan 2006 - Dec 2009	Women who had antenatal care and IOL at term for maternal perception of RFM	Not explicit	Term	107	107

LeadAuthor & Year	Setting (Country)	Study Design	Study Period	Inclusion Criteria	Definition of RFM	Gestational age of RFM reporting	RFM (n)	No RFM (N)
O'Sullivan 2009 [RF, O]	UK	Retrospective	Jan 2007-Dec 2007	Women with a primary complaint of RFM & a viable fetus	Not explicit	After 24 weeks	203	3896
Pagani 2014 [RF, O]	UK	Retrospective	Jan 2008 - Dec 2012	All singleton pregnancies excluding pregnancies with major fetal structural abnormalities, aneuploidy or multiple gestations	Subjective perception	> 36 weeks	865	16926
Ross 2015 [O, A]	UK	Retrospective	Jan 2005-Dec 2010	Women with singleton pregnancies who presented to the Obstetric Day Assessment Unit with RFM after 20 weeks gestation	Not specified	>20 weeks gestation	Unknown	Unknown
Sadovsky 1974 [RF]	Israel	Prospective	Not specified	Not specified	< 3 movements/hr	2nd half of pregnancy	15	65
Sadovsky 1981 [RF, O]	Israel	Not specified	Nov 1976 -Apr 1980	Women admitted to high-risk pregnancy unit	Total absence or less than 10 FM per 12 hours	27-41 weeks'	55	767
Sage 2012 [RF, O, A]	US	Not specified	1 Oct 2010-30 Sept 2011	All women who presented with initial complaint was RFM.	Not explicit	Third trimester	371	7224
Sheikh 2014 [RF, O]	Iran	Prospective	Feb 2012 - March 2013	Normotensive singleton uncomplicated pregnant women who gave birth to healthy term newborns excluding fetal anomaly or multiple gestations	< 4 FMs/hour	> 28 weeks'	59	670
Simon 1985 [RF]	Israel	Not specified	Not specified	Hypertensive pregnancies attending high risk clinic	≤ 10 movements in 12hrs	≥ 25 weeks	15	258

LeadAuthor & Year	Setting (Country)	Study Design	Study Period	Inclusion Criteria	Definition of RFM	Gestational age of RFM reporting	RFM (n)	No RFM (N)
Sinha 2007 [RF, O]	UK	Retrospective Matched	Jan 2004 - Aug 2004	Women attending the DAU primarily with a history of RFM excluding pregnancies complicated with maternal medical complications, congenital fetal anomalies, women with previous CS	Not explicit	≥ 24 weeks	90	90
Skornick-Rapaport 2004 [O, A]	Israel	Not specified	Not specified	Women with primary complaint of subjective RFM.	Not explicit	Not explicit	769	28119
Smith 2012 [RF, O, A]	Ireland	Retrospective	Jan 2011-Dec 2011	All women with primary complaint of RFM	Maternal perception	≥28 weeks'	1008	16627
Stacey 2011 [O]	New Zealand	Retrospective Matched	July 2006-Jun 2009	Women with a singleton, late stillbirth without congenital abnormality	Changes in strength and frequency of FMs, unusually vigorous activity, and fetal hiccups	After 28 weeks	155	310
Tuffnell 1991 [RF]	UK	Prospective	Jan 1989-Oct 1989	All patients reporting RFM	Maternal perception	Not explicit	180	1051
Valencia-Rincon 2017 [RF, O]	Venezeula	Prospective Case-Control	Jun 2015-Apr 2017	Mothers over 18 years with normal pregnancy delivering at term excluding multiple pregnancy and any other complication of pregnancy	at least two hours of RFM in the previous 12hrs that differed from usual pattern	37-41 weeks'	93	550
Valentin 1987 [O]	Sweden	Not specified	Not specified	Not specified	FM counts fell below the individual lowest normal limit in two consecutive counting sessions (alarm signal)	Not explicit	158	1756

LeadAuthor & Year	Setting (Country)	Study Design	StudyPeriod	Inclusion Criteria	Definition of RFM	Gestational age of RFM reporting	RFM (n)	No RFM (N)
Warrander 2012 [RF, O]	UK	Not specified	Aug 2009-Oct 2010	RFM and subsequently delivered within 7 days of presentation excluding fetal anomaly, multiple pregnancy or abnormal fetal heart rate on CTG	Subjective maternal perception of RFM for at least 12 hours	> 28 weeks	36	36
Whitty 1991 [RF, O]	USA	Not specified	Jan 1985 - Apr 1990	All low risk patients presenting with a complaint of RFM	<four FMs/hr for 2 consecutive hrs	< 36 weeks	223	623
Williams 2014 [O,A]	UK	Retrospective	2009-2012	Multifetal pregnancies and congenital anomalies were excluded	Any change in perceived quality or frequency of FMs	Not explicit	23621	108102
Winje 2012 [RF, O]	Norway	Prospective	July 2009 - July 2011	All women with singleton pregnancies presenting with RFM	Any maternal concern leading to a hospital examination	last 7 days before birth	129	191
Yogev 2003 [RF, O]	Israel	Prospective matched	Jan 1998 - Dec 2000	Women with consistent reduced perception of FM excluding pregnancies with contraindication to induction of labour and vaginal birth	< five fetal movements/day for 2 consecutive days	Not explicit	115	510

A Abstract only; *O* Outcomes; *RF* Risk Factors; *CS* Caesarean section; *CTG* Cardiotocography; *DAU* Day Assessment Unit; *ER* Emergency Room; *FAU* Fetal assessment unit; *IOL* Induction of labour; *IUD* Intrauterine death; *RFM* Reduced fetal movements.

Of the 27 studies that examined risk factors, 12 exclusive factors reported in at least two studies were identified. These were maternal age, body mass index, education level, ethnicity, parity, anterior placenta, smoking, postdates >42 weeks', abnormalities of amniotic fluid, diabetes, hypertensive disorders of pregnancy and antenatal bleeding. Table 3.2 illustrates the number of studies that reported on each risk factor. For pregnancy/birth/neonatal outcomes, stillbirth was the most commonly reported outcome, reported in 18 of the 30 studies, followed by SGA (n=14 studies). Table 3.3 presents the studies that reported on each of the review's pre-specified outcomes.

3.6.3. Quality assessment

Table 3.4 presents a summary of the results of the quality (risk of bias) assessments. Six abstracts were not assessed due to the limited information provided; therefore, 28 studies were assessed using the QUIPs tool. Appendix 4 provides an example of the QUIPs assessment for included studies.

3.6.3.1. Study participation

Nineteen studies were rated low risk of bias for study participation (domain 1). Eight studies were rated moderate risk of bias as the description of the sampling frame, recruitment and inclusion or exclusion criteria were not explicit or evident. One study (Leader *et al.* 1981) was rated high risk of bias as only 61% of eligible participants were evaluated, description of source population was not evident, and the inclusion/exclusion criteria were not clearly specified.

3.6.3.2. Study attrition

All except two studies were rated low rate of bias for study attrition. Two studies were rated moderate risk of bias as they did not report reasons for attrition or loss of participants to follow up.

Table 3.2 Number of studies reporting on each risk factor

Author	Maternal Age	Parity	Education	Ethnicity	BMI	Previous caesarean Section	Smoking	Anterior Placenta	Postdates ≥42weeks	Hypertensive Disorders	Diabetes	Abnormality Amniotic Fluid	Antenatal Bleeding
Aviram	X	X				X				X	X	X	
Binder	X	X		X	X								
Daly		X											
Ho	X	X			X					X	X		
Holm Tveit	X	X			X		X		X				
Leader	X	X								X	X		X
Linde	X	X	X		X								
McCarthy	X	X			X								
Mohr Sasson	X	X			X			X	X				
Naz									X				
O'Sullivan	X	X			X								
Olagbuji	X	X	X										
Pagani	X	X		X	X		X						
Sadovsky 1981									X			X	X
Sadovsky 1974										X	X	X	
Sage		X											
Sheikh	X	X						X				X	
Simon 1985										X			
Sinha	X	X											
Smith		X			X	X	X						
Tuffnell		X						X					
Valencia	X	X			X								
Warrander	X	X			X		X						
Whitty	X	X											
Winje	X	X					X						
Yogev	X	X						X				X	
No. Studies	18	22	2	2	11	2	5	4	3	5	4	5	2

Table 3.3 Number of studies reporting pre-specified outcomes

Author	Stillbirth	PTB	SGA	NND	IOL	CS	Instrumental Birth	Birthweight	Gestational age at birth	Apgar <7 at 5 mins	Meconium	Metabolic acidosis pH<7.05	Admission NICU	Gender
Aviram	X			X	X	X	X	X	X	X	X	X	X	X
Binder	X		X	X					X					
Daly	X	X		X	X	X	X		X	X			X	
Eng	X													
Harrington		X				X				X			X	
Heazell	X													
Ho	X	X	X			X		X	X	X	X	X	X	
Holm Tveit		X	X	X		X								X
Leader	X		X											
Linde					X									
McCarthy	X				X	X	X	X	X	X			X	
Mohr Sasson	X	X		X										
O'Sullivan	X	X				X	X							
Olagbuji			X	X	X	X		X	X	X			X	
Pagani	X		X					X	X					X
Ross	X		X		X									
Sadovsky 1974	X		X											
Sage		X	X			X			X				X	
Sheikh														X
Sinha	X	X	X	X		X	X			X		X	X	
Skornick-Rapport						X	X		X	X			X	
Smith	X	X			X		X	X						
Stacey	X													
Valencia Rincon					X	X		X	X	X				
Valentin	X	X	X							X				
Warrander			X		X	X							X	
Whitty						X		X		X	X		X	
Williams	X		X											
Winje		X	X		X	X		X	X					
Yogev					X	X	X	X	X	X				
No. Studies	**18**	**11**	**14**	**7**	**11**	**12**	**8**	**10**	**12**	**12**	**3**	**3**	**11**	**4**

Table 3.4 Quality Assessment/Risk of Bias using QUIPS Tool (Hayden, 2013)

Reference (Author/Year)	Study Participation	Study Attrition	Risk Factor Management	Outcome Measurement	Study Confounding	Statistical Analysis & Presentation
Aviram et al, 2016	Moderate	Low	Low	Low	Low	Low
Binder et al, 2018	Low	Low	Low	Low	Low	Low
Daly et al, 2011	Low	Low	Low	Low	Low	Low
Eng et al, 2016	Low	Low	Low	Low	Low	Low
Harrington et al, 1998	Moderate	Low	Not applicable	Moderate	High	Low
Heazell et al, 2017	Moderate	Low	Moderate	Moderate	Low	Low
Ho et al, 2018	Low	Low	Low	Low	Low	Low
Holm Tveit et al, 2009	Low	Low	Low	Low	Low	Low
Leader et al, 1981	High	Low	Low	Moderate	Unknown	Low
McCarthy et al, 2016	Low	Low	Low	Low	Low	Moderate
Mohr Sasson et al, 2016	Low	Moderate	Low	Low	Low	Low
Naz et al, 2010	Low	Low	Low	Not applicable	Unknown	Low
Olagbuji et al, 2011	Low	Low	Low	Low	Low	Low
O'Sullivan et al, 2009	Low	Low	Low	Low	Low	Low
Pagani et al, 2014	Low	Low	Low	Low	Low	Low
Sadovsky et al, 1981	Low	Low	Moderate	Not applicable	High	High
Sadovsky et al, 1974	Moderate	Low	Moderate	High	High	High
Sheikh et al, 2014	Low	Low	Low	Low	Low	Low
Simon et al, 1985	Moderate	Low	High	Not applicable	High	High
Sinha et al, 2007	Low	Low	Low	Low	Low	Low
Stacey et al, 2011	Moderate	Low	Low	Low	Low	Low
Tuffnell et al, 1991	Low	Low	Moderate	Not applicable	Low	Low
Valencia-Rincon et al, 2017	Moderate	Moderate	Low	Low	Moderate	Low
Valentin and Marsal, 1987	Moderate	Low	Not applicable	Low	High	Low
Warrander et al, 2012	Low	Low	Low	Low	Moderate	Low
Whitty et al, 1991	Low	Low	Low	Low	High	Low
Winje et al, 2012	Low	Low	Low	Low	Low	Low
Yogev et al, 2003	Low	Low	Low	Low	Low	Low

3.6.3.3. Risk Factor Measurement

This domain was rated only if applicable; that is if the study reported review outcomes only, this domain was rated as 'not applicable'. Twenty-one studies were rated as low risk of bias for risk factor measurement. Five studies were rated either moderate risk or high of bias because no clear definitions or description of risk factors were provided or if it was not known from reporting of the study if the risk factor measurement was valid or reliable.

3.6.3.4. Outcome Measurement

Twenty studies were rated low risk of bias for domain 4 (outcome measurement). Studies were rated moderate or high risk of bias for this domain if the definitions for outcome measurement were unclear or not reported (n=4).

3.6.3.5. Study Confounding

Eight studies were rated as either moderate or high risk of bias for domain 5 (study confounding), due to no multivariate regression or no reporting of confounding within the paper. Studies were rated low risk of bias if the studies reported methods of case-controlling, matching or control groups (n=18).

3.6.3.6. Statistical Analysis and Presentation

Twenty-four studies were rated low risk of bias for domain 6 (statistical analysis and presentation). Four studies were rated either moderate or high risk of bias due to either no documentation of analytical strategy or insufficient presentation of data to assess the analytical strategy.

3.6.4. Findings

3.6.4.1. Risk factors associated with RFM in pregnancy

Five of the twelve identified risk factors were found to be predictive of RFM in pregnancy. These were ethnicity, anterior placenta, smoking, oligohydramnios and polyhydramnios (see Table 3.5 for results). Forest plots for each reported risk factor are provided in Appendix 5.

Table 3.5 Risk factors associated with RFM

Risk Factor	No. of Studies	No. of participants	OR (95% CI)	I^2
Ethnicity (Caucasian versus Non-Caucasian)	2	5365	2.59 (2.40-2.80)	0%
Anterior placenta	3	6852	1.31 (1.11-1.55)	0%
Smoking	5	29557	1.18 (1.02-1.35)	4%
Oligohydramnios	3	39407	4.04 (3.29-4.97)	0%
Polyhydramnios	4	39487	2.01 (1.44-2.81)	28%

CI, confidence interval; OR, odds ratio

Two additional studies not included in a meta-analysis reporting on education level found that women with a higher education level were more likely to seek care for RFM than women with low educational level (primary school or equivalent) ($p<0.001$; Linde *et al*. 2017) and (82.2% vs 51.4%, $p<0.001$, 107 women; Olagbuj *et al.* 2011).

Table 3.6 presents the meta-analysed summary effect measures for other identified risk factors not found to be predictive of RFM. Amongst women with RFM, no difference was found for parity (nulliparous women versus multiparous women (OR 1.26 95% CI 0.88-1.81; 17 studies, 11368 participants, $I^2=97\%$). Five studies provided continuous data that could not be pooled. Four of these studies found that the rates of RFM were comparable between nulliparous and multiparous women. Only one study (Linde *et al.* 2017) reported that primipara more often seek care for RFM ($p<0.001$).

Eighteen studies reported on maternal age as a risk factor for RFM. Continuous data from six studies were combined in a meta-analysis. No difference between the RFM and no-RFM groups was found (MD 0.11 95% CI -0.62-0.83; 6 studies; 6635 participants,

I^2=51%). Aviram *et al.* (2016), O' Sullivan *et al.* (2009), Pagani *et al.* (2014), Sinha *et al.* (2007) and Warrander *et al* (2012) also narratively reported no difference in age of women presenting with RFM compared to women who did not have RFM. Five studies provided data for a meta-analysis based on age ≥35 years and age <35 years of age. The results showed that fewer women aged ≥35 years' present with RFM when compared to women aged <35 years. Binder *et al.* (2018) and Linde (2017) also report that women presenting with RFM were younger (p<0.01 and p=0.005 respectively).

Table 3.6 Factors not predictive of RFM during pregnancy

Risk Factor	No. of Studies	No. of Participants	OR (95% CI)	I^2
Maternal age	6	6635	0.11 (-0.62-0.83)**	51%
Maternal age >35yrs v ≤35 yrs	5	2887	0.18 (0.01-2.15)*	99%
BMI ≥25 kg/m²	2	3088	1.24 (0.62-2.46)*	54%
BMI ≥35 kg/m²	3	4992	0.87 (0.44-1.72)*	86%
Parity (Primiparous versus Multiparous)	17	11368	1.26 (0.88-1.81) *	97%
Previous CS	2	30260	0.86 (0.48-1.53)*	92%
Postdates >42 weeks	3	301	1.14 (0.40-3.24)	0%
Diabetes	4	38197	1.16 (0.87-1.55)	48%
Chronic Hypertension	2	38119	1.58 (0.90-2.78)	0%
Gestational Hypertension	4	38390	0.87 (0.32-2.39)*	54%
Pre-eclampsia	2	353	1.02 (0.36-2.84)	0%
Antenatal Bleeding	2	983	0.35 (0.03-4.62)*	54%

*Random Effect Model; ** Mean Difference; CS Caesarean Section; CI, confidence interval; OR, odds ratio

Eleven studies reported on BMI as a risk factor for RFM. Data from three studies reporting specific categories of BMI were pooled in a meta-analysis. Neither a BMI ≥25 (OR 1.02, 95% CI 0.85-1.23, 2 studies; 3088 participants, I^2=54%) nor a BMI ≥ 35 kg/ m² (OR 1.05 95% CI 0.89-1.23, 2 studies; 4992 participants, I^2=53%) were identified as risk factors for RFM. Of the other eight studies, four reported no differences between the RFM and no RFM groups based on BMI (O'Sullivan *et al.* 2009, Warrander *et al.* 2012, Valencia-Rincon *et al.* 2017, Binder *et al.* 2018b), three reported higher rates of RFM

with higher BMI (Holm Tveit *et al.* 2009, Pagani *et al.* 2014a, Linde *et al.* 2017a) and one study (McCarthy *et al.* 2016) reporting on the RFM groups only, stated that nearly one quarter of women with RFM (n=275) had a body mass index over 30kg/m². Table 3.7 summarises the results for BMI.

Table 3.7 Body Mass Index (BMI)

Study	RFM Group	No RFM Group	OR 95%CI	p value
Binder *et al* (2018)	Median 24.6 (IQR 21.9-28.3), n=4500	Median 24.5 (IQR 22.0-28.8), n=1527		ns
Warrander *et al.* (2012)	Mean 24.4 (SD 18.1-45.6 kg/m²), n=36	Mean 24.6 (SD 17.8-41.9 kg/m²), n=36		ns
McCarthy *et al.* (2016)	BMI over 30kg/m², n=63	No data available		
O'Sullivan *et al.* (2009)	Mean 23.8 (range 17.4-45.7 kg/m²), n=203, p=0.7		1.01 (0.95-1.07)	ns
Valencia-Rincon *et al* (2017)	Mean 26.1 (SD ± 5.1kg/ m²), n=93	Mean 27.0 (SD ± 6.2 kg/ m²), n=550		ns
Pagani *et al* (2014)	BMI ≥ 35 kg/ m²		2.10 (1.49-2.95)	p<0.001
Linde *et al* (2017)	BMI 30-34.9 kg/m²			P<0.001
Holm Tveit (2009)	BMI >25 kg/ m²		1.2 (1.3-2.0)	P<0.001

CI, confidence interval; OR, odds ratio; ns, not significant; SD, standard deviation;

3.6.4.1.1. Publication bias

When ten or more studies contributed to the analyses, funnel plots were inspected for evidence of asymmetry and possible publication bias. A funnel plot for parity (17 studies) (Figure 3.4) showed a gap in the middle and bottom left and right of the plot suggesting that smaller studies with large effects may be underrepresented.

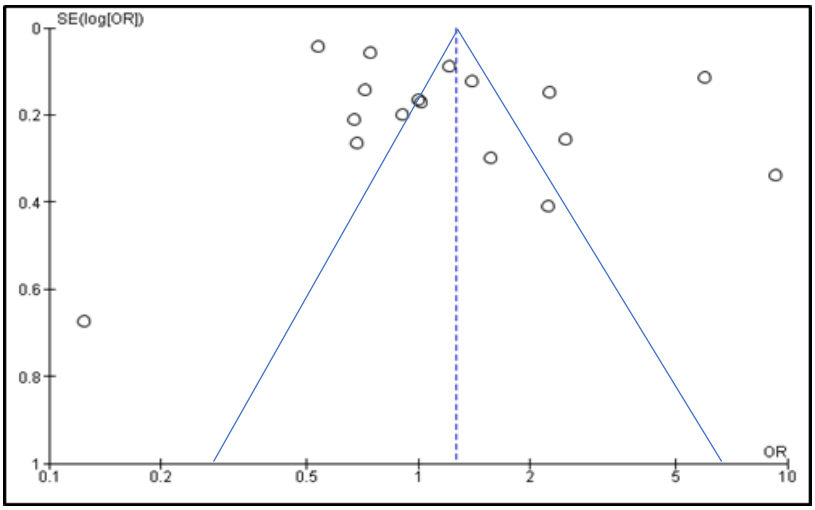


Figure 3.4 Funnel plot analysis (parity)

The findings for pregnancy, birth and neonatal outcomes associated with RFM are summarised in the next section.

3.6.4.2. Pregnancy, birth and neonatal outcomes associated with RFM

3.6.4.2.1. Stillbirth

Eighteen studies contributed data on stillbirth. Fourteen studies were included in a meta-analysis. The results demonstrated that women who experienced RFM during pregnancy were almost six times more likely to have a stillbirth than women who did not experience RFM (OR 5.80, 95% CI 4.58-7.35, 14 studies, 95,649 women, I^2=81%). Due to high statistical heterogeneity a random effects model was applied; the average RFM effect remained significant; OR 5.23, 95% CI 2.49-10.98, although heterogeneity remained high at 81% (Figure 3.5). All 14 studies included in the meta-analysis except one (Ho *et al.* 2018) individually found fewer stillbirth cases in the no RFM group, six significantly so. Ho *et al.* (2018) contributed the least number of participants and stillbirth events to the meta-analysis (0 versus 1, RFM v No RFM respectively), and for one other study (Sinha *et al.* 2007) there were no stillbirths reported in either group. When no events occur in either group being compared, the summary effect measure (OR) is not estimable, nor does the study contribute to the overall meta-analysed result. For this reason, Sinha *et al.* (2007) was not included in the meta-analysis (Figure 3.5).

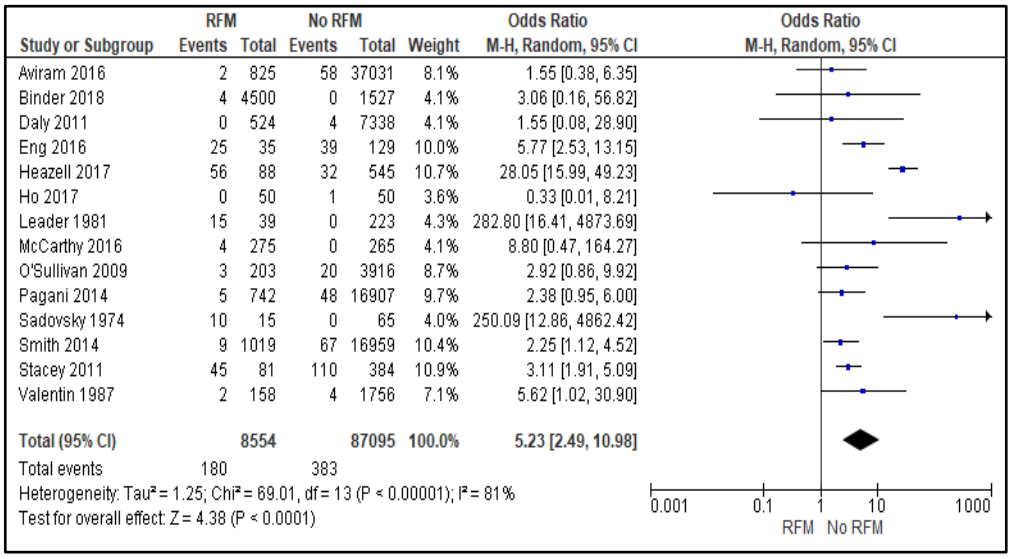


Figure 3.5 Stillbirth (Random Effect Model)

Three studies reported on stillbirth ≥36 weeks' gestation. The RFM effect also remained significant for stillbirth at gestational age ≥36 weeks although less so overall; (OR 2.16, 95% CI 1.02-4.57, 3 studies; 61,532 participants, I^2=0%) (Appendix 6).

To investigate the robustness of the results for the outcome stillbirth, sensitivity analyses based on study design and risk of bias (i.e., studies with overall low risk of bias) were conducted. Irrespective of study design, stillbirth remained significantly higher in RFM groups, although the summary effect measures were varied. The OR result combining studies of low risk of bias only was altered to 3.86 with greater precision around the effect estimate (95% CI 2.08-7.18), and 0% heterogeneity. The results of the sensitivity analyses are presented in Table 3.8.

Table 3.8 Stillbirth

Outcome: Stillbirth	No. of Studies	No. of participants	OR (95% CI)	I^2
Stillbirth	15	95,829	5.23 (2.49-10.98) *	81%
Studies reporting stillbirth ≥36 weeks gestation	3	61,532	2.16 (1.02-4.57)	0%
Low Risk of Bias Studies	6	18,452	3.86 (2.08-7.18)	0%
Retrospective studies only	9	94,050	2.74 (1.97-3.81)	0%
Prospective studies only	3	882	71.77 (12.07-426.71)	44%
Case-Control studies only	3	897	6.88 (1.24-38.10) *	88%

* Random Effects Model; CI, confidence interval; OR, odds ratio;

3.6.4.2.2. Preterm birth (>37 weeks' gestation)

Eleven studies reported on preterm birth and ten of these studies contributed data to a meta-analysis. There was no difference in the rates of preterm birth in women who experienced RFM during pregnancy compared to women who did not experience RFM (OR 1.02, 95% CI 0.73-1.43; 10 studies, 49,941 women, I^2=74%) (Figure 3.6). Mohr Sasson *et al.* (2016) also reported that RFM was not associated with pre-maturity (p=0.41).

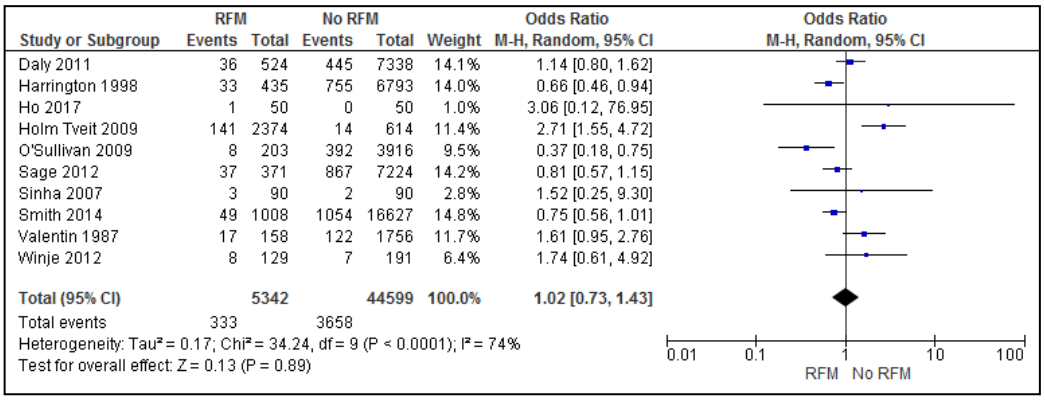


Figure 3.6 Preterm Birth

3.6.4.2.3. Small for gestational age at birth

Fourteen studies reported on small for gestational age (SGA) at birth and thirteen contributed data to a meta-analysis. Women who experienced RFM during pregnancy were nearly twice as likely to have infants who were SGA compared to women who did not experience RFM in pregnancy (OR 1.73 95% CI 1.31-2.30; 169,165 participants, I^2=85%) (Figure 3.7). Ross *et al.* (2015) reported no statistical difference in the incidence of SGA.

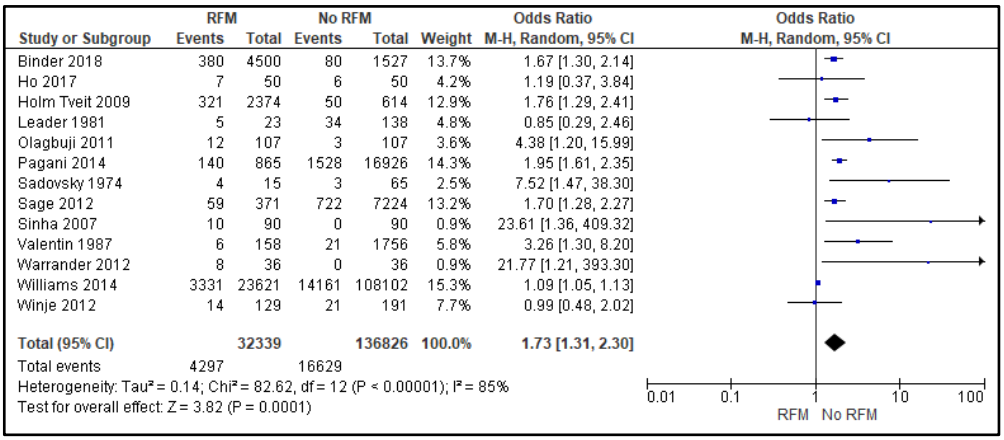


Figure 3.7 Small for gestational age (Random Effects Model)

3.6.4.2.4. Neonatal death

Seven studies reported on neonatal death (NND) of which three studies contributed data to a meta-analysis. The results found no differences in the rates of NND in the RFM versus no RFM groups (OR 1.60 95% CI 0.32-7.98; 3 studies, 15,803 women, I^2=0%) (Figure 3.8). The numbers of NNDs, however were very few across the groups (3 of 5,182 versus 9 of 10,621). The wide confidence interval is likely explained by the few event rates in both groups. Three of the seven studies were not included in the meta-analysis as there were no NNDs reported in either group (Sinha *et al.* 2007, Olagbuji *et al.* 2011, Aviram *et al.* 2016). For the remaining study, Mohr Sasson *et al.* (2016) reported that RFM was not associated with NND. Two of the seven studies (Binder *et al.* 2018; Sinha *et al.* 2007) excluded women with congenital fetal anomalies from their studies. It is not explicit if the other five studies also excluded women with congenital fetal anomalies.

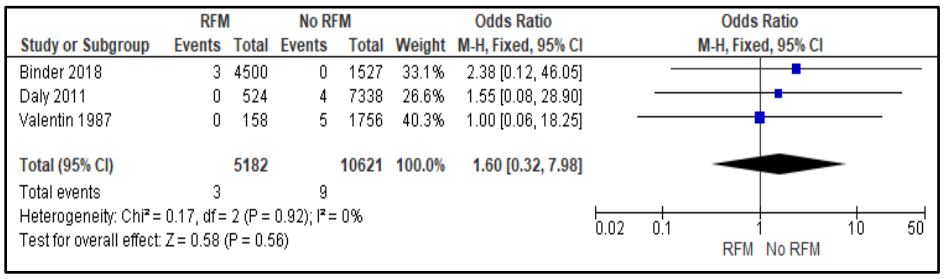


Figure 3.8 Neonatal Death (Fixed effect model)

3.6.4.2.5. Secondary outcomes

Table 3.9 and Appendix 6 presents the results for the pre-specified secondary outcomes. Women with RFM in pregnancy compared to women without RFM were more likely to have induction of labour, instrumental birth, caesarean section (overall and emergency) and less likely to have a planned CS. No differences were found between groups in any of the remaining pre-specified secondary outcomes (meconium-stained liquor, Apgar score <7 at 5 mins, metabolic acidosis, admission to NICU, gender). There was also no difference in the mean gestational age at birth for women with RFM or no RFM. Pagani *et al.* (2014) and Aviram *et al.* (2016) also found no difference in the median and interquartile range (IQR) of gestational age at birth of women with or without RFM. Binder *et al.* (2018) did however report that women with RFM were more likely to birth earlier (p<0.001).

Table 3.9 Meta-analysis of Secondary Outcomes

Outcome	No. of Studies	No. of participants	OR (95% CI)	I^2
Induction of Labour	10	76,856	1.52 (1.13-2.05) *	93%
Meconium-stained Liquor	3	38,801	0.98 (0.78-1.23)	44%
Instrumental Birth	8	97,705	1.14 (1.05-1.25)	1%
Caesarean Section (overall)	10	69,914	1.12 (1.03-1.22)*	90%
Planned CS	4	12,373	0.61 (0.45-0.82)	46%
Emergency CS	8	87, 218	1.43 (1.29-1.59)	0%
Apgar Score <7 at 5 mins	12	86,893	0.96 (0.58-1.57) *	59%
Metabolic acidosis	3	38,072	1.89 (0.87-4.14)	0%
Admission to NICU/SCBU	10	83,785	0.77 (0.49-1.23) *	70%
Gender-Male	4	58,364	0.91 (0.73-1.12) *	79%

*Random Effects Model

3.6.4.3. Sensitivity analysis

Sensitivity analysis was conducted to explore the effect of study quality on the outcomes preterm birth, SGA and NND, excluding those studies considered to be either moderate or high risk of bias for any of the QUIP tool domains. The results are presented in Table 3.10. Results were not altered overall for the outcomes of preterm birth or SGA, although heterogeneity was significantly reduced for SGA. The confidence interval for NND was further widened, possibly due to studies contributing few events.

Table 3.10 Sensitivity Analysis Preterm birth, SGA and NND

Outcome	No. of Studies	RFM (n)	No RFM (n)	OR (95% CI)	I^2
Preterm Birth (<37 weeks' gestation)	6	3370	12,199	1.26 (0.64-2.45) *	74%
Small for Gestational Age (SGA)	6	7250	2579	1.72 (1.44-2.06)	38%
Neonatal Death	4	5221	9062	2.01 (0.26-15.64)	0%

CI, confidence interval; OR, odds ratio

3.6.4.4. Publication bias

When ten or more studies contributed to the analyses, funnel plots were inspected for evidence of asymmetry and possible publication bias. Funnel plots were conducted for the following outcomes: stillbirth (15 studies), preterm birth (10 studies), SGA (12 studies), induction of labour (10 studies), Apgar score <7 at 5 mins (12 studies) and admission to NICD (10 studies). Funnel plots for stillbirth, preterm birth, SGA, Apgar score <7 at 5 mins and admission to NICU were relatively symmetrical indicating minimal publication bias or small study effect (Appendix 7). The funnel plot for induction of labour was visually asymmetrical possibly due to two studies having no events in either group (Appendix 7). Publication bias cannot be out ruled.

3.7 Chapter summary

The findings of this chapter show that women presenting with RFM during pregnancy are significantly more likely to be Caucasian, smokers, and have an anterior placenta, oligohydramnios and polyhydramnios. However, variation in the reporting of risk factors in studies on RFM was highlighted. Few studies (n=3), reporting fetal movement perception in women who have a BMI > 35 kg/m2 were identified. Only seven studies have been conducted to evaluate the association of medical conditions such as diabetes and hypertensive disorders of pregnancy with RFM and of these, four were conducted up to forty years ago. No studies were found that investigated an association between previous obstetric history, including assisted conception, history of miscarriage, previous stillbirth or previous NND. Globally, maternity care is becoming more complex due to changing social demographics and lifestyle of childbearing women. The proportion of women with medical co-morbidities and multimorbidity becoming pregnant are increasing (Lee *et al.* 2022, Tanner *et al.* 2022). Caesarean section rates are rising year on year (World Health Organization 2015, Betrán *et al.* 2016, Blencowe *et al.* 2019) and the proportion of low-birth-weight babies (Blencowe *et al.* 2019) are increasing. Preterm birth, one of the leading causes of death in children under the age of five worldwide (Perin *et al.* 2022) is also increasing. Studies that have examined potential risk factors demonstrated conflicting results possibly due to divergent research

designs, small sample sizes, incompleteness of data for control group, and selection bias of participants.

With regards to pregnancy, birth and neonatal outcomes associated with RFM in pregnancy, results demonstrate that RFM presents a significant burden for pregnancy and birth adversity, especially for stillbirth and SGA. Critically, when the results from high quality/low risk of bias studies only were considered, the increased likelihood of stillbirth with RFM was almost 4-fold, with heterogeneity of 0%, indicating no statistical variability in the data. This further emphasises the importance of focusing on FMs in either awareness or management strategies aimed at reducing stillbirth. The review did not find an association between RFM and preterm birth or NNDs, however, the numbers of NNDs across the groups were minimal (12 NNDs in total). This could be explained by the evolution of advances in medical and technological neonatal critical care, in more recent decades, and their resulting impact on reducing NNDs. This review also confirms that when women present with RFM in pregnancy they are more likely to have increased intervention such as induction of labour, caesarean section and instrumental birth. The management of RFM is challenging for maternity healthcare professionals. A balance is required to acknowledge women's concern of RFM, respond appropriately to avoid potential fetal death or injury 'being born too late' but at the same time avoiding iatrogenic harm to women such as induction of labour and caesarean section.

Of the 34 studies included in the review, eight were conducted over 30-40 years ago. Of the remaining studies, the most recent study period/date of data collection was six years ago (Valencia-Rincon, 2017). Temporal changes to practices, such as creating enhanced awareness about FMs in pregnancy, routine clinical assessment of fetal growth and local or national clinical guidelines for the management of RFM (such as the use of CTG and doppler ultrasound to exclude fetal compromise) have the potential to impact modifiable risk factors and outcomes related to RFM. Continuing evaluations for contemporaneous evidence and understandings is thus important for clinical care. In addition, the reporting of outcomes varied significantly across the studies. For example, of the 30 studies reporting on the review's pre-specified outcomes, only eight studies reported on interventions such as instrumental birth and ten studies on caesarean

section. Rates of birth interventions are rising year on year; it is important to further identify factors that may be contributing to this.

This systematic review provides important evidence on risk factors and outcomes associated with RFM in pregnancy. The evidence will aid policy development and clinical decision making regarding the care and management of women with RFM. Limitations, however, highlighted in this review (e.g., absent or limited evidence on some risk factors and outcomes, poorly designed or executed studies, data from ≥ six years ago) emphasise the need for a contemporary robust investigation of the maternal characteristics, risk factors for and pregnancy, birth and neonatal outcomes associated with RFM. Although three Irish studies addressing this topic were identified (Daly *et al.* 2011, Smith *et al.* 2014, McCarthy *et al.* 2016), the findings of these studies are based on data collected between 2011 and 2013, 10 to 12 years ago. Furthermore, the studies had characteristic and methodological weaknesses, including retrospective designs (Daly *et al.* 2011; Smith *et al.* 2014) and variation in the risk factors and outcomes that were reported. For these reasons it was considered timely and clinically warranted to conduct a prospective case-control study exploring perinatal risk factors and outcomes, in the context of contemporary Irish maternity care**.** Chapter 4 presents the methodology and methods for this study.

Chapter 4 Methodology and Methods

4.1 Introduction

This chapter presents the theoretical and philosophical perspectives underpinning the methodology of the study. This includes a discussion on research paradigms, and justification for the study design used to address the study aims and objectives. Details of the study methods and ethical considerations are presented. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (von Elm *et al.* 2014) were used to report the case-control study. The completed STROBE checklist is provided in Appendix 8.

4.2 Aims and objectives of this research

The study aim was to identify potential predictors of RFM and perinatal outcomes following maternal report of RFM in pregnancy. The research objectives were:

a) To describe potential risk (predictive) factors (e.g. maternal age, ethnicity, BMI, smoking status, position of placenta) for RFM in pregnancy;
b) To describe pregnancy, birth and neonatal outcomes in women ≥24 weeks' gestation who present to the maternity hospital with RFM in pregnancy;
c) To determine any differences in identified risk factors between women who experience RFM and women who do not experience RFM;
d) To determine any differences in pregnancy, birth and neonatal outcomes between women who experience RFM and women who do not experience RFM.

As the study was ongoing at the onset and during the COVID-19 pandemic, an additional objective was later added:

e) To determine the impact of the first pandemic-related national lock-down on attendances for RFM during pregnancy in a large urban maternity unit in Ireland.

4.3 Philosophical underpinnings

In 1962, American Philosopher Thomas Kuhn first coined the term research 'paradigm', a word used to describe a researcher's 'worldview', including assumptions, perspectives, values or beliefs that in turn will guide and influence what should be studied, how it is studied and how the results should be interpreted (Guba & Lincoln 1994, Kivunja & Kuyini 2017). A research paradigm is comprised of four elements: ontology (the nature of reality), epistemology (how we know what we know), axiology (values) and methodology (research process) (Creswell & Creswell 2018, Denzin & Lincoln 2018, Mertens 2020). A paradigm thus represents a researcher's philosophical orientation and has significant implications for every decision made in the research process, including choice of methodology and methods (Creswell and Creswell 2018). Two dominant and contrasting paradigms exist: objectivism (*positivists)* and subjectivism (*constructivists)* (Gray 2009, Polit & Beck 2020). The philosophical underpinning of this study is objectivism/positivism. Objectivism or positivism (terms which are often used interchangeably) is recognised as the philosophical basis for most quantitative research. To illustrate how the current study was situated within a positivist worldview, an examination of the differences between objectivism and subjectivism is presented.

Ontology is the philosophical study of the nature of existence or reality. Philosophical assumptions about the nature of reality are crucial to understanding the meaning of research, helps to orientate thinking about a research problem, its significance, and the approach needed to contribute to its solution (Kivunja & Kuyini 2017). Ontology is divided into two main configurations: relativism and realism. *Relativism* contends that reality is subject to perception of experiences and behaviours whereas *realism* ontology is content with accepting that facts are real and independent.

Epistemology originates from the Greek word 'episteme', meaning knowledge (Kivunja & Kuyini 2017) and is concerned with understanding how knowledge, 'truth or reality' is acquired or created. Epistemology is important as it can influence how researchers frame their research in an attempt to create knowledge.

Two dominant epistemological positions exist: objectivism and subjectivism (Figure 4.1). Objectivism embraces ontological realism, asserting that reality exists independent of perception and experience, lending itself to objective measurement of the phenomenon under study (Crotty 2014). Objectivists or positivists (terms which are often used interchangeably) follow a deductive approach (test a hypothesis), whereby the researcher is independent from the study and does not interact with participants during the study. Facts are concentrated on instead of perceptions or experiences (Collins 2010). Subjectivism (i.e., constructionism or interpretivism) offers an alternative dimension of knowing and engaging with reality, assuming relativist ontology. Constructivists / interpretivists reject the notion of a single reality, believing that reality is socially constructed, subjective as opposed to objective with knowledge constructed or generated through social interactions with the world or people (research participants/researchers or both) (Guba & Lincoln 1994, Crotty 2014). The researcher becomes immersed in the phenomena under investigation through induction as opposed to deduction. Constructivists reject the notion of the researcher being neutral and acknowledge that the researchers' values can impact on the phenomenon being studied. The researcher actively identifies and reports their values and biases in relation to the context and setting of the research (Creswell & Creswell 2018).

While both objectivism and subjectivism have their place within healthcare research, it is important to ensure that the research paradigm underpinning the design of a study is ontologically and epistemologically congruent, not only with the study's aim and research questions, but also with the chosen methodology and methods (Houghton *et al.* 2012). Given that the current study's research objectives were to determine risk factors for, and outcomes associated with RFM and to determine differences in risk factors for and outcomes between women with RFM and women without RFM, the ontological and epistemological perspective of the study is rooted in objectivism rather than subjectivism (Figure 4.1). A quantitative methodology was appropriate to address the research aim and objectives.

Paradigm	Ontology	Epistemology	Methodology
Objectivism (Positivism)	There is only one reality and truth	Reality can be measured. Phenomenon is observed and facts are provided. Objective	Quantitative
Subjectivism (Interpretivism Constructivism)	There is no single truth or reality.	Reality or truth is dependent upon subjective interpretations	Qualitative

Figure 4.1 Research paradigm

Axiology relates to how we conceptualise our role as ethical and moral actors within research. From an axiological perspective the researcher is obliged to adhere to ethical principles and norms in the pursuit and conduct of good research (Mertens 2020). Axiologically, objectivists/positivists work independently, remaining detached from their own values and beliefs, and bias can be eliminated through use of rigorous procedures throughout the research process, in contrast to subjectivists/constructivists where values and bias may be inherent within the study and thus should report about their values and biases.

After determining the ontological and epistemological positions about reality, research methodology informs the researcher about the procedures required for knowledge generation. A methodology is the strategy or plan of action which subsequently decides the types of research methods to be used (Crotty 2014, Cronin *et al.* 2014) and should be the most appropriate approach to answer the research questions (Cronin *et al.* 2014). Objectivism and subjectivism support two distinct research methodologies within which there are several research designs. Objectivists typically assume a quantitative research methodology, where 'factual' knowledge, and answers to the research question or hypothesis is gained through observation, manipulation and measurement (Denzin & Lincoln 2018). This is because quantitative research is concerned with outcomes that are measurable and quantifiable when investigating a phenomenon. In contrast, subjectivism, assumes a qualitative methodological research approach. Qualitative research pursues knowledge through the study of human behaviours, contextualising information such as experiences, perceptions, attitudes and beliefs. Themes are

interpreted from the information gathered and used to explain the phenomena under investigation.

An important relationship exists between the choice of paradigm and research methodology because the methodological implications of paradigm choice permeate, the research question/s, study design, participants' selection, data collection methods and procedures, as well as data analysis techniques (Kivunja & Kuyini 2017). When choosing research methodology and design it is also important to consider the aims and objectives of the study and how best to achieve these. In considering the aims and objectives of this research study, a quantitative research methodology was required. This was because, to identify risk factors for and perinatal outcomes associated with RFM, numerically comparable (women with and without RFM), objectively measurable, and quantity data were needed. Thus, paradigmatically, and philosophically, to address the study aims and objectives a quantitative research approach, underpinned by objectivist ontology and epistemology was required.

4.4 Study design

Research design refers to the strategies used to answer the research question (Polit & Beck 2020). Quantitative research is defined as a '*formal, objective, systematic study process implemented to obtain numerical data to answer a research question*' (Gray & Grove 2021, p. 31). It is used to describe variables and examine relationships within or between phenomena (Gray & Grove 2021). Three forms of quantitative research designs exist: experimental, quasi-experimental, or non-experimental (Cronin *et al.* 2014, Boswell & Cannon 2020, Polit & Beck 2020, Gray & Grove 2021). Experimental designs, for example, the randomised controlled trial (RCT), involve an 'experiment' where an intervention or treatment is introduced (Cronin *et al.* 2014), intending to look for cause and effect. In quasi-experimental designs, although the researcher introduces an intervention with the purpose of also examining causality, randomisation is not applied. Nonexperimental research designs, often referred to collectively as observational studies, alternatively, focus on observing and recording phenomena found within a

sample or groups of samples of a population that is representative of the whole. Observational studies can describe a phenomenon (or phenomena) (*descriptive*), examine differences between two independent groups or within single groups at one or different time-points (*comparative*), or describe and predict a relationship(s) between several variables (*correlational*) (Boswell & Cannon 2020). Observational comparative and correlational studies, also known as analytical observational studies, are often used to examine event exposure, disease prevalence and risk factors in a population (Elwood 2017). There are two general types of analytical studies: cohort and case-control studies.

A cohort study focuses on a specific population who are 'free' from a disease/condition or outcome of interest and are followed over a specified period of time to monitor changes in health status and assess the proportion of participants that develop specified outcomes of interest and identify risk factors associated with developing the outcome (Cohen *et al.* 2018). A comparative group, however, is not used in a cohort design. Furthermore, cohort studies can be affected by loss of participants over time, either through unwillingness to participate or death, be expensive and time-consuming, especially if a long follow-up period is chosen or the disease/condition itself is rare or has a long latency. This poses a risk to the validity and can limit the generalisability of the study (Polit & Beck 2020).

In contrast to a cohort design, case-control studies, at the time of recruitment, participants are selected, in the first instance, based on having an exposure (cases) and subsequently a comparative group (controls) of participants are selected based on not having the exposure. Participants are followed up and comparisons can be made to determine risk factors associated with the exposure and/or to determine outcomes associated with the exposure. Case-control study designs (as with cohort studies) can be prospective or retrospective. For example, in a prospective case-control study, participants with the specified exposure are recruited and followed 'forward' for a time-period to investigate whether, or not, a specified outcome develops or occurs in the future. Participants unaffected by the exposure are enrolled to represent the control group for comparison and whether the specified outcomes occur, or not, in these participants is also investigated. Prospective case-control study can be designed with

specific data collection methods, tailored to collect specified outcomes or conditions of interest (i.e., possible risk factors) resulting in data that can or should be more complete. Prospective studies however can require lengthy follow up periods. Taking this aspect into consideration for the current study, the latent period between a pregnant woman presenting with RFM and giving birth, based on the inclusion criterion of ≥ 24 weeks gestation, was a maximum of 18 weeks (i.e., up to 42 weeks gestation), therefore the time period within which this study could be conducted was feasible. In contrast, retrospective studies examine pre-existing data, the outcome or risk factor of interest will already have developed. While retrospective designs require less time to be conducted and are less expensive than prospective designs (Polit & Beck, 2020), they are less accurate and prone to bias than prospective designs as data in records are often incomplete, or absent altogether, for example on risk factors of interest to study, or are not specifically devised to answer a particular question (Cohen *et al.*, 2018; Wang & Kattan, 2020).

Taking into consideration the aims and objectives of the study, it was therefore appropriate to choose a non-experimental analytical design that allowed for the study of correlation/associations as well as capture prevalence data over time. A prospective case-control study was considered appropriate, robust and feasible. Women who presented to the hospital with a primary complaint of RFM during pregnancy at ≥ 24 weeks pregnancy represented the study case group, while women who did not present with any RFM during pregnancy during the study period represented the control group. This study design allowed for the specified latent period between women being exposed, or not, to RFM and subsequently giving birth, as well as collecting data on intentionally (prospectively) identified variables (risk factors and outcomes).

4.5 Addressing random and systematic error

After choosing the design, methodological elements of the case-control study required consideration, especially as observational studies are known to be susceptible to measurement errors, which can, erroneously influence the findings of the study. Measurement errors can be random or systematic. Random error is a chance difference between an observed and true value. Random error affects the precision of the measurements and is directly related to the study sample and its size (Rivas-Ruiz *et al.* 2012) (e.g., a sample size that is too small can lead to a wide confidence interval and thus a result with low/poor precision). In the context of this study, efforts to reduce random error included calculating a maximum study sample size in advance and calculating confidence intervals during analyses to show and assess for precision (sections 4.11 and 4.16). Systematic errors or bias occur when measurements differ from the truth in a systematic way. The presence of systematic error can directly affect the internal validity of the study, and indirectly affect the external validity of the results obtained. A case-control study can be biased in the way in which participants are selected (known as selection bias), the way in which variables are measured or classified (information bias/misclassification) or due to confounding. Efforts to address systematic error in the study involved consideration of confounding and bias.

4.5.1. Confounding

In observational studies, the exposure-outcome association can invariably be confounded by factors that cause spurious (i.e., noncausal) associations. Confounding refers to the misrepresentation of the association between the independent (RFM) and dependent variables (risk factors/outcomes) because a third variable (the confounder) is independently associated with both and may have a hidden effect on the dependent variables. For example, in this study, I wished to ascertain the strength of an association between RFM (exposure) and stillbirth (outcome). Smoking can be described as a known confounding factor because it is associated with both the exposure RFM (Carroll *et al.* 2019) and the outcome stillbirth, independently (see figure 4.2).

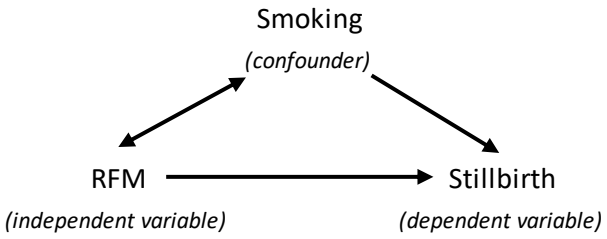


Figure 4.2 Confounding

Without adjustment for smoking, that is, if the confounding influence of smoking is not accounted for in the study design or analysis phase, there may be an association of exposure and outcome, even in the absence of a correlated effect. Standard methods for dealing with known confounders in the design phase include restriction, matching, and controlling for confounding in the analysis phase.

4.5.1.1. Restriction

During the design stage of the study decisions may be made to restrict the enrolment or recruitment of participants to the study in such a way as to eliminate potential confounding factors. For example, if smoking is the confounding factor, the study population could be limited to only non-smokers thus minimising the potential confounding effect of smoking on the study results. Restricting the current study in this way was problematic, in particular, to the precision and generalisability of the results. For example, if women who identified as smokers were excluded from the study, then the effect of smoking as a risk factor for RFM could not be evaluated. Furthermore, the study findings would only be generalisable to non-smoking pregnant women. For this reason, restriction as a strategy for dealing with confounding was not used in the current study.

4.5.1.2. Matching

Design decisions may be made to select a control group who are matched to cases with respect to potential confounding factors for example, age and parity. There are different types of matching protocols; individual matching and frequency matching (Greenland

1986). In individual matched studies, for every individual case, a control is selected who is identical to the case on certain characteristics, for example, by date of birth and parity, and therefore becomes a matched pair. However, if a control match is not found for the case, any unmatched study participants are subsequently excluded from the analysis, leading, therefore, to a loss of case data.

Frequency matching is a method used to enhance equal representation of participants with certain confounders among study groups, thereby causing the characteristics of cases and controls to be equally distributed (Rothman & Greenland 1998). Matching, of this type, can therefore improve study efficiency and statistical precision (Pearce 2016). However, matching can also have a counterintuitive effect, whereby the distributions of certain variables (confounders) are identical across both study and control groups. In other words, systematic error or bias is introduced as the cases and controls will resemble each other resulting in a lower effect estimate, that is an odds ratio (OR) closer to 1 (de Graaf *et al.* 2011). In the study design phase, I considered, and discussed with my supervisors, using frequency matching on parity and gestational age at birth, whereby the number of primigravidae and multigravidae and the number of women who birthed at term or pre-term gestation would have been equally distributed between the case and control groups. While this may have improved statistical precision, it also had the potential to introduce bias, as the controls may no longer have been representative of the hospital (source) population. The literature advocates that it is possible and preferred therefore for confounders to be adjusted for in the analysis using regression modelling to remove confounding and adjust for imbalances between the groups (Brazauskas & Logan 2016). A matched approach to sampling in this study was therefore not chosen, rather a decision was made to control for any possible confounders in the analysis.

4.5.1.3. Controlling for confounding at analysis

During data analysis a potential confounding variable may be stratified, and the statistical effect estimate (that is odds ratio in the current study) may be computed for each stratum. The dataset is divided into homogenous subgroups. For example, if age is

a confounding factor, the analysis could be stratified into separate age groups to evaluate the association of RFM and adverse outcomes for each age group.

A second and most frequently used strategy to control for confounding in case-control studies is multivariable regression analysis. In a univariable analysis, only one independent variable is included in the model and the model shows the association between that variable and the outcome, without any consideration of other characteristics. Multivariable regression models can depict the relationship between multiple independent variables and the outcome, allowing for the impact of other characteristics. This is referred to as an adjusted association. It is therefore possible using this method to adjust for many confounding variables in one model using statistical software (Kahlert *et al.* 2017). To control for confounding effects in the current study, a comprehensive set of potential confounding variables identified from the literature as being associated with RFM and the primary outcomes, were adjusted for in the analyses using unconditional logistic regression.

4.6 Consideration of bias

4.6.1. Selection bias

Selection bias is a systematic error in a study that can stem from the procedures used to select participants and from the factors that influence study participation. This occurs when the association between the exposure and disease (or outcome) differs from those who participate and those who do not participate in the study (Rothman 2002). In this study, selection bias was mitigated as the healthcare professionals directly involved in the care of women with or without RFM were unaware of the study being in progress, were not required to recruit women to the study and were not aware of when women were being enrolled. Selection bias was further minimised by using prospective data collection that waived the requirement for maternal consent (see section 4.17.1 for details). This reduced the risk of registration fatigue which can occur in prospective studies that rely on clinicians to enrol participants. It also reduced the potential effect from increased enthusiasm of clinicians or women to be included in the study, and

minimised/avoided any possible hawthorn effect from knowing the study was in progress, e.g., altering clinical care surrounding FMs than that was usual by being aware that the study was in progress.

Selection bias can also occur in the selection of control participants, that is, controls included in the study are not representative of the source population. In a case-control study, the control group should be characteristically representative of the same population as the study case group to increase the efficiency of the study (Pearce 2016). Ratios of cases to controls can be 1:1 or 1: >1. No more than four or five controls per case are however advised (Hennessy *et al.* 1999), although equally, there is little to be gained in terms of statistical power by including more than two controls per case particularly if there is no foreseen issue with the available number of cases (Wacholder *et al.* 1992a, Wacholder *et al.* 1992b, Hennessy *et al.* 1999). Following discussion with my PhD supervisors and a statistician, a decision was taken to enrol a control group at a ratio of 1:2 (two controls to every one case). Randomly selecting two controls from the total hospital population guaranteed that any differences between the sample and total hospital population were by chance; thus further reducing the risk of introducing selection bias (Polit & Beck 2020). Controls were randomly selected from the database of all non-exposed women (without RFM) giving birth during the study period. Section 4.10.3 below describes how this was achieved. The characteristics of the control group (e.g., maternal age, parity, gestational age at birth) were also compared with the general hospital population and reported to see if there were any differences (see Chapter 5).

4.6.2. Information bias (misclassification)

Information bias can occur during data collection. The most common type of information bias is misclassification where for example, exposed participants are classified as non-exposed or vice-versa, or participants with an outcome are classified as not having the outcome. At the time of the study, RFM was not coded in the Electronic Health Record (EHR) and there is currently no International Statistical Classification of Diseases and Related Health Problems code for RFM. An accurate method(s) for identifying study participants (exposed and non-exposed) to minimise information bias was thus required. Section 4.9 describes how this was achieved.

4.7 Description of the study setting and access

The research was undertaken in a large urban standalone maternity hospital in the east of Ireland, with an annual birth rate of approximately 8000 babies. The site is one of Europe's largest maternity hospitals and is a national referral centre for complicated pregnancies, premature and sick infants. The hospital provides Maternity, Gynaecology, Neonatology, Fetal Medicine, Anaesthetics, Pathology, Radiology, Maternal Medicine, Perinatal Mental Health, Urogynaecology, National Neonatal Transfer Service and Community Midwifery Services. The study site also supports an Emergency Department (ED), which offers a twenty-four-hour, 365 days/year emergency service for women who have complications during pregnancy and for the first six weeks after the birth, or for acute gynaecology emergencies. Approximately 15,000 women are assessed in the ED per year. Common reasons for women presenting during pregnancy to the ED include:

- Concern regarding FMs
- Abdominal pain
- Vaginal bleeding
- Following trauma: e.g., after a fall, abdominal trauma or a road traffic accident
- Fever / high temperature
- Urinary retention
- Hypertension
- Suspected miscarriage and ectopic pregnancy
- Vomiting in pregnancy

The service is staffed full time with senior midwives with qualifications to perform early pregnancy ultrasound and supported by the on call obstetric team, both non-consultant and consultant hospital doctors.

Request for permission to gain access to the hospital for purposes of conducting the study was formally sought from and granted by the Obstetric lead and the Director of Midwifery (see Appendix 9 and Appendix 10 for confirmation of support). A series of meetings were also held with key staff to discuss the study. It was identified early in these discussions that the majority of women presenting with a primary complaint of RFM were directed to the ED for assessment and further investigation.

Meetings were initiated in April 2019 with the ED clinical midwife manager and hospital information officer together to explain the study in more detail (i.e., study aims and objectives, recruitment and how best to collect the required data) and to seek their support as study gatekeepers and study committee members. The study site captures women's clinical information using electronic databases called the Integrated Patient Management System (iPMS) and the Maternity and Newborn Clinical Management System (MN-CMS). The ED clinical manager, who was familiar with the day to day running of the ED department, described the clinical information usually captured for women attending with RFM, while the hospital information officer, described the clinical information that could be run as a report from the MN-CMS and iPMS hospital electronic systems. Collectively, we discussed the type of clinical information recorded, who recorded the information and who could access the MN-CMS. In addition, I also corresponded with the MN-CMS hospital team to gain a better understanding of the variable information documented by clinicians at various times during a woman's pregnancy, labour and birth. Other study procedures including enrolment to the study, randomisation of the control group, and study outcomes were also discussed. These meetings helped to clarify the details necessary for the optimal daily conduct of the study, including how eligible women for inclusion in the case and control groups would be identified and in finalising the study outcomes.

4.7.1. The electronic health record (MN-CMS and iPMS)

The MN-CMS is the first National Maternity Electronic Health Record (EHR) for women and babies which was implemented between 2016 and 2018 in four maternity units in Ireland initially (including the study site) and for roll-out to all 19 units subsequently. A maternity EHR is a digital version of a maternity paper chart. EHRs are patient-centred records, built to share information recorded by all healthcare professionals involved in a woman or baby's care. A woman's (and her baby's) information are recorded directly into the EHR in real-time by midwives, obstetricians and other healthcare administrative personnel and allied healthcare professionals as appropriate. Local reports can be run to retrieve relevant information for audit and research use (Health Service Executive & Cerner 2016). At the time of the study, the MN-CMS had only been recently introduced; however, through discussions, I was informed that RFM was listed as a pre-specified

reason on the MN-CMS system and that midwives in the ED recorded this as part of routine clinical care when a woman presented to the ED with RFM. Thus, through this system and mechanism, case and control participants could be identified.

The iPMS is a Patient Administration System (PAS) to hospitals, supporting day-to-day operations and is used to record all activity including referrals, admissions, outpatient appointment/attendances, ED attendances and transfers/discharges. It is also used to capture and collate patient demographic data. Both the MN-CMS and iPMS are hosted on the Health Service Executive's (HSE) secure network to store client clinical information. In this study, the iPMS was used to obtain demographic details of participants, such as age and ethnicity.

4.8 Study approval

Ethical approval to conduct the study was sought and granted by the Research Ethics committee of the study site on 13th May 2019 (Ref: 19.2019) (Appendix 11) and the School of Nursing and Midwifery, Trinity College Dublin, Research Ethics Committee on 5th June 2019 (Appendix 12). Ethical principles and related issues in conducting the study ethically are described in section 4.17. A plan was initiated to conduct a pilot study in advance of the main study to test the study processes and procedures, and to make any amendments, if required, to the study protocol prior to commencing the study.

4.9 Pilot study

Pilot studies can help to identify any potential practical challenges in conducting a research study (van Teijlingen & Hundley 2002). It was necessary to 'try out' the steps of the planned research process for operational validity and reliability. A pilot study was thus designed to review operational logistics and to gather necessary information that could help improve the main study's quality and efficiency. The pilot phase of the study was commenced in June 2019. It was agreed among the study committee members that the data available on women attending the ED during a single month would be piloted to aid identification of any unanticipated issues with the study process and procedures and to assess the adequacy of the MN-CMS and iPMS systems as a source of routine clinical data for the purposes of the study. All data obtained from the pilot study were

excluded from the main study analysis. The pilot study consisted of enrolling all women presenting with RFM who met the study eligibility criteria (section 4.10.1) during a single month (n=90) and compared with a random selection of women who did not present with RFM and had birthed in the same time period (n=180). Three main components of the proposed main study were evaluated during the pilot phase: process, resources and data management. The pilot phase identified issues, and solutions to overcome these were implemented for the main study.

Although RFM is an ED admission reason recorded in the MN-CMS, the pilot study highlighted that as the MN-CMS was still in its infancy, it was not possible for the information officer to create a report of the list of women presenting with RFM for auditing purposes and it could take up to four months for this type of request to be implemented by the technology company. To avoid any further delays in commencing the study, the ED clinical manager identified that this information is captured in the ED admissions daybook. Upon admission to the ED department, the admitting midwife records details of the woman's name, hospital number, date and time of referral, reason for referral, gestation on admission, and the time and location of discharge, for example, home, ward, another hospital. The admission daybook is also used for auditing daily/monthly/yearly ED activity levels, including numbers and reasons for admission and is usually kept in the ED admission office, accessible only to hospital clinical midwives and obstetricians. It was also identified that to obtain an accurate control group (women without RFM) and minimise misclassification of participants, identifying women who had presented with RFM first and then excluding these women from the database of women who had given birth during the study period was required. In light of this, a meeting was set up with the hospital data protection officer (DPO) to seek permission for (1) the ED clinical manager to access the ED department daybook to identify all women who presented to the ED department with a primary complaint of RFM, and extract only their medical hospital number (MRN) and expected date of delivery/birth (EDD) onto a monthly password protected encrypted excel file, (2) the hospital information officer to populate a separate password protected encrypted excel database with MRNs only for all women who had given birth during the study period (3) grant permission for me to access these excel databases also.

To identify the control group, the MRNs of women who had sought care for RFM could be removed from the MRN database of all women who gave birth. Only I, the ED clinical manager and the hospital information officer would have access to the encrypted, password protected excel databases for the purposes of (1) removing MRNs of women with RFM from the MRN database of women who gave birth for subsequent randomisation to obtain the no RFM group, (2) identifying women who had referred themselves more than once with RFM during the study period, and (3) assigning a unique study ID number e.g. RFM0001 to each participant enrolled. At this point, access or linkage to any identifiable participant data such as names and addresses or any other clinical data was not possible without having secured access to the hospitals MN-CMS and iPMS systems which have two factor authentication (access-controlled security requiring two methods to access each system). Only clinicians with MN-CMS training are provided with security passwords to access the MN-CMS and iPMS systems directly and therefore I did not have any direct access to these or any identifiable participant data. Permissions (1), (2) and (3) were granted by the hospital DPO.

The pilot study also identified that the iPMS and MN-CMS reports ran by the hospital information officer did not classify the gestational age of a woman's first referral date with RFM. The clinical manager also highlighted that the gestational age of women presenting with RFM recorded in the admission daybook by ED staff was not completely accurate as some midwives had a tendency to round up the gestation when manually recording it in the daybook, e.g. for a woman who presented at 39 weeks and 5 days, the gestation could have been recorded as 40 weeks gestation. A solution was identified by the gatekeepers to amend the monthly data extraction excel sheet (Appendix 13) to include date of referral with RFM. This enabled both calculating accurately the gestational age[6] at first referral with RFM and to identify women who had any additional referrals with RFM in the same pregnancy. The ED clinical manager acted as a gatekeeper for enrolling women with RFM into the study, populating a pre-specified password protected excel sheet identifying the women eligible for the study, along with

[6] Using the expected date of birth and date of referral with RFM, I was subsequently able to calculate accurately gestational age at date of referral with RFM for the purposes of data analysis.

identifying women who were ineligible e.g. multiple pregnancy, age <18 years and gestational age <24 weeks.

In addition, the pilot study validated for the hospital information officer the length of time required to run the MN-CMS reports, sort the data, and compile the data extraction excel sheet (completely anonymised risk factor and outcome data) for the study and control group using a pre-specified data collection form/excel database (Appendix 14). Piloting these processes further identified that it would not be possible to collect the data on the length of RFM episode (e.g., hours), presence of meconium during labour and pH at birth without manual extraction from the electronic chart, which also meant being able to identify a participant. Although further discussions took place in an effort to find alternative solutions, it was ultimately decided, so as to uphold participant confidentiality, that these data could not be extracted. These three variables were subsequently omitted from data collection; although having data on these variables would have been informatively useful (clinically), omitting them was not necessarily a limitation as they were neither essential nor primary data for answering the study aim. In consideration for the hospital information officer's workload, it was agreed that data for the case and control groups could be requested quarterly rather than monthly. The pilot study processes were completed in November 2019. Between June and August 2019, 118-145 women with RFM attended the ED department during these months and were eligible for the study. Therefore, it was anticipated that the study sample could be achieved within eight months (see section 4.11 and Appendix 15 for sample size calculation). The study protocol was refined, and a decision was subsequently made with the research study committee to commence the main study on 01 January 2020.

4.10 Participants

Pregnant women ≥24 week's gestation presenting to the ED of the study site with a primary complaint of RFM were eligible for inclusion in the study.

4.10.1. Eligibility criteria for participants

Case (RFM) Group

Women were eligible for entry into the case (RFM) group if they were:

- Age ≥18 years
- Singleton pregnancy
- Booked to attend low or high-risk antenatal care at the study site for pregnancy, labour and birth
- ≥ 24 weeks' gestation with a primary complaint of RFM or absent FMs

Control (No RFM) Group

The control group were randomly sampled using the hospital database, from the total population of women with a singleton pregnancy who gave birth during the study period and did not attend with RFM in pregnancy. The process for selecting the control group, randomly, is described in section 4.10.3 below.

4.10.2. Ineligibility criteria for participants

Participants with maternal age less than 18 years, those presenting with RFM < 24 weeks gestation and if it was the woman's first contact with the study site (i.e not yet booked for care) were excluded from study. Multiple pregnancies were also excluded from this study, albeit not extensively researched, it is assumed that FM patterns in twins are significantly different to those in singleton pregnancies and it may not be possible to differentiate RFM in one or either baby as there is high degree of synchronous movement within babies of a multiple pregnancy (Sadovsky *et al.* 1986, Gallagher *et al.* 1992). Twenty-four weeks gestation or more was also agreed as the cut off gestation for presentation with RFM as a fetus of this gestation and above is considered 'viable' in Ireland and was necessary for exploring associations with adverse neonatal outcomes such as stillbirth. Women presenting with RFM at less than 24 weeks' gestation were

therefore ineligible for inclusion. The definition of stillbirth in Ireland and for the purposes of this study was in accordance with the Irish Stillbirths Registration Act (1994), which specifies stillbirth as a child born weighing 500 grammes or more or having a gestational age of 24 weeks or more, showing no sign of life. Pregnancy loss occurring in Ireland before 24 weeks' gestation is defined as a miscarriage.

4.10.3. Selection of the control group

Women who sought care for RFM were firstly excluded from the database of women who had birthed during the study period. This was done by cross checking for duplicate MRN hospital numbers of participants with RFM and No RFM using the conditional formatting function in Excel. Any RFM cases found were subsequently deleted from the No RFM database. Once this was done, I then randomly selected controls each month from the No RFM database of women birthing during the study period using a random sequence generator[7]. The random sequence was copied into the MRN Excel sheet. For example, if 650 women birthed during the month of January 2020 and there were 100 women with RFM in January, assuming 1: 2 controls, the first 200 numbers from the sequence generated were selected and MRNs with these corresponding numbers in the excel sheet were included as the controls (No RFM). Each MRN listed for the control group was then allocated a unique study number chronologically e.g., NoRFM0001.

4.11 Sample size

Sample size refers to the number of participants required for inclusion in a research study to answer the research question. It is one of the primary steps in designing a research study to ensure that the study is sufficiently powered, to minimise chance error and is required for interpreting the relevance of study findings. Sample size can vary depending on the type of research being undertaken and the research aim(s) (Cronin *et al.* 2014). The main aim of a sample size calculation is to determine the number of participants needed to detect clinically meaning differences. Clinical research studies

[7] https://www.random.org/sequences/

are usually performed in a sample from a specified population rather than a whole study population. It is important to optimise the sample size, because if a sample is too small, an important clinically meaning difference may not be detected, while too large a sample will waste time, money and resources (Noordzij *et al.* 2010). Hypotheses are tested to determine whether sample populations differ from each other based on the independent variable, that is, for this study, RFM versus No RFM.

To calculate a sample size for case-control studies, the following data was required:

a) The desired type I error rate (i.e., the probability of falsely rejecting the null hypothesis and detecting a statistically significant difference when the groups in reality are not different; the chance of a false-positive result),
b) the minimum odds ratio regarded as statistically significant,
c) the control-to case ratio,
d) the estimated prevalence of exposure in the control group was required.

(Dupont 1988, Hennessy *et al.* 1999)

This study's primary outcome measure was stillbirth. A retrospective cohort study of 1008 women, conducted in 2012 in two large Dublin maternity units in Ireland (Smith et al, 2014) found a stillbirth rate of 0.9%, in women who experienced at least one episode of RFM in pregnancy, versus a stillbirth rate of 0.4% for the total population of women attending the maternity units in the calendar year (Jan-Dec) 2011 (non-exposed controls). Due to similarity in population and birth rates in these maternity units to that of the current study site, while also acknowledging the potential for temporal changes in rates over time, these figures were deemed appropriate for use in this study's sample size calculation in providing the estimated prevalence of exposure in the control group. The systematic review that I conducted (Chapter 3) identified an odds ratio (OR) of 3.86 for stillbirth occurring in women with RFM compared with women with no RFM (based on high quality studies), thus providing the the minimum odds ratio regarded as statistically significant. Using these rates and assuming 2 control(s) per case (the control to case ratio) and an attrition rate of approximately 5% (that is, women lost to follow up, no records available, or moving hospital during the study period), a total sample size of 2490 was required for the study, 830 participants in RFM study group versus 1660

participants in the no RFM control group. This sample size had sufficient power (80%) to detect a difference in stillbirth in women with RFM compared to No-RFM with an alpha (significance) level of 0.05. The sample size calculation was performed under the expert guidance of a statistician (Appendix 15).

Based on this sample size calculation and an estimated recruitment rate of approximately 100 women with RFM per month to the study group (based on rates identified in the pilot study), it was anticipated that the data collection phase would take approximately twelve months; from 01 Jan 2020 to 31 Dec 2020. This timeline allowed for the inclusion of women who attended with RFM at 24 weeks' gestation and gave birth any time up to 42 weeks' gestation. A contingency of a further two months was then added to the 12-month period to allow for abstraction of data.

4.12 Selecting the variable data

To select the study variables, a search of the Core Outcome Measures in Effectiveness Trials (COMET) database (www.comet-initiative.org) for a core outcome set (COS) for studies on RFM was performed. A COS is an agreed standardised set of outcomes that should be measured and reported, as a minimum, in all studies on a topic or specific health condition. At the time of searching, a COS for studies on RFM was not available although a RFM COS development project is in progress (Hayes *et al.* 2021). Supported by discussions with the research team (PhD supervisors and hospital staff), I therefore pre-specified potential risk factors and outcomes based on knowledge of the topic, findings from review of the existing literature (Chapter 2) and the systematic review (Chapter 3), outcomes commonly reported in recent studies, and outcomes that are likely to be meaningful to clinicians and the public. For example, in conducting the systematic review (Chapter 3) few studies reporting FM perception in women who have a BMI > 35 kg/m² were identified. Very few studies that explored the association of medical conditions such as diabetes and hypertensive disorders of pregnancy with RFM were also identified. Of those identified (n=7), four were conducted forty years ago. No studies were found that investigated an association between previous obstetric history,

such as assisted conception, history of miscarriage, or previous stillbirth or neonatal death. Given this gap in the literature/previous research, collecting data on these variables, for example, was thus considered clinically important and informative. Following a period of careful consideration and re-consideration for relevance, importance (to the study aim and objectives) and feasible to extract, the variable data for the study were determined (Figure 4.3).

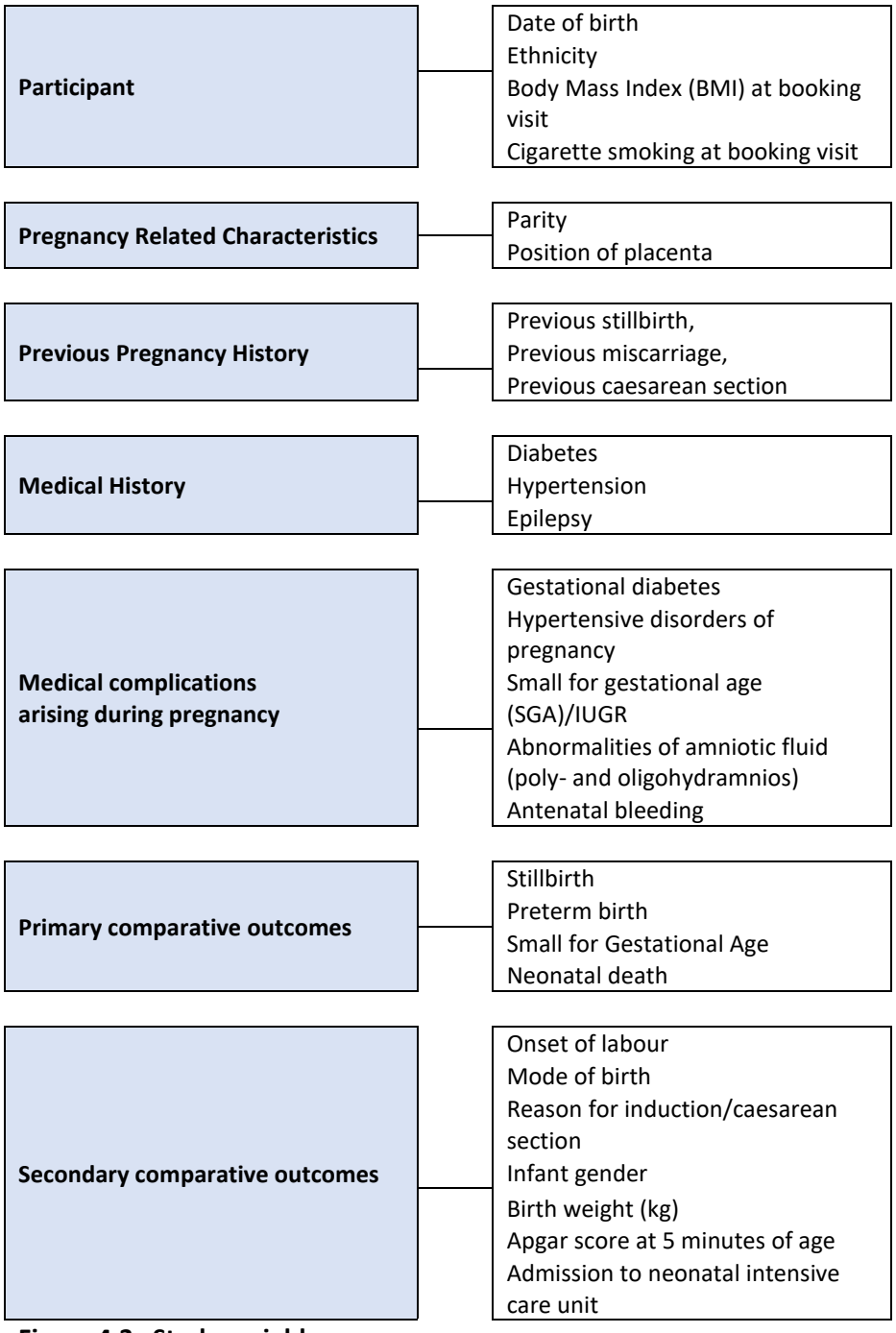


Figure 4.3 Study variables

4.12.1. Data sources and measurement

Participant characteristics, potential risk factors and outcomes were extracted and measured as follows:

- Ethnicity was recorded as per the Central Statistics Office (CSO) categorisation[8]
- Cigarette smoking was recorded if the woman had self-reported smoking at her antenatal booking visit[9].
- BMI was calculated from maternal height and weight measurements taken by the midwife at the antenatal booking visit and documented in the MN-CMS. BMI (kg/m²) was further categorised into five categories using the International Obesity Task Force cut-offs, underweight (<18.5 kg/m²), healthy weight (18.5-24.99 kg/m²), overweight (25-29.99 kg/m²), obese (30-39.99 kg/m²) and severely obese (≥40 kg/m²) (Cole *et al.* 2000).
- Gestational age was determined based on affirmed expected date of birth recorded at the antenatal anomaly ultrasound scan, usually performed between 20-22 weeks gestation.
- Placental location was determined from the antenatal anomaly ultrasound scan which was recorded as either anterior, posterior, fundal, lateral or low-lying.
- Data on parity, previous pregnancy history and known risk factors for stillbirth (previous stillbirth, previous miscarriage, previous caesarean section) and medical conditions present at booking visit (diabetes, hypertension and epilepsy) were also extracted as recorded in the electronic records.
- Medical complications arising during pregnancy included diabetes, hypertensive disorders of pregnancy, oligohydramnios, polyhydramnios and antenatal bleeding were also recorded.
- Gestational age at first presentation with RFM was calculated by subtracting the date of first presentation with RFM from the estimated date of birth (EDD).
- Stillbirth was defined as a baby born without signs of life at ≥24 weeks gestation or with a birthweight greater than 500 grams (Government of Ireland 1994).

[8] https://www.cso.ie/en/releasesandpublications/ep/p-cp8iter/p8iter/p8e/

[9] The antenatal booking visit at the research site usually takes place between 10-15 weeks of pregnancy

- Preterm birth was defined as a baby born alive before 37 weeks of pregnancy and further subcategorised into extremely preterm (<28 weeks), very preterm (28 to <32 weeks) and moderate to late preterm (32 to <37 weeks) (World Health Organisation 2017a).
- Small for gestational age (SGA) was defined as an infant born with a birth weight less than the 10th centile for gestational age (Royal College of Obstetricians and Gynaecologists 2014).
- Neonatal death was categorised as early if the death of an infant occurred between 0 and 7 completed days.
- Secondary outcomes were extracted as recorded in the medical records. This included onset of labour (induction of labour) and mode of birth (instrumental, caesarean section). Caesarean sections were subcategorised into elective (pre-labour planned) versus emergency (prelabour or in labour).
- Fetal outcome measures included infant gender, birth weight at birth (kg), Apgar score at 5 minutes of age and admission to neonatal intensive care units (NICU) or special care baby units (SCBU).

4.13 Data collection methods

At the beginning of each month, I sent a blank template excel sheet via email to the ED clinical manager (gatekeeper). The clinical manager, on a hospital secure computer, inputted the following data from the department admission daybook of women presenting to the department with a primary complaint of RFM:

- Hospital (MRN) number
- Date of referral with RFM
- Gestation of referral with RFM

I then collected this data, in person, via a password protected and encrypted external hard drive at the end of each month (Jan-March 2020 and then again once COVID travel restrictions had lifted). From this data, I was able to identify women not eligible for inclusion to the study, reasons for their ineligibility, women with repeat referrals with RFM and the interval (days/weeks) between first and repeat referrals with RFM. After excluding those who were ineligible, the remaining MRNs were assigned a

corresponding study ID number (RFM00001, RFM0002, etc.). Each quarter, the hospital information officer prepared a list of MRNs of women who had given birth in the preceding three months, which I also collected in person using a password protected and encrypted external hard drive. From this list, I then randomly selected the MRNs for women with No RFM.

The blank data excel pre-specified form (populated with the MRN and study number) was returned to the hospital information officer for populating with the extracted data from the iPMS and MN-CMS hospital systems. The hospital information officer subsequently returned anonymised aggregated data (minus the MRNs) for the RFM and No RFM groups to me (i.e., collected in person) via an encrypted portable external hard drive (used for the purposes of this study only) until all required data for each RFM and No RFM group was received. This data was subsequently transferred from the encrypted portable hard drive to an encrypted file on my personal laptop for the purposes of data cleaning and analysis.

Throughout the study period, I maintained frequent communication between the study committee (ED clinical midwife manager, hospital information office and PhD supervisors) about the study. This included email communication and brief presentations about the progression of the study (Appendix 16), whereby I provided updates on numbers enrolled and sought feedback of any issues that might have been encountered during data collection or extraction.

4.13.1. Quality control in data collection

To ensure the collection of high-quality data and minimise potential problems with data collection and extraction, the following quality assurance strategies were implemented during the study:

- Use of a study protocol with clearly defined entry criteria, outcomes criteria and study methodology to minimise any confusion on what data should be collected in the study.
- Use of well-designed electronic data collection forms (excel format) that had been piloted and amended accordingly.

- The ED clinical midwife manager singularly identified participants who presented with RFM from the admission daybook and extracted this data onto the excel sheet. The clinical midwife manager's on-site knowledge of the clinical setting, care and department record-keeping helped optimise the accuracy of data extraction.
- The hospital information officer, an experienced data administrator involved in collating data for annual hospital clinical reports, singularly ran all of the necessary electronics reports in the iPMS and MN-CMS systems to extract the anonymous data required for the study.

Collectively, these processes ensured familiarity and consistency, reduced the need for further training of personnel and reduced any potential variability arising if multiple personnel were involved.

4.14 Data management

The purpose of data management is to ensure that all data are collected, verified and organised in preparation for statistical analysis (Gray & Grove 2021). In advance of data collection, a data management plan was developed. This involved:

- Predetermining who was responsible for data collection from the ED department.
- Establishing a procedure for transfer of information to and from the ED clinical midwife manager and to and from the hospital information officer.
- Establishing a procedure for transfer of anonymised data from the hospital information officer to me.
- Checking all completed data extraction files for any missing data.
- Performing logical checks for any data that was inconsistent and correcting as appropriate; for example, infant date of birth and gestational age or mode of birth if known pre-labour caesarean section.

- Maintaining a Microsoft Excel file to keep track of the number of participants enrolled into the study group and the numbers of participants required for the control group each month throughout the period of the study.
- Maintaining accurate records of women deemed not eligible for inclusion in the study and reasons for exclusion.
- Preparation, cleaning and sorting of data (described in section 4.14.2)
- Inputting of data into IBM SPSS

4.14.1. Data preparation and cleaning

Data preparation and cleaning refers to a process to determine inaccurate or incomplete data and then improving it through error detection and correction (Van den Broeck *et al.* 2005). The data were initially sorted and cleaned in Microsoft Excel to ensure that it was complete and consistent. A separate excel sheet containing a record of the total number of women presenting to the ED with RFM per month along with the total number of women referred to the ED per month and the number of women with recurrent RFM was maintained throughout the study (Appendix 17). Cases with recurrent episodes of RFM were found using the conditional formatting function (conditional formatting-highlight cell rules-duplicate values) in the RFM MRN Excel file. In cases where the attendance date with RFM was different, the excel cells were highlighted and the variable 'Number of referrals with RFM' was changed to reflect the appropriate number of referrals with RFM. The highlighted cell/row for each duplicate case with RFM was subsequently deleted. After receiving the anonymised data sets, cases not meeting the eligibility criteria e.g. multiple pregnancy, <24 weeks gestation or <18 years of age were noted, and their data were subsequently deleted and excluded from the analysis.

The data for the RFM group and No RFM group were initially sorted in individual Excel datasets. The dataset for the 'No RFM' group was assigned a variable 'study group' coded as 1 and the dataset for the 'RFM group' was assigned a variable 'study group' coded as 2. Variables were further sorted in order of pregnancy and birth events (Appendix 18). Some of the variables within the anonymised dataset were entered in

the Excel file as text e.g., labour onset, mode of birth, neonatal outcome, gender. Therefore, a data dictionary was created, and a set of data entry rules determined (Appendix 18). For example, before transferring the dataset from Excel to SPSS, any variables involving categorical responses were recoded as numeric data using the 'filter' command in Excel. Variables such as 'labour onset', were coded as 'spontaneous' (1), 'assisted' (2) and 'pre-labour caesarean section' (3). Following sorting and cleaning, both datasets were grouped into one Excel file and imported into SPSS for statistical analysis.

4.14.2. SPSS data entry and cleaning

IBM SPSS Statistics for Windows, version 24 (IBM Corp 2016) was used for statistical analysis. The merged data set was checked for errors. Variable scores were visually checked for any discrepancies and for values that were out of range of possible values as documented in the data dictionary (see Appendix 18). Any outliers were then checked for accuracy and determined if it was due to incorrect coding. Data were further checked for outliers using frequency distributions for categorical data and descriptive statistics for continuous data and to confirm that the minimum and maximum values were within range. Values found outside of range were verified again by checking the case data in the Excel database file and corrected accordingly. This occurred on only two occasions whereby the variable 'labour onset' was incorrectly coded as 33 instead of 3 for one case and the variable 'infant outcome' was coded as 11 instead of 1 in another case.

4.14.3. Missing data

The SPSS file was inspected for missing data by running descriptive statistics to find out the proportion of missing data in each variable. Missing data for gestational age at birth and infant date of birth were found for two participants. For these cases, gestational age at birth was inputted by manually calculating gestational age at birth from EDD and actual date of birth. Infant date of birth was further inputted by reviewing EDD and gestational age at birth. It was also noted that there was a proportion of data missing or unknown for variables BMI, ethnicity and admission to NICU. This information was fed back to the hospital information officer. A decision was made in the case of all missing

data to use the 'exclude cases pairwise', which meant that if a woman had a value missing for a particular variable then her data were excluded only from the analysis of that variable, but included in all other analyses for which information was present (Pallant 2016).

4.15 Data analysis

Data analysis involved conducting descriptive, bivariate, univariate and multivariable logistic regression analysis of the quantitative data. Narrative text, figures and summary tables were used to present the results (Chapter 5).

4.15.1. Descriptive statistical analysis

Descriptive statistics were used to provide a description of the characteristics of the study participants, for example, participant demographics or obstetric and medical history. Categorical variables were described and summarised using frequency counts and percentages. Continuous variables data, for example, maternal age, BMI and gestational age were described and summarised using means, standard deviations, medians, quartiles and ranges as appropriate. Women's characteristics for the No RFM group were compared to 2020 national data (National Womens and Infants Health Programme 2021) and/or the study site's clinical annual report data to assess the representativeness of the control group. There is no national data available on ethnicity for the pregnant population in Ireland, therefore the female population data from the National Census 2016 as reported in the most recent NPEC perinatal statistics report by O'Farrell *et al.* (2021) was used for comparison. Data on parity, labour onset, mode of birth, and neonatal outcomes were also compared with hospital site clinical report data.

4.15.2. Bivariate analysis

For comparisons between RFM and no RFM groups, bivariate descriptive statistics were performed. Different statistical techniques were used depending on the type of data being analysed, e.g., continuous and categorical. Continuous variables were compared using the T-test for comparison of means between the two groups. Differences between categorical variables were described as frequencies and percentages (n (%)) and

assessed using the Pearson Chi square test using the crosstabulation function in SPSS. Differences with a *p* value ≤ 0.05 were regarded as statistically significant (i.e., not likely to have occurred by chance).

4.15.3. Univariable and multivariable logistic regression

Univariate logistic regression analysis was used to measure and quantify the size and strength of the association between the dichotomous dependant variable (RFM) and one independent variable at a time (e.g., maternal age, BMI, labour onset, mode of birth). Binary logistic regression analysis was performed as the dependent variable had only two categories, that is, RFM or No-RFM.

Statistics available for measuring and quantifying the size of the relationship or association in logistic regression include the hazards ratio (HR), likelihood ratio (LR), relative risk (RR) or odds ratio (OR). The HR is used to measure survival or rates of change over time in a group of participants who for example have been given a specific treatment compared to a control group given another treatment or a placebo (George *et al.* 2020), for example, survival over time in cancer studies. The LR, alternatively, provides an indication of how many times more (or less) likely individuals with the condition of interest are to have a positive or negative test result compared to those individuals without the condition of interest (Altman & Bland 1994, Deeks & Altman 2004). The LR is often used as the test statistic in studies that evaluate the performance or accuracy of a diagnostic test. The RR and OR, in contrast, are estimates of chance; that is the risk or odds of an outcome occurring, or not.

Applying RR or OR to the current study, both statistics could be used to describe the probability that participants exposed to RFM will have an outcome (e.g. stillbirth, caesarean section) compared to participants who are not exposed to RFM (i.e., exposed or non-exposed to the same condition) (Peat & Barton 2005). The choice of using either statistic is dependent on the study design. RR is most often used when participants have been selected as a random sample of the population, such as in a cohort or a cross-sectional study. OR can be used in any study design including case-control studies to measure the odds that a case has been exposed compared to the odds that a control

has had the same exposure (Barton & Peat 2014). For this reason, for comparative analyses involving binary variables (e.g., risk factor present/absent and RFM or RFM versus No RFM and outcome present), the OR statistic, with 95% Confidence Intervals (CI), was chosen in this study.

OR values >1 or <1 indicate, respectively, an increased or decreased chance of the variable occurring (Szumilas 2010, Bruce *et al.* 2018), and by proxy, a statistically significant or non-significant association, and the strength of the association. The 95% confidence interval (CI) provides an upper and lower value around the OR test statistic within which we can be 95% confident that the 'true' result lies when inferring the study result to the wider population in general. It is also used to estimate precision around the OR whereby a wide CI indicates a low level of precision and a narrow CI indicates high level precision around the OR (Szumilas 2010). For non-binary continuous data, the Mean difference (MD), with 95% CIs, was used to compare group data. The MD measures the absolute difference between two groups for a variable reported as a mean value or average datum.

To obtain a more precise effect measure of potential risk factors for and outcomes associated with RFM in pregnancy, multivariable logistic regression models were developed (discussed in Chapter 5). Various methods can be used for entering independent variables into a multivariable logistic regression model: forced entry method (all selected variables are entered simultaneously), forward selection (selected variables are entered one by one, starting with the strongest, and stopping if a factor does not improve the prediction), backward elimination (all variables are introduced initially and then factors are withdrawn one by one until the prediction does not deteriorate) or a mix of forward and backward methods (Pallant 2016, Ranganathan *et al.* 2017). A forced entry method was selected so that in addition to variables that were identified as significant on univariate analysis, other important confounding variables of clinical importance could be retained, possibly resulting in a stronger prediction model (Bursac *et al.* 2008).

To choose which variables to enter into the multivariable model, univariate analyses were run first and variables with a cut-off for statistical significance of $p \leq 0.15$ (Bursac *et*

al. 2008) were considered for inclusion, if they were found to be non-correlated with one another (multicollinearity). Some variables that were non-statistically significant following univariate analysis were also included in the models based on prior knowledge from the literature and systematic review (Chapter 3) or considered to have clinical significance. This approach was adopted to ensure a precise estimate in the probability of RFM or an outcome occurring, by also taking into account known confounders (Field 2018). Both the univariate and multivariable analyses are presented in Chapter 5.

4.15.3.1. Testing of assumptions

The validity and accuracy of research findings depends on researchers knowing the type of data generated in a study, ensuring that specific requirements (assumptions) are fulfilled so that the appropriate statistical test is performed on data. Violation of requirements or assumptions (for example, that the data should be normally distributed) can result in misleading findings (Verma *et al.* 2019). Testing of assumptions was carried out by obtaining descriptive statistics on continuous variables e.g., mean, standard deviation, range of scores, skewness and kurtosis. Skewness is a measure of symmetry, determining if a data set, is symmetric, that is, looks the same to the left and right of the centre point. Kurtosis is used to find the presence of outliers in data (Pallant 2016). Using the 'explore' function in SPSS, the Kolmogorov-Smirnov test for normality was used and histograms were visualised to assess the distribution of the data, with an expectation that the study sample has been drawn from a normally distributed target population. A non-significant result, that is, p-value >0.05 indicated normality was returned, suggesting no violation of the assumption of normality. Prior to conducting bivariate analysis, the underlying assumptions for using a Chi-square test (Peat & Barton 2005) was first checked and confirmed (Box 2).

1	Both categorical variables are categorical.
2	Each observation is independent,
3	Each participant is represented once only in the contingency table (the observed frequencies).
4	At least 80% of expected cell counts exceed five and all expected cell frequencies exceed one.

Box 2: Assumptions for using a chi-square test (Peat and Barton, 2005 pg. 207)

For any variable with a cell frequency less than 5, the variable was collapsed and recategorised[10] for a meaningful Chi-square test in testing the relationship between variables (Appendix 19). If it was found upon cross tabulation that more than 20% of cells had expected frequencies < 5 and it was not appropriate to collapse and recategorise the variable category (e.g., stillbirth), a Fisher's exact test was used.

In preparation for logistic regression, the underlying assumptions for using Chi-square tests (Barton & Peat 2014) were first checked and confirmed. The underlying assumptions for using logistic regression were then confirmed:

a) the study sample was representative of the population to which the inferences are being made.
b) The sample size was sufficient to support the model, in that there are at least ten events per category of an independent risk factor.
c) The data have been collected in a period when the relationship between the outcome (i.e., RFM) and the independent risk factor(s) (e.g., age or parity) remained constant.
d) To conduct this analysis, the dichotomous 'study group' variable was re-coded with 'O' as 'No RFM' and '1' as 'RFM'.

In preparation for multivariable logistic regression, the underlying assumptions for Chi-Square tests and logistic regression were first checked and confirmed (Peat and Barton, 2005 pg. 207). In addition, multicollinearity was investigated to ensure that two or more independent variables were not correlated with each other, such that a change in one independent variable (e.g., maternal age) is associated with a change in another independent variable (e.g., BMI). The stronger the correlation, the more difficult it is to change one variable without changing the other. Multicollinearity was investigated using 'tolerance' and 'variance inflation factor' (VIF) analysis scores by running a linear regression in SPSS. The tolerance score is an indication of the percent of variance in an independent variable that cannot be accounted for by any other variable. Tolerance scores less than 1 are acceptable. VIF is calculated as 1/tolerance score and values less

[10] Recoded the variable into smaller/fewer categories.

than five suggests low collinearity (Field 2018). The analysis showed that there was no evidence of multicollinearity between variables as all predictor variables had tolerance score that ranged from 0.42 to 0.96 and VIF values that ranged from 1.03 to 2.36.

4.15.4. Subgroup analysis

Subgroup analyses can be beneficial in research to test hypotheses or explore data in more detail, based on a certain characteristic, event or criterion. In this study, using the 'split file', 'compare groups' or 'organise output by groups' function in SPSS, statistical analyses were run to compare results across *a priori* defined subgroups for the study primary outcomes, that is stillbirth, preterm birth, SGA and NND. These subgroups were:

a) Episodes of RFM: Women with single versus multiple episodes of RFM.

b) Gestation of first presentation with RFM: Women who presented with RFM at a pre-term gestation versus women who presented only at a term gestation.

The one-way between groups analysis ANOVA with post-hoc tests were used to explore if there were any significant difference in the mean scores of dependent variables (e.g. maternal age, BMI) across a categorical variable containing three groups (e.g. No RFM, one episode RFM, recurrent episodes of RFM). Post-hoc tests were used to determine where any differences were.

4.16 Ethical considerations

The principles underpinning midwifery practice include promoting and maintaining the safety of women and babies, respecting dignity and rights, providing quality care, facilitating autonomy, informed choice and evidence-based decision-making (Nursing and Midwifery Board of Ireland 2022). These principles also apply to the conduct of research activity (Nursing and Midwifery Board of Ireland 2021). In this section I explore key ethical principles and how they governed the conduct of the study: respect for persons, beneficence and justice. In addition, issues relating to consent, confidentiality and anonymity are discussed.

4.16.1. Respect for persons and informed consent

Within the Belmont Report (Department of Health Education and Welfare 1979), respect for persons refers to autonomy and a person's right to determine their participation in research and enter into a study voluntarily. Seeking written consent from women for the current study raised several issues, most notably, the potential to decrease the validity of the study results as it may have prompted women to attend unnecessarily and more often for reassurance to the study site by virtue of 'knowing' about a study on RFM (Heazell *et al.* 2017). Written consent also risked a "Hawthorne effect" whereby participants' behaviour and thus the outcome of the study could have been influenced significantly by the participants' awareness of being part of the study. Studies such as case control studies, that access large clinical datasets, more often waiver individual participant consent to ensure study integrity, with precedent for this identified in similar studies conducted on RFM; for example, a prospective cohort study of 2988 participants (Holm Tveit *et al.* 2009) and a retrospective study of 1008 participants attending 2 large urban maternity units in Ireland (Smith *et al.* 2014). My systematic review (Chapter 3) also identified that the results of some studies were inhibited by the selection of participants. Selection bias or participation bias can decrease the validity of study results. It is possible that clinicians may, for example, be reluctant to ask certain women (e.g., women who are very anxious and upset, or subsequently have a stillbirth) to consent for this study. Some women might have been less likely to give consent than others such as women of ethnic minority or some women may not have been able to consent at all especially in an emergency situation, for example an emergency caesarean section for fetal distress at admission with RFM (Ho *et al.* 2018a). Prior to taking a decision on the requirement of written consent for participation in this study, and following discussions with my supervisors, I reviewed the processes on how women's' clinical data were handled at the research site. The General Data Protection Regulation (GDPR) which came into force in May 2018, was still relatively new and required careful consideration. GDPR together with it's application in Irish legislation amended the data protection laws and enhanced the accountability and transparency obligations of organisations and researchers when collecting and processing personal data.

A review of the hospital's processes identified that routinely, all pregnant women booking for maternity care with the study site are provided with and sign a copy of the 'Data Privacy Statement' (Appendix 20- page 3), a document also widely available through the study site's website. The privacy statement informs women of what and how the hospital collects, processes, discloses and shares their personal information. It informs women that information may be collected during '*attendance at a clinic or emergency room*' and '*admission to the hospital'*, details the information that is collected such as '*date of birth'*, '*records of treatment and care'*, '*results of diagnostic tests*' and other information such as '*race or ethnic origin'*. Women are informed that their data are stored on a restricted access controlled electronic record management system that only individuals who have a need to know the information can get access. It also informs women that their data are '*routinely used to improve services'* and for research purposes- *'anonymised data is used as a basis for clinical audit and for research purposes.'*

The data required for this study was clinical information that was routinely collected during the clinical management of women and infants during pregnancy, birth and the postnatal period. Following discussions with the hospital information officer it was confirmed that data could be returned to me in aggregated anonymised format for the purposes of the study upon formal request. Data can be considered 'anonymised' when individuals identifiers are no longer identifiable. For this study, clinical information of women with RFM and No RFM could be provided with identifiers, such as names and addresses, being concealed from non-hospital staff or researchers. Anonymised data falls outside of the scope of the GDPR, since anonymised data is not considered personal data if the disclosure risk is non-existent or minimal. Processing of anonymised data therefore does not require written participant consent necessarily, and in the study setting, women attending, by virtue of signing the Data Privacy Statement have been informed and have agreed that their clinical data, once anonymised, may be used for audit and research purposes. As such, the requirement for individual participant written informed consent, in the context of this case-control study, was waived by the hospital and the university research ethics committees.

4.16.2. Beneficence

The ethical principle of beneficence obligates researchers to do no harm, maximise possible benefits for society and participants and, minimise possible harms to participants (Department of Health Education and Welfare 1979, Nursing and Midwifery Board of Ireland 2021, Polit & Beck 2020). To address this principle, I anticipated short-term and long-term benefits/harms during the planning phase of my study. During this study, there was very low risk of harm to participants as they did not have to engage in any additional activities, procedures or interventions. No direct contact with participants, for the purposes of the study, was required, and there was no change warranted in how they received maternity care when the study was in progress.

While there was no potential short-term benefit for women through enrolment into the study, the study has the potential long-term benefits of advancing midwifery and healthcare professionals' knowledge about the risk factors and outcomes associated with RFM, for the benefit of future women birthing in Ireland, and internationally. The findings arising from this study could also be used to advise and educate pregnant women further about RFM, inform clinical practice and policy, and further assist midwives and obstetricians in their clinical decision making surrounding the management of RFM in pregnancy.

Investigators and study site personnel involved in the study adhered to hospital and university policies regarding electronic maternity care records and abided by the Data Protection Act (2018), General Data Protection Regulation EU (2016) and Health Research Regulation (2018) such that the confidentiality and privacy of participant data, data storage, processing and destruction were addressed and respected at each stage of the study (see sections 4.17.3 and 4.17.4).

4.16.3. Anonymity and confidentiality

The ethical principle of justice pertains to participants' right to privacy and involves outlining procedures taken to protect participants anonymity and confidentiality. The concepts of confidentiality and anonymity are essentially relevant within Irish Healthcare services; particularly as regions providing maternity care are relatively small and could be readily identified (Treacy & Hyde 1999).

All data collected during the study were treated with strict confidentiality and were stored and managed appropriately as per hospital, university and research guidelines and regulations. Each person involved in an aspect of study (i.e., PhD supervisors, hospital personnel assisting with enrolment of participants and data sharing) completed or updated as appropriate the GDPR Training provided either through the University or HSEland between 2018 and 2022. Only the hospital information officer and the ED clinical midwife manager (as hospital employees and the study gatekeepers), both of whom had no other involvement in the study, had access to any personal and sensitive data such as name and addresses of participants enrolled in the study.

As discussed in Section 4.14, MRNs were assigned a study ID number (master key). The study ID number acted as a unique identifier, subsequently replacing the need to use individual MRNs as identifiers of the participants in the final excel sheet of anonymised aggregated data. I only had access to the 'master key' data on an encrypted password protected excel sheet on an encrypted password protected external hard drive for a short period of time (assigning the study ID number and providing the hospital information officer this information). Once the hospital information officer had the 'master key' information for the purpose of running the reports from the iPMS and MN-CMS systems, I deleted this excel file from my external hard drive. The hospital information officer was therefore the only person who subsequently had access to the 'master key' file to re-identify the data in case of missing data or any potential future queries during analyses. This 'master key' file was kept separate to the anonymised dataset provided to me and was retained at the hospital site by the hospital information officer in a password protected folder on a password protected work personal computer (PC) located in a locked office when not in use. The hospital information officer removed

any identifiers (i.e., MRN, name and address) from the excel file prior to providing me with aggregated data in anonymised format via an encrypted password protected excel file on a password protected external hard drive for sorting and analysis purposes.

Only I had access to aggregated anonymised data excel files. As received, excel files were subsequently transferred from the encrypted portable hard drive to an encrypted password file on my personal laptop that had restricted password protected access and had up to date firewall and anti-virus security updates installed. It was also backed up in a TCD Microsoft OneDrive folder, a file-hosting service and synchronisation service operated by Microsoft as part of its web version of Office. The data from the excel files were subsequently imported into a password protected SPSS file for comparison and analyses purposes. Encrypted password protected electronic (Microsoft excel, SPSS) files were used only on a password protected laptop, that, when not in use, was stored away in a locked filing cabinet in a locked office in my house, set up for the purposes of working from home during COVID. Only combined aggregated anonymised findings from the study are submitted to Trinity College Dublin as part of this PhD thesis and were/will be published in peer-reviewed journals, posters and oral presentations at national and international conferences.

4.16.4. Retention and destruction of data

In accordance with the GDPR Act (2018), data retention and deletion schedules will be addressed after examination of this PhD thesis. This activity will include directing the hospital information officer and clinical midwife manager to permanently delete any electronic files e.g., 'master key' pertaining to this research study, and provide me with written confirmation that this has successfully been done. The anonymised dataset will be retained only for as long as it is needed, e.g. further subgroup analysis and future reference during publication of findings but for no longer than seven years, as per recommended in TCD policy (Trinity College Dublin 2021). All electronic excel files on hard drives and on TCD Microsoft OneDrive will also be permanently deleted.

4.17 Chapter summary

Using the STROBE statement for case-control studies as a guiding framework for presenting this chapter, the rationale for the study design was presented underpinned by ontological, epistemological and methodological perspectives. The study design and methods used in undertaking the study were presented. Ethical and data protection issues were also discussed. The findings of the case-control study are presented in Chapter 5.

Chapter 5 Study Findings

5.1 Introduction

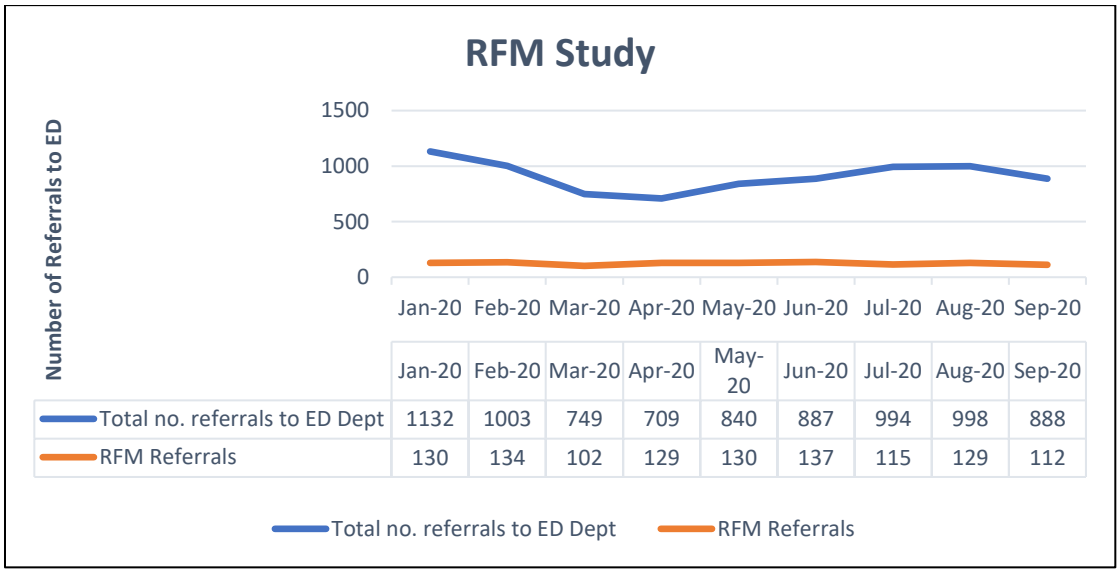
This chapter presents the participant characteristics, numbers included and the findings of the case-control study. The data reported in all tables represents the valid percent, that is, after excluding any missing values.

5.2 Study participants

5.2.1. RFM study group (cases)

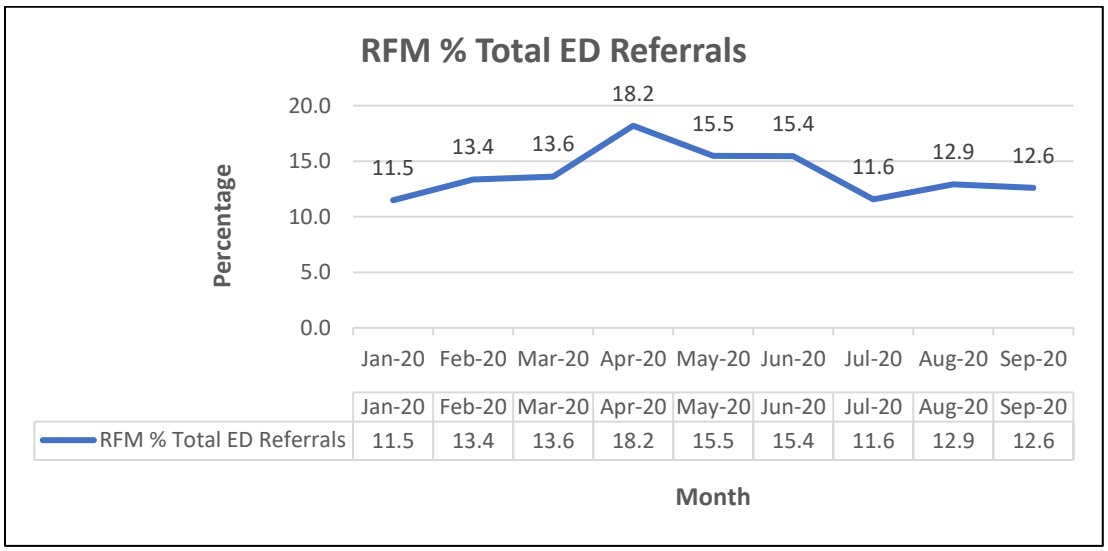
During the data collection period (01 January 2020 – 31st September 2020), there were 8200 referrals to the ED of the study site, of which 1118* (13.6%) were referrals for RFM at ≥24 weeks gestation. Of the 1118 referrals with RFM, 90 were individual women who did not meet the study inclusion criteria (13 had multiple pregnancies, 73 presented at < 24 weeks' gestation, and 4 were < 18 years of age) and were excluded from the study. Of the 1028 remaining referrals, 150 referrals involved the same woman presenting on more than one occasion with RFM. This resulted in a study sample of 878 women who presented on at least one occasion with RFM. A further 28 of these 878 women were lost to follow up due to records being unavailable for unknown reasons. This loss represents 3.2% of all women eligible for the case group. The final RFM cohort was thus 850 women who presented on at least one occasion with RFM. Of the 850 women with RFM, 707 (83.2%) women presented with RFM once during their pregnancy, 108 (12.7%) women presented with RFM on two occasions, and 35 (4.1%) women presented three or more times. The numbers and percentages of referrals with RFM, by month and during the study period are presented respectively in Figures 5.1 and 5.2.

* Represents individual women also who may have referred more than once with RFM



	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20
Total no. referrals to ED Dept	1132	1003	749	709	840	887	994	998	888
RFM Referrals	130	134	102	129	130	137	115	129	112

Figure 5.1 Referrals to Emergency Department



	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20
RFM % Total ED Referrals	11.5	13.4	13.6	18.2	15.5	15.4	11.6	12.9	12.6

Figure 5.2 Percentage of RFM referrals per month

5.2.2. No RFM study group (controls)

During the study period, 5466 women gave birth at the study site; excluding the RFM cohort of 850 women, 4616 women remained to potentially represent the No-RFM cohort. Of these, 116 women did not meet the study inclusion criteria (114 women had multiple pregnancies, one woman was <24 weeks' gestation and one woman was < 18 years of age). This resulted in a control cohort of 4500 eligible for randomisation. Based on the initial number of women with RFM included in study (n=878) and a 1:2 ratio of cases to controls, 1756 women were subsequently randomised for inclusion as the

control group. A further 13 (0.7%) were lost to follow up due to the unavailability of data for unknown reasons. The control group thus comprised of 1743 women. Figure 5.3 illustrates the number of women who were screened eligible, ineligible and excluded (with reasons) and who were included in the analyses in both the RFM (case) and No RFM (control) study groups.

5.3 Description of sample

5.3.1. Demographic and baseline characteristics

The demographic and baseline characteristics of the study population, sub-divided by RFM cases and no RFM controls are presented in Table 5.1. Where possible, to assess the representativeness of the control group, and thus study internal and external validity and generalizability, demographics were compared with study site annual report data for 2020 (Clinical Report 2021), the Irish Maternity Indicator System (NWIHP, 2021) and Central Statistics Office (CSO) for the year 2020 (https://www.cso.ie/en/releasesandpublications/ep/pvsys/vitalstatisticsyearlysummary2020/). A z-score for differences in two population proportions with alpha set at 0.05 was calculated using https://www.socscistatistics.com/tests/ztest/default2.aspx and reported. In narratively reporting the results, proportions were rounded to the nearest whole % point.

Overall, 52% (1341/2593) of the study sample were nulliparous women, although proportionately more women in the RFM than no-RFM group were nulliparous (68%, n=575/850 versus 44% n=764/1743). Compared to national data (2020), the proportion of nulliparous women in the No-RFM study group was significantly higher (39.3% vs 43.8%, z= *z*=3.79, p=0.00016).

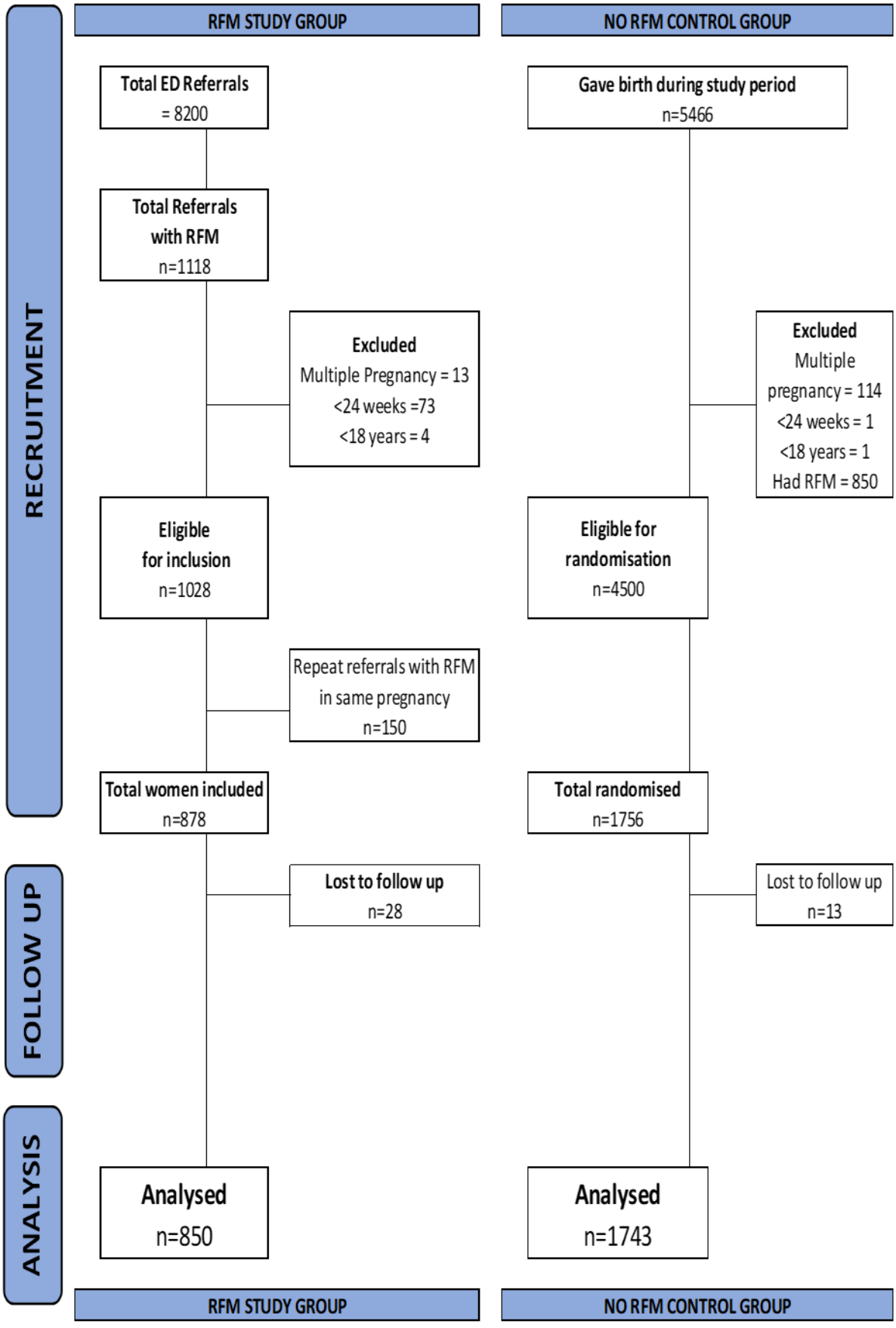


Figure 5.3 Study Participant Flow Diagram

The average maternal age was 33.8 (SD 5.0) in the RFM group (at first presentation) and 34.4 (SD 4.9) years in the No-RFM group. Most women were > 30 years in both groups, with 9% and 10% respectively in each group >40 years (Table 5.1). This demographic for the no-RFM group is consistent with hospital data for 2020; however, compared with national data those aged over 35 years and 40 years are overrepresented in the study, and women aged less than 30 years are under-represented.

The majority of women in both groups reported their ethnicity at the booking visit as either Irish or any other white background. Hospital data on ethnicity for 2020 were not publicly reported. Of the 55,959 births in 2020, there were 43,019 babies (76.9%) born to mothers of Irish nationality (cso.ie). Compared with available national figures, the proportion of women of Irish ethnicity are underrepresented in the study (67.5% versus 76.9%, z=-9.08, p<0.00001). Comparing the percentage of women presenting with RFM and women in the no-RFM group from a particular ethnic group with a comparable group from the 2016 Census population (15–49-year-olds), showed that the proportion of women of Chinese or other Asian background was greater for both RFM and No RFM groups than the proportion in the 2016 Census population. Women of African or other black background were underrepresented in both case and control groups, compared to 2.7% of the female 15–49-year-old population (O'Farrell *et al.* 2021).

The mean (SD) BMI (kg/m^2) for women with RFM and no-RFM at the time of booking for pregnancy care (approx. 15 weeks gestation) was respectively 26.57 (5.76) and 25.89 (5.10). Table 5.1 illustrates the proportions in each group per International Obesity Task Force category, highlighting that >50% of the study sample are in the overweight or above categories. There were no hospital or national data available for comparison.

Table 5.1 Demographics of women with and without RFMs

Characteristic	RFM (n=850) n	(%)	No RFM (n=1743) n	(%)	Hospital (2020) (n=7263) n	(%)	National (2020) (n=55,799) n	(%)
Parity								
Nulliparous	577	(67.9)	764	(43.8)	3201	(44.1)	21943	(39.3)
Multiparous	273	(32.1)	979	(56.2)	4062	(55.9)	33858	(60.7)
Age								
Maternal age (mean (SD))	33.79	(5.04)	34.4	(4.93)				
<20 years	4	(0.5)	9	(0.5)	57	(0.8)	662	(1.2)
20-24 years	54	(6.4)	87	(5.5)	316	(4.2)	4210	(7.5)
25-29 years	114	(13.5)	198	(11.4)	931	(12.4)	9396	(16.8)
30-34 years	315	(37.2)	596	(34.4)	2601	(34.7)	19239	(34.4)
35-39 years	288	(33.8)	673	(38.6)	2945	(39.3)	17583	(31.4)
>40 years	75	(8.7)	180	(10.3)	641	(8.6)	4701	(8.4)
BMI								
BMI (mean (SD))	26.57	(5.76)*	25.89	(5.10)ǂ	*not reported*		*not reported*	
Underweight (<18.5)	9	(1.1)	21	(1.2)				
Healthy weight (18.5-24.99)	365	(42.9)	792	(45.4)				
Overweight (25-29.99)	249	(29.3)	486	(27.9)				
Obese (30-39.99)	134	(15.8)	250	(14.3)				
Severely Obese (≥40)	32	(3.8)	28	(1.6)				
Not reported	61	(7.2)	166	(9.5)				
Ethnicity								
Irish	595	(70.0)	1177	(67.5)	*not reported*			(77.1)**
Any other white background	128	(15.1)	308	(17.7)				(13.3)
African	7	(0.8)	20	(1.1)				(2.7)
Chinese	12	(1.4)	14	(0.8)				(1.6)
Any other black background	5	(0.6)	9	(0.5)				
Any other Asian background	29	(3.4)	64	(3.7)				
Any other mixedbackground	23	(2.7)	32	(1.8)				(1.8)
Irish Traveller	3	(0.4)	6	(0.3)				(0.7)
Unknown/Not reported	48	(5.6)	113	(6.5)				(2.7)

ǂ n=1577 (due to missing variable data) * n=789 (due to missing variable data) ** Population data from the National Census 2016; SD: Standard Deviation

5.3.2. Medical and obstetric history

Table 5.2 presents the medical and obstetric history of the RFM and No RFM study cohorts. Seventy-two women (2.8%) in the study sample reported smoking cigarettes at their booking visit; 2.4% (20/850) and 3% (52/1743) in the RFM and no-RFM groups respectively. Less than 1% of women in both RFM and no-RFM groups had a previous history of either hypertension, diabetes or epilepsy. Rates of history of miscarriage were relatively equivalent across the study groups (28.8% and 26.7%; Table 5.2), although the proportion of women with a history of three or more miscarriages was higher in the RFM group (3% vs 2.1%; Table 5.2). Rates of assisted conception were also equivalent across the study groups (4.5% and 4.0%; Table 5.2). Of women with RFM and no-RFM, 0.8% (n=7) and 1.0% (n=17) respectively had a history of stillbirth and 1.1% (n=9) and 0.2% (n=4) had a history of neonatal death. Proportionately more women in the RFM group had an anterior positioned placenta (54.6% vs 48.5%) while proportionately more women in the control group had a history of previous caesarean section (8.4% v 14.8%) Table 5.2.

Table 5.2 Medical and obstetric history of women with and without RFM

Characteristic	RFM (n=850) n	(%)	No RFM (n=1743) n	(%)
Smoking				
Cigarette smoking (at booking)	20	(2.4)	52	(3.0)
Medical History				
Hypertension	4	(0.5)	6	(0.3)
Diabetes	5	(0.6)	10	(0.6)
Epilepsy	3	(0.4)	12	(0.7)
Previous Obstetric History				
Miscarriage	245	(28.8)	465	(26.7)
3 or more miscarriages	28	(3.3)	36	(2.1)
Stillbirth	7	(0.8)	17	(1.0)
Neonatal Death	9	(1.1)	4	(0.2)
Previous Caesarean Section	71	(8.4)	258	(14.8)
Conception				
Spontaneous	812	(95.5)	1674	(96.0)
Assisted conception (IVF)	38	(4.5)	69	(4.0)
Placental Location				
Anterior Placenta	464	(54.6)	845	(48.5)
Unknown/Not reported	16	(1.9)	64	(3.7)

5.3.3. Complications during pregnancy

Table 5.3 presents the numbers and percentages of women in the RFM and No RFM study groups with complications during pregnancy such as gestational hypertension, pre-eclampsia, SGA, gestational diabetes, oligohydramnios, polyhydramnios.

Table 5.3 Complications during pregnancy of women with and without RFM

	RFM (n=850)		No RFM (n=1743)	
Characteristic	**n**	**(%)**	**n**	**(%)**
Gestational Hypertension	2	(0.2)	20	(1.1)
Pre-Eclampsia	3	(0.4)	21	(1.2)
Small Gestational Age	4	(0.5)	8	(0.5)
Gestational Diabetes	20	(2.4)	56	(3.2)
Oligohydramnios	1	(0.1)	2	(0.1)
Polyhydramnios	7	(0.7)	12	(0.7)
Congenital Abnormality	7	(0.8)	30	(1.7)

5.4 Univariate logistic regression analysis assessing risk factors for RFM

Comparing RFM and no RFM groups respectively, women with RFM:

- were on average younger (33.8 (SD 5.04) versus 34.4 (SD 4.93) years; p=0.004, mean difference 0.61, 95% CI 0.12-1.02.
- were nulliparous (577 women [67.9%] versus 764 women [43.8%]; p<0.001; OR 2.71, 95% CI 2.28-3.22.
- were severely obese (32 women [3.8%] versus 28 [1.8%]; p=0.001; OR 2.48, 95% CI 1.47-4.18.
- had an anterior placenta (464 women [54.6%] versus 845 [48.5%]; p=0.01; OR 1.24, 95% CI 1.05-1.46.
- had a history of neonatal death in a previous pregnancy (9 [1.1%] versus 4 [0.2%]; p=0.01; OR 4.65, 95% CI 1.43-15.15.
- had a history of three or more miscarriages (28 [3.3%] versus 36 [2.1%]; p=0.05, OR 1.64, 95% CI 0.99 - 2.72.
- were less likely to have a previous caesarean section or hypertensive disorders of pregnancy.

No significant associations between the groups were found for ethnicity, smoking, conception, congenital abnormality, or other complications in pregnancy such as, SGA during pregnancy, gestational diabetes or abnormalities of amniotic fluid (Table 5.4 and Table 5.5). The numbers of women diagnosed with small for gestational age and oligohydramnios were small, and whilst all the expected cell counts exceeded 1, 25% (n=1) and 50% (n=2) of cells had an expected frequency less than 5 thus violating the assumptions required for performing chi-square tests and logistic regression on these factors respectively.

Women who attended with RFM were more likely to be younger than 35 years (487 women (57.3%) versus 890 women (51.1%); p=0.003; OR 1.29 95% CI 1.09-1.51). To further explore associations by age category, the categories '<20 years' and '20-24 years' were combined due to small numbers, to create a new category 'up to 24 years' and the category '25 to 29 years' was used as the reference category. The analysis found that fewer women aged 35-39 years attended with RFM than women aged 25 to 29 years (p=0.03; OR 0.74, 95% CI 0.57-0.97) (Table 5.4).

Women with RFM were more likely to have a higher mean BMI (26.57 kg/m^2 [5.76] versus 25.89 kg/ m^2 [5.10]; p=0.005; MD -0.68 95% CI -1.16 to -0.21] than women with No-RFM. Univariate analysis with BMI 18-24.99 kg/m^2 (healthy weight) as the reference category found that severely obese women (BMI ≥40 kg/m^2) were almost 2.5 times more likely to present with RFM than women of healthy BMI (18-24.99 kg/m^2) (OR 2.48 95% CI 1.47-4.18, p=0.001). There was no significant association found between the other BMI categories of underweight (<18.5 kg/m^2), overweight (25-29.99 kg/m^2) or obese (30-39.99 kg/m^2) (Table 5.4).

With regard to ethnicity, due to small numbers in some of the categories (i.e., any other black background and Irish traveller), categories were collapsed and re-categorised from eight categories to four categories (Appendix 19). There was no significant association found between ethnicity and RFM in pregnancy when 'Irish/White/Traveller' was used as the reference category (Table 5.4).

Table 5.4 Maternal characteristics associated with women with RFM

Predictor	RFM (n=850) n	%	No RFM (n=1743) n	%	Unadjusted OR [95% CI]	*p*-value
Age						**0.04**
Up to 24 years	58	(6.8)	96	(5.5)	1.05 [0.70, 1.56]	0.81
25-29 years	114	(13.4)	198	(11.4)	reference	
30-34 years	315	(37.1)	596	(34.4)	0.92 [0.70, 1.02]	0.53
35-39 years	288	(33.9)	673	(38.6)	0.74 [0.57, 0.97]	**0.03**
≥40 years	75	(8.8)	180	(10.3)	0.72 [0.51, 1.03]	0.07
BMI						**0.01**
Underweight (<18.5)	9	(1.1)	21	(1.2)	0.93 [0.42, 2.05]	0.86
Healthy weight (18.5-24.99)	365	(42.9)	792	(45.4)	reference	
Overweight (25-29.99)	249	(29.3)	486	(27.9)	1.11 [0.91, 1.35]	0.29
Obese (30-39.99)	134	(15.8)	250	(14.3)	1.16 [0.91, 1.48]	0.23
Severely Obese (≥40)	32	(3.8)	28	(1.6)	2.48 [1.47, 4.18]	**0.001**
Not reported/Missing	61	(7.2)	166	(9.5)		
Parity						
Nulliparous	577	(67.9)	764	(43.8)	2.71 [2.28, 3.22]	**<0.001**
Multiparous	273	(32.1)	979	(56.2)	reference	
Ethnicity						0.50
Irish/White/Traveller	726	(90.5)	1491	(91.5)	reference	
Asian/Chinese	41	(5.1)	78	(4.8)	1.08 [0.73, 1.59]	0.70
African/Black	12	(1.5)	29	(1.8)	0.85 [0.43, 1.68]	0.64
Other ethnicity	23	(2.9)	32	(2.0)	1.48 [0.86, 2.54]	0.16
Unknown/Missing	48	(5.6)	113	(6.5)		
Smoking						
No	830	(97.6)	1691	(97.0)	reference	
Yes	20	(2.4)	52	(3.0)	0.78 [0.47, 1.32]	0.36

CI, confidence interval; OR, odds ratio; $p < 0.05$

Table 5.5 Pregnancy characteristics associated with women with RFM

Predictor	RFM (n=850) n	%	No RFM (n=1743) n	%	Unadjusted OR [95% CI]	*p*-value
Anterior Placenta						
No	370	(44.4)	834	(49.7)	reference	
Yes	464	(54.6)	845	(48.5)	**1.24 [1.05, 1.46]**	**0.01**
Unknown/Missing	16	(1.9)	64	(3.7)		
Conception						
Spontaneous	812	(95.5)	1674	(96.0)	reference	
Assisted	38	(4.5)	69	(4.0)	1.14 [0.76-1.70]	0.54
Previous obstetric history						
Miscarriage	245	(28.8)	465	(26.7)	1.11 [0.93- 1.34]	0.25
3 or more miscarriages	28	(3.3)	36	(2.1)	**1.64 [0.99-2.72]**	**0.05**
Stillbirth	7	(0.8)	17	(1.0)	0.84 [0.35, 2.04]	0.71
Neonatal Death	9	(1.1)	4	(0.2)	**4.65 [1.43-15.15]**	**0.01**
Previous Caesarean Section	71	(8.4)	258	(14.8)	**0.52 [0.40, 0.69]**	**<0.001**
Congenital Abnormality						
No	843	(99.2)	1713	(98.3)	reference	
Yes	7	(0.8)	30	(1.7)	0.47 [0.21, 1.08]	0.08
Complications during Pregnancy						
Gestational Hypertension	2	(0.2)	20	(1.1)	**0.20 [0.05, 0.87]**	**0.02**
Pre-Eclampsia	3	(0.4)	21	(1.2)	**0.29 [0.09, 0.98]**	**0.03**
Small Gestational Age	4	(0.5)	8	(0.5)		1.00
Gestational Diabetes	20	(2.4)	56	(3.2)	0.73 [0.43, 1.22]	0.22
Oligohydramnios	1	(0.1)	2	(0.1)		1.00
Polyhydramnios	6	(0.7)	12	(0.7)	1.20 [0.47, 3.05]	0.95

CI, confidence interval; OR, odds ratio; p <0.05

5.5 Multivariable logistic regression assessing risk factors for RFM

To obtain a more precise estimate of risk factors for RFM in pregnancy, a multivariable logistic regression model, with RFM as the dependent variable was developed. The model contained the independent variables: age (using 25-29 years as the reference category), BMI (using BMI ≥18.5-24.99 as the reference category), nulliparity, anterior placenta, three or more miscarriages, previous history of neonatal death, previous caesarean section, gestational hypertension and pre-eclampsia. None of the variables had tolerance levels less than 0.20, suggesting low collinearity. The VIF scores for all predictor variables were near to one and none were substantially greater than two, suggesting that collinearity between predictor variables was not an issue. The Omnibus Test of Model Coefficients (testing for 'goodness') was statistically significant (X^2=178.241, df=15, p<0.001), indicating good performance of the model. The Hosmer and Lemeshow Test also supported the model with a non-significant result >0.05 (X^2=13.556, df=8, p=0.094).

Adjusting for the effects of the included variables on each other, BMI (specifically overweight, obese and severe obesity), nulliparity, three miscarriages or more and previous neonatal death were identified as factors significantly associated with women presenting with RFM in pregnancy. Maternal age was not found to be a significant factor in the multivariable analysis. Anterior placenta was near significant (Table 5.6).

Table 5.6 Multivariable analysis of risk factors associated with RFM

Predictor	Unadjusted OR [95% CI]	*p*-value	Adjusted aOR [95% CI]	*p*-value
Age				0.99
Up to 24 years	1.05 [0.70, 1.56]	0.81	0.98 [0.64, 1.50]	0.92
25-29 years	reference		reference	
30-34 years	0.92 [0.70, 1.02]	0.53	1.01 [0.75, 1.34]	0.97
35-39 years	0.74 [0.57, 0.97]	0.03	0.97 [0.72, 1.30]	0.83
≥40 years	0.72 [0.51, 1.03]	0.07	0.93 [0.63, 1.39]	0.73
BMI				**<0.001**
Underweight (<18.5)	0.93 [0.42, 2.05]	0.86	0.90 [0.39, 2.06]	0.8
Healthy weight (18.5-24.99)	reference		reference	
Overweight (25-29.99)	1.11 [0.91, 1.35]	0.29	**1.23 [1.00, 1.51]**	**0.05**
Obese (30-39.99)	1.16 [0.91, 1.48]	0.23	**1.34 [1.03, 1.73]**	**0.03**
Severely Obese (≥40)	2.48 [1.47, 4.18]	0.001	**3.30 [1.89, 5.77]**	**<0.001**
Nulliparity	2.71 [2.28, 3.22]	<0.001	**2.96 [2.41, 3.64]**	**<0.001**
3 or more miscarriages	1.64 [0.99-2.72]	0.05	**2.10 [1.22, 3.65]**	**0.01**
Anterior Placenta	1.24 [1.05, 1.46]	0.01	**1.19 [0.99, 1.42]**	**0.06**
Previous Neonatal Death	4.65 [1.43-15.15]	0.01	**7.11[2.11,24.03]**	**0.002**
Previous Caesarean Section	0.52 [0.40, 0.69]	<0.001	0.95 [0.69, 1.31]	0.75
Gestational Hypertension	0.20 [0.05, 0.87]	0.02	**0.22 [0.05, 0.98]**	**0.05**
Pre-eclampsia	0.29 [0.09, 0.98]	0.03	**0.18 [0.05, 0.63]**	**0.007**

OR odds ratio; CI confidence interval

5.6 Intrapartum outcomes

5.6.1. Onset of labour

With respect to study intrapartum outcomes, 38% (n=325) and 45% (n=783) of women in the RFM and no RFM groups respectively had a spontaneous onset of labour. Conversely, 45% (n=379) and 34% (n=590) respectively in the RFM and No-RFM groups had induction of labour and 17% (n=146) and 21% (n=370) of women with and without RFM had a pre-labour caesarean section (Table 5.7). Over half of women in both groups (52.7% and 55.9%) had a spontaneous vaginal birth, while 16% (n=132) and 13% (n=227) respectively had an assisted birth. Overall, a third of women in each group (31.8%, n=270 and 31%, n=540) had a caesarean section (Table 5.7).

Onset of labour outcomes for the No-RFM group were relatively equivalent to the available hospital data (Table 5.7). National data only reports on rates of induction of labour; spontaneous onset of labour or pre-labour caesarean section rates are not reported. The rate of induction of labour for the No-RFM cohort was comparable with the national rate (33.8% versus 34.4%) (Table 5.7).

5.6.2. Mode of birth

Overall, mode of birth outcomes for the No-RFM group (spontaneous birth, assisted birth and caesarean section) were comparable with hospital rates (Table 5.7). When compared with national data, however, rates of spontaneous birth were higher albeit non-significantly (55.9% versus 50.1%, z = 4.8185; p<.00001). Conversely, assisted birth (13% versus 14.5%, z = -1.6923; p= 0.09) was lower, although non-significantly, whereas caesarean section rates which were also lower, but significantly so (z = -3.798, p=.00014 (Table 5.7)). National data does not break down caesarean section into planned (elective) and emergency categories, therefore could not be compared.

Table 5.7 Intrapartum Outcomes

Intrapartum Outcomes	RFM (n=850) n	(%)	No RFM (n=1743) n	(%)	Hospital (2020) (n=7263) n	(%)	National (2020) (n=55,799) n	(%)
Labour Onset								
Spontaneous	325	(38.2)	783	(44.9)	3240	(44.6)	*not reported*	
Induction of Labour	379	(44.6)	590	(33.8)	2500	(34.4)	19450	(34.9)
Pre-labour caesarean section	146	(17.2)	370	(21.2)	1523	(21.0)	*not reported*	
Mode of Birth								
Spontaneous Vaginal Birth	448	(52.7)	976	(55.9)	4063	(55.9)	27975	(50.1)
Assisted Birth	132	(15.5)	227	(13.0)	921	(12.7)	8074	(14.5)
Caesarean Section (overall)	270	(31.8)	540	(31.0)	2279	(31.4)	19750	(35.4)

Further inferential statistical analysis was conducted to explore the relationship between onset of labour, mode of birth and RFM. Due to small numbers in one of the mode of birth categories (spontaneous vaginal breech birth), variables were collapsed and re-categorised from four categories to three categories (spontaneous vaginal birth and spontaneous breech birth were collapsed into one category-spontaneous vaginal birth) (Appendix 19) to allow for meaningful Chi-square test to be performed.

There was a significant difference in the onset of labour between the RFM and No-RFM groups (X^2=28.323, df=2, p<.001). Women with RFM had significantly lower rates of spontaneous onset of labour than women without RFM (38.2% versus 44.9%%, p=0.001), higher rates of induction of labour (44.6% versus 33.8%, p<0.001) and lower rates of pre-labour caesarean section (17.2% versus 21.2%, p=0.02). Table 5.8 outlines the reasons for induction of labour for the RFM and No RFM groups.

Table 5.8 Reasons for induction of labour

Reasons for induction of labour	RFM (n=379)		No RFM (n=590)	
	n	**(%)**	**n**	**(%)**
Fetal	161	(42.5)	161	(27.3)
SROM not in labour	68	(17.9)	93	(15.8)
Maternal	59	(15.6)	127	(21.5)
Unknown/not reported	52	(13.7)	73	(12.4)
Postterm (≥42 weeks)	17	(4.5)	46	(7.8)
Postdates (>40 & <42 weeks)	11	(2.9)	38	(6.4)
PET/hypertension	8	(2.1)	45	(7.6)
No medical indication	3	(0.8)	7	(1.2)

Irrespective of the number of times a woman presented to the hospital for RFM, proportionately IOL was consistently higher in the RFM group, one time (n=316/707, 44.7%), two times (n=42/108, 38.9%) and three or more times (n=21/35, 60%) versus No RFM (n=590/1743, 33.8%) (Figure 5.4).

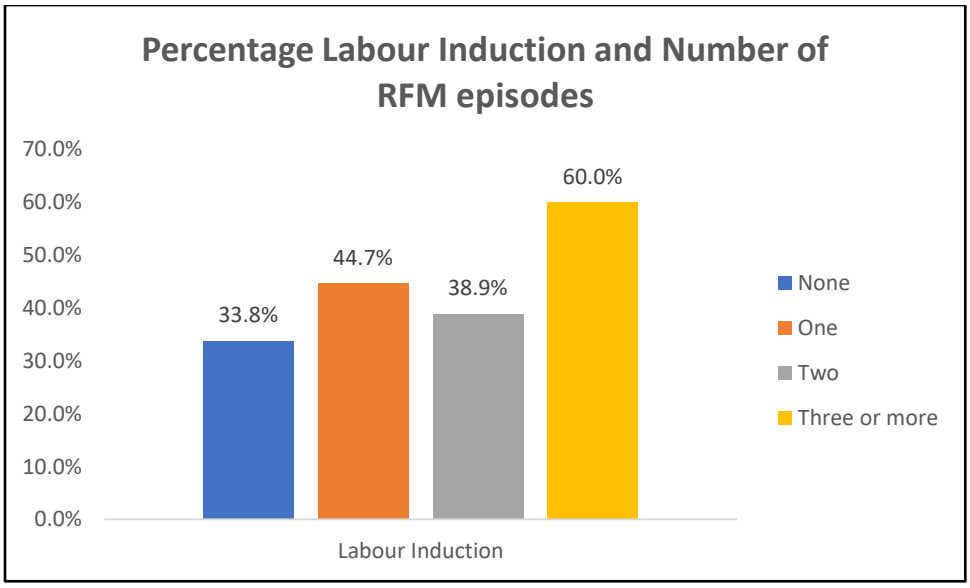


Figure 5.4 The percentage of labour induction and number of RFM episodes

When compared with women with No-RFM, women with RFM had lower rates of spontaneous vaginal birth (52.7% versus 55.9%, p=0.11), higher rates of assisted birth (15.5% versus 13%, p=0.08) and proportionately similar rates of caesarean section overall; differences between groups, however, were non-significant (X^2=3.830, df=2, p=0.15). Evaluating caesarean section by type, women with RFM were significantly more likely to have an emergency caesarean section during labour (162 women (19.1%) versus 250 women (14.3%); p=0.002), but less likely to have an elective caesarean section for previous caesarean section (41 women (4.8%) versus 172 women (9.9%); p<0.001) (Table 5.9).

Table 5.9 Onset of labour and mode of birth intrapartum outcomes

	RFM (n=850)		**No RFM** (n=1743)			
Intrapartum Outcomes	**n**	**(%)**	**n**	**(%)**	**X^2**	***p*-value**
Labour Onset					**28.32**	**<.001**
Spontaneous	325	(38.2)	783	(44.9)	10.44	0.001
Induction of Labour	379	(44.6)	590	(33.8)	28.151	<0.001
Pre-labour caesarean section	146	(17.2)	370	(21.2)	5.883	0.02
Mode of Birth					**3.830**	**0.15**
Spontaneous Vaginal Birth	448	(52.7)	976	(56.0)	2.497	0.11
Assisted Birth	132	(15.5)	227	(13.0)	3.008	0.08
Caesarean Section (overall)	270	(31.8)	540	(31.0)	0.163	0.69
					29.06	**<.001**
Planned (elective)	86	(10.1)	272	(15.6)		
For previous CS	41	(4.8)	172	(9.9)		**<0.001**
Emergency	162	(19.1)	250	(14.3)		**0.002**
Unknown	22	(2.6)	18	(1.1)		

The most common reasons for planned (elective) CS in the RFM and no RFM groups is presented in Table 5.10.

Table 5.10 Reasons for planned caesarean section

	RFM (n=86)		No RFM (n=272)	
Reasons for planned caesarean section	**n**	**(%)**	**n**	**(%)**
Previous caesarean section	41	(47.7)	172	(63.2)
Maternal medical reason/pains	23	(26.7)	0	(0.0)
Maternal request/non-medical reason	12	(14.0)	25	(9.2)
PET/hypertension	5	(5.8)	15	(5.5)
Medical reason/maternal request	3	(3.5)	51	(18.8)
SROM	2	(2.3)	8	(2.9)
Postdates	0	(0.0)	1	(0.4)

The most common reason for emergency (unplanned) CS in the RFM and No RFM groups was for fetal reason, 55% (n=89) and 54% (n=135) respectively. Other maternal and fetal reasons are presented in Table 5.11.

Table 5.11 Reasons for emergency caesarean section

	RFM (n=162)		No RFM (n=250)	
Reasons for emergency caesarean section	**n**	**(%)**	**n**	**(%)**
Fetal reason	89	(54.9)	135	(54.0)
IUA inability to treat fetal intolerance	34	(21.0)	45	(18.0)
IUA poor response to oxytocin	27	(16.7)	39	(15.6)
EUA persistent malposition	5	(3.1)	12	(4.8)
IUA no oxytocin given	4	(2.5)	11	(4.4)
EUA cephalopelvic disproportion	3	(1.9)	6	(2.4)
IUA inability to treat over contracting	0	(0.0)	2	(0.8)
Unknown				

EUA efficient uterine action; IUA inefficient uterine action

5.7 Univariable logistic regression analysis assessing intrapartum outcomes associated with reduced fetal movements

5.7.1. Onset of labour

Compared to spontaneous onset of labour (the reference group), women with RFM during pregnancy were 1.5 times more likely to have induction of labour (OR 1.55, 95% CI 1.29-1.86, p=<0.001) (Table 5.12).

Table 5.12 Association between RFM and onset of labour

	RFM (n=850)		No RFM (n=1743)			
Outcome	**n**	**(%)**	**n**	**(%)**	**OR [95% CI]**	***p*-value**
Labour Onset						
Spontaneous	325	(38.2)	783	(44.9)	reference	
Induction of Labour	379	(44.6)	590	(33.8)	**1.55 [1.29, 1.86]**	**<0.001**
Pre-labour caesarean section	146	(17.2)	370	(21.2)	0.95 [0.75, 1.20]	0.67

OR odds ratio; CI confidence interval

5.7.2. Mode of birth

When compared to women who had a spontaneous vaginal birth (reference group), women with RFM were more likely to have an assisted birth (OR 1.27, 95% CI 1.00-1.61, p=0.05), and emergency caesarean section (OR 1.74, 95% CI 1.29-2.34, p<0.001), and less likely to have a planned caesarean section (OR 0.46, 95% 0.34-0.63, p<0.001) than women without RFM (Table 5.13).

Table 5.13 Association between RFM and mode of birth

	RFM (n=850)		No RFM (n=1743)			
Outcome	**n**	**(%)**	**n**	**(%)**	**OR [95% CI]**	***p*-value**
Mode of Birth						
Spontaneous Vaginal Birth	448	(52.7)	976	(56.0)	reference	
Assisted Birth	132	(15.5)	227	(13.0)	1.27 [1.00, 1.61]	0.05
Caesarean Section (overall)	270	(31.8)	540	(31.0)	1.09 [0.91, 1.31]	0.36
Planned	86	(10.1)	272	(15.6)	0.46 [0.34, 0.63]	**<0.001**
Emergency	162	(19.1)	250	(14.3)	1.74 [1.29, 2.34]	**<0.001**

OR odds ratio; CI confidence interval

5.8 Multivariable logistic regression assessing labour outcomes associated with reduced fetal movements

5.8.1. Onset of labour

RFM during pregnancy remained associated with induction of labour on multivariable analysis even when adjusted for age, BMI, nulliparity, ethnicity, smoking, pre-pregnancy gestational diabetes and hypertension, previous history of stillbirth, congenital abnormality, assisted conception, gestational age at birth and pregnancy complications oligohydramnios and polyhydramnios (aOR 1.48, 95% CI 1.22-1.79, p<0.001).

5.8.2. Mode of birth

When adjusted for age, BMI, nulliparity, history of previous caesarean section, induction of labour and pre-labour caesarean section, neither caesarean section (overall) (aOR 0.93 95% CI 0.70-1.25), p=0.64), nor emergency caesarean section were found to be associated with RFM (aOR 1.13 95% CI 0.76-1.66, p=0.55) suggesting that other factors were involved than RFM only.

5.9 Primary Neonatal outcomes

Primary neonatal outcomes comparing women with RFM and without RFM are presented in Table 5.14.

Table 5.14 Primary neonatal outcomes

	RFM (n=850)		No RFM (n=1743)			
Outcome	**n**	**%**	**n**	**%**	**OR [95% CI]**	***p*-value**
Livebirth	845	(99.4)	1736	(99.6)		
Neonatal Death	0	(0.0)	2	(0.1)		
Stillbirth	5	(0.6)	5	(0.3)		
Gestation at birth (weeks)*	39.29	(1.62)	39.13	(1.97)		
Preterm (24-36 weeks)	38	(4.5)	94	(5.4)	0.82 [0.56, 1.21]	0.32
Term (37- 42 weeks)	812	(95.5)	1649	(94.6)		
Post term (42+ weeks)	0	(0.0)	0	(0.0)		
Birthweight centile						
≤10% (SGA)	75	(8.9)	107	(6.1)	1.48 [1.09, 2.02]	0.01

OR odds ratio; CI confidence interval

5.9.1. Stillbirth

Almost all women in both groups gave birth to a liveborn infant. Five women (0.6%) in the RFM study group had a stillbirth (three at preterm gestations 28-36 weeks and two at term gestation), while five women in the control group also had a stillbirth (0.3%) (four occurred at preterm gestations 24-29 weeks' and one at term gestation, 38 weeks'). These numbers were too small for any further univariate or multivariable analysis as one cell (25%) had an expected count less than 5. However, a Fishers exact test demonstrated that the difference was insignificant (p=0.31).

Table 5.15 outlines the demographics and pregnancy characteristics of women with a stillbirth, with and without RFM. Of the five women that had RFM and a stillbirth, all were nulliparous, 35 years or younger, two were of non-Irish ethnicity, 40% had a raised BMI above 25, 40% had a previous history of miscarriage and 60% had an anterior placenta. Of the five women in the control group who had a stillbirth, 80% were nulliparous, 60% were 35 years or older, mostly Irish, only 20% had a BMI more than 25 and only one woman had a history of miscarriage, while four women had a previous history of stillbirth. No women in the No RFM group had an anterior positioned placenta.

Table 5.15 Characteristics of women who had a stillbirth (RFM v No RFM)

	Stillbirth			
	RFM (n=5)		No RFM (n=5)	
Characteristic	**n**	**(%)**	**n**	**(%)**
Age ≥35 years	1	(20.0)	3	(60.0)
BMI ≥25	2	(40.0)	1	(20.0)
Nulliparity	5	(100.0)	4	(80.0)
Irish/White	3	(60.0)	4	(80.0)
Non-Irish/Non-White	2	(40.0)	1	(20.0)
History of Miscarriage	2	(40.0)	1	(20.0)
Anterior Placenta	3	(60.0)	0	(0.0)
Previous Stillbirth	2	(40.0)	4	(80.0)
Previous Caesarean Section	0	(0.0)	1	(20.0)
Assisted conception	0	(0.0)	1	(20.0)
Congenital anomaly	1	(20.0)	1	(20.0)

5.9.2. Preterm birth

The median gestation and range at first presentation with RFM was 34.7 (18, Min 24-Max 42) weeks. Forty per cent of women (n=343) presented for assessment with RFM at greater than 37 weeks' gestation. The majority of births in both groups occurred at term gestation. The mean (SD) gestation at birth (in weeks) for the RFM and no RFM groups was 39.3 (SD 1.62) and 39.1 (SD 1.97) respectively, which was not significantly different (mean difference 0.16 95% CI 0.02 -0.30). There was a lower proportion of infants born preterm overall (before 37 weeks' gestation), in the RFM group (n=38, 4.5%) when compared with the No RFM group (n=94, 5.4%), although the difference was not significant (p=0.32; OR 0.82; 95% CI 0.56-1.21). Further subgroup analysis however demonstrated that there was a higher proportion of preterm birth among women who presented with RFM before 37 weeks gestation.

5.9.3. Neonatal death

There was a total of twelve early neonatal deaths (within the first week of life) in the hospital population in 2020. During the study period, there were two known early neonatal deaths that were recorded in the No-RFM group (0.1%) at 34 weeks and 41 weeks' gestation. No neonatal deaths occurred in the RFM study group (0%). These numbers were too small for any further meaningful statistical analysis.

5.9.4. Small for gestational age at birth

There were significantly more infants born small for gestational age in the RFM group when compared with the No RFM group (75/847 [8.9%] versus 107/1741 [6.1%]; OR 1.48, 95% CI 1.09-2.02). A further subgroup analysis comparing single versus recurrent episodes of RFM, showed that women who presented once with RFM had significantly higher proportions of SGA infants when compared to the No-RFM group (p=0.02, OR 1.42 95% CI 1.06-2.04). Presentation with recurrent episodes of RFM was not associated with SGA (p=0.16, OR 1.54 95 % CI 0.84-2.81). Likewise, there was no significant difference in the proportion of SGA infants between pregnancies with single and those with recurrent episodes of RFM.

5.10 Secondary neonatal outcomes

5.10.1. Apgar score of than 7 at 5 minutes

Apgar score was recoded into two nominal categories, Apgar score 7-10 (normal) and Apgar score 1-6 (low). The majority of infants in both groups had normal Apgar scores (≥7) at five minutes of age. The proportion of infants with an Apgar score of less than 7 at five minutes of age was lower in the RFM group (n=6, 0.7%) than in the control group (n=18, 1.0%), however, this was a non-significant difference (p=0.41; OR 0.68; 95% CI 0.27-1.72). Of the six infants in the RFM group born with an Apgar score <7 at 5 minutes, four of the infants were born at pre-term gestations.

5.10.2. Birthweight

There was no significant difference in the mean birthweight (grams) between infants of women with RFM (3530 grams, SD 526.40) and infants of women with no-RFM (3506 grams, SD 567.26), p=0.70 (mean difference (MD) -24.92 95% CI -69.30 – 19.45). Birthweight was recoded initially into eleven categories and then further collapsed into four birthweight categories for meaningful analysis (≤2500g, >2500g to <3500g, ≥3500 to <4000g and ≥4000g). No difference was noted between the study groups, p=0.30. Univariate analysis was conducted with birthweight '>2500g to <3500g'as the reference category. RFM in pregnancy was not found to be associated with low birth weight (a birth weight of less than 2500g-up to and including 2499 g), as per the World Health Organization (WHO)). This did not change when birthweight '≥3500 to <4000g' was used as the reference category. Twenty-four infants (2.8%) of the RFM group had a low birth weight, of which 8 (1.0%) were born at term gestation, compared to 65 infants (3.7%) of women in the control group, of which 14 (0.9%) were born at term gestation.

5.10.3. Infant gender

The proportion of male infants born to women with RFM (n=449, 52.8%) was comparable to male infants born to women with no RFM (n=883, 50.7%), p=0.30; OR 1.09 95% CI 0.93 – 1.29).

5.10.4. Admission to the neonatal unit

There was a considerable amount of missing data for the outcome admission to neonatal unit (511 cases (60.1%) missing for the RFM group and 940 (53.9%) missing for the No RFM group). This could be because a note is only made when babies are admitted to NICU, however, the reason for this missing data is unknown, and the analysis was thus based on the available data. The analysis showed that 6% (n=19/339) and 9% (n=70/803) of babies of women with and without RFM respectively, were admitted to NICU. Overall, this difference was not statistically significant (p=0.07; OR 0.62 95% CI 0.37 – 1.05). Of the infants admitted to NICU, 12 (3.7%) were term infants of women with RFM, compared to 41 (5.4%) term infants of women in the no-RFM group.

5.11 Risk factors for RFM and the risk of adverse neonatal outcomes

I intended to conduct binary logistic regression to identify potential risks factors associated with neonatal outcomes in the group of women experiencing RFM: stillbirth, SGA, preterm birth, neonatal death, Apgar score <7 at 5 mins and admission to NICU. Initial chi-square tests identified that there were insufficient numbers to perform further analysis for outcomes -stillbirth, neonatal death or apgars <7 at 5 minutes. Risk factors for SGA at birth, preterm birth, and admission to NICU were investigated only when assumptions for logistic regression were not violated (Table 5.16). Preterm birth was associated with RFM in nulliparous women only. No other risk factors for RFM identified in the current study were associated with adverse neonatal outcomes.

Table 5.16 Logistic regression analysis for the prediction of adverse neonatal outcomes

Outcome	Risk Factor	OR 95% CI	p value
	Nulliparous	1.80 (0.92, 3.53)	0.09
	BMI ≥25-29.99	0.54 (0.26, 1.12)	0.10
	BMI ≥30-39.99	2.53 (0.81, 7.91)	0.11
SGA at birth	BMI ≥40	-	1.00
	Previous NND	-	1.00
	≥3 miscarriages	3.75 (0.71, 19.87)	0.12
	anterior placenta	1.41 (0.76, 2.64)	0.28
	Nulliparous	**3.30 (1.37, 7.95)**	**0.008**
	BMI ≥25-29.99	1.82 (0.81, 4.09)	0.15
	BMI ≥30-39.99	1.56 (0.55, 4.41)	0.40
Preterm Birth	BMI ≥40	-	1.00*
	Previous NND	-	-
	≥3 miscarriages	7.97 (0.80, 79.22)	0.08
	anterior placenta	1.41 (0.65, 3.03)	0.38
	Nulliparous	0.84 (0.29, 2.42)	0.75
	BMI ≥25-29.99	1.24 (0.40, 3.83)	0.71
	BMI ≥30-39.99	2.45 (0.69, 8.75)	0.17
Admission to NICU	BMI ≥40	-	0.42*
	Previous NND	-	-
	≥3 miscarriages	-	0.04*
	anterior placenta	1.71 (0.58, 5.05)	0.33

*Fishers exact test; OR, odds ratio; CI, confidence interval; NICU, neonatal intensive care; SGA, small for gestational age at birth

5.12 Subgroup analysis

5.12.1. Single v recurrent episodes of RFM

The demographic, pregnancy characteristics and outcomes of women presenting with one or more than one episode of RFM are presented in Table 5.17. Women with recurrent episodes of RFM were, on average, younger than women without RFM (p<0.001) and women with one episode of RFM (p=0.007). Women with one or more episodes of RFM also had significantly higher BMI than women without RFM (p=0.04 and p=0.06 respectively). Compared to women with a single episode of RFM, nulliparous women were twice as likely to present with recurrent RFM during pregnancy than multiparous women (OR 2.07 95% CI 1.34-3.20, p=0.001). When compared with women without RFM, women with single and recurrent episodes of RFM were more likely to have an anterior placenta (p=0.04 and p=0.05 respectively). Women with recurrent RFM were more likely to present with their first episode of RFM at earlier gestations than women with one-episode of RFM (mean 30.1 weeks (SD 3.94) versus 34.6 weeks (SD 4.92); p=<0.001). There was no significant difference in ethnicity, previous history of miscarriage between the pregnancies with single and those with recurrent RFM presentations (Table 5.17).

There was no significant difference in the rates of stillbirth, preterm birth, gestational age at birth, birthweight or Apgars <7 at five minutes amongst women with single, recurrent or without RFM. When compared to the No-RFM group, women with a single episode of RFM had significantly higher proportion of SGA infants at birth. There was no significant difference in the proportion of SGA infants between pregnancies with single and recurrent episodes of RFM (Table 5.17).

Table 5.17 Comparison between single vs recurrent episodes of RFM vs controls

			RFM						
	No RFM (n=1743)		Single episode (n=707)		Recurrent episodes (n=143)				
Demographic	**n**	**(%)**	**n**	**(%)**	**n**	**(%)**	**p value***	**p value†**	**p value¥**
Age (mean)	34.40	(4.93)	34.02	(4.98)	32.64	(5.21)	0.21	**<0.001**	**0.007**
BMI	25.89	(5.10)	26.49	(5.68)	26.97	(6.11)	**0.04**	**0.06**	0.61
Nulliparity	764	(43.8)	463	(65.5)	114	(79.7)	**<0.001**	**<0.001**	**0.001**
Irish/White	1491	(91.5)	602	(90.3)	124	(91.9)	0.67	0.06	0.56
Non-Irish/Non-White	139	(8.5)	65	(9.7)	11	(8.1)			
History of Miscarriage	465	(26.7)	206	(29.1)	39	(27.3)	0.22	0.88	0.65
≥3 or more	36	(2.1)	24	(3.4)	4	(2.8)	0.10	0.58	
History of Neonatal Death	4	(0.2)	7	(1.0)	2	(1.4)	**<0.0001**	**0.02**	0.66
Anterior Placenta	845	(50.3)	380	(55.0)	84	(58.7)	**0.04**	**0.05**	0.41
Gestational age 1st presentation RFM			34.60	(4.92)	30.10	(3.94)			**<0.001**
Outcomes at birth									
Stillbirth	5	(0.3)	4	(0.6)	1	(0.7)	0.31	0.42	0.85
Preterm Birth	94	(5.4)	32	(4.5)	4	(4.2)	0.38	0.54	0.86
Birthweight <10th centile	107	(6.1)	62	(8.8)	13	(9.2)	**0.02**	0.16	0.89
Neonatal Death	2	(0.1)	0	(0.0)	0	(0.0)			
Gestational age at birth	39.1	(1.97)	39.3	(1.66)	39.1	(1.43)	0.08	0.94	0.75
Birthweight (grams)	3506	(567)	3542	(529)	3476	(509)	0.31	0.81	0.40
Apgar <7 at 5 minutes	18	(1.0)	5	(0.7)	1	(0.7)	0.45	0.7	1.00

*****control v single-episode RFM; **†**control vs recurrent episode RFM; **¥**single vs recurrent-episodes EFM.
Continuous variables are presented as mean± and categorical variables as n (%). Values in bold are statistically significant. RFM reduced fetal movements;

5.12.2. Gestational age at first presentation with RFM v No RFM

During the study period, of the 850 women who presented with RFM, 314 women (37%) presented first with RFM between 24-31^{+6} weeks gestation, 220 women (26%) first presented between 32-36^{+6} weeks and 316 women (37%) first presented ≥37 weeks gestation. Table 5.18 presents the number of referrals, primary and secondary outcomes of interest by gestational age when women first presented with RFM. Women who presented with RFM at earlier gestations were more likely to have recurrent referrals for RFM than women who presented with RFM ≥37 weeks gestation (p<0.001). For women who had their first presentation with RFM at term (≥37 weeks gestation), the mean interval between RFM, spontaneous labour and birth was less than two weeks (mean 9.7 days, SD 13.3) (Figure 5.5).

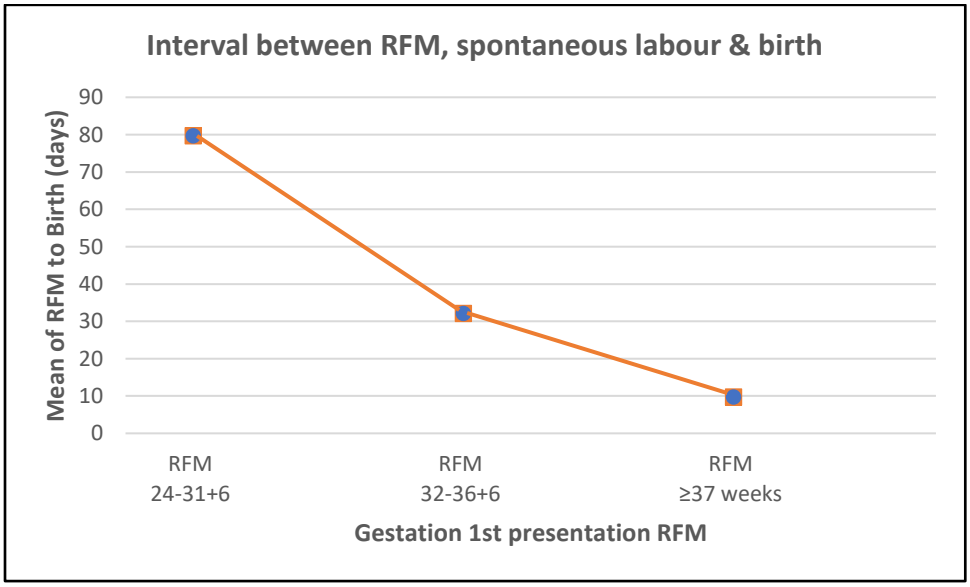


Figure 5.5 Interval between RFM, spontaneous labour & birth

Compared with women with No RFM, women who presented with RFM at earlier gestations had proportionately higher rates of preterm birth (p<0.001). Rates of induction of labour and emergency caesarean section were proportionately higher in women with RFM when compared with women with no RFM, regardless of the gestational age of first presentation with RFM. Women who presented with RFM at term were twice more likely to have induction of labour when compared with women who presented with RFM before 37 weeks gestation (OR 2.09 95 % CI 1.58-2.76; p<0.001). The rates of SGA infants at birth were proportionately higher in women with RFM when

compared with women with no RFM, regardless of gestational age, although this did not reach significance (p=0.06). Further analysis was not conducted on stillbirth, neonatal death or Apgar score <7 at 5 minutes due to small numbers in each group (Table 5.18).

Table 5.18 Subgroup analysis by gestational age when first presented with RFM

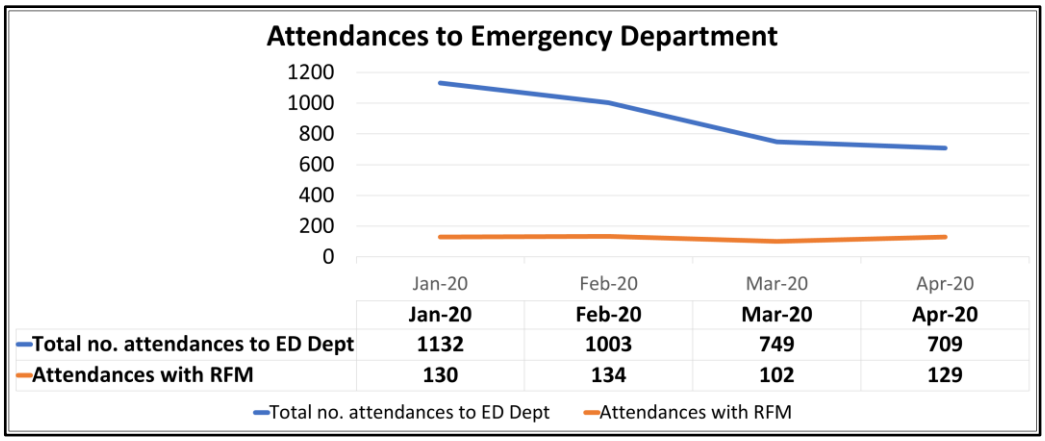
Outcome (s)	RFM 24-31^{+6} (n=314) n	(%)	RFM 32-36^{+6} (n=220) n	(%)	RFM ≥37 weeks (n=316) n	(%)	No RFM (n=1743) n	(%)	*p*
Number of referrals with RFM									
One	216	(68.2)	185	(84.1)	306	(96.8)			<0.001
Two	71	(8.6)	27	(12.1)	8	(3.6)			<0.001
Three or more	27	(8.6)	8	(3.6)	0	(0.0)			<0.001
Interval RFM to spontaneous labour & birth (days)*	79.66	(21.82)	32.11	(14.78)	9.67	(13.33)			<0.001
Primary									
Stillbirth	2	(0.6)	1	(0.5)	2	(0.6)	5	(0.3)	
Preterm Birth	22	(7.0)	16	(7.3)	0	(0.0)	94	(5.4)	<0.001
Birthweight <10th centile	31	(9.9)	18	(8.2)	26	(8.3)	107	(6.1)	0.06
Neonatal Death	0	(0.0)	0	(0.0)	0	(0.0)	2	(0.1)	
Secondary									
Induction of Labour	119	(37.9)	82	(37.3)	178	(56.3)	590	(33.8)	<0.001
Emergency CS	64	(15.5)	44	(20.0)	54	(17.1)	250	(14.3)	<0.001
Apgars <7 at 5 mins	3	(1.0)	1	(0.5)	2	(0.6)	18	(1.0)	

* mean (SD); p<0.05 is significant; RFM reduced fetal movements

5.13 The impact of COVID19 on attendances for RFM

Data collection for this study was ongoing during the first wave and lockdown of COVID19. Concerns were raised about whether women during pregnancy were fearful of accessing maternity services during the lockdown, and the possible impacts this could have on maternal and fetal wellbeing. For this reason, I decided to explore the data, in a secondary/post-hoc analysis, to determine if COVID19 had an impact on women's attendance with RFM during pregnancy. Rates of participants presenting with RFM to the ED pre-COVID (01-Jan to 29-Feb 2020, n=264/2135) and during the first COVID lockdown (01-Mar to 30 April 2020, n=231/1458) were compared.

Although fewer women overall attended the ED during the first national lockdown, a decrease in the numbers of women presenting with RFM was not observed. Conversely, proportionate to total attendances, the proportion of women attending with RFM increased during COVID, 12.4% versus 15.8%, z -2.97, p<0.003 (Carroll *et al.* 2022)[11] (See Figure 5.6 and Table 5.19).



	Jan-20	Feb-20	Mar-20	Apr-20
Total no. attendances to ED Dept	1132	1003	749	709
Attendances with RFM	130	134	102	129

Figure 5.6 Rate of attendance with RFM

[11] Carroll L, Byrne F, Canty G, Gallagher L, Smith, V. (2022). The impact of COVID-19 on attendance for reduced FMs during pregnancy. In *'Resilience, Rehabilitation and Reablement', Trinity Health and Education International Research Conference 2022 (THEConf2022)*. School of Nursing and Midwifery, Trinity College Dublin, 8-10 March 2022, Virtual. (Appendix 24)

Table 5.19 Rate of attendance with RFM pre and during COVID19

	PRE-COVID period (01-Jan to 29-Feb 2020) n (%)	DURING-COVID period (01-Mar to 30 April 2020) n (%)	Difference
ED attendances (overall)	2135	1458	-37%
Attendances with RFM	264 (12.4%)	231 (15.8%)	12.4% versus 15.8%, z -2.97, p<0.003

ED Emergency department; RFM reduced fetal movements

5.14 Chapter summary

This chapter presented the results of a prospective case-control study conducted to identify risk factors for and pregnancy, birth and neonatal outcomes associated with RFM during pregnancy. The findings showed that during the study period, almost 15% of women presented to the ED with a maternal perception of RFM at ≥24 weeks gestation. Of those presenting with RFM, nearly 40% were at >37 weeks gestation. A secondary analysis also found that while attendances to the ED were reduced overall during the first national lockdown of the global pandemic, a reduction in the numbers of women attending the ED with RFM was not observed. The study identified several risk factors and outcomes that were significantly associated with RFMs, although surprisingly not stillbirth. In the next chapter the results of this study are comprehensively discussed.

Chapter 6 Discussion

6.1 Introduction

The overall aim of this study was to identify the risk factors and outcomes associated with RFMs during pregnancy. This chapter discusses the key findings together with an exploration as to how or why these findings may have occurred. To provide the totality of the available evidence in one place, the systematic review presented in Chapter 3 is also updated in this Chapter, adding the data from this study as well as data from additional eligible studies published since the review's original search date (23 March 2018). Updating the review was done to identify any changes in the evidence based on further studies of the risk factors and outcomes associated with RFM, as well as to provide up-to-date contemporary evidence on the topic. The strengths and limitations of the study are also discussed.

6.2 Prevalence of reduced fetal movements

Presentation with RFM is a common reason for attending maternity services outside of normal routine antenatal care. My study demonstrated that women self-referring with RFM accounted for 13.6% of all admissions to the ED department of a large urban maternity unit in the East of Ireland. This rate is similar to the rate found in a previous review of activity in the ED of the same site, three years previously in 2017; 9,020 women attended for emergency care with 13% of women presenting with RFM (O'Brien *et al.* 2019), but has nearly doubled when compared with a review conducted three decades ago (1992-1993) whereby RFM accounted for 8% of attendances to the ED department (McAuliffe *et al.* 1997). The rate of attendance with RFM in the current study, is almost double the rate previously reported in three other Irish studies on RFM, which ranged from 4.4% to 7% (Daly *et al.* 2011, Smith *et al.* 2014, McCarthy *et al.* 2016). International cohort studies show a prevalence between 6%-34% (Kapaya *et al.* 2020, Radestad *et al.* 2021, Turner *et al.* 2021).

There are possible reasons for the higher rate of women seeking care for RFM in the current study. Women who sought care for RFM from ≥24 weeks gestation were included whereas other Irish and international studies used ≥28 weeks gestation as the cut- off gestation for inclusion. The gestational age threshold of ≥24 weeks was used in the current study as this is consistent with the current definition of stillbirth in Ireland (Government of Ireland 1994). While this may have contributed to some degree, the additional four weeks probably does not fully account for the rate being double the rate in other studies. Raising awareness of the importance of FMs in pregnancy over time seems the most plausible reason to explain why the rates at the study site have changed in the last three decades. The number of women presenting with RFM in the current study was therefore likely associated with increased awareness through written information booklets received at their booking visit, posters about FMs displayed in the outpatient department and within the hospital, along with social media campaigns of the importance of FMs. Clinicians may also have advised women about the importance of FMs and to present as soon as possible to the hospital for assessment should they perceive a reduction or change in the pattern of FMs. Due to the unavailability of contemporary national data on the incidence of RFM in pregnancy, it is unknown if the rates of attendance with RFM in the current study are reflective for the other 18 maternity hospital/units in Ireland. What is known and concerning though is that there is limited public awareness for RFM as a potential risk factor for stillbirth, and other adverse outcomes (Nuzum *et al.* 2018a). This emphasises the need for a national awareness campaign regarding FMs, and contemporary data on risk factors for and outcomes associated with RFM in pregnancy.

The current study identified several risk factors for RFM. These were maternal age, parity, BMI, anterior placenta, and previous obstetric history. In the following section, these are discussed individually under their respective headings. Other maternal characteristics such as assisted conception, ethnicity, cigarette smoking and complications during pregnancy are also discussed to provide up-to-date contemporary evidence.

6.3 Risk factors

6.3.1. Maternal age

The current study demonstrated that women younger than 35 years were more likely to present with RFM than women of advanced maternal age >35 years. Although why this might be the case remains unclear, the finding is consistent with findings from other studies conducted in Sweden and Australia (Radestad *et al.* 2021, Turner *et al.* 2021).

Advanced maternal age in pregnancy (described as a woman over 35 years of age), is a continuing and growing trend both nationally and internationally and is associated with increased risk of obesity, diabetes, infertility and stillbirth (Flenady *et al.* 2011a, San Lazaro Campillo *et al.* 2022). National perinatal reports published since 2012 consistently emphasise an association between advanced maternal age and perinatal mortality (Murphy 2022). The overall number of stillbirths in the current study was more or less similar in age groups ≤35years and over 35 years (n=6 and n=4 respectively). It is of particular interest therefore if age and RFM is related to awareness, knowledge and attitudes towards FMs and RFM. Saastad *et al.* (2008), in a cross-sectional survey of 691 women in Norway found that maternal age more than 35 years was associated with low maternal awareness of FMs. A national study of women's awareness, knowledge and attitudes towards FMs and RFM in pregnancy is required to identify any deficits in knowledge that could inform the development of a national FM awareness campaign.

The majority of women presenting with RFM in the current study had good neonatal outcomes. A plausible link could potentially exist between younger maternal age, perinatal mental health and RFM that was not investigated in this study. Along with finding that those of younger maternal age attended more often with RFM, Radestad *et al.* (2021), Sterpu *et al.* (2020) and Turner *et al.* (2021) also found that women with a history of psychiatric care or Edinburgh Postnatal Depression Scale ≥12 sought care more often for RFM ($p<0.001$, $p<0.01$ and $p<0.001$ respectively). In Ireland, the prevalence of perinatal depression varies between studies, ranging from 1% (McAuliffe *et al.* 2011) to 86% (Carolan-Olah & Barry 2014). Hannon *et al.* (2022) in a multi-site longitudinal cohort study of over 2,000 women recently found that primigravid women aged 18–24 years in pregnancy had higher odds of reporting depressive symptoms

(OR = 2.8, 95% CI 1.8–4.2), anxiety (OR = 3.5, 95% CI, 2.2–5.4) and stress (OR = 2.4, 95% CI 1.7–3.6) compared to women in the median age (30–34 years). To date, no studies have investigated if there is an association between age, history of perinatal mental health and RFM and therefore further investigation is warranted.

6.3.2. Parity

The current study found that nulliparity is a risk factor for attending with RFM during pregnancy. These findings resemble recent large cohort studies conducted in Sweden, Australia and Israel (Akselsson *et al.* 2019, Levy *et al.* 2020, Sterpu *et al.* 2020, Radestad *et al.* 2021, Turner *et al.* 2021) which also found an association between RFM and nulliparity. This may be explained by nulliparous women having a tendency to be more focused on FMs and consequently promptly seeking reassurance if any change or reduction in FMs occurs. Notably also, Australia and Sweden, and Ireland (including the current research site) have been involved in the implementation of interventions and initiatives such as AFFIRM, Mindfetalness trials and Safer Baby Care Bundles that included raising awareness about FMs and RFM in pregnancy (as discussed in Chapter 2) which may have potentially influenced results. Saastad *et al.* (2008) previously surveyed 691 women in Norway about their level of maternal awareness of fetal activity, maternal concern about RFM, and pregnancy outcomes. An association was identified between nulliparity and high awareness of fetal activity and increased risk of being concerned about FMs.

The current study found no association between parity, RFM and adverse neonatal outcomes. Cohort studies conducted in the UK and Israel have reported similar findings (Dutton *et al.* 2012, Zamstein *et al.* 2019, Levy *et al.* 2020). Of note and similar to the current study, rates of past medical, obstetric history and complications in pregnancy were not significantly higher among the RFM cohort groups. Higgins *et al.* (2018) in a prospective cohort study also reported no association between parity, RFM and adverse pregnancy outcomes but did identify that women with RFM and adverse outcomes were more likely to report a longer duration of absent FMs of more than 12 hours (p=0.014) than women with RFM and no adverse outcome. Sterpu *et al.* (2020) in a Swedish retrospective cohort study reported that nulliparous women with RFM were almost at

a twofold increased risk of having a poor neonatal outcome (OR 1.8, 95% CI 1.4-2.3) compared with multiparous women with RFM. Remarkably though of the 21 stillbirths in the RFM group in Sterpu *et al's* (2020) study, 15 (71.4%) were diagnosed upon first presentation with RFM. Aviram *et al.* (2016) in a retrospective cohort study in Israel also reported that nulliparous women were at increased risk of stillbirth ($p<0.05$). This suggests that women with adverse outcome upon admission, in the absence of medical, obstetric or pregnancy complications may have delayed presenting to the hospital with absent FMs or RFM.

The literature describes how maternal perception of FMs changes throughout pregnancy in response to gestational age and fetal growth. It may be that multiparous women are more familiar from previous pregnancies with the sensation of FMs and changes that occur as pregnancy advances. Changes in the character of FMs may therefore be interpreted as RFM by inexperienced nulliparous women. Knowing that parity is a key factor in women attending with RFM provides opportunities. That is, the '*the unknown'* could be minimised for nulliparous women through targeted antenatal information and education about normal fetal development, normal changes that occur in FMs during the third trimester and into late pregnancy and when to seek care for FM concerns.

6.3.3. Body Mass Index

The current study identified that >50% of women were in the overweight or above BMI categories. Maternal obesity is a known risk factor for adverse pregnancy outcomes, including SGA (Xu *et al.* 2017), stillbirth and preterm birth (Torloni *et al.* 2009). The risk of stillbirth is reported to be almost twice as high among obese pregnant women when compared with normal weight pregnant women (Chu *et al.* 2007, Flenady *et al.* 2011a). Maternal obesity is also associated with gestational diabetes and preeclampsia (Schummers *et al.* 2015, Fuchs *et al.* 2017), of which these pregnancy conditions are also associated with stillbirth and neonatal death.

The current study demonstrated that women who attended with RFM during pregnancy had a higher mean BMI than women with no RFM. Severely obese women (BMI ≥40 kg/m²) were also more likely to present with RFM than women with healthy BMI (18-24.99 kg/m²). No association was found between women with RFM who were overweight or obese and in the incidence of stillbirth, SGA or preterm birth. Due to the small numbers of stillbirth and neonatal death events in the RFM group results should be considered with caution. Severe obesity was also not associated with SGA or preterm birth. There are conflicting reports about the association of RFM in women with obesity and adverse neonatal outcomes. Like the current study, a retrospective cohort study conducted in the UK by Pagani *et al.* (2014b) women with BMI ≥35 kg/m² were twice as likely to present with RFM at term (OR 2.10, 95% CI 1.49-2.95, p<0.001) but did not have an increased risk of SGA (OR 0.82, 95% CI 0.58-1.16), p=0.26). In a prospective cohort study of 2,168 women with RFM at ≥28 weeks in otherwise uncomplicated pregnancy, a multivariable analysis of women presenting with RFM demonstrated that women with SGA at birth or stillbirth were more likely to have a pre-pregnancy BMI >25kg/m² (SGA OR 1.6, 95% CI 1.2-2.1 and stillbirth OR 1.8, 95% CI 1.0-3.2 respectively) (Tveit *et al.* 2009b). Two retrospective studies by O'Sullivan *et al.* (2009) and Sinha *et al.* (2007) found no association between BMI and risk of stillbirth, but these studies were not sufficiently powered to adequately assess this outcome. In studies where a composite poor pregnancy outcome (e.g. stillbirth, SGA neonatal death, 5 minute Apgar score <7 and admission to NICU) was used, no association was found between BMI and poor pregnancy outcome (Dutton *et al.* 2012, Higgins *et al.* 2018). No studies have reported on the relationship between increased maternal body size or obesity in women presenting with RFM and individual neonatal outcomes such as preterm birth, NICU admission or low Apgar score and therefore could not be compared with the current study.

Based on current evidence, it is difficult to draw concrete conclusions. Individual studies (as discussed in Chapter 2), albeit of various study designs, do not seem to support an association between obesity and impaired maternal perception of FMs. Two systematic reviews have reported contrasting results that women with increased BMI are associated with attending hospital with RFM during pregnancy (Bradford *et al.* 2018b,

Carroll *et al.* 2019). This is conceivably due to the method used to synthesise studies. Bradford *et al.* (2018b) amalgamated by study design whereas Carroll *et al.* (2019) synthesised per BMI category. Uncertainty also continues as to the clinical significance of RFM in women with increased BMI. Further studies are required that are adequately powered to investigate RFM, raised BMI, particularly in women with BMI >35kg/m^2, and neonatal outcomes.

Nonetheless, obesity is a modifiable risk factors therefore modification of this lifestyle factor could contribute to optimising maternal and fetal health in pregnancy, and consequently improve maternal and fetal outcomes. Support for weight management should be advocated for by midwives, GPs and obstetricians at each interaction with women either before and/or during pregnancy thus supporting and integrating current government initiatives such as the '*Making Every Contact Count*' Programme. International organisations and guidelines recommend that all women should receive nutrition and weight counselling during pregnancy (World Health Organization 2016, Simon *et al.* 2020). FIGO recently recommended that routine discussion of nutritional needs should occur at every contact during pregnancy by using the FIGO Nutrition Checklist (McAuliffe *et al.* 2020). The FIGO Nutrition Checklist (Killeen *et al.* 2023) is a validated questionnaire that collates information from women about weight, diet and nutrition and therefore should be implemented as part of routine antenatal care to facilitate and support conversations between women and healthcare professionals' about healthy lifestyle in pregnancy and identify areas for improvement. A recent review of midwives' and obstetricians' knowledge of gestational weight gain guidelines, however, demonstrated that, overall, healthcare professionals have inadequate knowledge of these guidelines to provide evidence-based advice to women during pregnancy (Callaghan *et al.* 2020). Barriers such as lack of time, competing priorities during pregnancy assessments, and lack of education and resources have been reported by healthcare professionals (Heslehurst *et al.* 2014). This evidence demonstrates the need for a review of undergraduate and postgraduate midwifery and medical education programmes to ensure that adequate education, such as the '*Making Every Contact Count*' training programme, is being provided to future midwifery, nursing and medical personnel, including information on the importance of prioritising lifestyle behavioural

change strategies during each antenatal contact. For qualified staff, audits should be conducted to ensure that all staff involved in maternity services have completed the '*Making Every Contact Count*' training programme and have adequate knowledge of the FIGO Nutrition Checklist and Smoking Cessation Programmes.

6.3.4. Ethnicity

The current study found that Irish, white Caucasian women proportionately sought care more often for RFM than Asian/Chinese or African/Black ethnic groups. Due to the non-reporting and unavailability of hospital and national ethnicity data for the pregnant population in Ireland, it was difficult to make accurate comparisons. It is noted though that limited focus has been given in the literature to ethnicity and RFM, in particular ethnic minorities. Pagani *et al.* (2014b) and Turner *et al.* (2021) observed in retrospective cohort studies conducted in the UK and Australia that women of Asian origin were more likely to present with RFM than Caucasian women, while Afro-Caribbean or women from other ethnic groups sought care less often for RFM. An observational study conducted in 67 maternity clinics and 6 obstetrical clinics in Sweden by Radestad *et al.* (2021), also found that women born outside of Sweden (mostly African and Asian) sought care to a lesser extent for RFM in pregnancy.

The relationship between RFM and neonatal outcomes in various ethnic groups has received limited attention in the literature. One retrospective cohort study in the UK of 17,791 pregnancies (865 with RFM and 16,926 without RFM) found that women of Asian ethnicity were twice as likely to have a pregnancy complicated by SGA (OR 2.12 95% CI 1.83-2.45, $p<0.001$) than presenting with RFM at term (OR 1.27 95% CI 1.02-1.59, $p=0.03$). Afro-Caribbean women were found to be at higher risk of SGA (OR 1.60 95% CI 1.33-1.93, $p<0.001$) but with no increase in the risk of presenting with RFM at term (OR 1.03 95% CI 0.80-1.34, $p=0.81$). Further subgroup analysis of the current study is planned as postdoctoral work to further investigate RFM in various ethnic groups and pregnancy, birth and neonatal outcomes.

Factors such as health behaviours in pregnancy, access to maternity care, and environmental factors (e.g. housing conditions) may be driving observed inequalities (Duffy *et al.* 2022). Narratives from ethnic minority women including Black African women seeking asylum describe financial (difficulties arranging travel to hospital or childcare), language, social and cultural difficulties as explanations for varied access to maternity care (Kennedy & Murphy-Lawless 2003, Tobin *et al.* 2014, Thomson *et al.* 2022). A qualitative synthesis of 22 studies of ethnic minority women's experiences and needs when accessing maternity care in high income countries identified other critical barriers such as, ineffective communication, not being taken seriously, cultural insensitivity and being treated differently, and feelings of healthcare staff discriminating and being dismissive of their needs (Toh & Shorey 2023). How various ethnic groups perceive maternity healthcare providers and experience maternity services may to some extent underpin paradoxically national and international perinatal reports of increasing rates of maternal and perinatal death among women from ethnic minority backgrounds, in particular African born women.

Latest figures show that 9.4.% of births in Ireland occur to women born outside of Ireland (non-EU)[12]. The risk of a perinatal death for African born women (relative to Irish-born) increased from 1.48 in the period 2004-2008 to 2.04 in the period 2014-2019 (Duffy *et al.* 2022). Findings of increasing stillbirth rates in women of Black or Asian ethnicity when compared with those of white ethnicity are echoed in other high-income countries including the UK (Draper *et al.* 2022), Australia (Drysdale *et al.* 2012, Davies-Tuck *et al.* 2017), New Zealand (Norris *et al.* 2017), North America (Pruitt *et al.* 2020) and other countries in Europe such as Norway (Vik *et al.* 2019) and Denmark (Rasmussen *et al.* 2021). It is nearly 30 years now since Black African women arrived in Ireland seeking asylum. Two qualitative studies previously conducted that sought asylum-seeking women's experiences and perceptions of maternity care in Ireland, although informative, are now outdated (Kennedy & Murphy-Lawless 2003, Tobin *et al.* 2014), especially in the context of societal and maternity care change (e.g., the National Maternity Strategy (2016)).

[12](https://www.cso.ie/en/releasesandpublications/ep/pvsar/vitalstatisticsannualreport2020/births2020/)

Notably, ethnic minorities were underrepresented in a recent National Maternity Experience Survey, and women whose babies had died were excluded (Health Information and Quality Authority (HIQA) *et al.* 2020). Further efforts are required to explore the experience and perceptions of contemporary maternity care of 'hard to reach' groups. Research is required to explore the cultural qualities expected by Black African women during antenatal care. This knowledge could be used to develop culturally competent and sensitive antenatal care services, which in turn may improve access and engagement, and reduce the risk of maternal and infant morbidity and mortality. Consideration should also be given to ensuring that BAME women are adequately represented in any future research that will assess women's awareness, knowledge and attitudes about FMs/RFM; and experiences and perceptions of contemporary maternity care. The first National Maternity Bereavement Experience Survey is now complete, and findings are awaited. Secondary analysis of this survey could also provide valuable information on the experiences of BAME women if they were adequately represented in the survey.

Notably, the current study had some missing data for the variable ethnicity, 5.6% and 6.5 % in the RFM and No RFM groups respectively. Since 2008, The National Perinatal Epidemiology Centre (NPEC) at University College Cork collate data on perinatal deaths and produce annual reports on perinatal deaths in Ireland (O'Farrell *et al.*, 2021). These reports have also been hindered by the absence of national data on ethnicity for pregnant women in Ireland, resorting to using 2016 National Census data for female aged 14-49 years for comparison. Attention is required to improve the collection of data on ethnicity/country of birth of the pregnant population, so that we can better understand the impact of socio-economic factors on maternity care in Ireland.

6.3.5. Cigarette smoking

Smoking was found to be a risk factor for RFM in the systematic review reported in Chapter 3. In contrast, the current study did not find that cigarette smoking was a risk factor for RFM during pregnancy. This resembles findings from large cohort studies on RFM conducted over the last decade in Sweden and Australia (Akselsson *et al.* 2020,

Radestad *et al.* 2021, Turner *et al.* 2021). Levy *et al.* (2020) however in a large retrospective cohort study of 13,338 women spanning over 10 years (2009-2019) in Israel reported that women who smoked were more likely to attend with RFM during pregnancy (18% v 12%, p<0.001). Differences in results of studies could invariably be due to the characteristics of women in the populations studied, the prevalence of smoking in different countries and reporting of smoking status.

In the current study, cigarette smoking status reported at each woman's antenatal booking visit was used as the indicator for smoking in pregnancy which could have impacted on study results. The antenatal booking visit occurs usually at or before 15 weeks gestation'. Research shows that women often cease or reduce smoking upon confirmation of being pregnant. A cross sectional study of women attending a large maternity unit in Dublin identified that almost 70% of women quit smoking before pregnancy and a further 22% stopped smoking upon becoming pregnant, while 8% were still smoking but had reduced the number of cigarettes smoked (Frazer *et al.* 2020). The study site like almost all maternity units in Ireland relies on women to self-report their smoking status at their first antenatal booking visit appointment. Global prevalence rates of smoking during pregnancy are estimated to range from 10% to 20% (Lange *et al.* 2018). An 11% smoking prevalence rate among pregnant women was reported in 2017 in an audit of the 19 maternity units in Ireland (Reynolds *et al.* 2017). It is plausible that social norms may discourage women from either smoking in pregnancy or reporting smoking during pregnancy. An Irish study that included measurement of carbon monoxide levels identified underreporting of active smoking by 40% (Reynolds *et al.* 2018). Carbon monoxide testing at first antenatal appointment or smoking cessation support and services were not available to pregnant women at the time the study was being conducted. The hospital was also a tobacco free campus at the time of the study.

Previous studies have shown that pregnant smokers are more likely to be single, of younger age, unemployed, have low levels of education, multiparous, low socioeconomic status (SES), history of mental health issue and living with a partner who smokes (Reynolds *et al.* 2017). While data was not collated on SES, level of education or employment status in the current study, it is plausible that the findings of this study may

be directly related to the population studied. Anecdotally, women attending the hospital site tended to be older, educated and in employment which may have influenced findings also.

There is no known reason why smoking might inhibit maternal perception of FMs, indicating that it is the effects of smoking that impacts the fetus. A systematic review of 16 studies found that maternal smoking during pregnancy was associated with reduced fetal size and growth from the second trimester (Abraham *et al.* 2017). Smoking during pregnancy is also linked with various pregnancy complications such as miscarriage, pre-eclampsia, pre-term birth and low-birth weight (Lange *et al.* 2018). These studies suggest that smoking cause a reduced oxygen-carrying capacity of maternal blood and reduced uteroplacental blood flow, as a consequence of high carboxyhaemoglobin levels from inhaled carbon monoxide (Räisänen *et al.* 2014). In the current study smoking and RFM was not identified as a risk factor for stillbirth, SGA, preterm birth or NND. A prospective cohort study performed between 2009 and 2010 in the UK by Dutton *et al.* (2012) reported an increasing trend towards an association between RFM, smoking and poor perinatal outcome (p=0.06, OR 1.96 95% CI 0.96-4.00). Notably 14.1% of participants with RFM reported smoking cigarettes ranging from 2-20 cigarettes per day in Dutton *et al's* (2012) study in comparison to less than 2.5% reporting smoking in the current study. This reason along with increasing public awareness of the dangers of smoking in pregnancy and supports available for smoking cessation during pregnancy could account for the differences in findings.

Smoking is a modifiable risk factor; therefore, modification of this lifestyle factor may contribute to a reduction in women presenting with RFM in pregnancy, optimising maternal and fetal health in pregnancy, thereby improving maternal and fetal outcomes. Research is emerging about the positive effects of dedicated smoking cessation clinics in Ireland. Women who attended a dedicated antenatal smoking cessation clinic were over three times more likely to quit smoking (OR 3.62; 95% CI 1.43–9.17) or smoke fewer cigarettes daily at the time of birth (5±4 cigarette versus 7±5 cigarettes, OR 0.28; 95% CI 0.13–0.59) when compared with women receiving routine antenatal care (McDonnell *et al.* 2023). In this trial, continued cigarette smoking during pregnancy was associated with

increased rates of FGR, placental abruption, and stillbirth (McDonnell *et al.* 2023). In the first year of implementation of a government funded free dedicated stop smoking service for pregnant women in two large maternity units in Cork and Dublin, known as the Slaintecare *'Smoke Free Start'* programme, 691 referrals were received. An evaluation of the service demonstrates that quit smoking rates after four weeks were in excess of 75% and the 12 week quit rates were in excess of 60%, while more than 100 babies were born 'smoke-free'. Qualitative responses from women who used the services highlighted the importance of dedicated support and the development of positive relationships with Stop Smoking Midwives as crucial to their success in quitting smoking. Emerging positive research evidence supports the premise that smoking cessation programmes should be made available in all maternity units in Ireland (Health Service Executive 2022). Support for cessation of smoking during pregnancy should be advocated for by midwives, GPs and obstetricians at each interaction with women either before and/or during pregnancy thus supporting and integrating current government initiatives such as the '*Making Every Contact Count*' Programme.

6.3.6. Anterior placenta

In the current study, women who attended with RFM were nearly 1.5 times more likely to have an anterior placenta. This is congruent with the findings of three studies meta-analysed in the systematic review of risk factors in Chapter three. One other matched case-control study conducted in the US also found that more than half of the women presenting with RFM had an anterior placenta compared with the control group (58.3% v 35.1%, $p<0.001$). Women that presented with RFM were 2.9 times more likely to have an anterior placenta (CI 1.5-5.5) (Greenberg *et al.* 2021).

Results from ultrasound studies indicate that when the fetus moves, the uterus and abdominal wall are stimulated. An anterior placenta acts as a barrier, obstructing direct contact between the fetus and the uterus or abdominal wall. This might explain women's reduced ability to perceive FMs and therefore present more often with RFM.

The current study also found no association between RFM, anterior placenta and outcomes such as SGA at birth, preterm birth or admission to NICU. No published

studies to date have investigated this. A limited number of studies have investigated the association between placental location and pregnancy complications or perinatal outcomes separately. A prospective study of 810 women in Ireland found that anterior placentation was statistically associated with IUGR and preterm birth (Cooley *et al.* 2011). A retrospective study of 474 women in Saudi Arabia also found an association between anterior placenta and IUGR (Zia 2013). Caution is required in the interpretation of these findings due to the retrospective nature of the study, small numbers involved and various reporting styles and experience of sonographers. In contrast, other retrospective studies however describe a positive correlation between posterior or lateral placentas and IUGR rather than anterior located placentae (Kofinas *et al.* 1989, Granfors *et al.* 2019). Further large prospective studies, where the placental positions are determined by only one experienced sonographer are required. Until more studies investigate, the overall clinical significance of RFM in pregnancies with anterior placental location remains unclear. Women should be informed that an anterior placenta may inhibit perception of FMs. Until further robust evidence is available on outcomes associated with pregnancies with RFM and anterior placenta, caution should remain, and women should be advised to attend if any concerns of RFM. Taking into consideration the evidence suggesting a link between anterior placenta and IUGR, clinicians should consider assessment of fetal growth in women with an anterior placenta who present with RFM.

6.3.7. Medical history

Women with a medical history of either hypertension, diabetes or epilepsy were not found to attend more often with RFM during pregnancy. Notably though there were small numbers of previous medical events in the RFM cohort. One explanation could be that at the research site, women with pre-existing hypertension, diabetes and epilepsy are cared for antenatally in either a specialist high risk Fetal Medicine Cardiac, Neurological or Diabetic antenatal clinic. In the current study, only women who presented to the ED with a primary complaint of RFM were studied. It is possible that women who attended high risk clinics may have had a complaint of RFM but were cared and managed in a different department of the hospital and therefore were not captured or enrolled into the current study. These findings are consistent with one other recently

reported study; an observational study comparing the characteristics of women who attended with RFM (n=2059) and without RFM (n=37806) in Sweden (Radestad *et al.* 2021). Past medical history events were also low in the RFM cohort. O'Sullivan *et al.* (2009) however found that women with RFM and past medical history such as thrombophilia, hypertension or diabetes were at increased risk of poor pregnancy outcome, defined as stillbirth, SGA and PTB by the authors. Notably the women with RFM in O'Sullivan *et al's* study had significantly higher rates of past medical history than the women with no RFM (p=0.05) which could account for variances in the different studies. This suggests that women with high-risk pregnancies should be educated on the importance of FMs, to attend if any concerns of RFM and may require increased antenatal fetal surveillance.

6.3.8. Previous obstetric history

The systematic review in Chapter 3 highlighted the dearth of data available investigating associations between women's previous obstetric history and RFM. Obstetric history such as prior caesarean section, miscarriage, stillbirth and neonatal death and assisted conception were investigated in the current study. Women with a previous history of caesarean section were not found to attend more often with RFM. This is consistent with the findings of a meta-analysis of two studies described in Chapter 3 and a recent cohort study carried out over a ten-year period of 101 597 women in a tertiary centre in Australia (Turner *et al.* 2021). This is unsurprising given that the four studies found that nulliparous women were more likely to present with RFM than multiparous women.

A pregnancy loss through either miscarriage, stillbirth or neonatal death is a difficult and devastating time for parents and families. In Ireland, miscarriage occurs in approximately one fifth of clinical pregnancies equating to approximately 14,000 miscarriages per year. The population prevalence is ~1.9% for women with two miscarriages and 0.7% for three or more (Quenby *et al.* 2021). It is also estimated that 1-2% of all pregnancies end in ectopic pregnancy (Spillane *et al.* 2018) and there are over 100 molar pregnancies reported in Ireland each year (Jeffers *et al.* 1993), although these latter rates are based on data from 30 years ago. From 2012-2020 the number of

stillbirths and neonatal deaths each year fluctuated between 217-324 and 111-166 respectively (San Lazaro Campillo *et al.* 2022).

The decision for parents to become pregnant again following a pregnancy loss are often overwhelmed with underlying fears of a repeated negative outcome (Bailey *et al.* 2019, Murphy *et al.* 2021). An international online survey of nearly 3000 parents from 40 high- and middle-income countries found that the majority of parents will conceive again within a year (Wojcieszek *et al.* 2018). Other studies also confirm these findings (Hughes *et al.* 1999, Linehan *et al.* 2022). This period is often the time when parents and families are still grieving their previous pregnancy loss (Murphy *et al.* 2021). For decades the impact of pregnancy or neonatal loss on parents, families and the wider society was vastly unrecognised and underappreciated '*shrouded in an unspoken cloak of silence and invisibility'* (Nuzum & O'Donoghue 2022). Over the last twenty years there has been growing recognition and research into the physical, psychological, and emotional burden on bereaved parents and families. This is evident also during an update of the systematic review for this thesis (section 6.7).

In a PhD study and thesis, Murphy (2018) interviewed eight heterosexual couples from the South of Ireland to explore the experiences of couples in pregnancy after stillbirth. Women in this study reported '*exerting control*' over their pregnancy by becoming more aware of and '*being constantly attentive'* to their baby's movements, viewing FMs as a reassuring sign of their baby's wellbeing. At times they engaged in non-evidenced based activities such as drinking cold fluids or night-time wakening to prompt FMs for reassurance. Constant awareness of FMs, while a source of reassurance, was exhausting and also a cause for concern. The men in the study expressed feeling reliant on their partners' experience of FMs for reassurance about their baby's wellbeing. If the couples were unduly concerned about FMs or their baby's wellbeing, they referred themselves to the hospital for professional confirmation of fetal well-being and *'proof of life'*. These findings are original in that they explore Irish couples' (women including men) experiences of pregnancy after stillbirth but are consistent with the findings from other qualitative studies from other countries of womens' experiences of '*being hypervigilant*' and seeking additional *'professional affirmations*' in a subsequent pregnancy (Côté-

Arsenault *et al.* 2006, Mills *et al.* 2014, Bailey *et al.* 2019). Quantitative studies have also highlighted that women often seek increased contact with HCPs for reassurance (Hutti *et al.* 2011, Gravensteen *et al.* 2018, Roseingrave *et al.* 2022).

The current study women found no association between women having a previous history of stillbirth and RFM. This finding resembles other recent studies on RFM (Eshraghi *et al.* 2020, Radestad *et al.* 2021) but in contrast to a cohort study of 101 597 women by Turner *et al.* (2021) spanning over ten years in Australia, who found that women with a history of stillbirth were more likely to attend with RFM in pregnancy (2.1% v 1.3%, p<0.001). O'Sullivan *et al.* (2009) also reported that women with RFM and past obstetric history such as stillbirth and late miscarriage were at increased risk of poor pregnancy outcome (defined as stillbirth, SGA and preterm birth by the authors). The disparities in findings across studies could be reflective of varying research designs and maternity services available for women with a pregnancy after loss (PAL).

A significant contribution of the present study to the advancement of knowledge on risk factors for RFM is the clear association that women with a history of recurrent miscarriages or neonatal death are more likely to attend with RFM during pregnancy. These novel findings have not been reported or investigated previously in quantitative studies reporting on the characteristics of women presenting with RFM during pregnancy.

In the literature, women commonly describe increasing anxiety and worry as they approach the gestation at which their previous baby died or when attending routine antenatal or ultrasound scan appointments (Arsenault & Marshall 2000, Côté-Arsenault & Donato 2007, Mills *et al.* 2014). The narrative stories told in these studies demonstrate that pregnancy after the loss of a pregnancy or baby is associated with increased maternal anxiety, emotional vulnerability and depression (Hughes *et al.* 1999, DeBackere *et al.* 2008, Gong *et al.* 2013, Kolte *et al.* 2015, Hunter *et al.* 2017). This raises concern because increased maternal stress and anxiety during pregnancy increases the risk of adverse pregnancy outcomes, in particular preterm birth and low birthweight (Graignic-Philippe *et al.* 2014) and has the potential to continue long-term beyond the next pregnancy and birth (Armstrong *et al.* 2009). A recent cross sectional national Irish

survey of 213 women and men's experiences of care following recurrent miscarriage, indicate that nearly a quarter of women rated their experience as poor and nearly half of women did not have any HCPs to talk to about their worries or fears (Flannery *et al.* 2022). Midwives are in a unique position to assist couples in dealing with issues that a perinatal loss may place on subsequent pregnancies. A meta synthesis of 52 studies across nine countries exploring parents and healthcare professional experiences of care after stillbirth recommends that a relationship with healthcare professionals, dedicated antenatal clinics, psychological support and continuity of care are important when caring for women and their families (Ellis *et al.* 2016). It seems plausible therefore that that these findings are relevant also for pregnancy after recurrent miscarriages or neonatal death, where the focus should not just be on the risk of adverse pregnancy outcome, but also on the emotional and psychosocial care needs of parents.

Currently in Ireland, there are national clinical practice guidelines and care pathways for termination of pregnancy following diagnosis of fatal fetal anomaly, termination of pregnancy after 12 weeks, management of first and second trimester miscarriage, diagnosis and management of ectopic pregnancy and investigation and management of stillbirth and intrauterine death (https://pregnancyandinfantloss.ie/guidelines/), however there is currently no national standard, care pathway or guidelines for the care and management of women with a pregnancy after previous perinatal loss (recurrent miscarriages, stillbirth or neonatal death).

Positive developments for the future of care of couples following loss of a pregnancy or baby are in progress. The development and publication in Ireland in 2016 of the National Standards for Bereavement Care Following Pregnancy Loss and Perinatal Death (Health Service Executive 2016) was a direct response to recommendations detailed in the National Maternity Strategy and reviews into maternal deaths (Department of Health 2016) and clinical complaints of bereavement care in maternity services (Arulkumaran 2013, Helps *et al.* 2020). These standards aim to put structures in place to guide hospitals and healthcare staff on how to lead and improve bereavement care and services available for couples who experience the loss of a pregnancy or baby. Arising from the implementation of the standards, all of the 19 maternity hospitals in the Republic of

Ireland have appointed one or more Bereavement Clinical Midwife Specialists (CMS). Personal email communication with a Bereavement CMS in the research site during the writing up of this discussion however implies that for pregnancy after loss, care remains fragmented. At the research site:

> *'Women with pregnancy after loss are cared for in either routine antenatal clinics or attend the most appropriate fetal medicine high risk clinic based on their obstetric history. There is a clinic for women pregnant following recurrent miscarriage but only in the 1st trimester for reassurance ultrasound scans. Following this the woman attends a routine antenatal clinic. The Bereavement CMS acts as first point of contact for women booking back into the hospital after a previous loss* but has no specified role throughout the pregnancy. *The mental health team receive lots of referrals for support in the pregnancy after loss.'*
>
> (Personal communication with Bereavement CMS on 14th November 2022)

The clinical and policy implications of this discussion are that women with recurrent miscarriage, stillbirth or neonatal could be better served by attending a specialist Pregnancy After Loss (PAL) antenatal clinic with dedicated bereavement and mental health supportive care services. Specialist high risk clinics for previous preterm birth and diabetes have been shown to improve clinical outcomes and parents' experiences (Stenhouse *et al.* 2013, Malouf & Redshaw 2017, Newman *et al.* 2021). There have been positive evaluations and findings from dedicated PAL clinics that exist currently in the UK and internationally, which include a reduction in the number of antenatal visits and a reduction in the number of preterm births and low birthweight infants (Mills *et al.* 2016, Meredith *et al.* 2017, Mills *et al.* 2022). Women valued the '*protective environment'* and continuity of care with health professionals that a PAL clinic offers by not having to repeat their pregnancy story at each antenatal visit, flexibility of appointments and access to specialist antenatal classes for bereaved parents resulting overall in less anxiety (Abiola *et al.* 2016, Meredith *et al.* 2017). A Social Return on Investment analysis conducted in the UK also suggests that a specialist PAL clinic provides significant long-term value and better outcomes for families without increasing maternity care costs (Abiola *et al.* 2016). Consideration could also be given for the development and implementation of continuity of bereavement midwife and/or perinatal mental health midwife across all maternity units for women in a subsequent pregnancy following perinatal loss. Comparative studies will be required to determine if this continuity model of care is superior to other types of high-risk care and to identify

the components of the services that are particularly valued. In the research site, since the completion of the current study, the bereavement team have developed support groups for women with PAL. It is suggested that these support groups for women with PAL should be evaluated.

6.3.9. Assisted conception

Despite an extensive search of the literature no studies were found that investigated RFM and assisted conception. The current study is one of the first studies to investigate if there is an association between assisted conception and women presenting with RFM during pregnancy. Since commencing the current study, and the systematic review (Chapter 3) five studies have since reported on this characteristic with contrasting results (Akselsson *et al.* 2019, Zamstein *et al.* 2019, Eshraghi *et al.* 2020, Sterpu *et al.* 2020, Radestad *et al.* 2021). The current study found no association between assisted conception and RFM.

Under-reporting of assisted conception pregnancies could be a possible reason for these findings in the current study as women are not obliged to disclose to maternity care professionals if their pregnancy was as a result of assisted conception. Of the studies that found an association (Akselsson *et al.* 2019, Zamstein *et al.* 2019, Eshraghi *et al.* 2020), one reason could be that women following fertility treatment are more susceptible to pregnancy-related anxiety due to fears of pregnancy-loss and are therefore more sensitive to reporting any problems during pregnancy (Gourounti 2016, Ranjbar *et al.* 2020). The clinical significance is unclear as to date only one study (Sterpu *et al.* 2020) has investigated assisted conception, RFM and neonatal outcomes. Sterpu *et al.* (2020) performed a retrospective cohort study at a tertiary maternity in Stockholm in Sweden of 15,187 pregnancies (3243 with RFM and 11,944 with No-RFM). Pregnancies with assisted conception and RFM were 1.7 times at increased risk of having a poor composite neonatal outcome (defined by the authors as one or more of following: 5-minute APGAR score ≤7, arterial pH in the umbilical cord ≤7.10, transfer to neonatal ward for further care, intrauterine fetal death (IUFD). A systematic review of 20 matched cohort studies and 10 unmatched cohort studies found that IVF or ICSI singleton pregnancies are associated with higher risks of obstetric complications,

interventions and adverse perinatal outcomes such as preterm birth, SGA and perinatal mortality when compared with spontaneous conception (Pandey *et al.* 2012). As assisted conception rates continue to increase in the developed world further large studies are required to investigate links between pregnancies with assisted conception, RFM and subsequent neonatal outcomes to draw concrete conclusions and recommendations. Given the current available evidence it seems pragmatic that women with assisted conception pregnancies should be informed of the importance of FMs and to attend as soon as possible if any concerns.

6.3.10. Complications during pregnancy

The number of women attending with RFM and developing complications during pregnancy in the current study were small, therefore an association between complications such hypertensive disorders, diabetes, oligohydramnios or polyhydramnios was not found. This could have been as a direct result of the relatively newly implemented electronic health record (MN-CMS). Reporting of complications during pregnancy for the current study was dependant on clinicians documenting the issues in the woman's MN-CMS record. Should the clinician have inputted this information as a narrative 'clinical note' in the MN-CMS system, it is possible that this may not have been captured in the MN-CMS reports obtained during data extraction. Women who develop complications such as hypertensive disorders, diabetes, oligohydramnios or polyhydramnios also become 'high risk' pregnancies and are subsequently cared for antenatally in either a high-risk antenatal clinic for increased maternal assessment and fetal surveillance for the remainder of the pregnancy. Consequently, women who may have attended high risk clinics and had a complaint of RFM were cared for and managed in a different department of the hospital and therefore were not captured or enrolled into the current study. The literature remains conflicting. In a cohort study conducted in Israel that compared 439 women with RFM and 243,243 pregnancies without RFM between 1991-2014, Zamstein *et al.* (2019) found that women with oligohydramnios were more likely to present with RFM ($p<0.05$). In contrast, in a large cohort study of women with low-risk uncomplicated pregnancies in a different hospital in Israel between 2009 and 2019, Levy *et al.* (2020) no difference

was found between the RFM and No-RFM group in the rates of women with oligohydramnios (p=0.3). Varying definitions of oligohydramnios between studies and gestational age of assessment of amniotic fluid volumes may account for these varying study results.

In the next section, the findings in relation to RFM and pregnancy, birth and neonatal outcomes are discussed with reference to the current literature. This section is structured according to primary neonatal outcomes (stillbirth, preterm birth, neonatal death and SGA at birth), followed by intrapartum outcomes (onset of labour, mode of birth) and secondary neonatal outcomes such as Apgar score and admission to NICU. Recurrent RFM receives a separate discussion.

6.4 Pregnancy birth and neonatal outcomes

6.4.1. Primary outcomes

In the current study, RFM was not associated with increased odds of stillbirth after 24 weeks gestation. This finding was consistent irrespective of the number of attendances with RFM or gestational age at first presentation with RFM. These findings are consistent with recent cohort studies conducted over the last five years (Zamstein *et al.* 2019, Inukollu *et al.* 2021, Turner *et al.* 2021). The findings contrast however with the studies included in the meta-analysis in Chapter 3 where all fifteen studies except one (Ho et al, 2017) individually found that RFM was associated with stillbirth. Recent large prominent fetal movement awareness and interventions studies conducted in the UK and Ireland (Norman *et al.* 2018), Australia and New Zealand (Flenady *et al.* 2022) and Sweden (Akselsson *et al.* 2020) have also seen a reduction in stillbirth rates, albeit non-significant reductions. It is possible that with increasing awareness about FMs in pregnancy through antenatal education, social media campaigns, pregnancy brochures and mobile phone applications, women are more informed about FMs and are therefore presenting earlier to hospital for assessment with concerns of RFM, thus allowing time for additional investigation and intervention, reducing perinatal mortality.

As discussed in Chapter 2, delay in presenting for assessment for RFM is associated with stillbirth. While I was unable to gather data on the period of time between first maternal recognition of RFM and presenting to the hospital for assessment, it is possible that women who experienced RFM in the current study did not delay and presented at the earliest possible opportunity when they had concerns for fetal well-being. The relatively excellent perinatal outcomes in the RFM group may also be due to improved standardised care of women with RFM, such that all women enrolled in the study received, in addition to the availability of highly resourced facilities such as ultrasound/fetal medicine and neonatal intensive care. Any signs of fetal compromise were subsequently managed appropriately. In addition, the characteristics of women presenting with RFM in the current study show that women with RFM were largely low risk (low rates of smokers, medical and obstetrical complications). This suggests that the

association of stillbirth and RFM may be arbitrated by the presence of additional risk factors rather than RFM alone.

Consistent with results from various other studies (Norman *et al.* 2018, Akselsson *et al.* 2019, Zamstein *et al.* 2019, Turner *et al.* 2021), preterm birth or neonatal death was not found to be associated with RFM irrespective of the number of attendances with RFM. No neonatal deaths occurred in the RFM group and probably explained by the fact that over the past decades there have been many advances in antenatal and neonatal critical care.

Similar to the findings of the systematic review conducted in Chapter 3, the current study did however find an association between RFM and SGA babies at birth. In addition, there were proportionately higher rates of babies born SGA in both single episode and recurrent episode than No-RFM groups. Turner *et al.* (2021) in a large cohort study in Australia spanning over 10 years (2009-2019) found comparable findings. In contrast though, Akselsson *et al.* (2019) did not find an association. The authors however reported a five-fold increased risk of stillbirth among women with RFM (OR 5.5 95% CI 2.81-10.85), of which a higher percentage of stillbirths occurred where the fetus was SGA at birth suggesting nonidentification of SGA during pregnancy.

Studies report that up to 30% of the women with RFM will have a baby born small-for-gestational-age. Of concern though, in the current study a SGA fetus was diagnosed antenatally in only five women (0.5%) who presented with RFM whereas 75 (9%) babies were born small for gestational age. These findings are in congruence with a retrospective cohort study conducted in the UK. Scala *et al.* (2015) found that the percentage of SGA fetuses diagnosed at first presentation with RFM was 2% compared with 15.6% of babies SGA at birth in the cohort of women with RFM. National perinatal mortality statistics report published by NPEC annually since 2012 also report that antenatal diagnosis of FGR in stillbirth and early neonatal death cases is low, varying between 25-50% for stillbirth and early neonatal death cases respectively (O'Farrell *et al.* 2021, San Lazaro Campillo *et al.* 2022). The risk of stillbirth in pregnancies with growth restriction identified antenatally is 1% compared to an over 8-fold increased risk of stillbirth in pregnancies with unrecognized growth restriction (Gardosi *et al.* 2013)

suggesting that early detection of fetal growth and placental insufficiency can substantially reduce the risk of stillbirth. These findings indicate that a standardised approach to improve antenatal detection of FGR is required. Clinically, initial detection of FGR by midwives and obstetricians is usually based on identification of a fetus that is smaller than expected for gestational age by an abdominal palpation measuring symphysis-fundal height (SFH). Discordance of at least 2-3cms between the measured SFH and the expected size for gestational age, SGA is suspected, and the woman is usually referred for ultrasound.

There is currently a paucity of evidence that SFH measurement, a subjective tape measurement taken from the woman's symphysis pubis to the uterine fundus to measure fetal growth is an accurate and effective screening tool for detecting FGR. There are no randomised controlled trials that compare SFH measurement with serial ultrasound measurement of fetal biometry (Robert Peter *et al.* 2015). A Cochrane review conducted in 2015 found only one RCT involving 1639 women that compared SFH with abdominal palpation only (804 in the SFH intervention group and 835 in the abdominal palpation only control group). No significant difference was found between the two groups in relation to SGA or stillbirth (Robert Peter *et al.* 2015). In a meta-analysis of 34 observational studies, a sensitivity of 58% and a specificity of 87% for predicting SGA was reported, although there was considerable heterogeneity between studies (95-100%) due to the use of various SFH charts in different countries (Goto 2013). In a retrospective study of 92 case-notes of women with RFM, Heazell *et al.* (2005) found that measurement of SFH had a greater specificity than a single ultrasound assessment in the prediction of SGA at birth. Maternal and fetal factors such as parity, ethnicity, obesity, oligohydramnios and polyhydramnios along with inter and intra-observer variation also impacts on the accuracy of SFH (Griffiths *et al.* 2008). Nevertheless, SFH is inexpensive, easy to use, not resource intensive and is common practice amongst clinicians. Plotting of SFH measurements on customised growth charts is also advocated (San Lazaro Campillo *et al.* 2022), although recent evidence supporting this practice is conflicting.

A prospective, non-randomised controlled study of 1272 women found an increase in the detection of FGR with the use of customised antenatal growth charts (48% vs 29%, OR 2.2, 95% confidence interval 1.1-4.5) (Gardosi & Francis 1999) with no increase in antenatal interventions. In contrast though, a recent large cluster randomised control trial conducted in the UK that compared 11,096 births who received a Growth Assessment Protocol (GAP) antenatal package[13] with 13,810 births who received standard care, observed no improvement in the antenatal detection of FGR (Vieira *et al.* 2022).

The evidence supporting the use of ultrasound in reducing perinatal mortality in either women with RFM or the wider pregnant population is unclear. A meta-analysis of 13 RCTs (34,980 women) that assessed the effect of routine ultrasound from 24 weeks gestation during pregnancy found no difference in the risk of stillbirth (RR 1.01; 95% CI 0.67–1.54) (Bricker *et al.* 2015). This evidence led to current antenatal guidelines recommending an ultrasound scan only if clinically indicated e.g. concerns for SFH or RFM (National Institute for Health and Care Excellence (NICE) 2021), mainly to identify FGR or oligohydramnios; potential risk factors for stillbirth. New evidence however is emerging. A recent retrospective matched cohort study conducted in Australia compared the outcomes of 1,466 women with RFM who had a comprehensive ultrasound assessment (fetal biometry[14], EFW[15], assessment of liquor volume, umbilical and middle cerebral artery pulsatility index, and cerebro-placental ratio) within 48 hours of presentation with 2,207 women who had a third trimester ultrasound scan for another indication (Turner *et al.* 2023). No difference in the rate of stillbirth, birthweight or low Apgar scores between the two groups was found. No difference was found in the rate of abnormal ultrasound scan findings either although there was a higher rate of induction of labour in the RFM group which could suggest that ultrasound findings were not used to inform timing of birth. Thirty newly identified cases of SGA fetuses were identified in the RFM cohort, suggesting that 48 women need to be scanned to detect one case of SGA in women with RFM. In the same study, 1351 women with RFM did not

[13] serial fundal height or scans during second and third trimester and plotted on a Gestation-Related Optimal Weight (GROW) chart
[14] fetal growth measurements
[15] Estimated fetal weight

have an ultrasound scan. No difference was found in neonatal outcomes when compared to women who had an ultrasound scan. Thus, it seems that an ultrasound scan does not improve outcomes for women with RFM although larger studies will be required to confirm these findings.

Paradoxically, other evidence to support the use of ultrasound to reduce perinatal mortality is also limited. In a RCT, Ashimi Balogun *et al.* (2018) reported that serial third trimester ultrasound scanning of uncomplicated pregnancies (n=104) was superior in detecting a composite outcome of FGR and amniotic fluid abnormalities than routine care of SFH measurements (n=102). No difference in the incidence of stillbirth was found between the intervention or control group. The study was however underpowered to detect a difference in perinatal outcomes. In contrast, the Pregnancy Outcome Prediction (POP) study prospectively compared the detection rate of SGA by routine ultrasound versus clinically indicated ultrasound in the third trimester in 3977 nulliparous women. The detection rate of SGA was nearly tripled in the routine ultrasound group (57% v 20%; RR2.9, 95% CI 2.4–3.5; p<0.0001) (Sovio *et al.* 2015). Evidence is also forthcoming that a combined screening model that includes assessment of maternal characteristics, third trimester ultrasound for estimated fetal weight and placental Doppler, and biochemical markers[16] (placental growth factor (PIGF) and estriol) could achieve better predictions rates of FGR/SGA at birth than ultrasound alone (Miranda *et al.* 2017, Nowacka *et al.* 2022) and in predicting adverse outcomes in pregnancies with RFM (Higgins *et al.* 2018, Heazell *et al.* 2019). However, this screening model is not yet known to be established as part of routine clinical practice.

This evidence is important for midwives and obstetricians when deciding on the clinical investigations to implement for women who present with RFM in pregnancy. Albeit the majority of evidence is inconclusive, at a minimum the suggested management should include; a review of the woman's antenatal history for risk factors for FGR, SGA and stillbirth, and a physical examination that includes an abdominal palpation and measurement of SFH. This initial assessment approach may assist clinicians in selecting women who should undergo further assessment and investigations.

[16] Blood test for placental growth factor and estriol

6.4.2. Intrapartum outcomes

In the current study, of the women attending with RFM at term gestation, a third of women subsequently laboured spontaneously and gave birth within two weeks of the RFM event. To my knowledge, this is the first-time quantitative information on RFM before birth has been reported. Contrary to data found in large case-control studies presented in Chapter 2, the current study suggests that perception of FMs is altered prior to spontaneous labour in some women, prompting them to attend the hospital for assessment. It is unknown however if the women in the current study had a change in the pattern of movements or actual absent or RFM. Further quantitative studies are required to confirm these findings. Studies previously conducted on women's perceptions of FMs in the third trimester have used interviews or questionnaires with women at mean gestations of 37+ weeks and 38+5 weeks. It is possible that information on FMs in the days before spontaneous labour has not been fully explored. Further research is required to seek and document women's perceptions of FMs in late third trimester up to the onset of spontaneous labour.

Consistent with findings from other studies (Akselsson *et al.* 2019, Levy *et al.* 2020, Sterpu *et al.* 2020, Turner *et al.* 2021), the current study demonstrates that when women attend with RFM in pregnancy they are more likely to have increased intervention such as induction of labour and assisted birth. The association between RFM and emergency caesarean section became non-significant when demographic and pregnancy factors were included in the multiple logistic regression model. This suggests that other factors are involved in the reason for emergency caesarean section, not just RFM. Like the current study, many other studies have demonstrated an association between RFM and emergency caesarean section using univariate logistic regression, however, have not adjusted for known demographic and pregnancy factors associated with caesarean section.

The Cochrane Review conducted in 2012 found no evidence to direct the clinical management of women presenting with RFM (Hofmeyr & Novikova 2012). Current international guidance available on the management of RFM is based on observations studies conducted over a decade ago (Royal College of Obstetricians and Gynaecology

2011). NICE Antenatal Care guidelines do not offer any guidance either and there is currently no national guideline for the management of women who attend with RFM. While large RFM awareness and intervention trials have been conducted within the last decade, no method or intervention has yet been found that significantly reduces the risk of stillbirth. A large, stepped wedged, cluster RCT conducted in the UK and Ireland that compared a care package for pregnant women and clinicians that increased the awareness of prompt reporting of RFM, a standardised management protocol, including timely birth for RFM, with standard care, did not significantly reduce the incidence of stillbirth but did increase the frequency of labour induction and birth by caesarean section and longer neonatal unit stay (Norman *et al.* 2018). Interestingly, compliance to the intervention package protocol was inconsistent with less than 40% of maternity units adhering to the overall package. Similar challenges have been experienced in other intervention studies to increase awareness of FMs (Grant *et al.* 1989, Akselsson *et al.* 2020a, Flenady *et al.* 2022). Several studies have also highlighted variation in maternity care professionals' views in relation to fetal movement screening, assessment, and clinical management (Heazell *et al.* 2008, Flenady *et al.* 2009, Unterscheider *et al.* 2010, Smith *et al.* 2014b, Smyth *et al.* 2016, Warland & Glover 2017).

The absence of robust higher-level evidence to support standard management guidelines for women attending with RFM presents a challenging situation for maternity healthcare professionals. A balance is required to acknowledge women's concern of RFM, respond appropriately to avoid potential fetal death or injury 'being born too late' but at the same time avoid iatrogenic harm to women such as induction of labour, and babies such as preterm birth 'being born too soon'. It is inevitable that clinicians may actively respond to any suspicion of fetal compromise by timely elective or caesarean birth in an effort to prevent an adverse event. Notably a Cochrane Review to assess the effects of interventions to improve awareness and detection of FMs and interventions to address the clinical management of RFM is proposed (Davies-Tuck *et al.* 2021).

6.4.3. Neonatal outcomes (secondary outcomes)

The current study did not find an association between RFM and Apgar score <7 at 5 minutes or admission to NICU. The results should be treated with caution though due to

a substantial amount of missing data for both of these variables. Nonetheless the findings are unsurprising given that low Apgar scores are more common in preterm infants than in term infants (Iliodromiti *et al.* 2014, Cnattingius *et al.* 2017) and RFM was not associated with preterm birth in the current study. These findings are incongruent to three recent cohort studies (Levy *et al.* 2020, Sterpu *et al.* 2020, Turner *et al.* 2021). These differences may be attributed to differences in study design, labour events and local pathways for admission to NICU in the other studies.

6.5 Recurrent reduced fetal movements

There is contrasting evidence that recurrent episodes of RFM increases the risk of adverse perinatal outcomes. In a case control study Heazell *et al.* (2018b) reported that women who had experienced stillbirth were more likely than women with ongoing pregnancies to report multiple episodes of RFMs from 26 weeks' gestation. The current study found no significant difference in the rates of stillbirth, preterm birth, gestational age at birth or Apgar scores <7 at five minutes amongst women with single, recurrent or without RFM. Women with single and recurrent episodes of RFM however had higher proportions of babies born SGA. Components of these findings are similar to the results of other studies. A prospective study of 305 women found no association between poor perinatal outcome and recurrent episodes of RFM although due to a small number of events in this study (n=69), there was limited power to detect a significant difference (Dutton *et al.* 2012). In a case-control study of 320 participants in Norway, ten women had more than one presentation with RFM. No association was found between having recurrent consultations for RFM and neonatal complications (OR 1.9, 95% CI 0.8-4.6, p=0.17) (Winje *et al.* 2012). A retrospective study involving six UK maternity units of 273 women also found no evidence that multiple episodes of RFM were associated with increased pregnancy risk including SGA (Bhatia *et al.* 2019). The study was conducted however over one month only. The absence of a control group in this study also prevented comparisons of women with one episode of RFM with those without RFM. In contrast, a retrospective study of 203 women presenting to an obstetric triage unit with RFM in the UK found that women with two or more presentations of RFM were more at risk of a composite poor pregnancy outcome (OR 1.92) (O'Sullivan *et al.* 2009). The

varying results between studies could also be due to a lower threshold for recurrent RFMs whereby intervention by means of induction of labour or earlier birth may prevent adverse events. Consistent with the current study, Scala *et al.* (2015) also found that women presenting with repeated episodes of RFM had increased risk of birthing a baby SGA. The prevalence of SGA at birth in women presenting with single and repeated episodes of RFM was 9.8% and 44.2% respectively (OR 7.3, 95% CI 5.1-10.4; $p<0.05$).

Of particular interest, studies exploring recurrent episodes of RFM have not differentiated between episodes of RFM and presentations with RFM, such that could some repeat attendances with RFM be recurrent presentations of one episode or actually separate events. Anecdotally, from my own clinical practice I have experienced cases where, for example, a woman has presented with RFM, had normal cardiotocograph testing and discharged, only to return two days later with a stillbirth. Further exploration of this phenomenon in the current study is planned in the future as postdoctoral work.

6.6 Strengths and limitations of the study

In preparation for this study, a systematic review of the literature on risk factors for and outcomes associated with RFM was conducted, therefore highlighting deficiencies in knowledge and qualities of previous studies conducted. It was clear from the systematic review that there was a dearth of robust observational studies comparing risk factors and outcomes affected by RFM in pregnancy, particularly in the Irish context. While three Irish studies have been conducted previously, the breadth of two of the studies was restricted due to limited availability of comparative data for the control group especially on risk factors for RFM (Smith *et al.* 2014, McCarthy *et al.* 2016). It also highlighted a number of limitations associated with previous studies. Studies that have examined potential risk factors for RFM in pregnancy demonstrated conflicting results possibly due to divergent research designs, small sample size, incompleteness of data for control group and selection bias of participants. This was a large-scale case-control study undertaken at one large urban maternity unit in the East of Ireland. A particular strength of this study also lies in collecting the data prospectively before the outcome of pregnancy was known in both groups, minimising the potential for selection bias.

Another major strength of the study is that there was minimal loss to follow up of participants enrolled initially into each group and the relatively few variables with missing data. This is testament possibly to the maternity electronic healthcare record system (MN-CMS) in use in the study site. According to the information officer this study was one of the first large scale studies conducted in the research hospital site using the MN-CMS reports following its implementation to the hospital. This gives confidence for the future use of the MN-CMS reports for research and audit purposes.

Midwives, obstetricians, and women were also blinded to the study being conducted. As this was an observational study on RFM, the study was not formally advertised, minimising the 'Hawthorn' effect' of either women or clinicians altering their behaviour in relation to RFM. The results are there unlikely to have been influenced by participants' awareness of being part of the study, and therefore any clinical interventions were based on concerns for maternal and/or fetal wellbeing, giving confidence in the findings.

This study however has a number of limitations that should be acknowledged. During the study period, coronavirus restrictions began in March 2020. It is possible that some women who had RFM chose not to present to the ED due to hospital restrictions or may have had a virtual consultation with a midwife or obstetrician. It is thus possible that the study did not capture all women who had a primary complaint of RFM during the study period. Nevertheless, the calculated sample size of participants for both groups was achieved.

The study is limited by the lack of information regarding the length of time between each RFM episode and presentation to ED department. The reporting of RFM in the MN-CMS also could not clearly differentiate between women who presented with perceived reduction in FMs and women with absent movements. The relatively small number of stillbirths in both the RFM and No-RFM groups suggests however that women did not delay in seeking medical assistance if they experienced RFM or had concerns for FMs.

The relatively small number of stillbirths in this study and a large tertiary hospital with clear guidelines for the clinical management of women with RFM may limit the generalisability of the study results. The number of women presenting with RFM is likely

associated with increased community awareness, through frequent media campaigns, and education from clinicians antenatally of the importance of monitoring FMs and seeking immediate medical advice in the event of maternal perception of RFM.

Findings may only be applicable to other maternity units that are comparable in terms of size, maternity services and available facilities, and demographics of pregnant women. It is not possible to know the extent to which the findings are transferable to other maternity units, in different locations, and perhaps with very different working structures, staffing, resources, protocols and guidelines for the clinical management of RFM. However, given the increased effort to highlight the importance of FMs in pregnancy for women and in maternity services, it is increasingly likely that the findings of this thesis and study will have relevance beyond this study site and internationally.

In case-control studies, there is the potential for selection bias, if women presenting with RFM were only from high-risk pregnancies that had been instructed to monitor their FMs closely, then there is the potential that the sample is biased. In fact, in this study approximately only 5% of women with RFM had maternal or fetal complications making this possibility unlikely.

Over the duration of my PhD studies, I have become more aware of the particular risks faced by Black, Asian and minority ethnic women in maternity care, particularly in relation to adverse perinatal outcomes (Draper *et al.* 2020). A further limitation relating to my choice of research site was the relatively homogenous population studied. Women who identified as Black, Asian or belonging to any other minority ethnic group were scarcely represented in both groups. In recent years there has been a demographic change in Ireland. Up to twenty five percent of all births in Ireland are to non-Irish women, with women from EU countries accounting for half.

There was some missing data for variables such as BMI, ethnicity and admission NICU. Missing data are common in routinely collected health data. It is therefore recommended that a method for auditing the prevalence of missing clinical information such as demographic data is measured systematically and regularly to monitor

improvements. This in turn could assist in gathering accurate national data for the pregnant population that is currently unavailable, particularly for BMI and ethnicity.

While errors in data collection and data entry cannot be eliminated, it is anticipated that the combination of quality control procedures for data collection and data management put in place has minimised errors and maximised consistency.

6.7 Update of the systematic review

The systematic review presented in Chapter 3 was updated on 8th September 2022 and a paper on pregnancy, birth and neonatal outcomes associated with RFM was published[17]. This section of the thesis further updates the systematic review on risk factors for RFM and outcomes associated with RFM to provide contemporary evidence on RFM in pregnancy, and to provide the totality of the evidence (at the time of write-up), as the update also includes the findings from my prospective case-control RFM study.

Following an updated database search and screening of studies as described in Chapter 3, 18 additional studies, inclusive of the current study were selected for inclusion, meaning a total of 52 studies were included. Of the additional included studies, eight studies examined risk factors only (total n=12), five examined the reviews' pregnancy/birth/neonatal pre-specified outcomes only (total n=12), and five studies reported on both risk factors and outcomes (total n=28). Six additional risk factors for RFM reported in at least two studies were identified. These were history of psychiatric illness, epilepsy, assisted conception, and previous history of miscarriage, stillbirth and neonatal death. The study selection process along with the characteristics and quality assessment of each additional study included in the updated systematic review are outlined in Appendix 21.

[17] Carroll L., Gallagher L. & Smith V. (2022) Pregnancy, birth and neonatal outcomes associated with reduced fetal movements: A systematic review and meta-analysis of non-randomised studies *Midwifery*

6.7.1. Risk factors for reduced fetal movements in pregnancy

Table 6.1 compares meta-analyses in the systematic review (Chapter 3) conducted up to March 2018 with meta-analyses for each assessed risk factor updated in September 2022. Forest plots for each assessed risk factor are presented in Appendix 22. The updated systematic review demonstrated that nulliparous, women with anterior placenta, assisted conception, a medical history of psychiatric illness and a history of previous neonatal death were more likely to attend with RFM during pregnancy. There was an increasing trend of women with previous miscarriage being more likely to attend with RFM, but this did not reach significance. A prior history of stillbirth was not found to be a risk factor for RFM. No further studies to the current study were found that investigated pregnancies with RFM after recurrent miscarriage or neonatal death. African Black ethnic groups were less likely to attend with RFM when compared with women of Asian/Chinese ethnicity. There was also an increasing trend for women >35 years being less likely to attend with RFM in pregnancy, but this did not reach significance. Recent evidence also changes the direction of effect for smoking, oligohydramnios and polyhydramnios to not being risk factors for RFM. The evidence regarding hypertensive disorders of pregnancy and diabetes remained unchanged.

Table 6.1 Comparison of meta-analyses from 2018 with meta-analyses 2022 of risk factors associated with RFM

		Systematic Review (March 2018)				Systematic Review (updated September 2022)			
	Risk Factor	**No. of Studies**	**No. of participants**	**OR (95% CI)**	**I²**	**No. of Studies**	**No. of participants**	**OR (95% CI)**	**I²**
Maternal characteristics	Maternal age >35yrs v ≤35 yrs	5	2887	0.18 (0.01-2.15)*	99%	8	16019	**0.49 (0.15-1.62)**	99%
	Parity (Nulliparous v Multiparous)	17	11368	1.26 (0.88-1.81)*	97%	26	64802	**1.38 (1.07-1.78)**	98%
	BMI ≥35 kg/m²	2	4992	0.87 (0.44-1.72)*	86%	5	55751	1.05 (0.67-1.63)	88%
	Anterior placenta	3	6852	**1.31 (1.11-1.55)**	0%	5	9589	**1.31 (1.17-1.47)**	34%*
	Smoking	5	29557	**1.18 (1.02-1.35)**	4%	11	230721	1.14 (0.93-1.41)	92%
	Ethnicity (African/Black v Asian/Chinese)	2	5365	**0.47 (0.38-0.57)**	56%	4	8274	**0.35 (0.24-0.52)**	88%
	Education level								
Medical History	Psychiatric disease/mental illness	*no studies*				3	156649	**1.56 (1.10-2.22)**	80%
	Epilepsy	*no studies*				2	42458	0.92 (0.51-1.63)	11%*
	Diabetes	*no studies*				1	2593	1.03 (0.35-3.01)	na
Obstetric History	Previous caesarean section	2	30260	0.86 (0.48-1.53)*	92%	4	134450	0.72 (0.55-0.94)	88%
	Assisted conception	*no studies*				6	330211	**1.52 (1.13-2.05)**	87%
	Previous miscarriage	*no studies*				2	2893	1.15 (0.96-1.37)	47%
	Previous stillbirth	*no studies*				4	144355	1.22 (0.71-2.09)	60%
	Previous neonatal death	*no studies*				1	329	**4.65 (1.43-15.15)**	na
Complications during pregnancy	Oligohydramnios	3	39407	**4.04 (3.29-4.97)**	0%	6	299020	2.77 (0.95-8.11)	98%
	Polyhydramnios	4	39487	**2.01 (1.44-2.81)**	28%	7	299100	1.38 (0.83-2.28)	75%
	Diabetes	4	38197	1.16 (0.87-1.55)*	48%	8	425934	1.15 (0.91-1.45)	46%
	Chronic Hypertension	2	38119	1.58 (0.90-2.78)*	0%	4	142309	1.05 (0.86-1.28)	6%
	Gestational Hypertension	4	38390	0.87 (0.32-2.39)	54%	7	386262	0.91 (0.62-1.32)	50%
	Pre-eclampsia	2	353	1.02 (0.36-2.84)*	0%	4	104542	0.76 (0.49-1.17)	19%
	Antenatal Bleeding	2	983	0.35 (0.03-4.62)	54%	*no additional studies*			
	Postdates >42 weeks	3	301	1.14 (0.40-3.24)*	0%	*no additional studies*			

OR, odds ratio; CI, confidence interval; *fixed effects model; na, not applicable

Taking into consideration the findings from the updated systematic review, it seems that nulliparous women, women with mental health issues and ethnic minority groups could benefit from additional support through contemporary information and education on normal fetal development and the characteristics of FMs at the various stages of pregnancy. Until more studies investigate, the overall clinical significance of RFM in pregnancies with anterior placental location remains uncertain. Women should be informed that an anterior placenta may inhibit perception of FMs. Until further robust evidence is available on perinatal outcomes associated with anterior placenta and RFM, caution should remain, and women should be advised to attend if any concerns for FMs. Taking into consideration that there is some evidence suggesting a link between anterior placenta and fetal growth restriction, clinicians should consider assessment of fetal growth in women with an anterior placenta who present with RFM.

Currently, severe obesity as a risk factor for RFM is not supported in the updated systematic review. This may suggest that women with increased BMI have altered perceptions of FMs. However, given that there is contrasting evidence about perinatal outcomes associated with RFM and obesity, caution should be applied. Women with increased BMI should therefore be informed that they may experience impaired perception of FMs, however, should attend the hospital if any concerns.

The change in direction of the effect of smoking as a risk factor for RFM is welcome. However, caution should be applied in interpreting these findings. Heterogeneity was considerable at 92% and may be reflective of divergent study designs or the demographics of women across studies. The updated result may nevertheless be reflective of global public health campaigns advertising the effects that cigarette smoking can have on the unborn child along with local, national and international efforts to assist women to quit smoking during pregnancy through smoking cessation clinics.

Given the current available evidence it seems pragmatic that women with pregnancies following assisted conception should be informed of the importance of FMs and to attend as soon as possible if any concerns. Larger studies will be required to assess fully the association between RFM, assisted conception and perinatal outcomes. The change

in direction of effect of abnormalities of amniotic fluid as risk factors for RFM should be treated with caution as heterogeneity is substantial (75% and 92%). This may be reflective of the varied management of pregnancies with abnormalities of amniotic fluid and service available. Women with pregnancies diagnosed with oligohydramnios or polyhydramnios before presenting with RFM will usually have increased antenatal fetal surveillance, often in different departments of the hospital.

6.7.2. Pregnancy, birth and neonatal outcomes associated with RFM

Table 6.2 compares the meta-analyses for primary and secondary outcomes as outlined in the systematic review (Chapter 3) conducted up to March 2018 with meta-analyses updated in September 2022, which includes the findings from the current study. Forest plots for each assessed outcome are presented in Appendix 23.

In the update of the systematic review, nine additional non-randomised studies, including the current study, resulting in a total of 24 studies reporting on stillbirth were found. When these additional studies are combined in the meta-analysis, there remains a more than 3-fold increased odd of stillbirth (OR 3.36; 95% CI 2.00-5.63, 24 studies, 515717 participants, I^2=79%). This is a reduction from the odds ratio of OR 5.23, 95% CI 2.49-10.98 reported nearly five years ago in 2018. In a sensitivity analysis including 17 studies published between 2012-2022, the odds ratio for stillbirth remains significant but less so overall (OR 2.61; 95% CI 1.41-4.84, 17 studies, 500835, I^2=87%). A further sensitivity analysis of six prospective studies published in the last five years (2017-2022), there is an even further reduction in the overall confidence interval to a non-significant difference (OR 2.05; 95% CI 0.86-4.87, 6 studies, 46184 participants, I^2=41%) (Table 6.2).

An additional two studies reported on stillbirth ≥36 weeks' gestation, totalling six studies. The effect of RFM remained significant for stillbirth at gestational age ≥36 weeks gestation although less so overall in the updated meta-analyses; (OR 2.61, 95% CI 1.50-4.53, 6 studies; 321145 participants, I^2=15%). Notably all of the studies included in this sensitivity analysis were published between 2014-2021. These results also show that the odds of stillbirth with RFM at term have increased slightly.

Table 6.2 Comparison of meta-analyses from 2018 with meta-analyses 2022 of outcomes associated with RFM

	Systematic Review (March 2018)				Systematic Review (updated September 2022)			
Outcome	**No. of Studies**	**No. of participants**	**OR (95% CI)**	**I^2**	**No. of Studies**	**No. of participants**	**OR (95% CI)**	**I^2**
Stillbirth overall	15	95,829	**5.23 (2.49-10.98)**	81%	24	515,717	**3.36 (2.00-5.63)**	79%
Stillbirth ≥36 weeks gestation	3	61,532	**2.16 (1.02-4.57)**	0%	6	321,145	**2.61 (1.50-4.53)**	15%
Studies published 2017-2022		*not applicable*			4	265,640	2.32 (0.66, 8.23)	41%
Low Risk of Bias Studies	6	18,452	**3.86 (2.08-7.18)**	0%	10	280,114	**3.08 (1.59, 5.94)**	39%
Retrospective studies only	9	94,050	**2.74 (1.97-3.81)**	0%	15	466,526	**3.06 (1.56, 6.00)**	87%
Prospective studies only	3	882	**71.77 (12.07-426.71)**	44%	9	46,084	2.24 (0.99, 5.56)	77%
Studies published 2017-2022		*not applicable*			6	46,184	2.05 (0.86, 4.87)	77%
Small for gestational age	13	169,165	**1.73 (1.31, 2.30)**	85%	20	458,795	**1.37 (1.17, 1.61)**	77%
Preterm birth	10	49,941	1.02 (0.73, 1.43)	74%	14	426,537	0.91 (0.72-1.15)	82%
Neonatal Death	6	54,053	1.60 (0.32, 7.98)	0%	9	171,581	0.94 (0.49-1.81)	0%
Induction of Labour	14	76, 856	**1.52 (1.13, 2.05)**	93%	16	499,611	**1.79 (1.50, 2.13)**	96%
Assisted birth	8	97,705	**1.14 (1.05, 1.25)***	1%	12	230,420	**1.14 (1.05, 1.25)**	48%
Caesarean section overall	10	69,914	**1.12 (1.03, 1.22)**	90%	17	474,203	**1.42 (1.18, 1.71)**	95%
Emergency	8	87,218	**1.43 (1.29, 1.59)***	0%	13	248,656	**1.35 (1.25, 1.47)**	52%
Apgar score <7 at 5 minutes	12	86,893	0.96 (0.58, 1.57)	59%	19	492,094	1.14 (0.76, 1.71)	87%
Admission to NICU	10	83,785	0.77 (0.49, 1.23)	70%	15	129,431	0.84 (0.61, 1.16)	78%

OR, odds ratio; CI, confidence interval; *fixed effects model; na, not applicable

Heterogeneity is also low (15%), providing confidence in the results and therefore suggesting that RFM occurring in the third trimester is clinically significant, should be taken seriously and further assessment of the woman for additional risk factors for stillbirth and evaluation of fetal wellbeing should be performed. A sensitivity analysis however of studies published in the last five years, changes the direction of the effect of RFM at > 36 weeks on stillbirth to non-significant. The reasons for decreased odds of stillbirth associated with RFM overall and at term could be as a result of the demographic and pregnancy characteristics of women included within studies (low risk v high risk), women's knowledge and awareness of RFM and attending sooner for assessment, and changes over the last decade in how pregnancies with RFM are managed, such that planned earlier birth (induction of labour) is reducing the incidence of stillbirth.

While the odds of babies born SGA have reduced slightly since the 2018 meta-analysis, babies born SGA at birth remains associated with RFM (OR 1.37, 95% CI 1.17-1.61, 20 studies, 458795 participants, I^2=77%). It is not known from studies how many pregnancies had a diagnosis of a SGA fetus or FGR before or after RFM. Given the current evidence that up to 30% of babies born SGA are undetected during pregnancy, this finding further highlights that improvements are required in the detection of FGR/SGA during pregnancy.

Consistently, preterm birth (OR 0.91, 95% CI 0.72-1.15, 14 studies,426,537 participants, I^2=82%) and neonatal death (0.94, 95% CI 0.49-1.81, 9 studies, 171581 participants, I=0%) remain non associated with RFM. Notably the confidence interval for neonatal death has narrowed from the previous meta-analysis in 2018. All studies except the current study were retrospective studies. The number of neonatal deaths, however, remains relatively few across the groups in the nine studies (11 of 18637 versus 104 of 152944). Significant advances in antenatal assessment and investigations and neonatal critical care are almost certainly the reason for these findings.

Induction of labour remains associated with RFM during pregnancy (OR 1.79, 95% CI 1.50-2.13, 16 studies, 499611 participants, I^2=96%), notably with slight increased odds from nearly five years ago. RFM also remains associated with increased odds of assisted

birth (OR 1.14, 95% CI 1.05-1.25, 12 studies, 230420 participants, I^2=48%), caesarean section (overall) (OR 1.42 95% CI 1.18-1.71, 17 studies, 474203 participants, I=95%) and emergency caesarean section (OR 1.35, 95% CI 1.25-1.47, 13 studies, 248656 participants, I^2=52%) (Appendix 23).

RFM remains non associated with Apgar score <7 at 5 minutes (OR 1.14, 95% CI 0.76-1.71, 19 studies, 492094 participants, I^2=87%) or admission to NICU (OR 0.84, 95% CI 0.61-1.16, 15 studies, 129431 participants, I^2=78%) (Appendix 23). These findings are not surprising given that low Apgar scores and admission to NICU are usually more common in preterm infants than in term infants (Iliodromiti *et al.* 2014, Cnattingius *et al.* 2017). RFM was not associated with preterm birth as found during the RFM study and in the updated meta-analysis.

Caution should be applied however in interpreting these results overall as unadjusted effect estimates were used which may have overestimated risks. Several included studies either did not control for the same confounders or control at all for the effect of confounders. Heterogeneity ranged from moderate to considerable also for some outcomes and should be taken into account when interpreting the results. Clinical practice variations in the management of women presenting with RFM were not always reported in included studies, which may also represent an unexplored source of heterogeneity. The criteria on which outcomes were defined and measured varied. In addition, the reporting of outcomes varied significantly across studies. The various definitions used therefore pose a methodological difficulty when attempting to interpret and accurately evaluate associations between adverse perinatal outcomes. It is therefore necessary to reach a consensus on the definition and classification for adverse pregnancy outcomes to be comparable. The development of a core outcome set relating to RFM is welcome (Hayes *et al.*, 2021). Standardizing a set of outcomes that should be measured and reported in all studies will optimise data synthesis of individual studies and interpretation of the research evidence surrounding RFM (Hayes *et al.*, 2021). For further updates of this systematic review, the COS which is now developed and is pending publication, once available, will be consulted to ensure that all relevant outcomes are included.

6.8 Chapter summary

This chapter provided a discussion on the main results of the study by comparing, contrasting, and combining and updating the systematic review presented in Chapter 3. This provides a comprehensive review of and presents contemporary evidence regarding perinatal risk factors for, and pregnancy, birth and neonatal outcomes associated with RFM. Finally, the overall strengths and limitation of the study have been outlined. Chapter 7 will provide a summary of the overall thesis along with recommendations for policy, practice, research and education.

Chapter 7 Summary of Thesis

7.1 Introduction

This chapter presents a summary of this thesis. It documents the evidence that has emerged from this thesis and describes the contribution this evidence provides to original knowledge on the topic and to my development as a midwife researcher. Recommendations for practice, policy, research and education are provided in addition to planned dissemination strategies. Post-doctoral work that will follow on from this thesis is outlined. A personal reflection of my PhD journey will conclude the thesis.

7.2 Summary of thesis

The *feeling* of the baby moving is one of the first positive signs of life for the majority of pregnant women. Most women are usually attentive to how and when their baby moves during pregnancy. The presence of FMs thus serves as a reassuring sign for both women and maternity healthcare professionals. A perception of RFM will subsequently not only perpetuate fear and anxiety in a woman that her baby is unwell or may have died but also in healthcare professionals. Concerns for FMs is thus a frequent reason for attending the maternity hospital. Of women who present with RFM, up to 70% will have a normal outcome and progress to have a healthy baby. For the remainder however, evidence demonstrates that RFM is associated with adverse perinatal outcomes such as stillbirth and SGA.

Current clinical guidance is for women to contact the maternity hospital for any concerns in a reduction or absence of FMs. Knowledge and guidance from healthcare professionals is variable, leading to variations in subsequent management. There is an abundance of literature about methods used to raise awareness of FMs, improve detection of RFM and to determine optimal management strategies of pregnancies with RFM e.g. formal FMC, mindfetalness, standardised management packages. The effectiveness of many strategies however remains inconclusive. The literature also highlights though that several maternal characteristics may impact on maternal

perception of FMs, some of which can equally be classified as risk factors for RFM e.g., anterior placenta and obesity. Given that RFM is identified as a key international component strategy to prevent stillbirth, it was essential to bring all the existing evidence together on perinatal risk factors and pregnancy, birth and neonatal outcomes associated with RFM together in the form of a systematic review.

The systematic review and meta-analyses reported in Chapter 3, I believe was of particular significance, providing up to date and new higher-level evidence, as well identifying gaps in current knowledge. While anterior placenta and abnormalities of amniotic fluid were identified as risk factors for RFM in the review, variation in the reporting of risk factors and outcomes was highlighted. Either studies of varying quality or even no studies were found for some factors deemed prominent in contemporary maternity care such as ethnicity, assisted conception, obesity, and medical comorbidities. Critically, when the results from high quality/low risk of bias studies were considered, the increased likelihood of stillbirth with RFM was almost 4-fold, and of babies born small for gestational age the increased risk was nearly two-fold. This further emphasises the importance of raising awareness of FMs and identifying management strategies for RFM. In addition, many studies included in the review were conducted nearly 40 years ago. Temporal changes to clinical practices and technology advances in maternity care had the potential to impact on modifiable and non-modifiable risk factors and outcomes associated with RFM. This emphasised the need for a contemporary robust investigation using a prospective case-control design to explore perinatal risk factors and outcomes associated with RFM in the context of Irish maternity care. Chapter 4 presented the rationale for this study design and the methods used to undertake the study.

The study highlighted that the rate of women attending with RFM to a large maternity unit in the East of Ireland over the past decade has nearly doubled but the rates are comparable with other international studies. In contrast to the findings of the systematic review, the study found that women aged >35 years and ethnic minority groups sought care less often for RFM, while nulliparous women, women with an anterior placenta and severe obesity were more likely to attend with RFM. A significant contribution of the

study to the advancement of knowledge on risk factors for RFM is the clear association that women with a history of pregnancy after loss, specifically recurrent miscarriages or neonatal death are more likely to attend with RFM during pregnancy. Women with previous history of caesarean section, medical disorders or complications of pregnancy were not more likely to attend with RFM. In contrast to the findings of the systematic review in Chapter 3, RFM was not found to be associated with stillbirth, preterm birth or neonatal death, however, was associated with babies born SGA. Of particular interest, the finding that of the 10% of babies born SGA, only 0.5% of pregnancies had been diagnosed with FGR/SGA, highlighting that improvements in detecting SGA fetus during pregnancy are required. Another particular finding of interest is that of the women presenting with RFM at term gestation, a third of these women subsequently laboured spontaneously and gave birth within two weeks of presenting with RFM. It is unknown however if the women perceived a changed in the pattern of movements or actual absent or RFM. Consistent with numerous studies, women with RFM were more likely to have induction of labour, although emergency caesarean section was not associated when other factors were included in the analysis. As identified in Chapter 2 and Chapter 6, the absence of robust higher-level evidence to support standardised management of women attending with RFM presents a challenging situation for maternity healthcare professionals.

To provide up to date contemporary evidence on perinatal risk factors for and outcomes associated with RFM, the systematic review presented in Chapter 3 was updated and included the findings from the prospective case-control study. Risk factors for RFM were identified as nulliparity, women with anterior placenta, assisted conception, a medical history of psychiatric illness and a previous history of neonatal death. African Black ethnic groups were less likely to attend for RFM than Asian/Chinese women, as well as women aged 35 years and over. Recent evidence changed the direction of effect of smoking, oligohydramnios and polyhydramnios. This evidence signifies the groups of women that may require additional support through information and education on FMs. It also highlights the continuing need for healthcare professionals to support women in cessation of smoking and weight management during pregnancy.

On a positive note, it seems as though the risk of stillbirth associated with RFM is declining. Though, this was only likely in cases where women had increased awareness of FMs and RFM, attended sooner for assessment and dependant on how their pregnancy with RFM was subsequently managed. The current evidence however indicates that improvements in the detection of FGR and SGA during pregnancy are required. Ultimately the evidence presented in this thesis has identified additional gaps in knowledge surrounding RFM. The next section will present recommendations for policy, practice, research and education, some of which will overlap between, education, policy and practice.

7.3 Recommendations and implications for practice, policy, research and education

7.3.1. Recommendations for practice

Providing optimal care for women with RFM is dependent on women, midwives and obstetricians having the requisite knowledge about FMs and RFM, but as demonstrated in Chapter 2, knowledge of FMs and management of RFM differs. This demonstrates the need for ongoing local, regional and national education for clinicians about assessment of fetal well-being in pregnancy. Chapters 2, 3 and my study findings demonstrate risk factors for RFM in pregnancy. Knowledge of risk factors could further assist clinicians to identify pregnancies at higher risk of adverse perinatal outcomes and aid decision making regarding need for further investigation and intervention when a woman presents with RFM during pregnancy. With relevance to midwifery practice, it is recommended that midwives keep up to date with current evidence regarding assessment of fetal well-being, in particular, FMs, either independently through publications or journal clubs, and by attendance at relevant study days.

Pregnant women need to be informed about FMs, what to expect regarding fetal movement strength, frequency and pattern and when to seek assessment for fetal movement concerns. Recently Bradford *et al.* (2022) developed a framework for conversations with women about FMs in pregnancy. Information provided is based on an '*Ask, Listen and Inform'* approach, of which could be adapted for the Irish setting. Table 7.1 below is adapted from the framework, but in addition offers examples of

questions and advice that clinicians could offer to women. Sharing information to all women about expected fetal movement patterns at different stages of pregnancy could empower women to assess their baby's wellbeing, giving them greater confidence to seek care if any concerns. In particular, educational support material on FMs should be tailored to ethnic minorities and women with characteristics over-represented in the perinatal loss statistics.

Table 7.1 Example of antenatal conversations about fetal movements

	Standard	Questions/Information examples
Ask	All healthcare professional involved in providing antenatal care during pregnancy should ask routinely at each antenatal visit about fetal movements.	• Have you noticed baby movements yet? • Tell me about your baby's movements? • What do movements feel like to you? • How strong are your baby's movements? • Is there a time of day that your baby is more active? • Does your baby have quiet times and busy times?
Listen	Listen to the woman's description of her baby's movements in terms of strength, frequency and pattern.	• Inform accordingly.
Inform	What to expect	• Range of normal fetal movement features depending on stage of pregnancy • Factors that may inhibit perception of FMs e.g. with anterior placenta or increased BMI, sitting or standing. • Changes that occur in FMs with advancing gestation • It is not true that babies move less often towards the end of pregnancy.
	When to seek care	• It is important that all women are informed to contact their midwife or hospital for an assessment if they notice a reduction in the strength or frequency of fetal movements, a reduction in evening time movements, if they feel no movements, or have any concerns at all or a sense that something is not right. • Not to wait until the next day. • Reassure women that they can be assessed out of hours and not to defer any concerns until the following day.

7.3.2. Recommendations for policy

Despite the overall improvement in recent decades in Ireland in perinatal mortality rates there remain a number of vulnerable groups with higher risks of mortality rates and requires further policy attention. Maternal characteristics such as ethnicity, level of education and BMI are not consistently captured in maternity records, resulting in the absence of national data for the pregnant population being available. These factors have been found to be associated with adverse pregnancy outcomes. Attention is required to improve the collection of information in maternity records including pregnant women's ethnicity, level of education, height and weight and economic status of women and their partner so that we can better understand the impact of socio-economic factors on maternity care and in the various maternity units in Ireland.

Perinatal loss through stillbirth or neonatal death is a personal tragedy for the families involved and a significant public health concern with far reaching social, emotional and financial consequences for those affected. As identified through the review of the literature in Chapter 2, the rate of perinatal loss in Ireland has remained static in recent years. There is currently no national method of confidential enquiry for stillbirth or neonatal deaths similar to that occurs in the UK (MBRRACE-UK Perinatal Mortality Surveillance Report), therefore it is currently unknown how many stillbirths occurring in Ireland are actually preceded by RFM and could have been avoided with improved knowledge, assessment and care. Reports from the UK states that deficiencies in maternity care contributed to up to 60% of antepartum stillbirth cases (Draper 2017). The establishment of a national confidential review of stillbirth and neonatal deaths, especially those of term gestation should be considered in order to enhance the learning and continue to assist in the improvement of maternity care in Ireland.

Through systematic review and meta-analysis of meta-analysis of 96 population-based studies, risk factors associated with stillbirth in high income countries are FGR, maternal medical co-morbidities (e.g. diabetes, hypertension), cigarette smoking and maternal perception of RFM (Flenady *et al.* 2011a). The introduction of a care bundle approach in countries such as the UK, Australia and New Zealand have seen reductions in stillbirth rates by up to 20% (Widdows *et al.* 2021, Centre of Research Excellence Stillbirth 2022).

Implementation of a similar care bundle in Ireland could potentially assist maternity services in Ireland to achieve a reduction in the perinatal mortality and morbidity rates. Care bundles are used widely across different healthcare settings, commonly consisting of three to five research evidence-informed interventions with the aim of preventing and managing different health conditions (Lavallée *et al.* 2017). Maternity care bundles implemented in the UK (Saving Babies Lives Bundle of Care), Australia and New Zealand (Safer Baby Bundle) are a collection of interventions designed for maternity healthcare professionals to assist in reducing late pregnancy stillbirth (Figure 7.1).

Country	Care Bundle Interventions
UK	▪Reducing smoking in pregnancy ▪Risk assessment and surveillance for fetal growth restriction ▪Raising awareness of reduced fetal movement ▪Effective fetal monitoring during labour
Australia & New Zealand	▪Smoking cessation ▪Improved screening and surveillance of fetal growth restriction ▪improving awareness and management of reduced fetal movements ▪improved awareness of maternal safe sleeping position ▪improving decision making around timing of birth for women with risk factors

Figure 7.1 Maternity Care Bundles

Taking into consideration the perinatal risk factors and outcomes associated with RFM identified from studies performed for this PhD thesis (Chapter 3, 4 and 5), it seems plausible that a care bundle applicable to the Irish settling should at least include initiatives that focus on:

1. Smoking cessation pre-conceptually and during pregnancy
2. Weight management before and during pregnancy
3. Raising awareness of the importance of FMs and RFM
4. Improved screening and surveillance of fetal growth restriction

Smoking and obesity are modifiable risk factors therefore, modification of these lifestyle factors could contribute to optimising maternal and fetal health in pregnancy, thereby improve maternal and fetal outcomes. Support for cessation of smoking and weight management should be advocated for by midwives, GPs and obstetricians at each

interaction with women either before and/or during pregnancy thus supporting and integrating current government initiatives such as the '*Making Every Contact Count'* Programme. Emerging positive research evidence also supports the premise that smoking cessation programmes should be made available in all maternity units in Ireland.

The FIGO Nutrition Checklist (Killeen *et al.* 2023) should be implemented as part of routine antenatal care to facilitate and support conversations between women and healthcare professionals about healthy lifestyle in pregnancy and identify areas for improvement such as weight management and nutrition.

Evidence based and accurate information is necessary to improve management of women with RFM during pregnancy. Available international guidelines (Royal College of Obstetricians and Gynaecologists 2011) predate recent studies on RFM, and these studies are therefore not included. It is timely now that international guidelines for the management of RFM are updated. National clinical guidelines should also be developed to ensure that standardised information is provided to women about FMs in pregnancy and a standardised pathway of care for women presenting to maternity services with RFM is implemented. A national multidisciplinary guideline working group should be established to address this.

In my case-control study, nearly 10% of women who presented with RFM during pregnancy birthed a baby that was small for gestational age, however only 0.5% of women presenting with RFM had an antenatal diagnosis of SGA. Attention is required to develop a national standardised care pathway around risk assessment and surveillance for fetal growth restriction to improve antenatal detection of SGA/FGR. A national multidisciplinary working group should be established to address this.

7.3.3. Recommendations for research

No particular reason has been put forward yet in the literature as to why women of younger age groups attend more frequently with RFM in pregnancy. To date, there are no studies conducted in Ireland investigating the association between maternal history of perinatal mental health and RFM. Further research is required to identify if there is a connection between parity, age, maternal history of depressive symptoms, anxiety and stress as reasons for presenting with RFM during pregnancy.

To further assist in improving clinical practice and support policy making, adequately powered research studies are warranted to further explore the relationship between RFM, maternal characteristics such as BMI, ethnicity, anterior placenta, assisted conception, and neonatal outcomes.

There is currently a paucity of published data on the experiences of Black, Asian and Minority Ethnic (BAME) women who access maternity services and give birth in Ireland. Consideration should be given to exploring BAME women experiences and perceptions of FMs in pregnancy, awareness and knowledge about FMs in pregnancy and knowledge of what to do if any concerns about RFM. Consideration should be given for dedicated antenatal education and care to meet the needs of this culturally diverse group. Dedicated on site antenatal care and education would make access easier and provide a small group approach that would enhance trust building and promote access to care. Research specifically reviewing the antenatal care and childbirth education needs of ethnic minority women is required.

7.3.4. Recommendations for education

Midwives, GPs and obstetricians are uniquely placed in maternity and women's health services to influence maternal and fetal health such as raising awareness about the risk of obesity, smoking and RFM in pregnancy. The literature review in Chapter 2 demonstrated that women often receive conflicting advice about FMs during pregnancy, are unsure what they should be feeling and what to do if they perceive RFM in tandem with inconsistent advice offered by midwives and obstetricians.

The findings from this thesis should be used to inform the development of a fetal movement awareness programme for all maternity healthcare staff.

A review of undergraduate and postgraduate midwifery and medical education programmes is required to ensure that adequate education, such as the '*Making Every Contact Count*' training programme, is being provided to future midwifery and medical personnel of the importance of prioritising lifestyle behavioural change strategies during each antenatal contact.

For qualified staff, audits should be conducted to ensure that all staff involved in maternity services have completed the '*Making Every Contact Count*' training programme and have adequate knowledge of the FIGO Nutrition Checklist and Smoking Cessation Programmes.

The HSE Second National Intercultural Health Strategy (NIHS) 2018-2023 (Health Service Executive 2018, p. 9) aims to: *'ensure the provision of high-quality, culturally responsive services to service users from diverse ethnic, cultural and religious backgrounds'* . A review of the educational components related to cultural awareness and understanding of midwifery and other maternity healthcare providers is recommended, and ultimately provide an overview of the deficits in current maternity healthcare provider education. Audits should be conducted to ensure that all maternity healthcare professionals, caring for diverse population groups have completed the HSEland 'Intercultural Awareness Training' e-learning programme. The Intercultural Awareness eLearning programme contains three modules:

- Inclusive Practices and Intercultural Awareness
- Working with Others
- Intercultural Awareness and Practice in Health and Social Care: Refugees, Protection Applicants and Trauma.

Until a national approach for the detection of fetal growth restriction is developed, it is vital that all maternity care clinicians involved in providing antenatal care for women are educated and competent in the use of standardised fundal height measurement.

7.4 Dissemination Plan

Dissemination of findings through peer-reviewed publications and conference presentations to maternity care professionals and the general public within and outside the Republic of Ireland commenced during my PhD and is ongoing. To date I have successfully published two systematic review articles in peer-reviewed journals and have presented at six national and international conferences (see page vii). The following is a plan for future dissemination:

1. Publish the findings of my case-control study in a peer-reviewed journal.
2. When opportunities arise, I plan to disseminate the findings of this thesis to healthcare professionals involved in maternity care, including midwives, obstetricians, general practitioners in Ireland and overseas through symposiums and conferences organised locally, nationally and globally.
3. Submission of abstracts for oral presentation at key international conferences such as the International Confederation of Midwives (ICM) conference and the International Stillbirth Alliance (ISA) conference.
4. Dissemination through the education of midwifery students, undergraduate and postgraduate students.

7.5 Postdoctoral objectives

The post-doctoral objectives related to this thesis include:

1. Findings of the systematic review of risk factors for RFM and pregnancy, birth and neonatal outcomes associated with RFM have already been published in peer-reviewed journals *European Journal of Obstetrics and Gynaecology* and *Midwifery.* The findings of the case-control study will also be submitted to a peer-reviewed journal for publication.
2. Write up the subgroup analysis of case-control study comparing single vs recurrent episodes of RFM vs controls and will be submitted to a peer-reviewed journal for publication.

3. Perform a pooled analysis of adjusted estimates controlling for competing risk factors for stillbirth, PTB and small for gestational age.
4. A protocol for the systematic review of risk factors for and pregnancy, birth and neonatal outcomes associated with *recurrent* RFM in pregnancy will be prepared.
5. Preterm birth was found to be associated with RFM in nulliparous women in the current study. Further analysis and investigation are required to explore this finding.
6. In the current study I did not differentiate between episodes of RFM and presentation with RFM such that could some repeat attendances with RFM be recurrent presentations of the one episode or actually separate events. The data will be further explored to review this phenomenon.

7.6 Personal reflection

These are words that I never thought that I would write about my PhD journey. In all honesty *'I loved it'* most of the time. In writing this section, I am proud to have come so far-from being a research 'novice' to now having the knowledge and confidence to prepare a systematic review protocol, conduct a systematic review, set up and manage a research project and prepare articles for publication. The many steep learning steps climbed, coupled with balancing a full-time University lecturer role and a young family are offset by the personal and research development accomplished along the way.

I am eternally grateful for the freedom to engage in taught graduate modules, workshops and training days (Table 7.2), develop and enhance my research project management skills, as well as the opportunities that arose to present and disseminate at national and international conferences and publish in peer-reviewed journals (see page vii). I have a renewed passion for research, and I look forward to the next project. There is no doubt that the positive experiences I encountered during the past six years are a result of the support and guidance from Valerie and Louise, my many colleagues, friends and family. *It Takes a Village.*

Table 7.2 Professional and research development

Taught Graduate Modules/Study Days	Workshops
• HRB-TMRN Systematic Review Study Day	• 'Planning Thesis Production'
• Library sessions on Systematic Review searching	• Basic and Advanced Endnote Reference Manager Training
• TCD Annual Research School-Introduction to Healthcare Statistics	• Microsoft EXCEL training
• TCD Annual Research School-Introduction to Systematic Review	• Managing Your PhD Masterclass
• 'Applied Research Methods and Data Management' Graduate Module (10 credits)	• Turbo Charging Your Writing Masterclass
• Statistics with SPSS two-day, online training course with CSTAR UCD	• Writing for Publication

Finally, I would again like to acknowledge the women and babies that the numbers and statistics presented throughout this thesis represent. My sincere condolences are with the parents who may have experienced pregnancy loss through either miscarriage, stillbirth or neonatal death during the period of this thesis. I truly hope that I have given you a 'voice' by raising awareness and knowledge of perinatal risk factors for and outcomes associated with RFM. Further gaps in knowledge have been identified, and additional research is required. It is important that we continue our quest to improve the quality of maternity services and care that all women and babies so richly deserve. Our quest to reduce perinatal mortality and morbidity can become a reality through continued policy, research and education.

References

Abiola J., Warrander L., Stephens L., Kither H., Harrison A. & Heazell A. (2016) The Manchester Rainbow Clinic: a dedicated clinical service for parents who have experienced a previous stillbirth improves outcomes in subsequent pregnancies. *BJOG: An International Journal of Obstetrics & Gynaecology* **123**, 46.

Abraham M., Alramadhan S., Iniguez C., Duijts L., Jaddoe V.W.V., Den Dekker H.T., Crozier S., Godfrey K.M., Hindmarsh P., Vik T., Jacobsen G.W., Hanke W., Sobala W., Devereux G. & Turner S. (2017) A systematic review of maternal smoking during pregnancy and fetal measurements with meta-analysis. *PLOS ONE* **12**(2), e0170946.

Akselsson A., Lindgren H., Georgsson S., Pettersson K. & Rådestad I. (2019) Increased labor induction and women presenting with decreased or altered fetal movements - a population-based survey. *PLOS ONE* **14**(5), e0216216.

Akselsson A., Lindgren H., Georgsson S., Pettersson K., Steineck G., Skokic V. & Rådestad I. (2020) Mindfetalness to increase women's awareness of fetal movements and pregnancy outcomes: a cluster-randomised controlled trial including 39 865 women. *BJOG: An International Journal of Obstetrics & Gynaecology* **127**(7), 829-837.

Altman D.G. & Bland J.M. (1994) Statistics notes: diagnostic tests 2: predictive values. *BMJ* **309**(6947), 102.

Armstrong D.S., Hutti M.H. & Myers J. (2009) The influence of prior perinatal loss on parents' psychological distress after the birth of a subsequent healthy infant. *Journal of Obstetric, Gynecologic & Neonatal Nursing* **38**(6), 654-666.

Arsenault D.C. & Marshall R. (2000) One foot in–one foot out: weathering the storm of pregnancy after perinatal loss. *Research in Nursing & Health* **23**(6), 473-485.

Arulkumaran S. (2013) *Investigation of Incident 50278 from time of patient's self referral to hospital on the 21st of October 2012 to the patient's death on the 28th of October, 2012*. Health Service Executive, Dublin.

Ashimi Balogun O., Sibai B.M., Pedroza C., Blackwell S.C., Barrett T.L. & Chauhan S.P. (2018) Serial third-trimester ultrasonography compared with routine care in uncomplicated pregnancies: a randomized controlled trial. *Obstetrics & Gynecology* **132**(6), 1358-1367.

Aviram A., Shmueli A., Hiersch L., Ashwal E., Wiznitzer A., Yogev Y. & Hadar E. (2016) Pregnancy outcome in women with decreased sensation of fetal movements at term according to parity. *Birth* **43**(1), 42-48.

Aviram A., Yogev Y., Bardin R., Meizner I., Wiznitzer A. & Hadar E. (2015) Small for gestational age newborns – does pre-recognition make a difference in pregnancy outcome? *The Journal of Maternal-Fetal & Neonatal Medicine* **28**(13), 1520-1524.

Bailey S.L., Boivin J., Cheong Y.C., Kitson-Reynolds E., Bailey C. & Macklon N. (2019) Hope for the best …but expect the worst: a qualitative study to explore how women with recurrent miscarriage experience the early waiting period of a new pregnancy. *BMJ Open* **9**(5), e029354.

Barton B. & Peat J. (2014) *Medical statistics: A guide to SPSS, data analysis and critical appraisal*. John Wiley & Sons

Bekedam D.J., Visser G.H.A., de Vries J.J. & Prechtl H.F.R. (1985) Motor behaviour in the growth retarded fetus. *Early Human Development* **12**(2), 155-165.

Bellussi F., Po G., Livi A., Saccone G., De Vivo V., Oliver E.A. & Berghella V. (2020) Fetal movement counting and perinatal mortality: A systematic review and meta-analysis. *Obstetrics & Gynecology* **135**(2), 453-462.

Berbey R., Manduley A. & Vigil-De Gracia P. (2001) Counting fetal movements as a universal test for fetal wellbeing. *International Journal of Gynecology & Obstetrics* **74**(3), 293-295.

Berndl A.M., O'Connell C.M. & McLeod N.L. (2013) Fetal movement monitoring: how are we doing as educators? *Journal of Obstetrics and Gynaecology Canada* **35**(1), 22-28.

Betrán A.P., Ye J., Moller A.B., Zhang J., Gülmezoglu A.M. & Torloni M.R. (2016) The increasing trend in caesarean section rates: global, regional and national estimates: 1990-2014. *PLOS ONE* **11**(2), e0148343.

Bhatia M., Mitsi V., Court L., Thampi P., El-Nasharty M., Hesham S., Randall W., Davies R., Impey L. & El-Nasharty M. (2019) The outcomes of pregnancies with reduced fetal movements: A retrospective cohort study. *Acta Obstetricia et Gynecologica Scandinavica* **98**(11), 1450-1454.

Bhattacharya S., Prescott G.J., Black M. & Shetty A. (2010) Recurrence risk of stillbirth in a second pregnancy. *BJOG: An International Journal of Obstetrics & Gynaecology* **117**(10), 1243-1247.

Binder J., Monaghan C., Thilaganathan B., Morales-Rosello J. & Khalil A. (2018) Reduced fetal movements and cerebroplacental ratio: evidence for worsening fetal hypoxemia. *Ultrasound in Obstetrics & Gynecology* **51**(3), 375-380.

Binder J., Monaghan C., Thilaganathan B., Morales-Roselló J., Khalil A. & Binder J. (2017) Cerebroplacental ratio in reduced fetal movements: evidence for worsening fetal hypoxemia. *Ultrasound in Obstetrics & Gynecology* **50**(10.1002).

Birnholz J.C., Stephens J.C. & Faria M. (1978) Fetal movement patterns: a possible means of defining neurologic developmental milestones in utero. *American Journal of Roentgenology* **130**(3), 537-540.

Blencowe H., Krasevec J., de Onis M., Black R.E., An X., Stevens G.A., Borghi E., Hayashi C., Estevez D., Cegolon L., Shiekh S., Ponce Hardy V., Lawn J.E. & Cousens S. (2019) National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. *The Lancet Global Health* **7**(7), e849-e860.

Bocking A., Adamson L., Carmichael L., Patrick J. & Probert C. (1984) Effect of intravenous glucose injection on human maternal and fetal heart rate at term. *American Journal of Obstetrics & Gynecol*ogy **148**(4), 414-420.

Boswell C. & Cannon S. (2020) *Introduction to nursing research: incorporating evidence-based practice*. Fifth edn. Jones & Bartlett Learning, Burlington, MA.

Brace R.A. (1997) Physiology of amniotic fluid volume regulation. *Clinical Obstetrics and Gynecology* **40**(2), 280-289.

Bradford B. & Maude R. (2014) Fetal response to maternal hunger and satiation – novel finding from a qualitative descriptive study of maternal perception of fetal movements. *BMC Pregnancy and Childbirth* **14**(1), 288.

Bradford B. & Maude R. (2018) Maternal perception of fetal movements in the third trimester: A qualitative description. *Women and Birth* **31**(5), e287-e293.

Bradford B., Cronin R., McCowan L., McKinlay C., Mitchell E. & Thompson J. (2018a) Maternal perception of fetal movement quality and risk of late stillbirth. *Journal of Paediatrics and Child Health* **54**(S1), 10-10.

Bradford B., Cronin R., McKinlay C., Thompson J. & McCowan L. (2020) Maternally perceived fetal movement patterns: The influence of body mass index. *Early Human Development* **140**, 104922.

Bradford B.F., Cronin R.S., McKinlay C.J.D., Thompson J.M.D., Mitchell E.A., Stone P.R. & McCowan L.M.E. (2019) A diurnal fetal movement pattern: Findings from a cross-sectional study of maternally perceived fetal movements in the third trimester of pregnancy. *PLOS ONE* **14**(6), e0217583.

Bradford B.F., Cronin R.S., Warland J., Akselsson A., Rådestad I., Heazell A.E.P., McKinlay C.J.D., Stacey T., Thompson J.M.D. & McCowan L.M.E. (2022) Fetal movements: A framework for antenatal conversations. *Women and Birth*.

Bradford B.F., Thompson J.M.D., Heazell A.E.P., McCowan L.M.E. & McKinlay C.J.D. (2018b) Understanding the associations and significance of fetal movements in overweight or obese pregnant women: a systematic review. *Acta Obstetricia et Gynecologica Scandinavica* **97**(1), 13-24.

Brazauskas R. & Logan B.R. (2016) Observational studies: matching or regression? *Biology of Blood Marrow Transplant* **22**(3), 557-563.

Bricker L., Medley N. & Pratt J.J. (2015) Routine ultrasound in late pregnancy (after 24 weeks' gestation). *Cochrane Database of Systematic Reviews 2015, Issue 6.* Art. No.: CD001451. DOI: 10.1002/14651858.CD001451.pub4.

Brown R., Higgins L.E., Johnstone E.D., Wijekoon J.H. & Heazell A.E.P. (2016) Maternal perception of fetal movements in late pregnancy is affected by type and duration of fetal movement. *The Journal of Maternal-Fetal & Neonatal Medicine* **29**(13), 2145-2150.

Bruce N., Pope D. & Stanistreet D. (2018) *Quantitative Methods for Health Research : A Practical Interactive Guide to Epidemiology and Statistics*. John Wiley & Sons, Incorporated, Newark, United Kingdom.

Bullough S., Navaratnam K. & Sharp A. (2021) Investigation and management of the small for gestational age fetus. *Obstetrics, Gynaecology & Reproductive Medicine* **31**(1), 1-7.

Burden C., Bradley S., Storey C., Ellis A., Heazell A.E.P., Downe S., Cacciatore J. & Siassakos D. (2016) From grief, guilt pain and stigma to hope and pride – a systematic review and meta-analysis of mixed-method research of the psychosocial impact of stillbirth. *BMC Pregnancy and Childbirth* **16**(1), 9.

Bursac Z., Gauss C.H., Williams D.K. & Hosmer D.W. (2008) Purposeful selection of variables in logistic regression. *Source Code for Biology and Medicine* **3**(1), 17.

Callaghan S., O'Brien E., Coughlan B. & McAuliffe F.M. (2020) Midwives' and obstetricians' level of knowledge of appropriate gestational weight gain recommendations for pregnancy: A systematic review. *Birth* **47**(4), 322-331.

Carolan-Olah M. & Barry M. (2014) Antenatal stress: An Irish case study. *Midwifery* **30**(3), 310-316.

Carroll L., Byrne F., Canty G., Gallagher L. & Smith V. (2022) The impact of COVID-19 on attendance for reduced fetal movements during pregnancy. *Trinity Health and Education International Research Conference 2022* (THEConf2022), Virtual.

Carroll L., Gallagher L. & Smith V. (2019) Risk factors for reduced fetal movements in pregnancy: A systematic review and meta-analysis. *European Journal of Obstetrics and Gynecology Reprodroductive Biology* **243**, 72-82.

Centre of Research Excellence Stillbirth (2022) *The Safer Baby Bundle*. Retrieved from https://stillbirthcre.org.au/about-us/our-work/the-safer-baby-bundle/ on 25 November 2022.

Chan L., Gordon A., Warrilow K., Wojcieszek A., Firth T., Loxton F., Bauman A. & Flenady V. (2021) Evaluation of movements matter: A social media and hospital-based campaign aimed at raising awareness of decreased fetal movements. *Australian and New Zealand Journal of Obstetrics and Gynaecology* **61**(6), 846-854.

Chu S.Y., Kim S.Y., Lau J., Schmid C.H., Dietz P.M., Callaghan W.M. & Curtis K.M. (2007) Maternal obesity and risk of stillbirth: a metaanalysis. *American Journal of Obstetrics & Gynecology* **197**(3), 223-228.

Clark J. (2021) *Diagnosing the 'at risk' fetus: an ethnographic study of practice following women's reports of altered fetal movement.* Unpublished PhD thesis, University of Leicester, Leicester.

Cnattingius S., Norman M., Granath F., Petersson G., Stephansson O. & Frisell T. (2017) Apgar score components at 5 minutes: risks and prediction of neonatal mortality. *Paediatric and Perinatal Epidemiology* **31**(4), 328-337.

Cohen L., Manion L. & Morrison K. (2018) *Research methods in education*. 8th edn. Routledge, New York.

Cole T.J., Bellizzi M.C., Flegal K.M. & Dietz W.H. (2000) Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* **320**(7244), 1240.

Collins H. (2010) *Creative Research: The Theory and Practice of Research for the Creative Industries*. AVA Publications

Cooley S.M., Donnelly J.C., Walsh T., McMahon C., Gillan J. & Geary M.P. (2011) The impact of ultrasonographic placental architecture on antenatal course, labor and delivery in a low-risk primigravid population. *The Journal of Maternal-Fetal & Neonatal Medicine* **24**(3), 493-497.

Côté-Arsenault D. & Donato K.L. (2007) Restrained expectations in late pregnancy following loss. *Journal of Obstetric, Gynecologic, & Neonatal Nursing* **36**(6), 550-557.

Côté-Arsenault D., Donato K.L. & Earl S.S. (2006) Watching & worrying: early pregnancy after loss experiences. *MCN: The American Journal of Maternal/Child Nursing* **31**(6).

Couper S., Clark A., Thompson J.M.D., Flouri D., Aughwane R., David A.L., Melbourne A., Mirjalili A. & Stone P.R. (2021) The effects of maternal position, in late gestation pregnancy, on placental blood flow and oxygenation: an MRI study. *The Journal of Physiology* **599**(6), 1901-1915.

Creswell J.W. & Creswell J.D. (2018) *Research design: qualitative, quantitative & mixed methods approaches*. 5th, International student edn. SAGE, Thousand Oaks, CA;London;.

Cronin P., Coughlan M. & Smith V. (2014) *Understanding Nursing and Healthcare Research*. Sage, London.

Crotty M. (2014) *The foundations of social research: meaning and perspective in the research process*. Sage Publications, London

Daly N., Brennan D., Foley M. & O'Herlihy C. (2011) Cardiotocography as a predictor of fetal outcome in women presenting with reduced fetal movement. *European Journal of Obstetrics Gynecology Reproductive Biology* **159**(1), 57-61.

Davies-Tuck M., Middleton P., Weller M.E., Gordon A., Smith V., Walker S.P. & Flenady V. (2021) Interventions relating to fetal movements for improving pregnancy outcomes. *Cochrane Database of Systematic Reviews 2021, Issue 7.* Art. No.: CD014714. DOI: 10.1002/14651858.

Davies-Tuck M.L., Davey M.A. & Wallace E.M. (2017) Maternal region of birth and stillbirth in Victoria, Australia 2000-2011: A retrospective cohort study of Victorian perinatal data. *PLOS ONE* **12**(6), e0178727.

de Graaf M.A., Jager K.J., Zoccali C. & Dekker F.W. (2011) Matching, an appealing method to avoid confounding? *Nephron Clinical Practice* **118**(4), c315-c318.

de Vries J.I.P., Visser G.H.A. & Prechtl H.F.R. (1982) The emergence of fetal behaviour. I. Qualitative aspects. *Early Human Development* **7**(4), 301-322.

de Vries J.P., Visser G.A. & Prechtl H.R. (1985) The emergence of fetal behaviour. II. Quantitative aspects. *Early Human Development* **12**(2), 99-120.

de Vries J.I.P., Visser G.H.A. & Precht H.F.R. (1988) The emergence of fetal behaviour. III. Individual differences and consistencies. *Early Human Development* **16**(1), 85-103.

DeBackere K.J., Hill P.D. & Kavanaugh K.L. (2008) The parental experience of pregnancy after perinatal loss. *Journal of Obstetric, Gynecologic & Neonatal Nursing* **37**(5), 525-537.

Deeks J.J. & Altman D.G. (2004) Diagnostic tests 4: likelihood ratios. *BMJ* **329**(7458), 168-169.

Deeks J.J., Higgins, J.P.T. & Altman DG (2022) Chapter 10: Analysing data and undertaking meta-analyses. In *Cochrane Handbook for Systematic Reviews of Interventions version 6.3* (Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ & Welch VA, eds), Cochrane.

D'Elia A., Pighetti M., Moccia G. & Santangelo N. (2001) Spontaneous motor activity in normal fetuses. *Early Human Development* **65**(2), 139-147.

D'Elia A., Pighetti M., Moccia G.F. & Di Meo P. (1998) Computer-assisted analysis of fetal movements in intrauterine growth retardation (IUGR). *Early Human Development* **51**(2), 137-145.

Denzin N.K. & Lincoln Y.S. (2018) *The SAGE handbook of qualitative research*. 5th edn. SAGE, Los Angeles.

Department of Health (2016) *National Maternity Strategy – Creating a Better Future Together 2016-2026*. Department of Health, Dublin.

Department of Health Education and Welfare (1979) *The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research*. Retrieved from https://www.hhs.gov/ohrp/sites/default/files/the-belmont-report-508c_FINAL.pdf on 18 February 2019.

Draper E., Gallimore I., Smith L., Matthews R.A., Fenton A., Kurinczuk J.J., Smith P., Manktelow B. & collaboration o.b.o.t.M.-U. (2022) *MBRRACE-UK Perinatal Mortality Surveillance Report, UK Perinatal Deaths for Births from January to December 2020*. The Infant Mortality and Morbidity Studies, Department of Health Sciences, University of Leicester. Retrieved from https://www.npeu.ox.ac.uk/assets/downloads/mbrrace-uk/reports/perinatal-surveillance-report-2020/MBRRACE-UK_Perinatal_Surveillance_Report_2020.pdf on 19 January 2023.

Draper E.S. (2017) *MBRRACE-UK Perinatal Confidential Enquiry: Term, singleton, intrapartum stillbirth and intrapartum-related neonatal death*. Department of Health Sciences, University of Leicester, Leicester.

Druzin M.L. & Foodim J. (1986) Effect of maternal glucose ingestion compared with maternal water ingestion on the nonstress test. *Obstetrics and Gynecology* **67**(3), 425-426.

Drysdale H., Rana S., Kendall A., Knight M. & Wallace E.M. (2012) Ethnicity and the risk of late-pregnancy stillbirth. *Medical Journal of Australia* **197**(5), 278-281.

Duffy K., Connolly S., Nolan A. & Maitre B. (2022) *Unequal Chances? Inequalities in Mortality in Ireland*. The Economic and Social Research Institute. Retrieved from https://www.esri.ie/system/files/publications/RS145_3.pdf on 20 January 2023.

Dupont W.D. (1988) Power calculations for matched case-control studies. *Biometrics* **44**(4), 1157-1168.

Dutton P.J., Warrander L.K., Roberts S.A., Bernatavicius G., Byrd L.M., Gaze D., Kroll J., Jones R.L., Sibley C.P., Froen J.F. & Heazell A.E. (2012) Predictors of poor perinatal outcome following maternal perception of reduced fetal movements--a prospective cohort study. *PLOS ONE* **7**(7), e39784.

Egger M., Higgins J. & Smith D. (2022) *Systematic Reviews in Health Research: meta-analysis in context*. 3rd edn. John Wiley & Sons, London.

Ehrström C. (1984) Orcadian rhythm of fetal movements. *Acta Obstetricia et Gynecologica Scandinavica* **63**(6), 539-541.

Eller D.P., Stramm S.L. & Newman R.B. (1992) The effect of maternal intravenous glucose administration on fetal activity. *American Journal of Obstetrics and Gynecology* **167**(4 Pt 1), 1071-1074.

Ellis A., Chebsey C., Storey C., Bradley S., Jackson S., Flenady V., Alexander Heazell A. & Siassakos D. (2016) Systematic review to understand and improve care after stillbirth: a review of parents' and healthcare professionals' experiences *BMC Pregnancy and Childbirth* **16**: 16

Elwood M. (2017) *Critical appraisal of epidemiological studies and clinical trials*. Oxford University Press

Erlandsson K., Lindgren H., Davidsson-Bremborg A. & Rådestad I. (2012) Women's premonitions prior to the death of their baby in utero and how they deal with the feeling that their baby may be unwell. *Acta Obstetricia et Gynecologica Scandinavica* **91**(1), 28-33.

Eshraghi N., Jamal A., Eshraghi N., Kashanian M. & Sheikhansari N. (2020) Cerebroplacental ratio (CPR) and reduced fetal movement: predicting neonatal outcomes. *The Journal of Maternal-Fetal & Neonatal Medicine*, 1-6.

Farrant K. & Heazell A.E.P. (2016) Online information for women and their families regarding reduced fetal movements is of variable quality, readability and accountability. *Midwifery* **34**, 72-78.

Field A.P. (2018) *Discovering statistics using IBM SPSS statistics*. Fifth edn. SAGE, Los Angeles.

Fisher M. (1999) Reduced Fetal Movements: a research based project. *British Journal of Midwifery* **7**, 733-737.

Flannery C., Hennessy M., Dennehy R., Matvienko-Skiar K., Lucey C. & O'Donoghue K. (2022) P03 The care experiences of women and men who have received recurrent miscarriage care in Ireland: a national survey. *Journal of Epidemiology and Community Health* **76**(Suppl 1), A50-A50.

Flenady V., Gardener G., Ellwood D., Coory M., Weller M., Warrilow K.A., Middleton P.F., Wojcieszek A.M., Groom K.M., Boyle F.M., East C., Lawford H., Callander E., Said J.M., Walker S.P., Mahomed K., Andrews C., Gordon A., Norman J.E. & Crowther C. (2022) My Baby's Movements: a stepped-wedge cluster-randomised controlled trial of a fetal movement awareness intervention to reduce stillbirths. *BJOG* **129**(1), 29-41.

Flenady V., Koopmans L., Middleton P., Frøen J.F., Smith G.C., Gibbons K., Coory M., Gordon A., Ellwood D., McIntyre H.D., Fretts R. & Ezzati M. (2011a) Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis. *The Lancet* **377**(9774), 1331-1340.

Flenady V., MacPhail J., Gardener G., Chadha Y., Mahomed K., Heazell A., Fretts R. & Froen F. (2009) Detection and management of decreased fetal movements in Australia and New Zealand: a survey of obstetric practice. *Australian and New Zealand Journal of Obstetrics and Gynaecology* **49**(4), 358-363.

Flenady V., Middleton P., Smith G.C., Duke W., Erwich J.J., Khong T.Y., Neilson J., Ezzati M., Koopmans L. & Ellwood D. (2011b) Stillbirths: the way forward in high-income countries. *The Lancet* **377**(9778), 1703-1717.

Fratelli N., Valcamonico A., Prefumo F., Pagani G., Guarneri T. & Frusca T. (2013) Effects of antenatal recognition and follow-up on perinatal outcomes in small-for-gestational age infants delivered after 36 weeks. *Acta Obstetricia et Gynecologica Scandinavica* **92**(2), 223-229.

Frazer K., Fitzpatrick P., Brosnan M., Dromey A.M., Kelly S., Murphy M., O'Brien D., Kelleher C.C. & McAuliffe F.M. (2020) Smoking prevalence and secondhand smoke exposure during pregnancy and postpartum—establishing risks to health and human rights before developing a tailored programme for smoking cessation. *International Journal of Environmental Research and Public Health* **17**(6).

Freda M.C., Mikhail M., Mazloom E., Polizzotto R., Damus K. & Merkatz I. (1993) Fetal movement counting: which method? *MCN: The American Journal of Maternal/Child Nursing* **18**(6), 314-321.

Froen J.F. (2004) A kick from within--fetal movement counting and the cancelled progress in antenatal care. *Journal of Perinatal Medicine* **32**(1), 13-24.

Frøen J.F., Heazell A.E.P., Tveit J.V.H., Saastad E., Fretts R.C. & Flenady V. (2008) Fetal movement assessment. *Seminars in Perinatology* **32**(4), 243-246.

Fuchs F., Senat M.-V., Rey E., Balayla J., Chaillet N., Bouyer J. & Audibert F. (2017) Impact of maternal obesity on the incidence of pregnancy complications in France and Canada. *Scientific Reports* **7**(1), 1-9.

Gallagher M.W., Costigan K. & Johnson T.R.B. (1992) Fetal heart rate accelerations, fetal movement, and fetal behavior patterns in twin gestations. *American Journal of Obstetrics and Gynecology* **167**(4, Part 1), 1140-1144.

Gardosi J. & Francis A. (1999) Controlled trial of fundal height measurement plotted on customised antenatal growth charts. *British Journal Obstetrics & Gynaecology* **106**(4), 309-317.

Gardosi J., Madurasinghe V., Williams M., Malik A. & Francis A. (2013) Maternal and fetal risk factors for stillbirth: population based study. *BMJ* **346**, f108.

Gebuza G., Zaleska M., Kaźmierczak M., Mieczkowska E. & Gierszewska M. (2018) The effect of music on the cardiac activity of a fetus in a cardiotocographic examination. *Advances in Clinical and Experimental Medicine* **27**(5), 615-621.

George A., Stead T.S. & Ganti L. (2020) What's the risk: differentiating risk ratios, odds ratios, and hazard ratios? *Cureus* **12**(8), e10047.

Georgsson S., Linde A., Pettersson K., Nilsson R. & Radestad I. (2016) To be taken seriously and receive rapid and adequate care - Womens' requests when they consult health care for reduced fetal movements. *Midwifery* **40**, 102-108.

Gettinger A., Roberts A.B. & Campbell S. (1978) Comparison between subjective and ultrasound assessments of fetal movement. *British Medical Journal* **2**(6130), 88-90.

Gillieson M, Dunlap H, Nair R & Pilon M (1984) Placental site, parity, and date of quickening. *Obstetrics & Gynecology* **64**(1), 44-45.

Gissler M., Durox M., Smith L., Blondel B., Broeders L., Hindori-Mohangoo A., Kearns K., Kolarova R., Loghi M., Rodin U., Szamotulska K., Velebil P., Weber G., Zurriaga O., Zeitlin J. & the Euro-Peristat Research Network. (2022) Clarity and consistency in stillbirth reporting in Europe: why is it so hard to get this right? *European Journal of Public Health* **32**(2), 200-206.

Glasziou P., Irwig L., Bain C. & Colditz G. (2001) *Systematic reviews in health care: a practical guide*. Cambridge University Press

Gold K.J., Kuznia A.L. & Hayward R.A. (2008) How physicians cope with stillbirth or neonatal death: a national survey of obstetricians. *Obstetrics & Gynecology* **112**(1), 29-34.

Gómez L.M., De la Vega G., Padilla L., Bautista F. & Villar A. (2007) Compliance with a fetal movement chart by high-risk obstetric patients in a Peruvian hospital. *Amercian Journal of Perinatology* **24**(2), 89-93.

Gong X., Hao J., Tao F., Zhang J., Wang H. & Xu R. (2013) Pregnancy loss and anxiety and depression during subsequent pregnancies: data from the C-ABC study. *European Journal of Obstetrics & Gynecology and Reproductive Biology* **166**(1), 30-36.

Gordon A., Raynes-Greenow C., Bond D., Morris J., Rawlinson W. & Jeffery H. (2015) Sleep position, fetal growth restriction, and late-pregnancy stillbirth: the Sydney stillbirth study. *Obstetrics & Gynecology* **125**(2), 347-355.

Goto E. (2013) Prediction of low birthweight and small for gestational age from symphysis-fundal height mainly in developing countries: a meta-analysis. *Journal of Epidemiology & Community Health* **67**(12), 999-1005.

Gourounti K. (2016) Psychological stress and adjustment in pregnancy following assisted reproductive technology and spontaneous conception: A systematic review. *Women & Health* **56**(1), 98-118.

Government of Ireland (1994) *Stillbirth Registration Act, 1994*. Retrieved from https://www.irishstatutebook.ie/eli/1994/act/1/enacted/en/print on 2nd December 2021.

Graignic-Philippe R., Dayan J., Chokron S., Jacquet A. & Tordjman S. (2014) Effects of prenatal stress on fetal and child development: a critical literature review. *Neuroscience & Biobehavioral Reviews* **43**, 137-162.

Granfors M., Stephansson O., Endler M., Jonsson M., Sandström A. & Wikström A.-K. (2019) Placental location and pregnancy outcomes in nulliparous women: A population-based cohort study. *Acta Obstetricia et Gynecologica Scandinavica* **98**(8), 988-996.

Grant A., Elbourne D., Valentin L. & Alexander S. (1989) Routine formal fetal movement counting and risk of antepartum late death in normally formed singletons. *Lancet* **2**(8659), 345-349.

Gravensteen I.K., Jacobsen E.M., Sandset P.M., Helgadottir L.B., Rådestad I., Sandvik L. & Ekeberg Ø. (2018) Healthcare utilisation, induced labour and caesarean section in the pregnancy after stillbirth: a prospective study. *BJOG: An International Journal of Obstetrics & Gynaecology* **125**(2), 202-210.

Gray J.R. & Grove S.K. (2021) *Burns and Grove's the practice of nursing research: Appraisal, synthesis, and generation of evidence*. 9th edn. Elsevier Health Sciences

Greenberg J., Gilroy L., Mitchell T. & Pardanani S. (2021) 586 Decreased fetal movement and anterior placentation: a case control study. *American Journal of Obstetrics and Gynecology* **224**(2), S369-S370.

Greenland S. (1986) Partial matching in case-control studies. In *Modern statistical methods in chronic disease epidemiology* (Moolgavkar S. & Prentice R., eds), Wiley, New York.

Gregory E., Valenzuela C. & Hoyert D. (2022) *National Vital Statistics Reports Fetal Mortality: United States, 2020*. Retrieved from https://www.cdc.gov/nchs/data/nvsr/nvsr71/nvsr71-04.pdf on 2 December 2022.

Griffiths A., Pinto A. & Margarit L. (2008) A survey of methods used to measure symphysis fundal height. *Journal of Obstetrics and Gynaecology* **28**(7), 692-694.

Grooten W.J.A., Tseli E., Äng B.O., Boersma K., Stålnacke B.-M., Gerdle B. & Enthoven P. (2019) Elaborating on the assessment of the risk of bias in prognostic studies in pain rehabilitation using QUIPS-aspects of interrater agreement. *Diagnostic and Prognostic Research* **3**(1), 5-5.

Guba E. & Lincoln Y. (1994a) Competing paradigms in qualitative research. In *Handbook of qualitative research* (Denzin N.K. ed), SAGE publications, Thousand oaks, California, pp. 105-117.

Hannon S., Gartland D., Higgins A., Brown S.J., Carroll M., Begley C. & Daly D. (2022) Maternal mental health in the first year postpartum in a large Irish population cohort: the MAMMI study. *Archives of Women's Mental Health* **25**(3), 641-653.

Harley D., Cunningham A., Love C., Pound C. & McInally D. (2016) *Fetal movement awareness: reducing stillbirth in Scotland*. Retrieved from https://www.npeu.ox.ac.uk/assets/downloads/mbrrace-uk/sharing-practice/pms-may-2016/prevention---management-of-risk-factors/Reducing%20stillbirth%20-%20improving%20fetal%20movement%20awareness.pdf on 5 September 2020.

Harrington K., Thompson O., Jordan L., Page J., Carpenter R.G. & Campbell S. (1998) Obstetric outcome in women who present with a reduction in fetal movements in the third trimester of pregnancy. *Journal of Perinatal Medicine* **26**(2), 77-82.

Hartling L., Hamm M., Milne A., Vandermeer B., Santaguida P.L., Ansari M., Tsertsvadze A., Hempel S., Shekelle P. & Dryden D.M. (2012) AHRQ Methods for Effective Health Care. In *Validity and Inter-Rater Reliability Testing of Quality Assessment Instruments*, Agency for Healthcare Research and Quality (US), Rockville (MD).

Hartling L., Milne A., Hamm M.P., Vandermeer B., Ansari M., Tsertsvadze A. & Dryden D.M. (2013) Testing the Newcastle Ottawa Scale showed low reliability between individual reviewers. *Journal of Clinical Epidemiology* **66**(9), 982-993.

Hayat T.T., Nihat A., Martinez-Biarge M., McGuinness A., Allsop J.M., Hajnal J.V. & Rutherford M.A. (2011) Optimization and initial experience of a multisection balanced steady-state free precession cine sequence for the assessment of fetal behavior in utero. *American Journal of Neuroradiology* **32**(2), 331-338.

Hayden J.A., Côté P. & Bombardier C. (2006) EValuation of the quality of prognosis studies in systematic reviews. *Annals of Internal Medicine* **144**(6), 427-437.

Hayden J.A., van der Windt D.A., Cartwright J.L., Cote P. & Bombardier C. (2013) Assessing bias in studies of prognostic factors. *Annals of Internal Medicine* **158**(4), 280-286.

Hayes D.J.L., Devane D., Dumville J.C., Smith V., Walsh T. & Heazell A.E.P. (2021) Development of a core outcome set (COS) for studies relating to awareness and clinical management of reduced fetal movement: study protocol. *Trials* **22**(1), 894.

He H., Huang J., Zhao X. & Li Z. (2021) The effect of prenatal music therapy on fetal and neonatal status: A systematic review and meta-analysis. *Complementary Therapies in Medicine* **60**, 102756.

Health Information and Quality Authority (HIQA), Department of Health & Health Service Executive (2020) *Findings of the National Maternity Experience Survey 2020*. HIQA. Retrieved from https://yourexperience.ie/wp-content/uploads/2020/09/National-Maternity-Experience-Survey-results.pdf on 14 November 2022.

Health Service Executive & Cerner (2016) *Maternal & Newborn Clinical Management System (MN-CMS).* Retrieved from https://www.ehealthireland.ie/ehealth-functions/acute-delivery/maternal-newborn-clinical-management-system-mn-cms-/ on 11 February 2018.

Health Service Executive (2016) *National Standards for Bereavement Care Following Pregnancy Loss and Perinatal Death*. Health Service Executive, Dublin.

Health Service Executive (2018) *Second National Intercultural Health Strategy 2018–2023*. Health Service Executive. Retrieved from https://www.hse.ie/eng/about/who/primarycare/socialinclusion/intercultural-health/second-national-intercultural-health-strategy.html on 01 February 2023.

Health Service Executive (2022) *Sláintecare "Smoke Free Start": An Evaluation*. Health Service Executive, Dublin.

Heazell A. & Evans K. (2017) Antenatal Care: Reduced fetal movements. In *MBRRACE-UK 2017 Perinatal Confidential Enquiry: Term, singleton, intrapartum stillbirth and intrapartum-related neonatal death* (Draper E., Kurinczuk J. & MBRRACE-UK., eds), University of Leicester: Leicester, The Infant Mortality and Morbidity Studies, Department of Health Sciences, , pp. 25-27.

Heazell A.E. & Froen J.F. (2008) Methods of fetal movement counting and the detection of fetal compromise. *Journal of Obstetrics & Gynaecology* **28**(2), 147-154.

Heazell A.E., Green M., Wright C., Flenady V. & Froen J.F. (2008) Midwives' and obstetricians' knowledge and management of women presenting with decreased fetal movements. *Acta Obstetricia et Gynecologica Scandinavica* **87**(3), 331-339.

Heazell A.E., Hayes D.J., Whitworth M., Takwoingi Y., Bayliss S.E. & Davenport C. (2019) Biochemical tests of placental function versus ultrasound assessment of fetal size for stillbirth and small-for-gestational-age infants. *Cochrane Database of Systematic Reviews 2019, Issue 5.* Art. No.: CD012245. DOI: 10.1002/14651858.

Heazell A.E., Li M., Budd J., Thompson J.M., Stacey T., Cronin R.S., Martin B., Roberts D., Mitchell E.A. & McCowan L.M. (2018a) Association between maternal sleep practices and late stillbirth–findings from a stillbirth case-control study. *BJOG: An International Journal of Obstetrics & Gynaecology* **125**(2), 254-262.

Heazell A.E., Siassakos D., Blencowe H., Burden C., Bhutta Z.A., Cacciatore J., Dang N., Das J., Flenady V. & Gold K.J. (2016) Stillbirths: economic and psychosocial consequences. *The Lancet* **387**(10018), 604-616.

Heazell A.E.P., Budd J., Li M., Cronin R., Bradford B., McCowan L.M.E., Mitchell E.A., Stacey T., Martin B., Roberts D. & Thompson J.M.D. (2018b) Alterations in maternally perceived fetal movement and their association with late stillbirth: findings from the Midland and North of England stillbirth case-control study. *BMJ Open* **8**(7), e020031.

Heazell A.E.P., Sumathi G.M. & Bhatti N.R. (2005) What investigation is appropriate following maternal perception of reduced fetal movements? *Journal of Obstetrics and Gynaecology* **25**(7), 648-650.

Heazell A.E.P., Weir C.J., Stock S.J.E., Calderwood C.J., Burley S.C., Froen J.F., Geary M., Hunter A., McAuliffe F.M., Murdoch E., Rodriguez A., Ross-Davie M., Scott J., Whyte S. & Norman J.E. (2017) Can promoting awareness of fetal movements and focusing interventions reduce fetal mortality? A stepped-wedge cluster randomised trial (AFFIRM). *BMJ Open* **7**(8), e014813.

Helps Ä., Leitao S., O'Byrne L., Greene R.A. & O'Donoghue K. (2020) Irish inquiry reports relating to perinatal deaths and pregnancy loss services. *Irish Medical Journal* **113**(2), 1-7.

Hennessy S., Bilker W.B., Berlin J.A. & Strom B.L. (1999) Factors Influencing the Optimal Control-to-Case Ratio in Matched Case-Control Studies. *American Journal of Epidemiology* **149**(2), 195-197.

Hertogs K., Roberts A.B., Cooper D., Griffin D.R. & Campbell S. (1979) Maternal perception of fetal motor activity. *British Medical Journal* **2**(6199), 1183-1185.

Heslehurst N., Newham J., Maniatopoulos G., Fleetwood C., Robalino S. & Rankin J. (2014) Implementation of pregnancy weight management and obesity guidelines: a meta-synthesis of healthcare professionals' barriers and facilitators using the Theoretical Domains Framework. *Obesity Reviews* **15**(6), 462-486.

Higgins J. & Thomas J. (2022) *Cochrane Handbook for Systematic Reviews of Interventions*. Chichester (UK). Retrieved from www.training.cochrane.org/handbook on 17 February 2023

Higgins L.E., Myers J.E., Sibley C.P., Johnstone E.D. & Heazell A.E.P. (2018) Antenatal placental assessment in the prediction of adverse pregnancy outcome after reduced fetal movement. *PLOS ONE* **13**(11), e0206533.

Hijazi Z., Callan S. & East C. (2010) Maternal perception of foetal movement compared with movement detected by real-time ultrasound: An exploratory study. *Australian and New Zealand Journal of Obstetrics and Gynaecology* **50**(2), 144-147.

Ho D., Wang J., Homann Y., Alphonse J., Beirne G., Welsh A.W. & Henry A. (2018) Use of the myocardial performance index in decreased fetal movement assessment: A case-control study. *Fetal Diagnosis and Therapy* **43**, 208-217.

Hofmeyr G.J. & Novikova N. (2012) Management of reported decreased fetal movements for improving pregnancy outcomes. *Cochrane Database of Systematic Reviews 2011, Issue 5.* Art. No.: CD009148. DOI: 10.1002/14651858.

Holden K.P., Jovanovic L., Druzin M.L. & Peterson C.M. (1984) Increased fetal activity with low maternal blood glucose levels in pregnancies complicated by diabetes. *American Journal of Perinatology* **1**(2), 161-164.

Holm Tveit J.V., Saastad E.L.I., Stray-Pedersen B., BØRdahl P.E. & FrØEn J.F. (2009) Maternal characteristics and pregnancy outcomes in women presenting with decreased fetal movements in late pregnancy. *Acta Obstetricia et Gynecologica Scandinavica* **88**(12), 1345-1351.

Houghton C., Hunter A. & Meskell P. (2012) Linking aims, paradigm and method in nursing research. *Nurse Researcher* **20 2**, 34-39.

Hug L., You D., Blencowe H., Mishra A., Wang Z., Fix M.J., Wakefield J., Moran A.C., Gaigbe-Togbe V., Suzuki E., Blau D.M., Cousens S., Creanga A., Croft T., Hill K., Joseph K.S., Maswime S., McClure E.M., Pattinson R., Pedersen J., Smith L.K., Zeitlin J. & Alkema L. (2021) Global, regional, and national estimates and trends in stillbirths from 2000 to 2019: a systematic assessment. *The Lancet* **398**(10302), 772-785.

Hughes P.M., Turton P. & Evans C.D. (1999) Stillbirth as risk factor for depression and anxiety in the subsequent pregnancy: cohort study. *BMJ* **318**(7200), 1721-1724.

Humphries A., Mirjalili S.A., Tarr G.P., Thompson J.M.D. & Stone P. (2019) The effect of supine positioning on maternal hemodynamics during late pregnancy. *The Journal of Maternal-Fetal & Neonatal Medicine* **32**(23), 3923-3930.

Hunter A., Tussis L. & MacBeth A. (2017) The presence of anxiety, depression and stress in women and their partners during pregnancies following perinatal loss: A meta-analysis. *Journal of Affective Disorders* **223**, 153-164.

Hutti M.H., Armstrong D.S. & Myers J. (2011) Healthcare utilization in the pregnancy following a perinatal loss. *MCN American Journal Maternal Child Nursing* **36**(2), 104-111.

IBM Corp (2016) *IBM SPSS Statistics for Windows*, Version 24.0. IBM Corp, Armonk, NY.

Iliodromiti S., Mackay D.F., Smith G.C.S., Pell J.P. & Nelson S.M. (2014) Apgar score and the risk of cause-specific infant mortality: a population-based cohort study. *The Lancet* **384**(9956), 1749-1755.

Inukollu P.R., Sulthana S., Solipuram D., Kunamneni S. & Kothagadi A.R. (2021) An emerging method in evaluation of reduced fetal movements using cerebroplacental ratio: A prospective case-control study. *Journal of Obstetrics and Gynaecology Research* **47**(12), 4203-4209.

Jeffers M.D., O'Dwyer P., Curran B., Leader M. & Gillan J.E. (1993) Partial hydatidiform mole: a common but underdiagnosed condition. A 3-year retrospective clinicopathological and DNA flow cytometric analysis. *International journal of gynecological pathology : official journal of the International Society of Gynecological Pathologists* **12**(4), 315-323.

Jovic E., Hadinata I.E. & Sheehan P. (2015) Induction of labour for decreased fetal movements (DFM). *Journal of Paediatrics and Child Health* **51** (Suppl. 1), 115.

Kafalİ H., Derbent A., Keskİn E., Sİmavlİ S. & Gözdemİr E. (2011) Effect of maternal anxiety and music on fetal movements and fetal heart rate patterns. *The Journal of Maternal-Fetal & Neonatal Medicine* **24**(3), 461-464.

Kahlert J., Gribsholt S.B., Gammelager H., Dekkers O.M. & Luta G. (2017) Control of confounding in the analysis phase - an overview for clinicians. *Clinical Epidemiology* **9**, 195-204.

Kapaya H., Almeida J., Karouni F. & Anumba D. (2020) Management of reduced fetal movement: A comparative analysis of two audits at a tertiary care clinical service. *European Journal of Obstetrics & Gynecology and Reproductive Biology* **248**, 128-132.

Kennedy P. & Murphy-Lawless J. (2003) The maternity care needs of refugee and asylum seeking women in Ireland. *Feminist Review* **73**(1), 39-53.

Killeen S.L., Donnellan N., O'Reilly S.L., Hanson M.A., Rosser M.L., Medina V.P., Jacob C.M., Divakar H., Hod M., Poon L.C., Bergman L., O'Brien P., Kapur A., Jacobsson B., Maxwell C.V., McIntyre H.D., Regan L., Algurjia E., Ma R.C., Adam S., McAuliffe F.M. (2023) Using FIGO Nutrition Checklist counselling in pregnancy: A review to support healthcare professionals. *International Journal of Gynecology & Obstetrics* **160**(S1), 10-21.

Kisilevsky B.S. & Low J.A. (1998) Human fetal behavior: 100 years of study. *Developmental Review* **18**(1), 1-29.

Kivunja C. & Kuyini A.B. (2017) Understanding and applying research paradigms in educational contexts. *International Journal of Higher Education* **6**(5), 26-41.

Kofinas A.D., Penry M., Swain M. & Hatjis C.G. (1989) Effect of placental laterality on uterine artery resistance and development of preeclampsia and intrauterine growth retardation. *American Journal of Obstetrics and Gynecology* **161**(6), 1536-1539.

Kolte A.M., Olsen L.R., Mikkelsen E.M., Christiansen O.B. & Nielsen H.S. (2015) Depression and emotional stress is highly prevalent among women with recurrent pregnancy loss. *Human Reproduction* **30**(4), 777-782.

Koshida S., Ono T., Tsuji S., Murakami T., Arima H. & Takahashi K. (2017) Excessively delayed maternal reaction after their perception of decreased fetal movements in stillbirths: Population-based study in Japan. *Women and Birth* **30**(6), 468-471.

Kurjak A., Carrera J., Medic M., Azumendi G., Andonotopo W. & Stanojevic M. (2005) The antenatal development of fetal behavioral patterns assessed by four-dimensional sonography. *The Journal of Maternal-Fetal & Neonatal Medicine* **17**(6), 401-416.

Lai J., Nowlan N.C., Vaidyanathan R., Shaw C.J. & Lees C.C. (2016) Fetal movements as a predictor of health. *Acta Obstetricia et Gynecologica Scandinavica* **95**(9), 968-975.

Lai J., Woodward R., Alexandrov Y., ain Munnee Q., Lees C.C., Vaidyanathan R. & Nowlan N.C. (2018) Performance of a wearable acoustic system for fetal movement discrimination. *PLOS ONE* **13**(5), e0195728.

Lamont K., Scott N.W., Gissler M., Gatt M. & Bhattacharya S. (2022) Risk of recurrent stillbirth in subsequent pregnancies. *Obstetrics & Gynecology* **139**(1), 31-40.

Lamont K., Scott N.W., Jones G.T. & Bhattacharya S. (2015) Risk of recurrent stillbirth: systematic review and meta-analysis. *BMJ : British Medical Journal* **350**, h3080.

Lange S., Probst C., Rehm J. & Popova S. (2018) National, regional, and global prevalence of smoking during pregnancy in the general population: a systematic review and meta-analysis. *The Lancet Global Health* **6**(7), e769-e776.

Lavallée J.F., Gray T.A., Dumville J., Russell W. & Cullum N. (2017) The effects of care bundles on patient outcomes: a systematic review and meta-analysis. *Implementation Science* **12**(1), 142.

Lawn J.E., Blencowe H., Waiswa P., Amouzou A., Mathers C., Hogan D., Flenady V., Frøen J.F., Qureshi Z.U., Calderwood C., Shiekh S., Jassir F.B., You D., McClure E.M., Mathai M., Cousens S., Flenady V., Frøen J.F., Kinney M.V., de Bernis L., Lawn J.E., Blencowe H., Heazell A., Leisher S.H., Azad K., Rahman A., El-Arifeen S., Day L.T., Shah S.L., Alam S., Wangdi S., Ilboudo T.F., Zhu J., Liang J., Mu Y., Li X., Zhong N., Kyprianou T., Allvee K., Gissler M., Zeitlin J., Bah A., Jawara L., Waiswa P., Lack N., de Maria Herandez F., Shah More N., Nair N., Tripathy P., Kumar R., Newtonraj A., Kaur M., Gupta M., Varghese B., Isakova J., Phiri T., Hall J.A., Curteanu A., Manandhar D., Hukkelhoven C., Dijs-Elsinga J., Klungsøyr K., Poppe O., Barros H., Correia S., Tsiklauri S., Cap J., Podmanicka Z., Szamotulska K., Pattison R., Hassan A.A., Musafi A., Kujala S., Bergstrom A., Langhoff -Roos J., Lundqvist E., Kadobera D., Costello A., Colbourn T., Fottrell E., Prost A., Osrin D., King C., Neuman M., Hirst J., Rubayet S., Smith L., Manktelow B.N. & Draper E.S. (2016) Stillbirths: rates, risk factors, and acceleration towards 2030. *The Lancet* **387**(10018), 587-603.

Leader L.R., Baillie P. & Van Schalkwyk D.J. (1981) Fetal movements and fetal outcome: a prospective study. *Obstetrics & Gynaecology* **57**(4), 431-436.

Lebit D.F. & Vladareanu P.D. (2011) The Role of 4D Ultrasound in the Assessment of Fetal Behaviour. *Maedica (Bucur)* **6**(2), 120-127.

Lee S.I., Azcoaga-Lorenzo A., Agrawal U., Kennedy J.I., Fagbamigbe A.F., Hope H., Subramanian A., Anand A., Taylor B., Nelson-Piercy C., Damase-Michel C., Yau C., Crowe F., Santorelli G., Eastwood K.-A., Vowles Z., Loane M., Moss N., Brocklehurst P., Plachcinski R., Thangaratinam S., Black M., O'Reilly D., Abel K.M., Brophy S., Nirantharakumar K., McCowan C. & on behalf of the MuM-PreDiCT Group. (2022) Epidemiology of pre-existing multimorbidity in pregnant women in the UK in 2018: a population-based cross-sectional study. *BMC Pregnancy and Childbirth* **22**(1), 120.

Lees C., Stampalija T., Baschat A., da Silva Costa F., Ferrazzi E., Figueras F., Hecher K., Poon L., Salomon L. & Unterscheider J. (2020) ISUOG Practice Guidelines: diagnosis and

management of small-for-gestational-age fetus and fetal growth restriction. *Ultrasound in Obstetrics & Gynecology* **56**(2), 298-312.

Levy M., Kovo M., Barda G., Gluck O., Koren L., Bar J. & Weiner E. (2020) Reduced fetal movements at term, low-risk pregnancies: is it associated with adverse pregnancy outcomes? Ten years of experience from a single tertiary center. *Archives of Gynecology and Obstetrics* **301**(4), 987-993.

Linde A., Georgsson S., Pettersson K., Holmstrom S., Norberg E. & Radestad I. (2016) Fetal movement in late pregnancy - a content analysis of women's experiences of how their unborn baby moved less or differently. *BMC Pregnancy Childbirth* **16**(1), 127.

Linde A., Pettersson K. & Radestad I. (2017a) Women who seek care for decreased fetal movements - Maternal characteristics and onset of labour. *BMC Pregnancy and Childbirth* **17 (Supplemt 1)**(299).

Linde A., Radestad I., Pettersson K., Hagelberg L. & Georgsson S. (2017b) "Better safe than sorry"-Reasons for consulting care due to decreased fetal movements. *Women and Birth* **30** (5), 376-381.

Linehan L.A., San Lazaro Campillo I., Hennessy M., Flannery C. & O'Donoghue K. (2022) Reproductive outcomes following recurrent first-trimester miscarriage: a retrospective cohort study. *Human Reproduction Open* (4), hoac045.

Malm M.C., Hildingsson I., Rubertsson C., Radestad I. & Lindgren H. (2016) Prenatal attachment and its association with foetal movement during pregnancy - A population based survey. *Women and Birth* **29**(6), 482-486.

Malm M.C., Lindgren H. & Radestad I. (2010) Losing contact with one's unborn baby--mothers' experiences prior to receiving news that their baby has died in utero. *Omega-Journal of Death and Dying* **62**(4), 353-367.

Malm M.C., Lindgren H., Rubertsson C., Hildingsson I. & Radestad I. (2014) Development of a tool to evaluate fetal movements in full-term pregnancy. *Sexual & Reproductive Healthcare* **5**(1), 31-35.

Malouf R. & Redshaw M. (2017) Specialist antenatal clinics for women at high risk of preterm birth: a systematic review of qualitative and quantitative research. *BMC Pregnancy and Childbirth* **17**(1), 51.

Mangesi L., Hofmeyr G.J., Smith V. & Smyth R.M. (2015) Fetal movement counting for assessment of fetal wellbeing. *Cochrane Database of Systematic Reviews 2015, Issue 10.* Art. No.: CD004909. DOI: 10.1002/14651858.

Marx V. & Nagy E. (2015) Fetal behavioural responses to maternal voice and touch. *PLOS ONE* **10**(6), e0129118.

McArdle A., Flenady V., Toohill J., Gamble J. & Creedy D. (2015) How pregnant women learn about foetal movements: Sources and preferences for information. *Women and Birth* **28**(1), 54-59.

McAuliffe A., Russell N.E. & Fenton J. (2011) Psychological services for women giving birth in a large Irish tertiary referral maternity unit. *The Psychiatrist* **35**(3), 92-94.

McAuliffe F., Hoey M. & Geary M. (1997) The National Maternity Hospital casualty department--a review. *Irish Medical Journal* **90**(1), 19.

McAuliffe F.M., Killeen S.L., Jacob C.M., Hanson M.A., Hadar E., McIntyre H.D., Kapur A., Kihara A.B., Ma R.C. & Divakar H. (2020) Management of prepregnancy, pregnancy, and postpartum obesity from the FIGO Pregnancy and Non-Communicable Diseases Committee: A FIGO (International Federation of Gynecology and Obstetrics) guideline. *International Journal of Gynaecology and Obstetrics* **151**(Suppl 1), 16.

McCarthy C.M., Meaney S. & O'Donoghue K. (2015) PP23 Perinatal outcomes of reduced fetal movements: a prospective cohort study. *Journal of Epidemiology and Community Health* **69**(Suppl 1), A62.

McCarthy C.M., Meaney S. & O'Donoghue K. (2016) Perinatal outcomes of reduced fetal movements: a cohort study. *BMC Pregnancy Childbirth* **16**(1), 169.

McCarthy K.E. & Narrigan D. (1995) Is There Scientific Support for the Use of Juice to Facilitate the Nonstress Test? *Journal of Obstetric, Gynecologic & Neonatal Nursing* **24**(4), 303-306.

McDonnell B.P., Dicker P., Keogan S., Clancy L. & Regan C. (2023) Smoking cessation Through Optimization of clinical care in Pregnancy: the STOP pragmatic randomized controlled trial. *American Journal of Obstetrics & Gynecology MFM* **5**(1), 100763.

McHugh M.L. (2012) Interrater reliability: the kappa statistic. *Biochemia Medica* **22**(3), 276-282.

McNamara K., O'Donoghue K. & Greene R.A. (2018) Intrapartum fetal deaths and unexpected neonatal deaths in the Republic of Ireland: 2011 – 2014; a descriptive study. *BMC Pregnancy and Childbirth* **18**(1), 9.

Meredith P., Wilson T., Branjerdporn G., Strong J. & Desha L. (2017) "Not just a normal mum": a qualitative investigation of a support service for women who are pregnant subsequent to perinatal loss. *BMC Pregnancy and Childbirth* **17**(1), 6.

Mertens D.M. (2020) *Research and evaluation in education and psychology: integrating diversity with quantitative, qualitative, and mixed methods*. 5th edn. SAGE, Los Angeles.

Mesbah M., Khlif M.S., East C., Smeathers J., Colditz P. & Boashash B. (2011) Accelerometer-based fetal movement detection. *Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 7877-7880.

Michaan N., Baruch Y., Topilsky M., Amzalag S., Iaskov I., Many A. & Maslovitz S. (2016) The effect of glucose administration on perceived fetal movements in women with decreased fetal movement, a double-blinded placebo-controlled trial. *Journal of Perinatology* **36**(8), 598-600.

Mikhail M.S., Freda M.C., Merkatz R.B., Polizzotto R., Mazloom E. & Merkatz I.R. (1991) The effect of fetal movement counting on maternal attachment to fetus. *American Journal of Obstetrics & Gynecology* **165**(4 Pt 1), 988-991.

Miller F.C., Skiba H. & Klapholz H. (1978) The effect of maternal blood sugar levels on fetal activity. *Obstetrics & Gynecology* **52**(6), 662-665.

Mills T.A., Ricklesford C., Cooke A., Heazell A.E.P., Whitworth M. & Lavender T. (2014) Parents' experiences and expectations of care in pregnancy after stillbirth or neonatal death: a metasynthesis. *BJOG: An International Journal of Obstetrics & Gynaecology* **121**(8), 943-950.

Mills T.A., Ricklesford C., Heazell A.E.P., Cooke A. & Lavender T. (2016) Marvellous to mediocre: findings of national survey of UK practice and provision of care in pregnancies after stillbirth or neonatal death. *BMC Pregnancy and Childbirth* **16**(1), 101.

Mills T.A., Roberts S.A., Camacho E., Heazell A.E.P., Massey R.N., Melvin C., Newport R., Smith D.M., Storey C.O., Taylor W. & Lavender T. (2022) Better maternity care pathways in pregnancies after stillbirth or neonatal death: a feasibility study. *BMC Pregnancy and Childbirth* **22**(1), 634.

Minors D.S. & Waterhouse J.M. (1979) The effect of maternal posture, meals and time of day on fetal movements. *British Journal of Obstetrics & Gynaecology* **86**(9), 717-723.

Miranda J., Rodriguez-Lopez M., Triunfo S., Sairanen M., Kouru H., Parra-Saavedra M., Crovetto F., Figueras F., Crispi F. & Gratacós E. (2017) Prediction of fetal growth restriction using estimated fetal weight vs a combined screening model in the third trimester. *Ultrasound in Obstetrics & Gynecology* **50**(5), 603-611.

Mohr Sasson A., Tsur A., Kalter A., Weissmann Brenner A., Gindes L. & Weisz B. (2016) Reduced fetal movement: factors affecting maternal perception. *The Journal of Maternal-Fetal & Neonatal Medicine* **29**(8), 1318-1321.

Moore T.R. & Piacquadio K. (1989) A prospective evaluation of fetal movement screening to reduce the incidence of antepartum fetal death. *American Journal of Obstetrics & Gynecology* **160**(5 Pt 1), 1075-1080.

Mor-Yosef S., Sadovsky E., Brzezinski A., Levinsky R. & Ohel G. (1983) Fetal movements and intrauterine growth retardation. *International Journal of Gynecology & Obstetrics* **21**(4), 315-318.

Murphy J. (2022) Perinatal Statistics and Current Trends. *Irish Medical Journal* **115**(1), 512-512.

Murphy M. (2018). *Experiences of couples in pregnancy after stillbirth: an interpretative phenomenological analysis*. Unpublished PhD Thesis. University College Cork, Cork.

Murphy M., Savage E., O'Donoghue K., Leary J.O. & Leahy-Warren P. (2021) Trying to conceive: An interpretive phenomenological analysis of couples' experiences of pregnancy after stillbirth. *Women and Birth* **34**(5), e475-e481.

Nasello-Paterson C., Natale R. & Connors G. (1988) Ultrasonic evaluation of fetal body movements over twenty-four hours in the human fetus at twenty-four to twenty-eight weeks' gestation. *American Journal of Obstetrics & Gynecology* **158**(2), 312-316.

Natale R., Nasello-Paterson C. & Turliuk R. (1985) Longitudinal measurements of fetal breathing, body movements, heart rate, and heart rate accelerations and decelerations at 24 to 32 weeks of gestation. *American Journal of Obstetrics and Gynecology* **151**(2), 256-263.

National Institute for Health and Care Excellence (NICE) (2021) *Antenatal Care (NG201)*. NICE. Retrieved from https://www.nice.org.uk/guidance/ng201 on 19th February 2022.

National Womens and Infants Health Programme (2021) *Irish Maternity Indicator System National Report 2020*, Dublin.

Neldam S. (1982) Fetal Movements : A Comparison between Maternal Assessment and Registration by Means of Dynamic Ultrasound. *Obstetrical & Gynecological Survey* **38**(1), 18-19.

Newman C., Egan A.M., Ahern T., Al-Kiyumi M., Balan G., Brassill M.J., Brosnan E., Carmody L., Clarke H., Coogan Kelly C., Culliney L., Davern R., Durkan M., Fenlon M., Ferry P., Hanlon G., Higgins T., Hoashi S., Khamis A., Kinsley B., Kirwan B., Kyithar P., Liew A., Matthews L., McGurk C., McHugh C., Murphy M.S., Murphy P., Nagodra D., Noctor E., Nolan M., O'Connor E., O'Halloran D., O'Mahoney L., O'Sullivan E., Peters M., Roberts G., Rooney H., Smyth A., Tarachand B., Todd M., Tuthill A., Wan Mahmood W.A., Yousif O. & Dunne F.P. (2021) Diabetes care and pregnancy outcomes for women with pregestational diabetes in Ireland. *Diabetes Research and Clinical Practice* **173**, 108685.

NHMRC Centre for Research Excellence in Stillbirth (2021) *The Safer Baby Bundle.* Retrieved from https://stillbirthcre.org.au/about-us/our-work/the-safer-baby-bundle/ on 11 January 2023.

Nishihara K., Ohki N., Kamata H., Ryo E. & Horiuchi S. (2015) Automated software analysis of fetal movement recorded during a pregnant woman's sleep at home. *PLOS ONE* **10**(6), e0130503.

Noordzij M., Tripepi G., Dekker F.W., Zoccali C., Tanck M.W. & Jager K.J. (2010) Sample size calculations: basic principles and common pitfalls. *Nephrology Dialysis Transplantation* **25**(5), 1388-1393.

Norman J.E., Heazell A.E.P., Rodriguez A., Weir C.J., Stock S.J.E., Calderwood C.J., Burley S.C., Froen J.F., Geary M., Breathnach F., Hunter A., McAuliffe F.M., Higgins M.F., Murdoch E., Ross-Davie M., Scott J., Whyte S. & Investigators A. (2018) Awareness of fetal movements and care package to reduce fetal mortality (AFFIRM): a stepped wedge, cluster-randomised trial. *Lancet* **392**(10158), 1629-1638.

Norris T., Manktelow B.N., Smith L.K. & Draper E.S. (2017) Causes and temporal changes in nationally collected stillbirth audit data in high-resource settings. *Seminars in Fetal and Neonatal Medicine* **22**(3), 118-128.

Nowacka U., Papastefanou I., Bouariu A., Syngelaki A., Akolekar R. & Nicolaides K.H. (2022) Second-trimester contingent screening for small-for-gestational-age neonate. *Ultrasound in Obstetrics & Gynecology* **59**(2), 177-184.

Nursing and Midwifery Board of Ireland (2021) *Code of Professional Conduct and Ethics for Registered Nurses and Registered Midwives*. Nursing and Midwifery Board of Ireland. Retrieved from https://www.nmbi.ie/NMBI/media/NMBI/Code-of-Professional-Conduct-and-Ethics.pdf?ext=.pdf on 09 January 2022.

Nursing and Midwifery Board of Ireland (2022) *Practice Standards for Midwives*. Nursing and Midwifery Board of Ireland. Retrieved from https://www.nmbi.ie/NMBI/media/NMBI/NMBI-Practice-Standards-for-Midwives.pdf?ext=.pdf on 09 January 2022.

Nuzum D., Meaney S. & O'donoghue K. (2014) The impact of stillbirth on consultant obstetrician gynaecologists: a qualitative study. *BJOG: An International Journal of Obstetrics & Gynaecology* **121**(8), 1020-1028.

Nuzum D. & O'Donoghue K. (2022) Pregnancy Loss: A silent loss and challenging birth. In *Birth and the Irish: a Miscellany* (Salvador R., ed), Wordwell Books.

Nuzum D., Meaney S. & O'Donoghue K. (2018a) The public awareness of stillbirth: an Irish population study. *BJOG: An International Journal of Obstetrics & Gynaecology* **125**(2), 246-252.

Nuzum D., Meaney S. & O'Donoghue K. (2018b) The impact of stillbirth on bereaved parents: A qualitative study. *PLOS ONE* **13**(1), e0191635.

O'Brien O.F., Lee S., Baby A., McAuliffe F.M. & Higgins M.F. (2019) The Profile of Women Attending the National Maternity Hospital Emergency Out Of Hours Service - Two Decades On. A Retrospective Review. *Irish Medical Journal* **112**(3), 895.

O'Farrell B., Manning E., Corcoran P., White E.J., Greene R. (2021) *Perinatal Mortality in Ireland Biennial Report 2018/2019*. National Perinatal Epidemiology Centre. Retrieved from www.ucc.ie/en/npec/ on 10 November 2022.

Olagbuji B.N., Ezeanochie M.C., Kubeyinje W., Dunsin T. & Ande A.B. (2011) Pregnancy outcome following induction of labor with intravaginal misoprostol for decreased fetal movements at term. *Journal of Maternal- Fetal Neonatal Medicine* **24**(10), 1225-1227.

O'Sullivan O., Stephen G., Martindale E. & Heazell A.E. (2009) Predicting poor perinatal outcome in women who present with decreased fetal movements. *Journal of Obstetrics & Gynaecology* **29**(8), 705-710.

Pagani G., D'Antonio F., Khalil A., Akolekar R., Papageorghiou A., Bhide A. & Thilaganathan B. (2014a) Association between reduced fetal movements at term and abnormal uterine artery Doppler indices. *Ultrasound in Obstetrics & Gynecology* **43**(5), 548-552.

Pagani G., D'Antonio F., Khalil A., Papageorghiou A., Bhide A. & Thilaganathan B. (2014b) Association between reduced fetal movements at term and first trimester markers of impaired placental development. *Placenta* **35**(8), 606-610.

Page M.J., McKenzie J.E., Bossuyt P.M., Boutron I., Hoffmann T.C., Mulrow C.D., Shamseer L., Tetzlaff J.M., Akl E.A., Brennan S.E., Chou R., Glanville J., Grimshaw J.M., Hróbjartsson A., Lalu M.M., Li T., Loder E.W., Mayo-Wilson E., McDonald S., McGuinness L.A., Stewart L.A., Thomas J., Tricco A.C., Welch V.A., Whiting P. & Moher D. (2021a) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* **372**, n71.

Page M.J., Sterne J.A.C., Higgins J.P.T. & Egger M. (2021b) Investigating and dealing with publication bias and other reporting biases in meta-analyses of health research: A review. *Research Synthesis Methods* **12**(2), 248-259.

Pallant J. (2016) *SPSS Survival Manual*. 6th edition edn. Open University Press

Pandey S., Shetty A., Hamilton M., Bhattacharya S. & Maheshwari A. (2012) Obstetric and perinatal outcomes in singleton pregnancies resulting from IVF/ICSI: a systematic review and meta-analysis. *Human Reproduction Update* **18**(5), 485-503.

Patrick J., Campbell K., Carmichael L., Natale R. & Richardson B. (1982) Patterns of gross fetal body movements over 24-hour observation intervals during the last 10 weeks of pregnancy. *American Journal of Obstetrics & Gynecology* **142**(4), 363-371.

Pearce N. (2016) Analysis of matched case-control studies. *BMJ* **352**, i969.

Pearson J.F. & Weaver J.B. (1976) Fetal activity and fetal wellbeing: an evaluation. *British Medical Journal* **1**(6021), 1305-1307.

Pearson J.F. (1977) Fetal movements--a new approach to antenatal care. *Nursing Mirror and Midwives Journal* **144**(16), 49-51.

Peat J. & Barton B. (2005) *Medical Statistics: A Guide to Data Analysis and Critical Appraisal*. John Wiley & Sons, Incorporated, Chichester.

Perin J., Mulick A., Yeung D., Villavicencio F., Lopez G., Strong K.L., Prieto-Merino D., Cousens S., Black R.E. & Liu L. (2022) Global, regional, and national causes of under-5 mortality in 2000–19: an updated systematic analysis with implications for the Sustainable Development Goals. *The Lancet Child & Adolescent Health* **6**(2), 106-115.

Perinatal Society of Australia and New Zealand and Centre of Research Excellence Stillbirth (2019) *Clinical practice guideline for the care of women with decreased fetal movements for women with a singleton pregnancy from 28 weeks' gestation*. Centre of Research Excellence in Stillbirth. Retrieved from https://stillbirthcre.org.au/wp-content/uploads/2021/03/Element-3_DFM-Clinical-Practice-Guideline-1.pdf on 19 February 2022.

Polit D. & Beck C. (2020) *Essentials of nursing research: Appraising evidence for nursing practice*. Lippincott Williams & Wilkins

Pollock D., Ziaian T., Pearson E., Cooper M. & Warland J. (2020) Breaking through the silence in antenatal care: Fetal movement and stillbirth education. *Women and Birth* **33**(1), 77-85.

Pruitt S.M., Hoyert D.L., Anderson K.N., Martin J., Waddell L., Duke C., Honein M.A. & Reefhuis J. (2020) Racial and ethnic disparities in fetal deaths—United States, 2015–2017. *Morbidity and Mortality Weekly Report* **69**(37), 1277.

Quenby S., Gallos I.D., Dhillon-Smith R.K., Podesek M., Stephenson M.D., Fisher J., Brosens J.J., Brewin J., Ramhorst R. & Lucas E.S. (2021) Miscarriage matters: the epidemiological, physical, psychological, and economic costs of early pregnancy loss. *The Lancet* **397**(10285), 1658-1667.

Rådestad I. & Lindgren H. (2012) Women's perceptions of fetal movements in full-term pregnancy. *Sexual & Reproductive Healthcare* **3**(3), 113-116.

Rådestad I. (2010) Fetal movements in the third trimester--Important information about wellbeing of the fetus. *Sexual & Reproductive Healthcare* **1**(4), 119-121.

Rådestad I. (2012) Strengthening mindfetalness. *Sexual & Reproductive Healthcare* **3**(2), 59-60.

Rådestad I. (2017) Mindfetalness a method for structured observation on fetal movements. *Women and Birth* **30**, 34-35.

Rådestad I., Pettersson K., Lindgren H., Skokic V. & Akselsson A. (2021) Country of birth, educational level and other predictors of seeking care due to decreased fetal movements: an observational study in Sweden using data from a cluster-randomised controlled trial. *BMJ Open* **11**(6), e050621.

Räisänen S., Sankilampi U., Gissler M., Kramer M.R., Hakulinen-Viitanen T., Saari J. & Heinonen S. (2014) Smoking cessation in the first trimester reduces most obstetric risks, but not the risks of major congenital anomalies and admission to neonatal care: a population-based cohort study of 1 164 953 singleton pregnancies in Finland. *Journal of Epidemiology and Community Health (1979)* **68**(2), 159-164.

Ranganathan P., Pramesh C.S. & Aggarwal R. (2017) Common pitfalls in statistical analysis: Logistic regression. *Perspectives Clinical Research* **8**(3), 148-151.

Ranjbar F., Warmelink J.C. & Gharacheh M. (2020) Prenatal attachment in pregnancy following assisted reproductive technology: a literature review. *Journal of Reproductive and Infant Psychology* **38**(1), 86-108.

Rasmussen T.D., Villadsen S.F., Andersen P.K., Jervelund S.S. & Andersen A.-M.N. (2021) Social and ethnic disparities in stillbirth and infant death in Denmark, 2005–2016. *Scientific Reports* **11**.

Rayburn W.F. (1990) Fetal body movement monitoring. *Obstetrics and Gynecology Clinics of North America* **17**(1), 95-110.

Raynes-Greenow C.H., Gordon A., Li Q. & Hyett J.A. (2013) A cross-sectional study of maternal perception of fetal movements and antenatal advice in a general pregnant population, using a qualitative framework. *BMC Pregnancy and Childbirth* **13**(1), 32-32.

Reeves B.C., Deeks J.J. & Higgins J. (2008) 13 Including non-randomized studies. *Cochrane handbook for systematic reviews of interventions* **1**, 391.

Reynolds C., Egan B., McKeating A., Daly N., Sheehan S. & Turner M. (2017a) Five year trends in maternal smoking behaviour reported at the first prenatal appointment. *Irish Journal of Medical Science (1971-)* **186**(4), 971-979.

Reynolds C.M.E., Egan B., Kennedy R.A., O'Malley E.G., Sheehan S.R. & Turner M.J. (2018) A prospective, observational study investigating the use of carbon monoxide screening to identify maternal smoking in a large university hospital in Ireland. *BMJ Open* **8**(7), e022089.

Reynolds C.M.E., Egan B., McKeating A., Daly N., Sheehan S.R. & Turner M.J. (2017b) Five year trends in maternal smoking behaviour reported at the first prenatal appointment. *Irish Journal of Medical Science (1971 -)* **186**(4), 971-979.

Riley R.D., Hayden J.A., Steyerberg E.W., Moons K.G., Abrams K., Kyzas P.A., Malats N., Briggs A., Schroter S., Altman D.G. & Hemingway H. (2013) Prognosis research strategy (PROGRESS) 2: prognostic factor research. *PLoS Med* **10**(2), e1001380.

Rivas-Ruiz F., Pérez-Vicente S. & González-Ramírez A.R. (2012) Bias in clinical epidemiological study designs. *Allergologia et immunopathologia* **41**(1), 54-59.

Robert Peter J., Ho J.J., Valliapan J. & Sivasangari S. (2015) Symphysial fundal height (SFH) measurement in pregnancy for detecting abnormal fetal growth. *Cochrane Database of Systematic Reviews 2015, Issue 9.* Art. No.: CD008136. DOI: 10.1002/14651858.

Roberts A.B., Griffin D., Mooney R., Cooper D.J. & Campbell S. (1980) Fetal activity in 100 normal third trimester pregnancies. *BJOG: An International Journal of Obstetrics & Gynaecology* **87**(6), 480-484.

Roberts A.B., Little D., Cooper D. & Campbell S. (1979) Normal patterns of fetal activity in the third trimester. *British Journal of Obstetrics & Gynaecology* **86**(1), 4-9.

Rolland Souza A.S., Cavalcante E.V.V., Macedo C.A., Freitas S.G., Figueiredo A.T.P., Alves S.A., Silva T., de Albuquerque Souza G.F. & Alves J.G. (2019) The impact of maternal touch of the abdomen on cardiotocography fetal patterns. *Brain Behaviour* **9**(8), e01345.

Roodenburg P.J., Wladimiroff J.W., van Es A. & Prechtl H.F.R. (1991) Classification and quantitative aspects of fetal movements during the second half of normal pregnancy. *Early Human Development* **25**(1), 19-35.

Roseingrave R., Murphy M. & O'Donoghue K. (2022) Pregnancy after stillbirth: maternal and neonatal outcomes and health service utilization. *American Journal of Obstetrics & Gynecology MFM* **4**(1).

Rossi A., Cornette J., Johnson M.R., Karamermer Y., Springeling T., Opic P., Moelker A., Krestin G.P., Steegers E., Roos-Hesselink J. & van Geuns R.-J.M. (2011) Quantitative cardiovascular magnetic resonance in pregnant women: cross-sectional analysis of physiological parameters throughout pregnancy and the impact of the supine position. *Journal of Cardiovascular Magnetic Resonance* **13**(1), 31.

Rothman K. & Greenland S. (1998) *Modern Epidemiology*. Lippincott, Williams & Wilkins

Royal College of Obstetricians and Gynaecologists (2011) *Reduced Fetal Movements: Green-top Guideline No.57*. RCOG, London. Retrieved from https://www.rcog.org.uk/media/2gxndsd3/gtg_57.pdf on 11 April 2018.

Royal College of Obstetricians and Gynaecologists (2014) *The Investigation and Management of Small-for-Gestational-Age Fetus*, London. Retrieved from https://www.rcog.org.uk/media/t3lmjhnl/gtg_31.pdf on 21 November 2019.

Ryo E., Kamata H., Seto M., Morita M., Nagaya Y., Nishihara K. & Ohki N. (2018) Reference values for a fetal movement acceleration measurement recorder to count fetal movements. *Pediatric Research* **83**(5), 961-968.

Ryo E., Nishihara K., Matsumoto S. & Kamata H. (2012) A new method for long-term home monitoring of fetal movement by pregnant women themselves. *Medical Engineering & Physics* **34**(5), 566-572.

Saastad E., Ahlborg T. & Froen J.F. (2008) Low maternal awareness of fetal movement is associated with small for gestational age infants. *Journal of Midwifery & Womens Health* **53**(4), 345-352.

Saastad E., Tveit J.V.H., Flenady V., Stray-Pedersen B., Fretts R.C., Børdahl P.E. & Frøen J.F. (2010) Implementation of uniform information on fetal movement in a Norwegian population reduced delayed reporting of decreased fetal movement and stillbirths in primiparous women - a clinical quality improvement. *BMC Research Notes* **3**(1), 2.

Saastad E., Winje B.A., Israel P. & Frøen J.F. (2012) Fetal Movement Counting—Maternal Concern and Experiences: A Multicenter, Randomized, Controlled Trial. *Birth* **39**(1), 10-20.

Sadovsky E. & Yaffe H. (1973) Daily fetal movement recording and fetal prognosis. *Obstetrics & Gynecol*ogy **41**(6), 845-850.

Sadovsky E., Samueloff A., Sadovsky Y. & Ohel G. (1986) Incidence of spontaneous and evoked fetal movements. *Gynecologic and Obstetric Investigation* **21**(4), 177-181.

Sage Y.H. & Fretts R. (2012a) Characteristics and pregnancy outcomes of women presenting with decreased fetal movement. *Prenatal Diagnosis* **32**((Supplement 1)), 70.

Sage Y.H. & Fretts R. (2012b) Intra-uterine growth restriction and decreased fetal movement in the third trimester. *Prenatal Diagnosis* **32**((Supplement 1)),70-71.

Sajapala S., AboEllail M.A.M., Kanenishi K., Mori N., Marumo G. & Hata T. (2017) 4D ultrasound study of fetal movement early in the second trimester of pregnancy. *Journal of Perinatal Medicine* **45**(6), 737-743.

San Lazaro Campillo I., Manning E., Corcoran P., Keane J., O'Farrell B., McKernan J., White E.J., Greene R. & Committee on behalf of the Perinatal Mortality National Clinical Audit Governance Committee (2022) *Perinatal Mortality National Audit in Ireland Annual Report 2020*. Retrieved from https://www.ucc.ie/en/media/research/nationalperinatalepidemiologycentre/NPECPerinatalMortalityinIrelandannualreport2020.pdf on 19 January 2023.

Sazali A. & Al-Ashwal R. (2018) Fetal Movement Simulator for Fetal Monitoring System Testing. *IEEE-EMBS Conference on Biomedical Engineering and Sciences (IECBES),* 544-547.

Scala C., Bhide A., Familiari A., Pagani G., Khalil A., Papageorghiou A. & Thilaganathan B. (2015) Number of episodes of reduced fetal movement at term: association with adverse perinatal outcome. *American Journal of Obstetrics and Gynecology* **213**(5), 678.e671-678.e676.

Schmidt W., Cseh I., Hara K. & Kubli F. (1984) Maternal perception of fetal movements and real-time ultrasound findings. *Journal of Perinatal Medicine* **12**(6), 313-318.

Schummers L., Hutcheon J.A., Bodnar L.M., Lieberman E. & Himes K.P. (2015) Risk of adverse pregnancy outcomes by prepregnancy body mass index: a population-based study to inform prepregnancy weight loss counseling. *Obstetrics & Gynecology* **125**(1), 133-143.

Sheikh M., Hantoushzadeh S. & Shariat M. (2014) Maternal perception of decreased fetal movements from maternal and fetal perspectives, a cohort study. *BMC Pregnancy Childbirth* **14**, 286.

Sherer D.M., Spong C.Y., Minior V.K. & Salafia C.M. (1996) Decreased amniotic fluid volume at < 32 weeks of gestation is associated with decreased fetal movements. *American Journal of Perinatology* **13**(8), 479-482.

Simon A., Pratt M., Hutton B., Skidmore B., Fakhraei R., Rybak N., Corsi D.J., Walker M., Velez M.P. & Smith G.N. (2020) Guidelines for the management of pregnant women with obesity: A systematic review. *Obesity Reviews* **21**(3), e12972.

Singh G. & Sidhu K. (2008) Daily fetal movement count chart : Reducing perinatal mortality in low risk pregnancy. *Medical Journal Armed Forces India* **64**(3), 212-213.

Sinha D., Sharma A., Nallaswamy V., Jayagopal N. & Bhatti N. (2007) Obstetric outcome in women complaining of reduced fetal movements. *Journal of Obstetrics and Gynaecology* **27**(1), 41-43.

Sival D.A., Visser G.H.A. & Prechtl H.F.R. (1990) Does reduction of amniotic fluid affect fetal movements? *Early Human Development* **23**(3), 233-246.

Sival D., Visser G. & Prechtl H. (1992) The effect of intrauterine growth retardation on the quality of general movements in the human fetus. *Early Human Development* **28**(2), 119-132.

Smith V., Begley C., Clarke M. & Devane D. (2014) Decreased fetal movements (DFM) in pregnancy: a retrospective cohort study. 30th International Confederation of Midwives (ICM) Triennial Conference, Prague.

Smith V., Begley C. & Devane D. (2014) Detection and management of decreased fetal movements in Ireland: a national survey of midwives' and obstetricians' practices. *Midwifery* **30**(1), 43-49.

Smyth R.M., Taylor W., Heazell A.E., Furber C., Whitworth M. & Lavender T. (2016) Women's and clinicians perspectives of presentation with reduced fetal movements: a qualitative study. *BMC Pregnancy Childbirth* **16**(1), 280.

Sovio U., White I.R., Dacey A., Pasupathy D. & Smith G.C. (2015) Screening for fetal growth restriction with universal third trimester ultrasonography in nulliparous women in the Pregnancy Outcome Prediction (POP) study: a prospective cohort study. *The Lancet* **386**(10008), 2089-2097.

Spellacy W.N., Cruz A.C., Gelman S.R. & Bum W.C. (1977) Fetal movements and placental lactogen levles for fetal-placental evaluation: A preliminary report. *Obstetrics and Gynecology (New York. 1953)* **49**(1), 113-114.

Spillane N., Meaney S. & O' Donoghue K. (2018) Irish women's experience of Ectopic pregnancy. *Sexual & Reproductive Healthcare* **16**, 154-159.

Stacey T., Thompson J.M., Mitchell E.A., Ekeroma A., Zuccollo J. & McCowan L.M. (2011a) Maternal perception of fetal activity and late stillbirth risk: findings from the Auckland Stillbirth Study. *Birth* **38**(4), 311-316.

Stacey T., Thompson J.M., Mitchell E.A., Ekeroma A.J., Zuccollo J.M. & McCowan L.M. (2011b) Association between maternal sleep practices and risk of late stillbirth: a case-control study. *BMJ* **342**.

Stacey T., Thompson J.M., Mitchell E.A., Zuccollo J.M., Ekeroma A.J. & McCowan L.M. (2012) Antenatal care, identification of suboptimal fetal growth and risk of late stillbirth: findings from the Auckland Stillbirth Study. *Australian and New Zealand Journal of Obstetrics and Gynaecology* **52**(3), 242-247.

Stearne J.A.C., Higgins J.P.T. & Reaves B.C. (2014) *A Cochrane risk of bias assessment tool: For non-randomized studies of interventions (ACROBAT-NRSI)*. Retrieved from http://www.riskofbias.info on 19th September 2018.

Stenhouse E., Letherby G. & Stephen N. (2013) Women with pre-existing diabetes and their experiences of maternity care services. *Midwifery* **29**(2), 148-153.

Sterne J.A.C., Sutton A.J., Ioannidis J.P.A., Terrin N., Jones D.R., Lau J., Carpenter J., Rücker G., Harbord R.M., Schmid C.H., Tetzlaff J., Deeks J.J., Peters J., Macaskill P., Schwarzer G., Duval S., Altman D.G., Moher D. & Higgins J.P.T. (2011) Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. *BMJ* **343**(7818), 302-307.

Sterpu I., Pilo C., Koistinen I.S., Lindqvist P.G., Gemzell-Danielsson K., Itzel E.W. & Gemzell-Danielsson K. (2020) Risk factors for poor neonatal outcome in pregnancies with decreased fetal movements. *Acta Obstetricia et Gynecologica Scandinavica* **99**(8), 1014-1021.

Stroup D.F., Berlin J.A., Morton S.C., Olkin I., Williamson G.D., Rennie D., Moher D., Becker B.J., Sipe T.A. & Thacker S.B. (2000) Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. *Journal of the American Medical Association* **283**(15), 2008-2012.

Szumilas M. (2010) Explaining odds ratios. *Journal of the Canadian Academy of Child and Adolescent* **19**(3), 227-229.

Tan K.H. & Sabapathy A. (2012) Maternal glucose administration for facilitating tests of fetal wellbeing. *Cochrane Database of Systematic Reviews 2001, Issue 4.* Art. No.: CD003397. DOI: 10.1002/14651858.

Tanner M.S., Malhotra A., Davey M.-A., Wallace E.M., Mol B.W. & Palmer K.R. (2022) Maternal and neonatal complications in women with medical comorbidities and preeclampsia. *Pregnancy Hypertension* **27**, 62-68.

Thomsen S.G., Legarth J., Weber T. & Kristensen J. (1990) Monitoring of normal pregnancies by daily fetal movement registration or hormone assessment. A random allocation study. *Journal of Obstetrics and Gynaecology* **10**(3), 189-193.

Thomson G., Cook J., Crossland N., Balaam M.-C., Byrom A., Jassat R. & Gerrard S. (2022) Minoritised ethnic women's experiences of inequities and discrimination in maternity services in North-West England: a mixed-methods study. *BMC Pregnancy and Childbirth* **22**(1), 958-958.

Tobin C., Murphy-Lawless J. & Beck C.T. (2014) Childbirth in exile: Asylum seeking women's experience of childbirth in Ireland. *Midwifery* **30**(7), 831-838.

Toh R.K.C. & Shorey S. (2023) Experiences and needs of women from ethnic minorities in maternity healthcare: A qualitative systematic review and meta-aggregation. *Women and Birth* **36**(1), 30-38.

Toker E. & KÖMÜRcÜ N. (2016) Effect of Turkish Classical Music on Prenatal Anxiety and Satisfaction: A Randomized Controlled Trial in Pregnant Women with Pre-eclampsia. *Complementary Therapies in Medicine* **30**, 1-9.

Tommy's (2021) *Movements matter-raising awareness of fetal movements*. Retrieved from https://www.tommys.org/pregnancy-information/pregnancy-symptom-checker/movements-matter-raising-awareness-fetal-movements on 04 April 2021.

Torloni M.R., Betran A.P., Daher S., Widmer M., Dolan S.M., Menon R., Bergel E., Allen T. & Merialdi M. (2009) Maternal BMI and preterm birth: a systematic review of the literature with meta-analysis. *The Journal of Maternal-Fetal & Neonatal Medicine* **22**(11), 957-970.

Treacy M. & Hyde A. (1999) *Nursing Research. Design of Practice*. University College Press, Dublin.

Trinity College Dublin (2021) *Data Protection Handbook*. Retrieved from https://www.tcd.ie/dataprotection/assets/docs/dataprotectionhandbook/DP_Handbook_09032021.pdf on 15 December 2022.

Tsakiridis I., Zerva C., Mamopoulos A., Kalogiannidis I., Athanasiadis A. & Dagklis T. (2022) Maternal perception of fetal movements: onset and associated factors. *Journal of Perinatal Medicine* **50**(9), 1174-1179.

Tuffnell D.J., Cartmill R.S. & Lilford R.J. (1991) Fetal movements; factors affecting their perception. *European Journal of Obstetrics & Gynecology and Reproductive Biology* **39**(3), 165-167.

Turner J.M., Cincotta R., Chua J., Gardener G., Petersen S., Thomas J., Lee-Tannock A. & Kumar S. (2023) Decreased fetal movements—the utility of ultrasound to identify infants at risk and prevent stillbirth is poor. *American Journal of Obstetrics & Gynecology* **5**(2), 100782.

Turner J.M., Flenady V., Ellwood D., Coory M. & Kumar S. (2021) Evaluation of pregnancy outcomes among women with decreased fetal movements. *JAMA Network Open* **4**(4), e215071.

Tveit J.V., Saastad E., Stray-Pedersen B., Bordahl P.E., Flenady V., Fretts R. & Froen J.F. (2009a) Reduction of late stillbirth with the introduction of fetal movement information and guidelines - a clinical quality improvement. *BMC Pregnancy Childbirth* **9**, 32.

Tveit J.V., Saastad E., Stray-Pedersen B., Børdahl P.E. & Frøen J.F. (2009b) Maternal characteristics and pregnancy outcomes in women presenting with decreased fetal movements in late pregnancy. *Acta Obstetricia et Gynecologica Scandinavica* **88**(12), 1345-1351.

Unterscheider J., Horgan R.P., Greene R.A. & Higgins J.R. (2010) The management of reduced fetal movements in an uncomplicated pregnancy at term: results from an anonymous national online survey in the Republic of Ireland. *Journal of Obstetrics & Gynaecology* **30**(6), 578-582.

Valencia-Rincon E., Reyna-Villasmil E., Torres-Cepeda D., Mejia-Montilla J., Reyna-Villasmil N., Fernandez-Ramirez A. & Rondon-Tapia M. (2017) Decreased fetal movements and perinatal outcome in term pregnancies. *Avances en Biomedicinia* **6**(2), 98-104.

Valentin L. & Marsal K. (1987) Pregnancy outcome in women perceiving decreased fetal movement. *European Journal of Obstetrics & Gynecology and Reproductive Biology* **24**(1), 23-32.

Valentin L., Löfgren O., Marsál K. & Gullberg B. (1984) Subjective recording of fetal movements. I. Limits and acceptability in normal pregnancies. *Acta Obstetricia et Gynecologica Scandinavica* **63**(3), 223-228.

Valentin L., Marŝsál K. & Lindström K. (1986) Recording of foetal movements: a comparison of three methods. *Journal of Medical Engineering & Technology* **10**(5), 239-247.

Valman H.B. & Pearson J.F. (1980) What the fetus feels. *British Medical Journal* **280**(6209), 233.

Van den Broeck J., Cunningham S.A., Eeckels R. & Herbst K. (2005) Data cleaning: detecting, diagnosing, and editing data abnormalities. *PLoS Med* **2**(10), e267.

van Teijlingen E. & Hundley V. (2002) The importance of pilot studies. *Nursing Standard* **16**(40), 33-36.

Verlijsdonk J.-W., Winkens B., Boers K., Scherjon S. & Roumen F. (2012) Suspected versus non-suspected small-for-gestational age fetuses at term: perinatal outcomes. *The Journal of Maternal-Fetal & Neonatal Medicine* **25**(7), 938-943.

Verma J.P., Abdel-Salam & Abdel-Salam G. (2019) *Testing statistical assumptions in research*. Wiley, Hoboken, NJ.

Vieira M.C., Relph S., Muruet-Gutierrez W., Elstad M., Coker B., Moitt N., Delaney L., Winsloe C., Healey A., Coxon K., Alagna A., Briley A., Johnson M., Page L.M., Peebles D., Shennan A., Thilaganathan B., Marlow N., McCowan L., Lees C., Lawlor D.A., Khalil A., Sandall J., Copas A. & Pasupathy D. (2022) Evaluation of the Growth Assessment Protocol (GAP) for antenatal detection of small for gestational age: The DESiGN cluster randomised trial. *PLoS Med* **19**(6), e1004004.

Vik E.S., Aasheim V., Schytt E., Small R., Moster D. & Nilsen R.M. (2019) Stillbirth in relation to maternal country of birth and other migration related factors: a population-based study in Norway. *BMC Pregnancy and Childbirth* **19**(1), 1-11.

von Elm E., Altman D.G., Egger M., Pocock S.J., Gøtzsche P.C. & Vandenbroucke J.P. (2014) The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: Guidelines for reporting observational studies. *International Journal of Surgery* **12**(12), 1495-1499.

Wacholder S., McLaughlin J.K., Silverman D.T. & Mandel J.S. (1992a) Selection of controls in case-control studies. I. Principles. *American Journal of Epidemiol*ogy **135**(9), 1019-1028.

Wacholder S., Silverman D.T., McLaughlin J.K. & Mandel J.S. (1992b) Selection of Controls in Case-Control Studies: III. Design Options. *American Journal of Epidemiology* **135**(9), 1042-1050.

Wackers K., Wassen M., Zeegers B., Bude L. & Nieuwenhuijze M.J. (2019) Effect of the use of a national information brochure about fetal movements on patient delay. *Women and Birth* **32**(2), 131-136.

Walker K.F. & Thornton J.G. (2018) Encouraging awareness of fetal movements is harmful. *The Lancet* **392**(10158), 1601-1602.

Warland J. & Glover P. (2017) Fetal movements: What are we telling women? *Women and Birth* **30**(1), 23-28.

Warland J., Heazell A.E.P., Stacey T., Coomarasamy C., Budd J., Mitchell E.A. & O'Brien L.M. (2018) “They told me all mothers have worries”, stillborn mother's experiences of having a ‘gut instinct’ that something is wrong in pregnancy: Findings from an international case–control study. *Midwifery* **62**, 171-176.

Warrander L.K., Batra G., Bernatavicius G., Greenwood S.L., Dutton P., Jones R.L., Sibley C.P. & Heazell A.E. (2012) Maternal perception of reduced fetal movements is associated with altered placental structure and function. *PLOS ONE* **7**(4), e34851.

Whitty J.E., Garfinkel D.A. & Divon M.Y. (1991) Maternal perception of decreased fetal movement as an indication for antepartum testing in a low-risk population. *American Journal of Obstetrics & Gynecology* **165**(4 Pt 1), 1084-1088.

Widdows K., Roberts S.A., Camacho E.M. & Heazell A.E.P. (2021) Stillbirth rates, service outcomes and costs of implementing NHS England's Saving Babies' Lives care bundle in maternity units in England: A cohort study. *PLOS ONE* **16**(4), e0250150.

Winje B.A., Roislien J. & Froen J.F. (2012) Temporal patterns in count-to-ten fetal movement charts and their associations with pregnancy characteristics: a prospective cohort study. *BMC Pregnancy and Childbirth* **12**, 124.

Winje B.A., Saastad E., Gunnes N., Tveit J.V., Stray-Pedersen B., Flenady V. & Froen J.F. (2011) Analysis of 'count-to-ten' fetal movement charts: a prospective cohort study. *BJOG: An International Journal of Obstetrics & Gynaecology* **118**(10), 1229-1238.

Winje B.A., Wojcieszek A.M., Gonzalez-Angulo L.Y., Teoh Z., Norman J., Froen J.F. & Flenady V. (2016) Interventions to enhance maternal awareness of decreased fetal movement: a systematic review. *BJOG: An International Journal of Obstetrics & Gynaecology* **123**(6), 886-898.

Wojcieszek A., Boyle F., Belizán J., Cassidy J., Cassidy P., Erwich J., Farrales L., Gross M., Heazell A., Leisher S., Mills T., Murphy M., Pettersson K., Ravaldi C., Ruidiaz J., Siassakos D., Silver R., Storey C., Vannacci A., Middleton P., Ellwood D. & Flenady V. (2018) Care in subsequent pregnancies following stillbirth: an international survey of parents. *BJOG: An International Journal of Obstetrics & Gynaecology* **125**(2), 193-201.

Wood C., Walters W.A.W. & Trigg P. (1977) Methods of recording fetal movement. *BJOG: An International Journal of Obstetrics and Gynaecology* **84**(8), 561-567.

World Health Organization (2015) *WHO statement on caesarean section rates*. World Health Organization. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/161442/WHO_RHR_15.02_eng.pdf on 4 September 2020.

World Health Organization (2016) *WHO recommendations on antenatal care for a positive pregnancy experience*. Retrieved from https://www.who.int/publications/i/item/9789241549912 on 11 April 2019.

World Health Organisation (2017a) *Preterm Birth*. Retrieved from http://www.who.int/mediacentre/factsheets/fs363/en/ on 11 April 2019.

World Health Organisation (2017b) *Stillbirth*. Retrieved from http://www.who.int/maternal_child_adolescent/epidemiology/stillbirth/en/ on 11 April 2019.

Xu Z., Wen Z., Zhou Y., Li D. & Luo Z. (2017) Inadequate weight gain in obese women and the risk of small for gestational age (SGA): a systematic review and meta-analysis. *The Journal of Maternal-Fetal & Neonatal Medicine* **30**(3), 357-367.

Yigiter A.B. & Kavak Z.N. (2006) Normal standards of fetal behavior assessed by four-dimensional sonography. *The Journal of Maternal-Fetal & Neonatal Medicine* **19**(11), 707-721.

Yogev Y., Ben-Haroush A., Horowitz E.R., Chen R., Hod M. & Kaplan B. (2003) PGE2 induction of labor for consistent decreased perception of fetal movements at term. *International Journal of Gynecology & Obstetrics* **82**(2), 173-178.

Zamstein O., Wainstock T. & Sheiner E. (2019) Decreased fetal movements: Perinatal and long-term neurological outcomes. *European Journal of Obstetrics & Gynecology and Reproductive Biology* **241**, 1-5.

Zia S. (2013) Placental location and pregnancy outcome. *Journal Of The Turkish-German Gynecological Association* **14**(4), 190-193.

Appendices

Appendix 1 Search Strategy

Database (Date)	Filters	Search	Number of citations			
			23rd March 2018	16th May 2019	8th July 2021	Total
PubMed	None	((((((((((fetal movement[MeSH Terms]) OR fetal movement*) OR foetal movement*) OR fetal activit*) OR foetal activit*) OR fetal movement*[Title/Abstract]) OR foetal movement*[Title/Abstract]) OR fetal activit*[Title/Abstract]) OR foetal activit*[Title/Abstract])) AND ((((reduc*) OR decreas*) OR decreas*[Title/Abstract]) OR reduc*[Title/Abstract])	980	30	1292	**2302**
CINAHL Complete	None	(MH fetal movement OR TI foetal movement* OR TI fetal movement* OR TI foetal activiat* OR AB foetal movement*OR AB fetal movement* OR AB fetal activit* OR AB foetal activit*) AND (TI reduc* OR decreas* AB reduc* OR reduc)	1384	128	222	**1734**
Maternity and Infant Care	None	1. Fetal movement.de. 2. fetal movement*.mp. [mp=abstract, heading word, title] 3. foetal movement*.mp. [mp=abstract, heading word, title] 4. fetal activit*.mp. [mp=abstract, heading word, title] 5. foetal activit*.mp. [mp=abstract, heading word, title] 6. (reduc* or decreas*).mp. [mp=abstract, heading word, title] 7. 1 or 2 or 3 or 4 or 5 8. 6 and 7	303	22	20	**345**
PsycINFO	None	(TI foetal movement* OR TI fetal movement* OR TI foetal activit* OR TI fetal activit* OR AB foetal movement* OR AB fetal movement* OR AB foetal activit* OR AB fetal activit* AND (TI (reduc* OR decreas*) OR AB (reduc* OR decreas*))	153	4	8	**165**
EMBASE	None	#10 #6 AND #9 #9 #7 OR #8 #8 'decreas*': ti, ab, kw #7 'reduc*': ti, ab, kw #6 #1 OR #2 OR #3 OR #4 OR #5 #5 'fetal activit*': ti, ab, kw #4 'foetal activit*': ti, ab, kw #3 'foetal movement*': ti, ab, kw	1459	166	285	**1910**

		#2 'fetal movement*':ti, ab, kw #1 'Fetus movement'/exp				
Science Citation	None	#8 #7 AND #6 #7 #5 OR #4 OR #3 OR #2 OR #1 #6 TI=reduc* OR TI=decreas* #5 TI=foetal activit* #4 TI=fetal activit* #3 TI=foetal movement* #2 TI=fetal movement* #1 TS=fetal movement*	260	22	2	**284**
			Total	4539	372	1829	**6740**
			Duplicates found in endnote	1389	125	200	**1714**
			Records imported into Covidence for screening	3150	247	1629	**5026**
			Total records imported into Covidence for screening				**5026**

Appendix 2 Data Extraction Form (per study) adapted from Excel file

STUDY	**Reference**	
	Lead Author	
	Year of Publication	
	Country	
	Study Setting *e.g., tertiery maternity unit*	
	Study Design *e.g., retrospective*	
	Data Collection Method *e.g., electronic chart*	
	Recruitment period	
PARTICIPANTS	**Participants Inclusion Criteria** *e.g., singleton pregnancy*	
	Participants Exclusion Criteria *e.g., multiple pregnancy*	
	Number of Participants *total no recruited*	
	Number of participants in analysis *e.g., 50/70*	
	Full Description of Cohort *e.g., parity, age*	
EXPOSURE	**Definition of Exposure (RFM)**	
	Time of Exposure (RFM) *e.g., gestation*	
RISK FACTORS	**Risk Factors for developing RFM** *please list*	

	RF Yes/RFM YES *n=*	
	RF Yes/RFM No *n=*	
	RF No/RFM YES *n=*	
	RF No/RFM No n=	
OUTCOMES	**Outcomes reported*please list e.g., stillbirth, IUGR***	
	Definition of Outcome reported	
	No of Participants included in analysis	
	RFM YES/Out YES *n=*	
	RFM YES/Out NO *n=*	
	RFM NO/Out YES *n=*	
	RFM NO/Out NO *n=*	
ANALYSIS	**Type of Risk Estimate used *e.g., odds ratio***	
	Unadjusted Risk Estimate	
	Adjusted Risk Estimate	
	Confounders adjusted for *please list*	
	Method of Analysis	

Appendix 3 Quality in Prognosis Studies (QUIPS) Tool

Quality In Prognosis Studies (QUIPS) tool	
REVIEWER: VS ☐ LG ☐ LC ☐	**DATE:**
STUDY No:	
AUTHOR/YEAR:	
REFERENCE/TITLE:	

BIASES	Issues to consider for judging overall rating of "Risk of bias"	Study Methods and Comments		Rating of reporting	Rating of risk of bias
Assess the risk of each potential bias	**These issues will guide your thinking and judgement about the overall risk of bias within each of the 6 domains.**	**Provide comments or excerpts to facilitate the consensus process that will follow**	**Page No:**	**Y: Yes N: No P: Partial U: Unknown NA: not applicable**	
1. STUDY PARTICIPATION	**The study sample adequately represents the population of interest**				
	a. Adequate participation in the study by eligible persons (>80%)				
	b. Description of the source population or population of interest				**HIGH ☐ MODERATE ☐ LOW ☐ UNKNOWN ☐**
	c. Description of the baseline study sample				
	d. Adequate description of the sampling frame and recruitment				
	e. Adequate description of the period and place of recruitment				
	f. Adequate description of inclusion and exclusion criteria				

2. STUDY ATTRITION	**The study data available (i.e. participants not lost to follow-up) adequately represent the study sample**	**Provide comments or excerpts to facilitate the consensus process that will follow**	**Page No:**	**Y: Yes N: No P: Partial U: Unknown NA: not applicable**	
	a. Adequate response rate for study participants *(> 80%)*				
	b. Description of attempts to collect information on participants who dropped out				**HIGH** ☐ **MODERATE** ☐ **LOW** ☐ **UNKNOWN** ☐
	c. Reasons for loss to follow-up are provided				
	d. Adequate description of participants lost to follow-up				
	There are no important differences between participants who completed the study and who did not				

Assess the risk of each potential bias	These issues will guide your thinking and judgement about the overall risk of bias within each of the 6 domains.	Provide comments or excerpts to facilitate the consensus process that will follow	Page No:	Y: Yes N: No P: Partial U: Unknown NA: not applicable	
3. RISK FACTORS MANAGEMENT	**The Risk Factor(RF) is measured in a similar way for all participants**				
	a. A clear definition or description of the RF is provided				**HIGH** ☐ **MODERATE** ☐ **LOW** ☐ **UNKNOWN** ☐
	b. Method of RF measurement is adequately valid and reliable (i.e. direct ascertainment; secure record, hospital record)				
	c. Continuous variables are reported or appropriate cut points are used				
	d. The method and setting of measurement of RF is the same for all study participants				
	e. Adequate proportion of the study sample has complete data for the RF *(> 80%)*				
	f. Appropriate methods of imputation are used for missing RF data				

4. OUTCOME MEASUREMENT	The outcome of interest is measured in a similar way for all participants	**Provide comments or excerpts to facilitate the consensus process that will follow**	**Page No:**	**Y: Yes N: No P: Partial U: Unknown NA: not applicable**	
	a. A clear definition of the outcome(s) of interest is provided				
	b. Method of outcome measurement used is adequately valid and reliable (i.e. independent blind assessment, hospital record or record linkage)				**HIGH** ☐ **MODERATE** ☐ **LOW** ☐ **UNKNOWN** ☐
	c. The method and setting of outcome measurement is the same for all study participants				

Assess the risk of each potential bias	These issues will guide your thinking and judgement about the overall risk of bias within each of the 6 domains.	Provide comments or excerpts to facilitate the consensus process that will follow	Page No:	Y: Yes N: No P: Partial U: Unknown NA: not applic	
5. STUDY CONFOUNDING	**Important potential confounder are appropriately accounted for**				**HIGH** ☐ **MODERATE** ☐ **LOW** ☐ **UNKNOWN** ☐
	a. *Most* important confounders are measured				
	b. Clear definitions of the important confounders measured are provided				
	c. Measurement of all important confounders is adequately valid and reliable				
	d. The method and setting of confounding measurement are the same for all study participants				
	e. Appropriate methods are used if imputation is used for missing confounder data				
	f. Important potential confounders are accounted for in the study design (by limiting the study to specific population groups, or by matching)				
	g. Important potential confounders are accounted for in the analysis *(by stratification, multivariate regression)*				

6. STATISTICAL ANALYSIS & PRESENTATION	**The, and all primary statistical analysis is appropriate outcomes are reported**	**Provide comments or excerpts to facilitate the consensus process that will follow**	**Page No:**	**Y: Yes N: No P: Partial U: Unknown NA: not applicable**	
	a. Sufficient presentation of data to assess the adequacy of the analytic strategy				**HIGH** ☐ **MODERATE** ☐ **LOW** ☐ **UNKNOWN** ☐
	b. Strategy for model building is appropriate and is based on a conceptual framework or model				
	c. The selected statistical model is adequate for the design of the study				
	d. There is no selective reporting of results (*based on the study protocol, if available, or on the method section*)				

Appendix 4 List of Excluded Studies

Abstract only: insufficient data provided to include (n=8)								
Authors	**Published Year**	**Title**	**Journal**	**Volume**	**Issue**	**Pages**	**DOI**	**Exclusion Reason**
Gordon, A.; Raynes-Greenow, C. H.; Bond, D.; Jones, R.; Morris, J. M.; Jeffery, H. E.	2011	The sydney stillbirth study: What is important when assessing maternal perception of fetal movements, quality vs quantity?	American Journal of Epidemiology	173		S140	10.1093/aje/kwr181	Exclusion reason: Abstract only (insufficient data provided to include)
Ross, C.; Narain, S.; Sharma, S.; Lakasing, L.	2015	Perinatal outcomes in women who present with reduced fetal movements	BJOG: An International Journal of Obstetrics and Gynaecology	122		60	10.1111/14710528.13373	Exclusion reason: Abstract only (insufficient data provided to include)
Tirlapur, A.; Jardine, J.; Agnihotri, S.	2015	Is there an association between decreased fetal movements and the incidence of stillbirth?		122		06-Jun		Exclusion reason: Abstract only (insufficient data provided to include)
Warland, J.; O'Brien, L. M.; Heazell, A. E. P.; Mitchell, E. A.	2016	Study of trends and associated risks for stillbirth: Findings from the stars study	J Paediatr Child Health	52		14	10.1111/jpc.13194	Exclusion reason: Abstract only (insufficient data provided to include)
Bischof, Helen; Greenwood, Susan; Sibley, Colin; Heazell, Alexander; Desforges, Michelle	2017	Increased markers of cell stress in placentas from women with reduced fetal movements	Placenta	57		253-253	10.1016/j.placenta.2017.07.105	Exclusion reason: Abstract only (insufficient data

								provided to include)
Bradford, B. F.; Cronin, R. M.; McCowan, L. M. E.; McKinlay, C. J. D.; Mitchell, E. A.; Thompson, J. M. D.	2018	Maternal perception of fetal movement quality and risk of late stillbirth	Journal of Paediatrics and Child Health	54		10	10.1111/jpc.13882_19	Exclusion reason: Abstract only (insufficient data provided to include)
	2019	RETROSPECTIVE REVIEW OF PATIENTS WITH REPEATED PRESENTATIONS FOR MATERNAL REDUCED FETAL MOVEMENTS (RFMS) AND VARYING NUMBERS OF PSANZ STILLBIRTH RISK FACTORS (SRFS) WITH NEONATAL BIRTH OUTCOMES IN A HIGH RISK AUSTRALIAN QUATERNARY MATERNAL FETAL ASSESSMENT UNIT (MFAU)	Journal of Paediatrics & Child Health	55		105-105	10.1111/jpc.14410_151	Exclusion reason: Abstract only (insufficient data provided to include)
	2019	FETAL CEREBROPLACENTAL RATIO AND ADVERSE PERINATAL OUTCOMES IN WOMEN PRESENTING WITH DECREASED FETAL MOVEMENTS IN THE THIRD TRIMESTER	Journal of Paediatrics & Child Health	55		109-109	10.1111/jpc.14410_162	Exclusion reason: Abstract only (insufficient data provided to include)
Abstract or Thesis of Included Full Text (n=3)								
Authors	**Published Year**	**Title**	**Journal**	**Volume**	**Issue**	**Pages**	**DOI**	**Exclusion Reason**
Turner, J.; Kumar, S.	2019	Fetal cerebroplacental ratio and adverse perinatal outcomes in women presenting with decreased fetal movements in the third trimester	Journal of Paediatrics and Child Health	55		109	10.1111/jpc.14410_162	Exclusion reason: Abstract of included full-text - no

								additional information
Levy, M.; Kovo, M.; Izaik, Y.; Cohen, I. L.; Herman, H. G.; Barda, G.; Bar, J.; Weiner, E.	2020	204: Is there an association between reduced fetal movements at term and placental histopathological findings?	American Journal of Obstetrics and Gynecology	222	1	S140-S141	10.1016/j.ajog.2019.11.220	Exclusion reason: Abstract of included full-text - no additional information
Sterpu, Irene	2021	Pregnancies with decreased fetal movements: Risk factors and strategies for mitigation of poor neonatal outcomes		82				Exclusion reason: Thesis of included full-text- no additional information

Duplicate (n=10)								
Authors	**Published Year**	**Title**	**Journal**	**Volume**	**Issue**	**Pages**	**DOI**	**Exclusion Reason**
Radivojevic, K.	1990	[Ante partum monitoring of fetal status by maternal recording of fetal movement]	Geburtshilfe Frauenheilkd	50	5	349-52	10.1055/s-2008-1026259	Exclusion reason: Duplicate
Stacey, Tomasina; Thompson, John M. D.; Mitchell, Edwin A.; Ekeroma, Alec; Zuccollo, Jane; McCowan, Lesley M. E.	2011	Maternal Perception of Fetal Activity and Late Stillbirth Risk: Findings from the Auckland Stillbirth Study	Birth: Issues in Perinatal Care	38	4	311-316	10.1111/j.1523-536X.2011.00490.x	Exclusion reason: Duplicate
Kellison, L.; Wolff, O.; Ferguson, E.	2013	An audit of reduced fetal movements in a district general hospital in Lanarkshire, 2012-2013	BJOG: An International Journal of Obstetrics and Gynaecology	120		43-44	10.1111/1471-0528.12293	Exclusion reason: Duplicate
Aviram, A.; Ashwal, E.; Hiersch, L.; Hadar, E.; Wiznitzer, A.; Yogev, Y.	2015	Decreased perception of fetal movements at term among nulliparous women - old complaint, new insights?	Am J Obstet Gynecol	212	1	S80-S80	10.1016/j.ajog.2014.10.171	Exclusion reason: Duplicate
Ho, D.; Wang, J.; Homann, Y.; Alphonse, J.; Beirne, G.; Welsh, A. W.; Henry, A.	2016	P13.11: Assessment of third trimester pregnancies complicated by decreased fetal movements (DFM) using the fetal myocardial performance index (MPI)	Ultrasound in Obstetrics & Gynecology	48		207-208	10.1002/uog.16622	Exclusion reason: Duplicate

Binder, J.; Monaghan, C.; Thilaganathan, B.; Morales-Rosello, J.; Khalil, A.	2017	Cerebroplacental ratio in recurrent reduced fetal movements: Evidence for worsening fetal hypoxemia	BJOG: An International Journal of Obstetrics and Gynaecology	124		22	10.1111/1471-0528.14586	Exclusion reason: Duplicate
Warland, J.; Heazell, A. E. P.; Stacey, T.; Coomarasamy, C.; Budd, J.; Mitchell, E. A.; O'Brien, L. M.	2018	Reduced fetal movements: Should we use 'altered fetal activity' instead?	Journal of Paediatrics and Child Health	54		51	10.1111/jpc.13882_129	Exclusion reason: Duplicate
Heazell, A.; Li, M.; Budd, J.; Cronin, R.; Bradford, B.; Mc Cowan, L. M. E.; Mitchell, E. A.; Stacey, E. A.; Martin, B.; Roberts, D.; Thompson, J. M. D.	2018	Patterns of fetal movement and the association with late stillbirth	Journal of Paediatrics and Child Health	54		24	10.1111/jpc.13882_57	Exclusion reason: Duplicate
Binder, J.; Monaghan, C.; Thilaganathan, B.; Morales-Rosello, J.; Khalil, A.	2018	Cerebroplacental ratio in recurrent reduced fetal movements: Evidence for worsening fetal hypoxemia	Geburtshilfe und Frauenheilkunde	78	5		10.1055/s-0038-1648256	Exclusion reason: Duplicate
Zhang, Y.; Wang, L.; Yin, C.; *et al.*,		Alterations in maternally perceived fetal movement and their association with late stillbirth: findings from the Midland and North of England stillbirth case-control study	BMJ Open					Exclusion reason: Duplicate

Full text not in English or Spanish (n=11)								
Authors	**Published Year**	**Title**	**Journal**	**Volume**	**Issue**	**Pages**	**DOI**	**Exclusion Reason**
Ehrstrom, C.	1979	Fetal movements and high-risk pregnancy	Lakartidningen	76	10	853-857		Exclusion reason: Full-text not in English or Spanish
Toldy, M.; Mlyncek, M.; Danko, J.	1982	Motile activity of fetuses in risk pregnancies	Bratislavske Lekarske Listy	77	6	687-694		Exclusion reason: Full-text not in English or Spanish

Radivojevic, K.	1990	Daily fetal movement charting - a simple test for fetal well-being	Geburtshilfe Frauenheilkd	50	5	349-352		Exclusion reason: Full-text not in English or Spanish
Romero Gutierrez, G.; Sanchez Cortes, R.; Soto Pompa, V.; Rodriguez Flores, P.	1994	[Perinatal morbidity and mortality associated with fetal hypomotility]	Ginecol Obstet Mex	62		222-5		Exclusion reason: Full-text not in English or Spanish
Sergent, F.; Lefevre, A.; Verspyck, E.; Marpeau, L.	2005	[Decreased fetal movements in the third trimester: what to do?]	Gynecol Obstet Fertil	33	11	861-9	10.1016/j.gyobfe.2005.07.041	Exclusion reason: Full-text not in English or Spanish
FrÃ¸en, J. F.; Saastad, E.; Tveit, J. V. H.; BÃ¸rdahl, P. E.; Stray-Pedersen, B.	2005	Reduced fetal movements: Guidelines for management and information to pregnant women	Tidsskrift for den Norske Laegeforening	125	19	2631-2634		Exclusion reason: Full-text not in English or Spansih
Froen, J. F.; Saastad, E.; Tveit, J. V.; Bordahl, P. E.; Stray-Pedersen, B.	2005	[Clinical practice variation in reduced fetal movements]	Tidsskr Nor Laegeforen	125	19	2631-4		Exclusion reason: Full-text not in English or Spanish
Boog, G.	2006	[Decreased fetal movements in the third trimester: what to do? Gynecol Obstet Fertil 2005;33:861-869]	Gynecol Obstet Fertil	34	9	874-6	10.1016/j.gyobfe.2006.07.019	Exclusion reason: Full-text not in English or Spanish
Acar, Z.; YalvaÃ§, S.; KarÃ§aaltincaba, D.; Kandemir, O.; Haberal, A.	2009	The effect of antenatal betamethasone on biophysical profile and Doppler velocimetry of fetal and uterine arteries and apgar scores in healthy preterm fetuses	Turk Jinekoloji ve Obstetrik Dernegi Dergisi	6	3	185-192		Exclusion reason: Full-text not in English or Spanish
Kabootari, M.; Mobasheri, E.; Qorbani, M.; Asayesh, H.	2012	Non-stress test diagnostic values for predicting fetal outcomes in high risk pregnancies	Iranian Journal of Obstetrics, Gynecology and Infertility	15	7	17-23		Exclusion reason: Full-text not in English or Spanish

Blumrich, A.; Meinig, S.; Bittrich, H. J.; Naumann, G.	2016	Subjectively decreasing fetal movement - expression of fetomaternal transfusion syndrome	Geburtshilfe Frauenheilkd	76	5	2	10.1055/s-0036-1583585	Exclusion reason: Full-text not in English or Spanish

No non-RFM cohort for comparison (n=52)								
Authors	**Published Year**	**Title**	**Journal**	**Volume**	**Issue**	**Pages**	**DOI**	**Exclusion Reason**
Sadovsky, E.; Weinstein, D.; Even, Y.	1981	Antepartum fetal evaluation by assessment of fetal heart rate and fetal movements	Int J Gynaecol Obstet	19	1	21-Jun		Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Sadovsky, E.; Ohel, G.; Simon, A.; Aboulafia, Y.	1986	Decreased fetal activity in complications of pregnancy	Int J Gynaecol Obstet	24	6	443-6		Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Ahn, M. O.; Phelan, J. P.; Smith, C. V.; Jacobs, N.; Rutherford, S. E.; Ahn, M. O.; Phelan, J. P.; Smith, C. V.; Jacobs, N.; Rutherford, S. E.	1987	Antepartum fetal surveillance in the patient with decreased fetal movement	American Journal of Obstetrics & Gynecology	157	4	860-864		Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Moore, T. R.; Piacquadio, K.; Moore, T. R.; Piacquadio, K.	1989	A prospective evaluation of fetal movement screening to reduce the incidence of antepartum fetal death	American Journal of Obstetrics & Gynecology	160	5	1075-1080		Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Sival, D. A.; Visser, G. H.; Prechtl, H. F.	1992	The effect of intrauterine growth retardation on the quality of general movements in the human fetus		28	2	119-32		Exclusion reason: Wrong control (no

								non-RFM cohort for comparison)
Chew, F. T.; Beischer, N. A.	1992	Antepartum cardiotocographic surveillance of patients with diminished fetal movements	Aust N Z J Obstet Gynaecol	32	2	107-13		Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Korszun, P.; Dubiel, M.; Kudla, M.; Gudmundsson, S.	2002	Doppler velocimetry for predicting outcome of pregnancies with decreased fetal movements		81	10	926-30		Exclusion reason: Wrong control (no non-RFM cohort for comparison)
FrÃ¸en, J. F.; Tveit, J. V. H.; Saastad, E.; BÃ¸rdahl, P. E.; Stray-Pedersen, B.; Heazell, A. E. P.; Flenady, V.; Fretts, R. C.	2008	Management of decreased fetal movements	Seminars in Perinatology	32	4	307-311		Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Ibrahim, A.; Saeed Abdul Hakim, F.; Powell, K.	2009	Management of changing fetal activity pattern at Stafford General Hospital, United Kingdom	International Journal of Gynecology and Obstetrics	107		S206	10.1016/S0020-7292(09)60772-4	Exclusion reason: Wrong control (no non-RFM cohort for comparison) ;
Tveit, J.; Saastad, E.; Stray-Pedersen, B.; Bordahl, P.; Froen, F.	2009	Concerns for decreased fetal movements in uncomplicated pregnancies-increased risk of fetal growth restriction and stillbirth among women being overweight, advanced age or smoking	International Journal of Gynecology and Obstetrics	107		S364	10.1016/S0020-7292(09)61327-8	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Heazell, A. E. P.; O'Sullivan, O.; Stephen, G.; Martindale, E. A.	2009	Predicting Poor Perinatal Outcome in Women Who Present with Decreased Fetal	Reproductive Sciences	16	3	308A-309A		Exclusion reason: Wrong control (no

		Movements - A Preliminary Study						non-RFM cohort for comparison)
Tveit, J. V. H.; Saastad, E.; Stray-Pedersen, B.; BÃ¸rdahl, P. E.; FrÃ¸en, J. F.	2010	Concerns for decreased foetal movements in uncomplicated pregnancies- Increased risk of foetal growth restriction and stillbirth among women being overweight, advanced age or smoking	Journal of Maternal-Fetal and Neonatal Medicine	23	10	1129-1135	10.3109/14767050903511578	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Warrander, L. K.; Greenwood, S. L.; Sibley, C.; Jones, R. L.; Heazell, A. E. P.	2011	Reduced fetal movements are associated with significant changes in placental structure and function	Archives of Disease in Childhood: Fetal and Neonatal Edition	96		Fa56	10.1136/adc.2011.300161.9	Exclusion reason: Wrong control
Warrander, L. K.; Kroll, J.; Greenwood, S. L.; Sibley, C. P.; Jones, R. L.; Heazell, A. E. P.	2011	Placentally-derived factors may be used to predict poor pregnancy outcome in reduced fetal movements	Archives of Disease in Childhood: Fetal and Neonatal Edition	96		Fa12	10.1136/adc.2011.300160.3	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Torkestani, F.; Zafarghandi, N.; Davati, A.; Hadav, S.; Farzinmoghadam, S.; Nasiri, Z.	2011	The value of reporting decreased or absent fetal movements by mothers in predicting the pregnancy outcome	Iran J Med Sci	36	3	235-6		Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Warrander, L.; Dutton, P.; Kroll, J.; Greenwood, S.; Sibley, C.; Jones, R.; Heazell, A.	2011	Placentally-derived factors can predict poor pregnancy outcome in reduced fetal movements	Placenta	32	9	A100	10.1016/j.placenta.2011.07.004	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Dutton, P.; Warrander, L.; Bernatavicius, G.; Kroll, J.; Gaze, D.; Jones, R.; Heazell, A.	2012	Placentally-derived factors in women with reduced fetal movements and their relationship to pregnancy outcome	BJOG: An International Journal of Obstetrics and Gynaecology	119	6	e3	10.1111/j.1471-0528.2012.03315.x	Exclusion reason: Wrong control (no non-RFM cohort for comparison)

Olowu, O.; Wong, M. H.; Deo, N.; Gupta, M.; Dalwatly, B.	2012	Management pathway of pregnant women who perceived decreased fetal movement in low risk population	BJOG: An International Journal of Obstetrics and Gynaecology	119		118	10.1111/j.1471-0528.2012.03376.x	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Hayi, S.; Samsudin, J.; Ng, P. Y.; Ravindran, J.	2012	Outcome of reduced fetal movements in singleton pregnancies after 24 weeks	BJOG: An International Journal of Obstetrics and Gynaecology	119		76	10.1111/j.1471-0528.2012.03376.x	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Hayi, S.; Samsudin, J.; Ng, P. Y.; Ravindran, J.	2012	Risk factors for reduced fetal movements in singleton pregnancies after 24 weeks	BJOG: An International Journal of Obstetrics and Gynaecology	119		45	10.1111/j.1471-0528.2012.03376.x	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Dutton, P. J.; Warrander, L. K.; Roberts, S. A.; Bernatavicius, G.; Byrd, L. M.; Gaze, D.; Kroll, J.; Jones, R. L.; Sibley, C. P.; FrÃ¸en, J. F.; Heazell, A. E. P.	2012	Predictors of poor perinatal outcome following maternal perception of reduced fetal movements - a prospective cohort study	PLoS One	7	7		10.1371/journal.pone.0039784	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Skorupskaite, K.; Love, C.	2013	Can we predict poor pregnancy outcomes in women presenting with reduced fetal movements?	Archives of Disease in Childhood: Fetal and Neonatal Edition	98			10.1136/archdischild-2013-303966.333	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Narain, S.	2013	Pregnancy outcomes in women presenting with reduced fetal movements	BJOG: An International Journal of Obstetrics and Gynaecology	120		149-150	10.1111/1471-0528.12293	Exclusion reason: Wrong control (no non-RFM cohort for comparison)

Kellison, L. R.; Ferguson, E.; Wolff, O.	2013	An audit of reduced fetal movements in a district general hospital in Lanarkshire	Archives of Disease in Childhood: Fetal and Neonatal Edition	98			10.1136/archdischild-2013-303966.318	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Sibley, C. P.; Abrahams, V.; Girard, S.; Higgins, L.; Johnstone, E. D.; Jones, R. L.; Heazell, A. E. P.	2014	Placental structure and function in fetal growth restriction and stillbirth	Placenta	35	9	A6	10.1016/j.placenta.2014.06.022	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Taylor-Hannan, C.; Pullinger, A.; Jayasinghe, H.; Bottomley, S.; Sparey, C.; Ciantar, E.	2014	Reduced Fetal Movements (RFM) at term-are we getting it right?	Archives of Disease in Childhood: Fetal and Neonatal Edition	99		A167-A172	10.1136/archdischild-2014-306576.493	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Gordon, A.; Chaku, J.; Anicq, A.; McCudden, L.; Wong-See, H.; Hyett, J.	2014	Impact of a decreased fetal movement policy on induction of labour and pregnancy outcomes	J Paediatr Child Health	50		49		Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Awad, N. A.; Jordan, T.; William, M.; Dan, F.	2014	Reduced fetal movements management and outcome	Am J Obstet Gynecol	210	1	S87	10.1016/j.ajog.2013.10.180	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Abu Awad, N.; Jordan, T.; William, M.; Dan, F.	2014	Reduced fetal movements-management and outcome	Am J Obstet Gynecol	210	1	S87-S87		Exclusion reason: Wrong control (no non-RFM cohort for comparison)

Nor Azlin, M. I.; Maisarah, A. S.; Rahana, A. R.; Shafiee, M. Nasir; Aqmar Suraya, S.; Abdul Karim, A. K.; Jamil, M. A.	2015	Pregnancy outcomes with a primary complaint of perception of reduced fetal movements	Journal of Obstetrics & Gynaecology	35	1	13-15	10.3109/01443615.2014.930108	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Emovon, Emmanuel; Brookes, Emily; Sinha, Monisha; Rajan, Deepa	2016	Neonatal outcome of patients presenting with reduced foetal movements	European Journal of Obstetrics & Gynecology & Reproductive Biology	206		e35-e35	10.1016/j.ejogrb.2016.07.115	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Ajibade, F.; Opare, N.	2016	EP16.04: The potential impact of patients' presentation with reduced fetal movements and drive to reduce stillbirth on service delivery	Ultrasound in Obstetrics & Gynecology	48		333-333	10.1002/uog.17006	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Ajibade, F.; Opare, N.; Kushanu, E.; Hirsi-Farah, S.	2017	EP17.10: Pregnancy outcome of presentation with reduced fetal movements (RFM) to day assessment unit	Ultrasound in Obstetrics & Gynecology	50		340-340	10.1002/uog.18603	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Awad, N. A.; Jordan, T.; Mundle, R.; Farine, D.	2017	Management and Outcome of Reduced Fetal Movements-is Ultrasound Necessary?	J Obstet Gynaecol Can				10.1016/j.jogc.2017.08.007	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Bellussi, F.; Cataneo, I.; Salsi, G.; Rizzo, R.; Youssef, A.; Simonazzi, G.; Pilu, G.	2017	EP16.03: The role of middle cerebral artery Doppler in the detection of fetal anemia in pregnancy with decreased perception of fetal movements	Ultrasound in Obstetrics & Gynecology	50		332-332	10.1002/uog.18577	Exclusion reason: Wrong control (no non-RFM cohort for comparison)

Kapaya, H.; Burnett, H.; Anumba, D.	2018	Prevalence and clinical outcome of patients presenting with reduced fetal movements (RFM)	BJOG: An International Journal of Obstetrics and Gynaecology	125		73	10.1111/1471-0528.15132	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Yong, N.; Morton, K.	2018	Reduced fetal movements: A cohort observational study at the Royal Surrey County Hospital	BJOG: An International Journal of Obstetrics and Gynaecology	125		12	10.1111/1471-0528.15493	Exclusion reason: Wrong control (no non-RFM cohort for comparison)
Lindner, E.	2019	Have induction rates for decreased fetal movements changed since a change in guideline?	Australian and New Zealand Journal of Obstetrics and Gynaecology	59		72	10.1111/ajo.13067	Exclusion reason: No comparator (NO RFM)
Tan, S.; Chandler, J.; Yap, J.; Alnaggar, E.	2019	Retrospective review of patients with repeated presentations for maternal reduced fetal movements (RFMS) and varying numbers of PSANZ stillbirth risk factors (SRFS) with neonatal birth outcomes in a high-risk Australian quaternary maternal fetal assessment unit (MFAU)	Journal of Paediatrics and Child Health	55		105	10.1111/jpc.14410_151	Exclusion reason: No comparator (NO RFM)
Salimeda, M.; Wijesiriwardana, N.; Karmakar, D.; Dam, J. V.	2019	Decreased fetal movements-How can we manage better?	Australian and New Zealand Journal of Obstetrics and Gynaecology	59		56	10.1111/ajo.13067	Exclusion reason: No comparator (NO RFM)
Rudra, T.; Pathmanathan, U.; Amaoko, A.; Wilkinson, R.	2019	Is routine kleihauer-betke test useful tool in the management of women with decreased fetal movements?	Australian and New Zealand Journal of Obstetrics and Gynaecology	59		50	10.1111/ajo.13067	Exclusion reason: No comparator (NO RFM)
Bradford, B. F.; Cronin, R. S.; McKinlay, C. J. D.; Thompson, J. M. D.; Mitchell, E. A.; Stone, P. R.; McCowan, L. M. E.	2019	A diurnal fetal movement pattern: Findings from a cross-sectional study of maternally perceived fetal movements in the third trimester of pregnancy	PLoS One	14	6	e0217583	10.1371/journal.pone.0217583	Exclusion reason: No comparator (NO RFM)

Bhatia, Meena; Mitsi, Vaia; Court, Lisa; Thampi, Premila; Elâ€Nasharty, Mohamed; Hesham, Saeed; Randall, Wendy; Davies, Rachel; Impey, Lawrence; El-Nasharty, Mohamed	2019	The outcomes of pregnancies with reduced fetal movements: A retrospective cohort study	Acta Obstetricia et Gynecologica Scandinavica	98	11	1450-1454	10.1111/aogs.13671	Exclusion reason: No comparator (NO RFM)
Akselsson, A.; Lindgren, H.; Georgsson, S.; *et al.*,	2019	Daily structured approach to awareness of fetal movements and pregnancy outcome - a prospective study	Sexual & Reproductive HealthCare	20		32-37		Exclusion reason: No comparator (NO RFM)
Weller, M.; Gardener, G.; Ellwood, D.; Warrilow, K.; Sexton, J.; Flenady, V.	2019	Decreased fetal movements: maternal and clinical responses	Women and Birth	32		S46-S47	10.1016/j.wombi.2019.07.291	Exclusion reason: No comparator (NO RFM)
Moran, O.; Heazell, A.	2019	Reduced fetal movements: Are women getting standardised care?	BJOG: An International Journal of Obstetrics and Gynaecology	126		74	10.1111/1471-0528.15634	Exclusion reason: No comparator (NO RFM)
Sterpu, I.; Pilo, C.; Lindqvist, P. G.; Ã…kerud, H.; Wiberg Itzel, E.	2020	Predictive factors in pregnancies with reduced fetal movements: a pilot study	Journal of Maternal-Fetal and Neonatal Medicine				10.1080/14767058.2020.1855135	Exclusion reason: No comparator (NO RFM)
Kapaya, H.; Almeida, J.; Karouni, F.; Anumba, D.	2020	Management of reduced fetal movement: A comparative analysis of two audits at a tertiary care clinical service	Eur J Obstet Gynecol Reprod Biol	248		128-132	10.1016/j.ejogrb.2020.03.040	Exclusion reason: No comparator (NO RFM)
Koshida, S.; Tokoro, S.; Katsura, D.; Tsuji, S.; Murakami, T.; Takahashi, K.	2021	Fetal movement counting is associated with the reduction of delayed maternal reaction after perceiving decreased fetal movements: a prospective study	Sci Rep	11	1	10818	10.1038/s41598-021-90240-4	Exclusion reason: No comparator (No RFM)
Marques-Fernandez, L.; Sharma, S.; Mannu, U.; Chong, H. P.	2021	Impact of Covid-19 on attendances for a 1st episode of reduced fetal movements: A retrospective observational study	PLoS One	16	6	e0253796	10.1371/journal.pone.0253796	Exclusion reason: No comparator (NO RFM)
Naqvi, A.; Mahindrakar, G.; Jain, A.; Gumma, A.	2021	Impact of Covid pandemic on attendance of patients with 'decreased fetal movements'	BJOG: An International Journal of	128	SUPPL 2	199	10.1111/1471-0528.15-16715	Exclusion reason: No

			Obstetrics and Gynaecology					comparator (NO RFM)
Vas, J.; Cintado, M. C.; Aranda-Regules, J. M.; *et al.*,		The outcomes of pregnancies with reduced fetal movements: A retrospective cohort study	Acta Obstetricia et Gynecologica Scandinavica					Exclusion reason: No comparator (NO RFM)

No exposed RFM cohort (n=22)								
Authors	**Published Year**	**Title**	**Journal**	**Volume**	**Issue**	**Pages**	**DOI**	**Exclusion Reason**
EhrstromC,	1979	Fetal movement monitoring in normal and high-risk pregnancy	Acta Obstetricia et Gynecologica Scandinavica	Suppl. 80				Exclusion reason: Wrong exposure (no exposed RFM cohort)
Mor-Yosef, S.; Sadovsky, E.; Brzezinski, A.; Levinsky, R.; Ohel, G.	1983	Fetal movements and intrauterine growth retardation	Int J Gynaecol Obstet	21	4	315-8		Exclusion reason: Wrong exposure (no exposed RFM cohort)
Kelly, J.; O'Conor, M.; Mathews, K. A.	1984	Smoking in pregnancy: Effects on mother and fetus	Br J Obstet Gynaecol	91	2	111-117		Exclusion reason: Wrong exposure (no exposed RFM cohort)
Chhabra, S.; Jeste, S.	1989	Variables in foetal kick count		39	6	764-767		Exclusion reason: Wrong exposure (no exposed RFM cohort)
Graca, L. M.; Cardoso, C. G.; Clode, N.; Calhaz-Jorge, C.	1991	Acute effects of maternal cigarette smoking on fetal heart rate and fetal body movements felt by the mother		19	5	385-90		Exclusion reason: Wrong exposure (no exposed RFM cohort

Sival, D. A.; Visser, G. H.; Prechtl, H. F.	1992	The relationship between the quantity and quality of prenatal movements in pregnancies complicated by intra-uterine growth retardation and premature rupture of the membranes		30	3	193-209		Exclusion reason: Wrong exposure (no exposed RFM cohort)
Sherer, D. M.; Spong, C. Y.; Minior, V. K.; Salafia, C. M.	1996	Decreased amniotic fluid volume at < 32 weeks of gestation is associated with decreased fetal movements		13	8	479-82	10.1055/s-2007-994431	Exclusion reason: Wrong exposure (no exposed RFM cohort)
Coppens, M.; Vindla, S.; James, D. K.; Sahota, D. S.	2001	Computerized analysis of acute and chronic changes in fetal heart rate variation and fetal activity in association with maternal smoking	Am J Obstet Gynecol	185	2	421-6	10.1067/mob.2001.115992	Exclusion reason: Wrong exposure (no exposed RFM cohort)
Mirghani, H. M.; Weerasinghe, D. S.; Ezimokhai, M.; Smith, J. R.	2003	The effect of maternal fasting on the fetal biophysical profile	Int J Gynaecol Obstet	81	1	17-21		Exclusion reason: Wrong exposure (no exposed RFM cohort)
Wouldes, T. A.; Roberts, A. B.; Pryor, J. E.; Bagnall, C.; Gunn, T. R.	2004	The effect of methadone treatment on the quantity and quality of human fetal movement	Neurotoxicol Teratol	26	1	23-34	10.1016/j.ntt.2003.09.003	Exclusion reason: Wrong exposure (no exposed RFM cohort)
Buscicchio, G.; Gentilucci, L.; Baldini, E.; Giannubilo, S. R.; Tranquilli, A. L.	2009	Computerized analysis of heart rate in fetuses from mothers under levothyroxin treatment	Gynecological Endocrinology	25	10	679-682	10.1080/09513590903015452	Exclusion reason: Wrong exposure (no exposed RFM cohort)
Buscicchio, G.; Gentilucci, L.; Tranquilli, A. L.	2010	Computerized analysis of fetal heart rate in pregnancies complicated by gestational diabetes mellitus, gestational hypertension,	J Matern Fetal Neonatal Med	23	4	335-7	10.3109/14767050903258712	Exclusion reason: Wrong exposure

		intrauterine growth restriction and premature rupture of membranes						(no exposed RFM cohort)
Winje, B. A.; Saastad, E.; Gunnes, N.; Tveit, J. V.; Stray-Pedersen, B.; Flenady, V.; Froen, J. F.	2011	Analysis of 'count-to-ten' fetal movement charts: a prospective cohort study	BJOG: An International Journal of Obstetrics and Gynaecology	118	10	1229-38	10.1111/j.1471-0528.2011.02993.x	Exclusion reason: Wrong exposure (no exposed RFM cohort)
Evers, A. C.; Nikkels, P. G.; Brouwers, H. A.; Boon, J.; van Egmond-Linden, A.; Hart, C.; Snuif, Y. S.; Sterken-Hooisma, S.; Bruinse, H. W.; Kwee, A.	2011	Substandard care in antepartum term stillbirths: prospective cohort study		90	12	1416-22	10.1111/j.1600-0412.2011.01251.x	Exclusion reason: Wrong exposure (no exposed RFM cohort)
EkÃ©us, Cecilia; Cnattingius, Sven; EssÃ©n, Birgitta; Hjern, Anders	2011	Stillbirth among foreign-born women in Sweden	European Journal of Public Health	21	6	788-792		Exclusion reason: Wrong exposure (no exposed RFM cohort)
Winje, B. A.; Roislien, J.; Froen, J. F.	2012	Temporal patterns in count-to-ten fetal movement charts and their associations with pregnancy characteristics: a prospective cohort study	BMC Pregnancy Childbirth	12		124	10.1186/1471-2393-12-124	Exclusion reason: Wrong exposure (no exposed RFM cohort)
Brea, L.; Hurtado, I.; Ga Ballesteros, A.; Rodriguez, N.; Morales, P. C.; GuzmÃ¡n, M. F.; Romera, G.; SÃ¡nchez de LeÃ³n, L.	2013	Severe feto-maternal hemorrhage	Journal of Perinatal Medicine	41			10.1515/jpm-2013-2003	Exclusion reason: Wrong exposure (no exposed RFM cohort)
Nahar, S.; Rahman, A.; Nasreen, H. E.	2013	Factors influencing stillbirth in Bangladesh: A casecontrol study	Paediatr Perinat Epidemiol	27	2	158-164	10.1111/ppe.12026	Exclusion reason: Wrong exposure (no exposed RFM cohort)
Mastrogiannis, D.; Barker, J.	2014	Developing interventions to target modifiable risk factors	Obstet Gynecol	123		69S	10.1097/01.AOG.0000447379.67802.6e	Exclusion reason: Wrong

		in pregnancy losses in philadelphia						exposure (no exposed RFM cohort)
	2016	RANZCOG 2016 Annual Scientific Meeting	Australian and New Zealand Journal of Obstetrics and Gynaecology	56				Exclusion reason: Wrong exposure (no exposed RFM cohort)
McCowan, L.	2017	Contribution of maternal going-to-sleep position and fetal movements to late stillbirth	Australian and New Zealand Journal of Obstetrics and Gynaecology	57		19-20	10.1111/ajo.12723	Exclusion reason: Wrong exposure (no exposed RFM cohort)
Heazell, A.; Li, M.; Budd, J.; Cronin, R.; Bradford, B.; McCowan, L. M. E.; Mitchell, E. A.; Stacey, T.; Martin, B.; Roberts, D.; Thompson, J. M. D.	2017	Patterns of fetal movement and the association with late stillbirth	BMC Pregnancy Childbirth	17			10.1186/s12884-017-1457-7	Exclusion reason: Wrong exposure (no exposed RFM cohort)

Wrong patient population (n=8)								
Authors	**Published Year**	**Title**	**Journal**	**Volume**	**Issue**	**Pages**	**DOI**	**Notes**
Mathews, D. D.	1975	Maternal assessment of fetal activity in small-for-dates infants	Obstet Gynecol	45	5	488-93		Exclusion reason: Wrong patient population
	2015	Proceedings of the British Medical Ultrasound Society 46th Annual Scientific Meeting	Ultrasound	23	2	NP1-NP42	10.1177/1742271X15579789	Exclusion reason: Wrong patient population
Peng, Y.; Bhatti, S.	2018	Perinatal management and outcomes in supermorbidly obese women with BMIâ‰¥ 50, at the Rosie Hospital, Cambridge, UK	BJOG: An International Journal of Obstetrics and Gynaecology	125		110	10.1111/1471-0528.15192	Exclusion reason: Wrong patient population

Adeyeye, T.; Greenwood, S.; Heazell, A.	2019	Increased fetal movements; a modifiable risk factor for stillbirth?	BJOG: An International Journal of Obstetrics and Gynaecology	126	6	e126-e127	10.1111/1471-0528.15677	Exclusion reason: Wrong patient population
Wei, L.; Gao, X.; Chen, S.; Zeng, W.; Wu, J.; Lin, X.; Zhang, H.; Sharifu, L. M.; Chen, L.; Feng, L.; Wang, S.	2020	Clinical characteristics and outcomes of childbearing-age women with COVID-19 in Wuhan: Retrospective, single-center study	Journal of Medical Internet Research	22	8		10.2196/19642	Exclusion reason: Wrong patient population
Akselsson, A.; Lindgren, H.; Georgsson, S.; Pettersson, K.; Skokic, V.; RÃ¥destad, I.	2020	Pregnancy outcomes among women born in Somalia and Sweden giving birth in the Stockholm area - a population-based study	Glob Health Action	13	1	1794107	10.1080/16549716.2020.1794107	Exclusion reason: Wrong patient population
Vallely, L. M.; Smith, R.; Bolnga, J. W.; Babona, D.; Riddell, M. A.; Mengi, A.; Au, L.; Polomon, C.; ogel, J. P.; Pomat, W. S.; Vallely, A. J.; Homer, C. S. E.	2021	Perinatal death audit and classification of stillbirths in two provinces in Papua New Guinea: A retrospective analysis	Int J Gynaecol Obstet	153	1	160-168	10.1002/ijgo.13431	Exclusion reason: Wrong patient population
Maida, S.; Granshaw, L.; Brobbey, P.; Navaneetham, N.	2021	Audit: the rise of inductions of labour - are they all indicated?	BJOG: An International Journal of Obstetrics and Gynaecology	128	Suppl 2	219	10.1111/1471-0528.17-16715	Exclusion reason: Wrong patient population

Study Design (n=25)								
Authors	**Published Year**	**Title**	**Journal**	**Volume**	**Issue**	**Pages**	**DOI**	**Notes**
Sadovsky, E.; Yaffe, H.	1973	Daily fetal movement recording and fetal prognosis		41	6	845-850		Exclusion reason: Wrong study design
Eriksen, P. S.; Gennser, G.; Lofgren, O.; Nilsson, K.	1983	Acute effects of maternal smoking on fetal breathing and movements	Obstet Gynecol	61	3	367-72		Exclusion reason: Wrong study design
Lobb, M. O.; Beazley, J. M.; Haddad, N. G.	1985	A controlled study of daily fetal movement counts in the prevention of stillbirths	Journal of Obstetrics and Gynaecology	6	2	87-91		Exclusion reason: Wrong study design

Valentin, L.; Marsal, K.; Wahlgren, L.	1986	Subjective recording of fetal movements. III. Screening of a pregnant population; the clinical significance of decreased fetal movement counts		65	7	753-8		Exclusion reason: Wrong study design
Rubinstein, T. H.; Schifrin, B. S.	1992	Decreased fetal movement with abnormal nonstress test preceding fetal death	J Perinatol	12	3	294-6		Exclusion reason: Wrong study design
Golde, S. H.	1993	Decreased fetal movement with abnormal nonstress test preceding fetal death	J Perinatol	13	2	174-5		Exclusion reason: Wrong study design
Cronin, R.; Maude, R.	2008	Third trimester itch: obstetric cholestasis a serious condition of pregnancy	New Zealand College of Midwives Journal		38	20-25		Exclusion reason: Wrong study design
Preston, S.; Mahomed, K.; Flenady, V.; Chadha, Y.; Gardener, G.; MacPhail, J.; Conway, L.; Koopmans, L.; Stacey, T.; Heazell, A.; Fretts, R.; FrÃ¸en, F.	2010	Clinical practice guidelines for the management of women with decreased fetal movements (DFM)	J Paediatr Child Health	46		33	10.1111/j.1440-1754.2010.01707.x	Exclusion reason: Wrong study design
Burden, C.; Male, S.; Fox, R.	2010	Spurious fetal movement after late fetal death	British Journal of Midwifery	18	10	659-659		Exclusion reason: Wrong study design
Gordon, A.; Raynes-Greenow, C. H.; Bond, D.; Jones, R.; Morris, J. M.; Jeffery, H. E.	2011	Maternal perception of fetal movements: Quality vs quantity? The sydney stillbirth study	J Paediatr Child Health	47		77	10.1111/j.1440-1754.2011.02047.x	Exclusion reason: Wrong study design
Warrander, L. K.; Heazell, A. E.	2011	Identifying placental dysfunction in women with reduced fetal movements can be used to predict patients at increased risk of pregnancy complications		76	1	17-20	10.1016/j.mehy.2010.08.020	Exclusion reason: Wrong study design
	2012	Proceedings of the Stillbirth Summit 2011	BMC Pregnancy Childbirth	12				Exclusion reason: Wrong study design

Higgins, L. E.; Johnstone, E. D.; Heazell, A. E. P.	2013	MANAGEMENT OF REDUCED FETAL MOVEMENTS	Fetal & Maternal Medicine Review	24	4	201-231	10.1017/S096553951300017X	Exclusion reason: Wrong study design
Hobbins, John C.	2014	Reduced Fetal Movement, Uterine Arteries, and Stillbirth	OB/GYN Clinical Alert	31	5	36-38		Exclusion reason: Wrong study design
Platts, J.; Mitchell, E. A.; Stacey, T.; Martin, B. L.; Roberts, D.; McCowan, L.; Heazell, A. E. P.	2014	The Midland and North of England Stillbirth Study (MiNESS)	BMC Pregnancy Childbirth	14	1		10.1186/1471-2393-14-171	Exclusion reason: Wrong study design
	2015	Proceedings of the Stillbirth Summit 2014	BMC Pregnancy Childbirth	15				Exclusion reason: Wrong study design
Heazell, A.	2015	A kick in the right direction-reduced fetal movements and stillbirth prevention	BMC Pregnancy Childbirth	15				Exclusion reason: Wrong study design
Chauveau, L.; Di Bartolomeo, A.; Noblot, E.; Fanget, C.; Raia-Barjat, T.; Chauleur, C.	2016	[Use of fetal movements counting for prolonged pregnancy: A comparative preliminary cohort study before and after implementation of an information brochure]	J Gynecol Obstet Biol Reprod (Paris)	45	7	760-6	10.1016/j.jgyn.2015.09.005	Exclusion reason: Wrong study design
Laas, Enora; Friszer, StÃ©phanie; Kayem, Gilles	2016	Number of episodes of reduced fetal movement at term: methodological considerations		215		254-255	10.1016/j.ajog.2016.04.015	Exclusion reason: Wrong study design
Koshida, S.; Ono, T.; Tsuji, S.; Murakami, T.; Arima, H.; Takahashi, K.	2019	Fetal movement frequency and the effect of associated perinatal factors: Multicenter study	Women and Birth	32	2	127-130	10.1016/j.wombi.2018.06.010	Exclusion reason: Wrong study design
	2019	Abstracts and Case Studies From the College of American Pathologists 2019 Annual Meeting (CAP19)	Archives of Pathology & Laboratory Medicine	143	9	e2-e226	10.5858/arpa.2019-0901-AB	Exclusion reason: Wrong study design
Saunders, A.; Griffin, C.	2019	Reduced fetal movements â€“ First do no harm	Australian and New Zealand Journal of	59	5	E15	10.1111/ajo.12976	Exclusion reason:

			Obstetrics and Gynaecology					Wrong study design
Wyeth, S.	2019	A retrospective study investigating the use of MCA/UA Doppler pulsatility index ratio as a prediction for interventions and poor obstetrics outcomes in the case of reduced foetal movements	Ultrasound	27	2	NP24	10.1177/1742271X19840271	Exclusion reason: Wrong study design
Gardener, G.; Weller, M.; Ellwood, D.; Flenady, V.	2019	Decreased fetal movements (DFM) â€“ finding the balance	Australian and New Zealand Journal of Obstetrics and Gynaecology	59	4	E14	10.1111/ajo.13024	Exclusion reason: Wrong study design
Flenady, V.; Weller, M.; Boyle, F.; Middleton, P.	2020	Consistent evidenced based information for women about fetal movements is important...Takahashi H, Matsubara T, Matsubara S. Mobile applications for fetal movement: Only decreased movement matters? Women & Birth. 2020;33(6):e574-e575	Women & Birth	33	6	e576-e576	10.1016/j.wombi.2020.02.001	Exclusion reason: Wrong study design

Did not report on pre- specified outcomes (n=21)								
Authors	**Published Year**	**Title**	**Journal**	**Volume**	**Issue**	**Pages**	**DOI**	**Notes**
Sadovsky, E.; Rabinowitz, R.; Yaffe, E.	1981	Decreased foetal movements and foetal malformations	Journal of Foetal Medicine	1	1	62-64		Exclusion reason: Wrong outcomes
Simon, A.; Ohel, G.; Mor-Yosef, S.; Brjejinski, A.; Sadovsky, E.	1985	Fetal movements in hypertensive pregnancies	Aust N Z J Obstet Gynaecol	25	3	179-81		Exclusion reason: Wrong outcomes
Simon, A.; Sadovsky, E.; Aboulafia, Y.; Ohel, G.; Zajicek, G.	1986	Fetal activity in pregnancies complicated by rheumatic heart disease		14	5	331-4		Exclusion reason: Wrong outcomes

Tuffnell, D. J.; Cartmill, R. S.; Lilford, R. J.	1991	Fetal movements; factors affecting their perception	Eur J Obstet Gynecol Reprod Biol	39	3	165-7		Exclusion reason: Wrong outcomes
James, D. K.; Telfer, F. M.; Keating, N. A.; Blair, M. E.; Wilcox, M. A.; Chilvers, C.	2000	Reduced fetal movements and maternal medication - new pregnancy risk factors for neurodevelopmental disability in childhood	J Obstet Gynaecol	20	3	226-34	10.1080/01443610050009494	Exclusion reason: Wrong outcomes;
Efkarpidis, S.; Alexopoulos, E.; Kean, L.; Liu, D.; Fay, T.	2004	Case-control study of factors associated with intrauterine fetal deaths	MedGenMed	6	2	53		Exclusion reason: Wrong outcomes
Heazell, A. E. P.; Warrander, L. K.; Greenwood, S. L.; Jones, R. L.; Sibley, C. P.	2010	Placental size is reduced and placental infarction and syncytial knots are increased in pregnancies complicated by decreased fetal movements	Placenta	31	9	A103	10.1016/j.placenta.2010.08.006	Exclusion reason: Wrong outcomes
Naz, F.; Javid, A.; Saeed, S.; Begum, A.; Zareen, A.	2010	Neonatal outcome in post-term pregnancy	Pakistan Journal of Medical and Health Sciences	4	3	248-251		Exclusion reason: Wrong outcomes
Warrander, L.; Greenwood, S.; Sibley, C.; Jones, R.; Heazell, A.	2011	Reduced fetal movements is associated with significant changes in placental structure and function	BJOG: An International Journal of Obstetrics and Gynaecology	118	8	1016-1017	10.1111/j.1471-0528.2011.03037.x	Exclusion reason: Wrong outcomes
Girard, S.; Heazell, A. E. P.; Sibley, C. P.; Allan, S. M.; Jones, R. L.	2013	Distinct inflammatory profile in placenta from women experiencing reduced fetal movements: A cause of placental dysfunction?	Reproductive Sciences	20	3	164A	10.1177/1933719113482088	Exclusion reason: Wrong outcomes
Nice, D. B.; Hayden, K.; Higgins, L.; Johnstone, E.; Heazell, A. E.	2014	The measurement of placental biomarkers in the detection of compromised pregnancies	Clinical Chemistry and Laboratory Medicine	52	11	eA372	10.1515/cclm-2014-0890	Exclusion reason: Wrong outcomes
Mohr Sasson, Aya; Tsur, Abraham; Kalter, Anat; Weissmann Brenner, Alina; Gindes, Liat; Weisz, Boaz	2016	Reduced fetal movement: factors affecting maternal perception	Journal of Maternal-Fetal & Neonatal Medicine	29	8	1318-1321	10.3109/14767058.2015.1047335	Exclusion reason: Wrong outcomes

Beneventi, F.; Cavagnoli, C.; Locatelli, E.; Bariselli, S.; Simonetta, M.; Viarengo, G.; Perotti, C.; Spinillo, A.	2017	Mild-to-moderate foeto-maternal haemorrhage in the third trimester and at term of pregnancy: quantitative determination and clinical-diagnostic evaluation	Blood Transfus			01-May	10.2450/2017.0316-16	Exclusion reason: Wrong outcomes
Higgins, L. E.; Myers, J. E.; Sibley, C. P.; Johnstone, E. D.; Heazell, A. E. P.	2018	Antenatal placental assessment in the prediction of adverse pregnancy outcome after reduced fetal movement	PLoS One	13	11		10.1371/journal.pone.0206533	Exclusion reason: Wrong outcomes
Zamstein, O.; Sheiner, E.; Wainstock, T.	2019	119: Decreased fetal movements and long-term neurological morbidity of the offspring	American Journal of Obstetrics and Gynecology	220	1	S94-S95	10.1016/j.ajog.2018.11.140	Exclusion reason: Wrong outcomes
Bradford, B.; Cronin, R.; McKinlay, C.; Thompson, J.; McCowan, L.	2020	Maternally perceived fetal movement patterns: The influence of body mass index	Early Human Development	140			10.1016/j.earlhumdev.2019.104922	Exclusion reason: Wrong outcomes
Clermont-Hama, Y.; Thibouw, K.; Devisme, L.; Franquet-Ansart, H.; Stichelbout, M.; Subtil, D.	2020	Risk factors for spontaneous hematoma of the umbilical cord: A case-control study	Placenta	99		152-156	10.1016/j.placenta.2020.07.020	Exclusion reason: Wrong outcomes
McKnoulty, M.	2021	Reduced fetal movenents: Do care pathways improve patient flow during emergency presentation?	Australian and New Zealand Journal of Obstetrics and Gynaecology	61	SUPPL 1	86-87	10.1111/ajo.13345	Exclusion reason: Wrong outcomes
Greenberg, J.; Gilroy, L.; Mitchell, T.; Pardanani, S.	2021	586 Decreased fetal movement and anterior placentation: a case control study	American Journal of Obstetrics and Gynecology	224	2	S369-S370	10.1016/j.ajog.2020.12.607	Exclusion reason: Wrong outcomes
Radestad, I.; Pettersson, K.; Lindgren, H.; Skokic, V.; Akselsson, A.	2021	Country of birth, educational level and other predictors of seeking care due to decreased fetal movements: an observational study in Sweden using data from a cluster-randomised controlled trial	BMJ Open	11	6	e050621	10.1136/bmjopen-2021-050621	Exclusion reason: Wrong outcomes

Appendix 5 Risk Factor Forest Plots

Risk Factors predictive of RFM in pregnancy

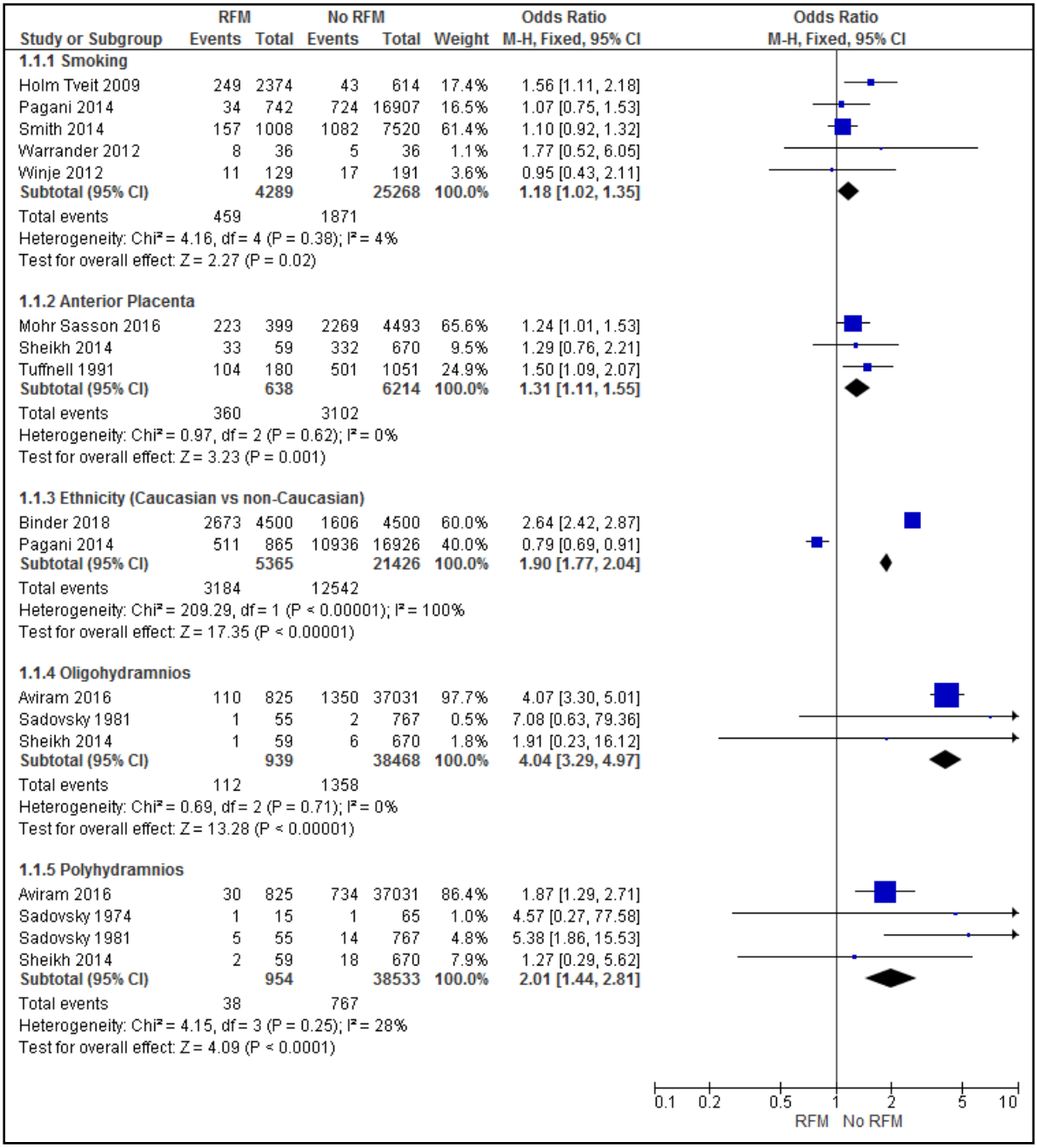


Figure A: Risk Factors associated with RFM in Pregnancy

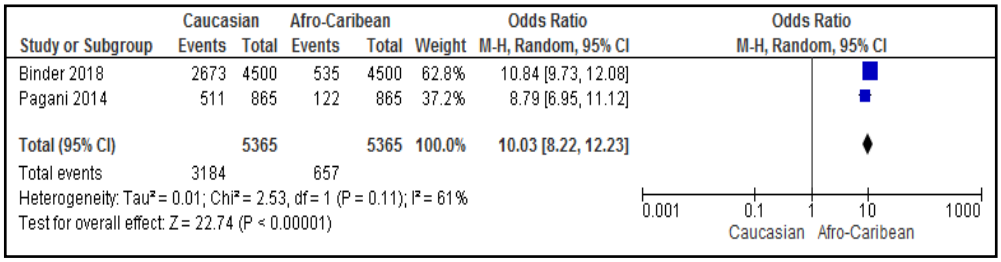


Figure B Ethnicity Caucasian versus Afro-Caribbean

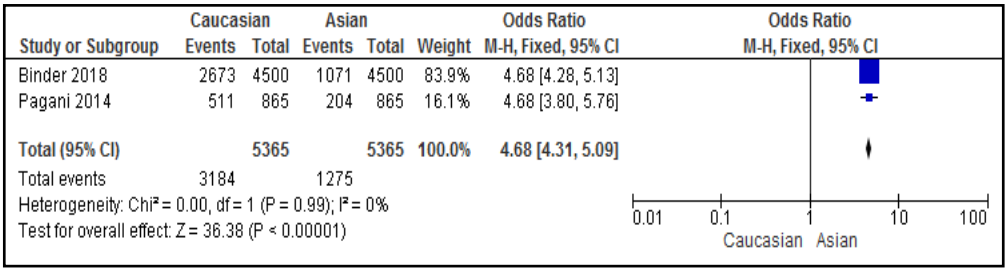


Figure C Ethnicity Caucasian versus Asian

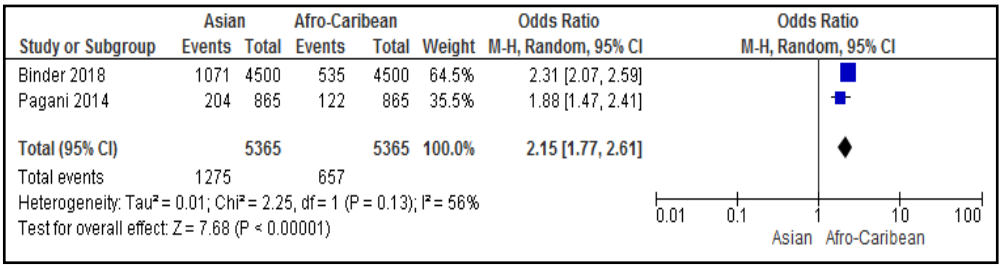


Figure D Ethnicity Asian versus Afro-Caribean

Risk factors not found to be predictive of RFM

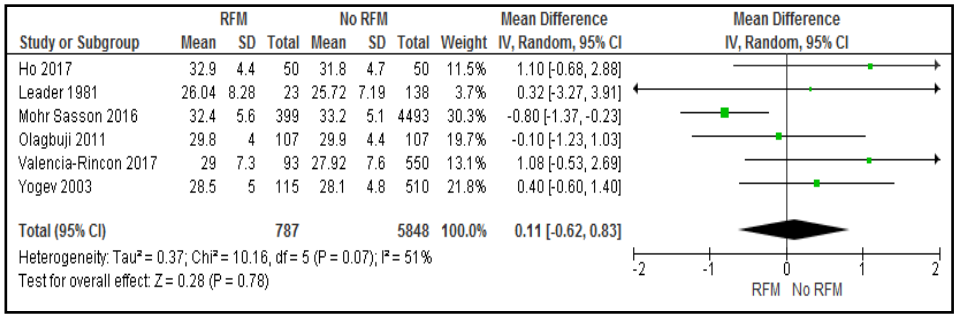


Figure E Maternal age (Random Effect Model)

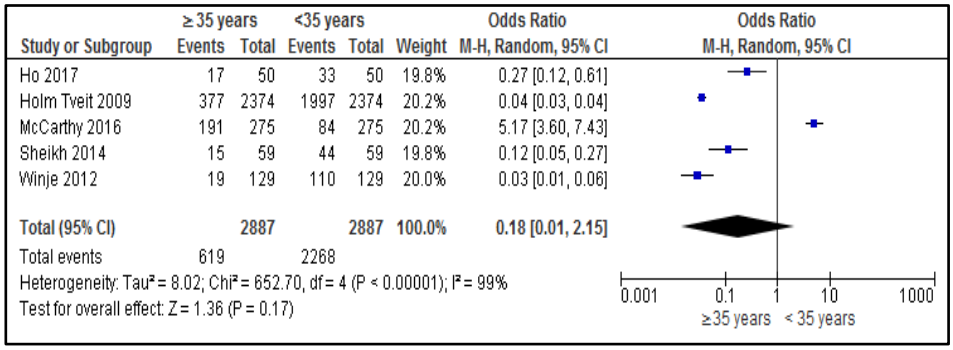


Figure F Maternal age ≥35 years versus < 35years (Random Effect Model)

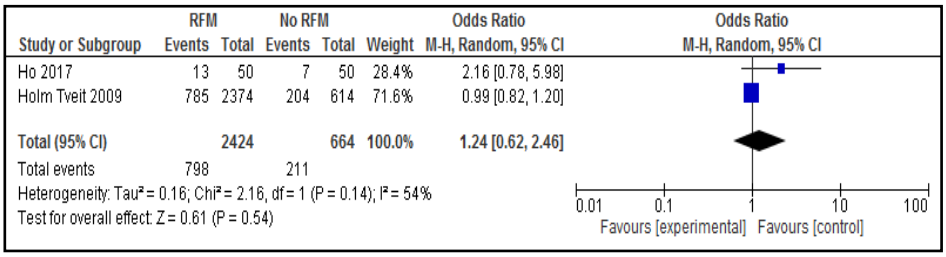


Figure G BMI ≥25kg/m² (Random Effects Model)

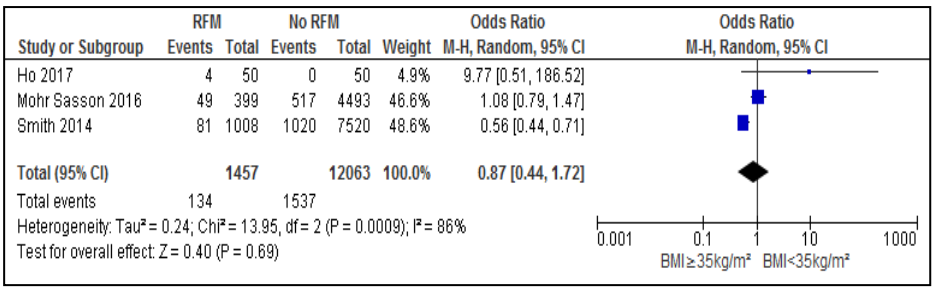


Figure H BMI ≥35kg/m² (Random Effects Model)

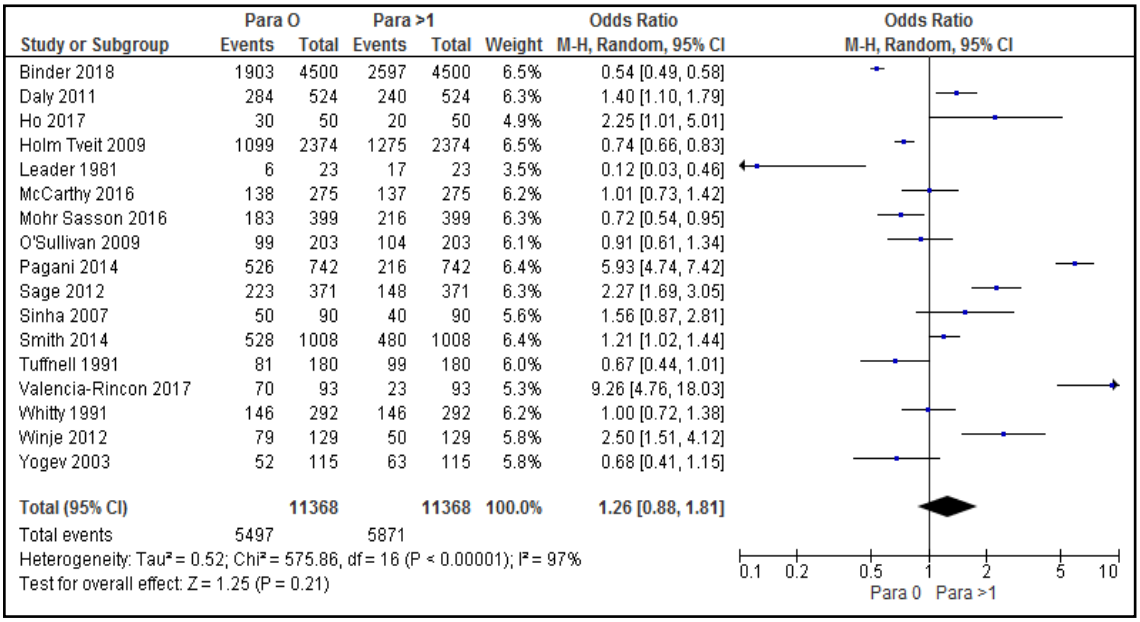


Figure I Parity Primiparous versus Multiparous Random Effect Model

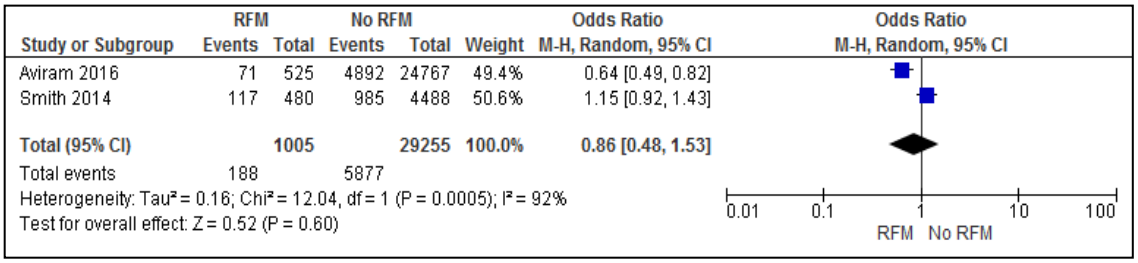


Figure J Previous CS (Random Effects Model)

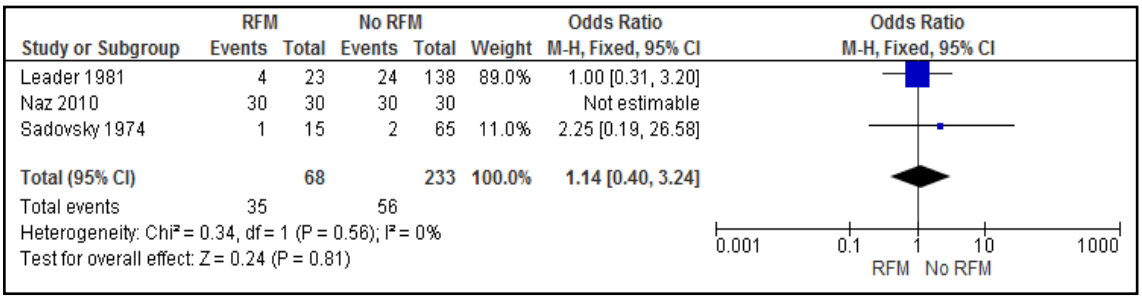


Figure K Postdates >42 weeks

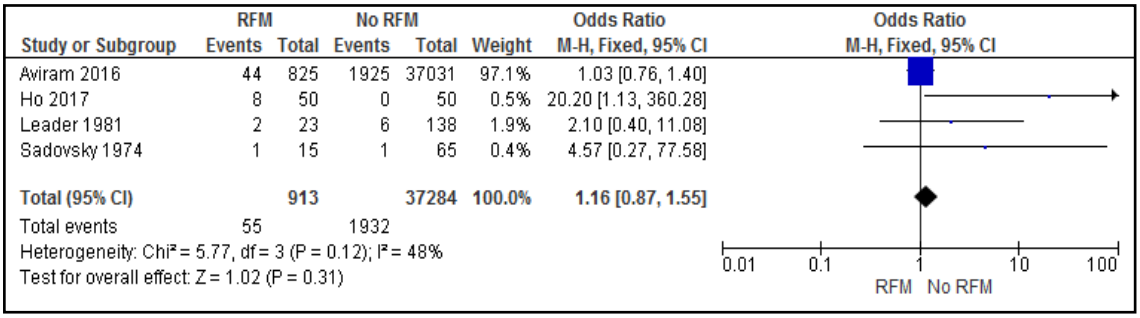


Figure L Diabetes

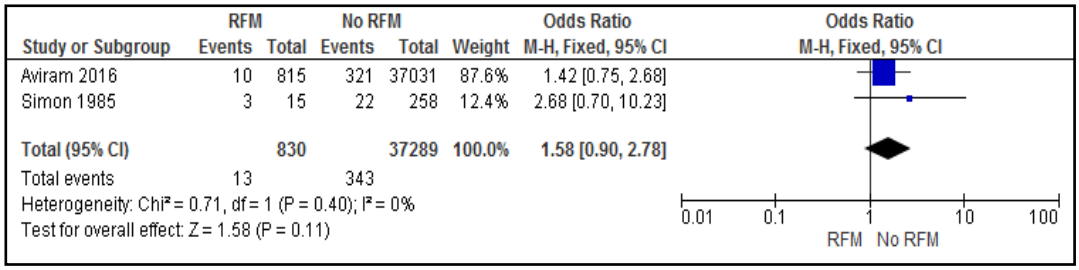


Figure M Chronic Hypertension

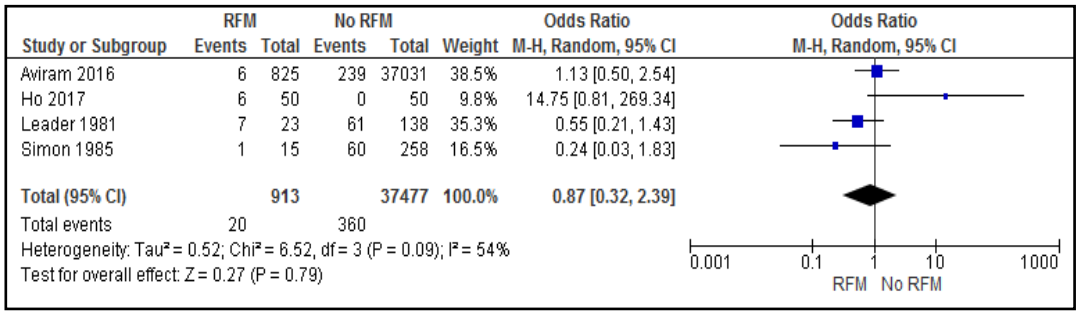


Figure N Gestational Hypertension

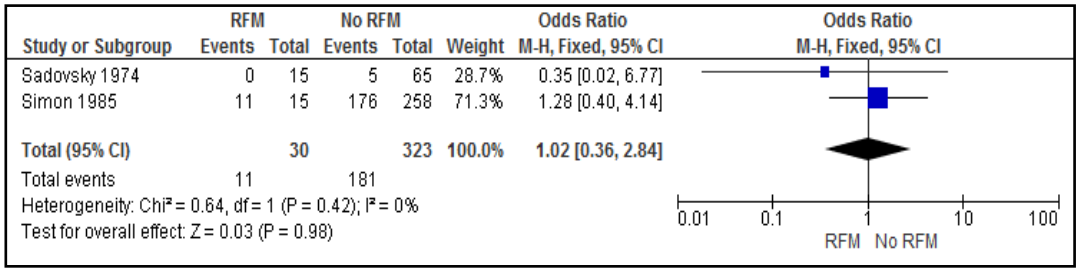


Figure O Pre-eclampsia

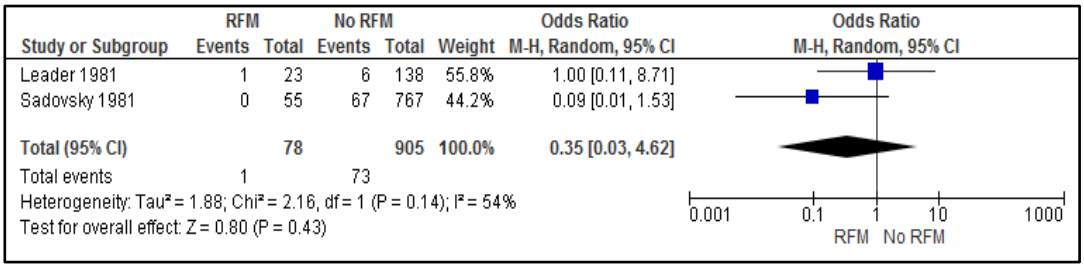


Figure P Antenatal Bleeding (random effects model)

Appendix 6 Pregnancy, birth and neonatal outcomes forest plots

Primary Outcomes

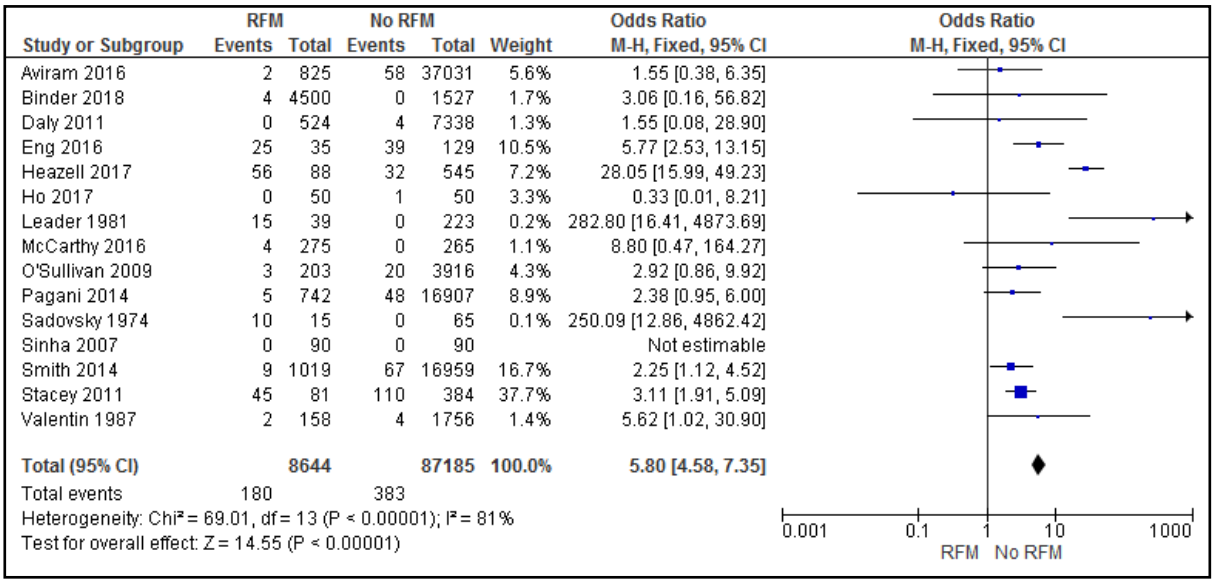


Figure A: Stillbirth (Fixed Effect Model)

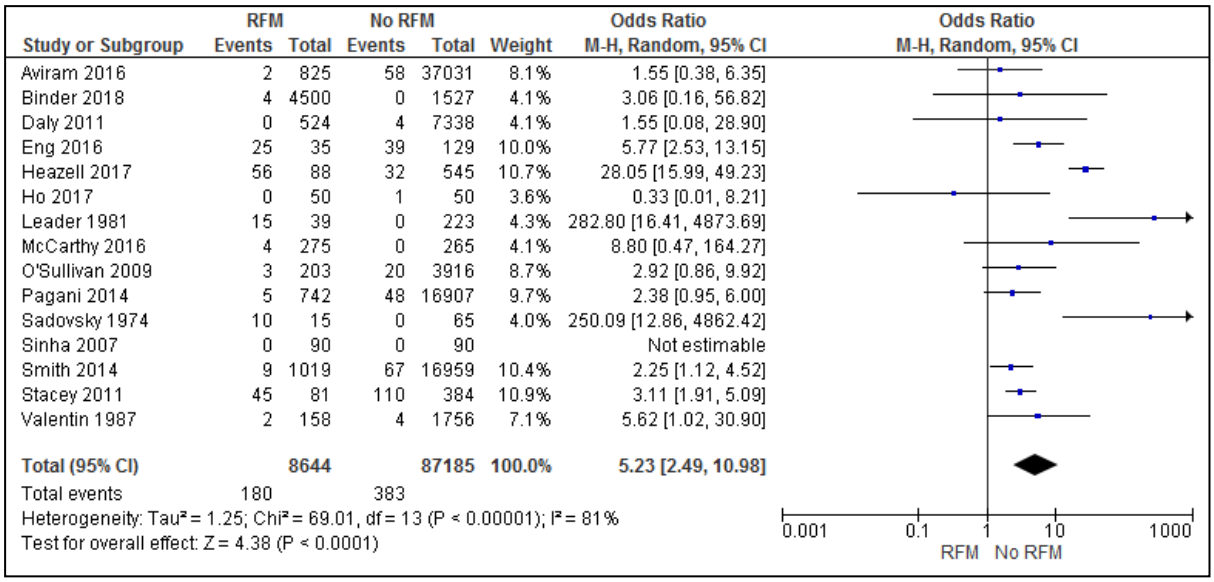


Figure B: Stillbirth (Random Effect Model)

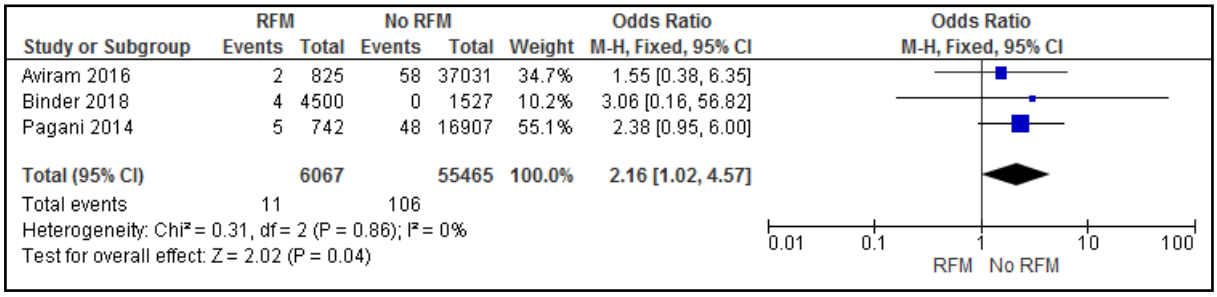


Figure C: Stillbirth ≥36 weeks' gestation

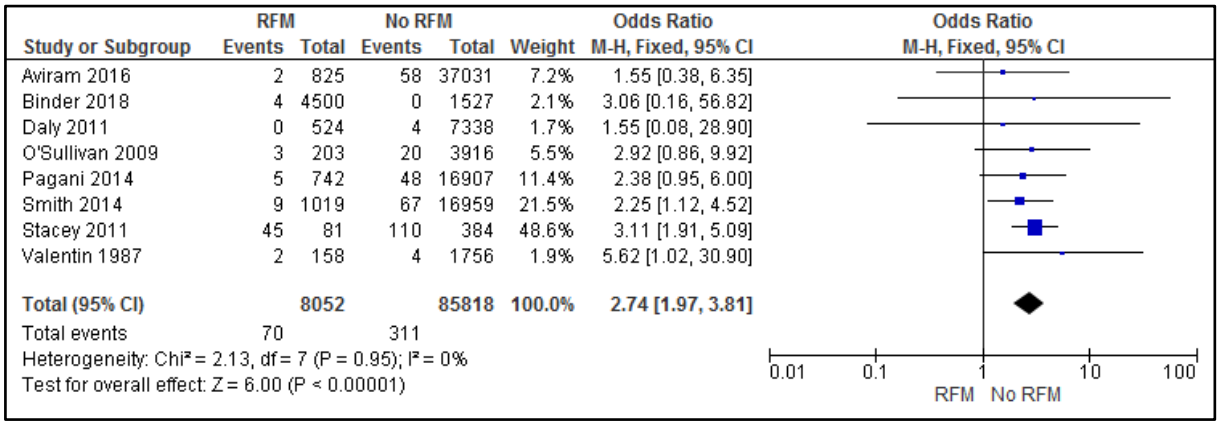


Figure D: Stillbirth (Retrospective Cohort Studies only)

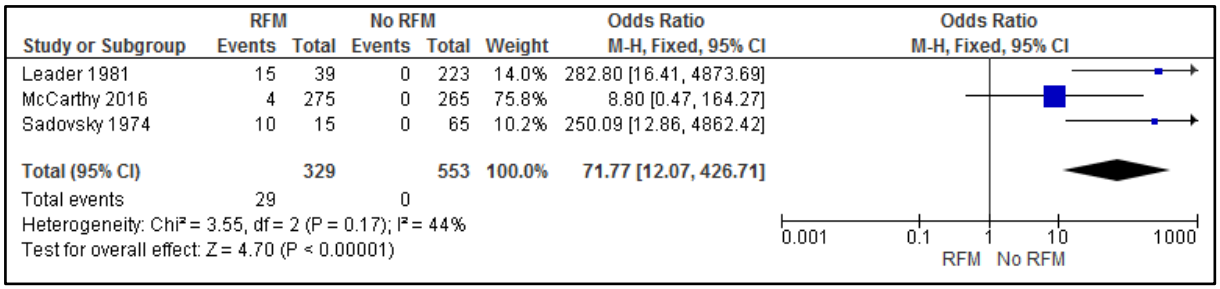


Figure E: Stillbirth (Prospective Studies only)

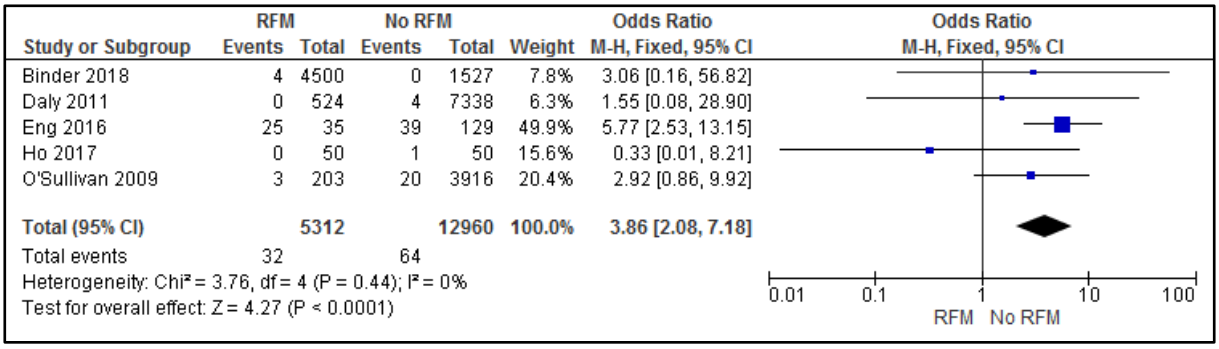


Figure F: Stillbirth (5 studies Low Risk of Bias)

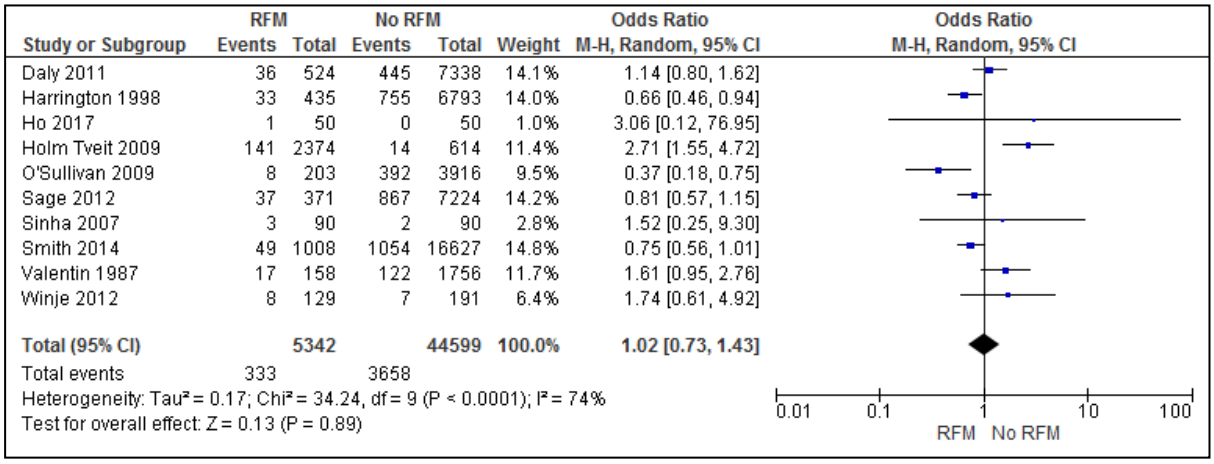


Figure G: Preterm Birth (Random Effects Model)

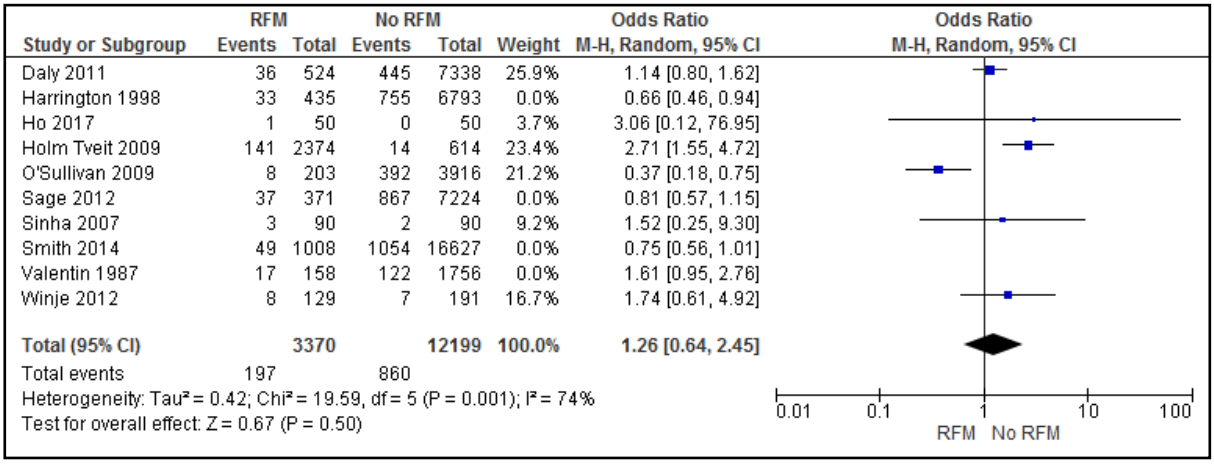


Figure H: Preterm Birth (6 studies Low Risk of Bias)

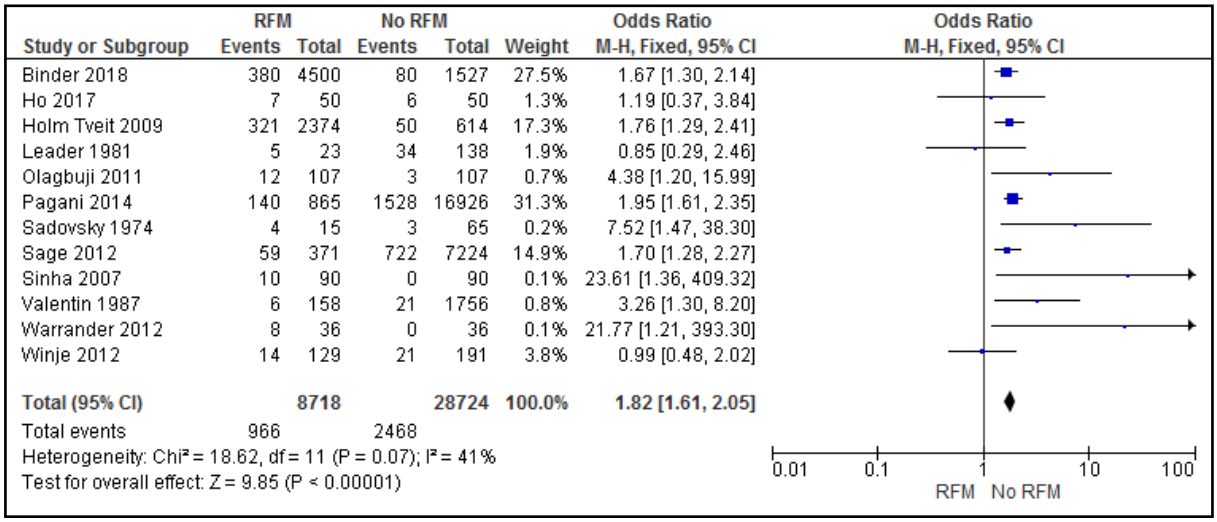


Figure I: Small for Gestational Age

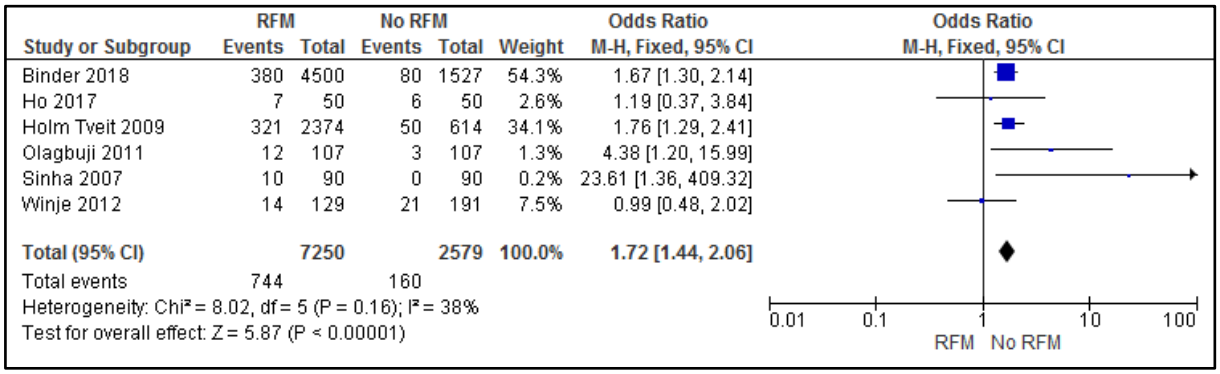


Figure J: Small for Gestational Age (Low Risk of Bias Studies)

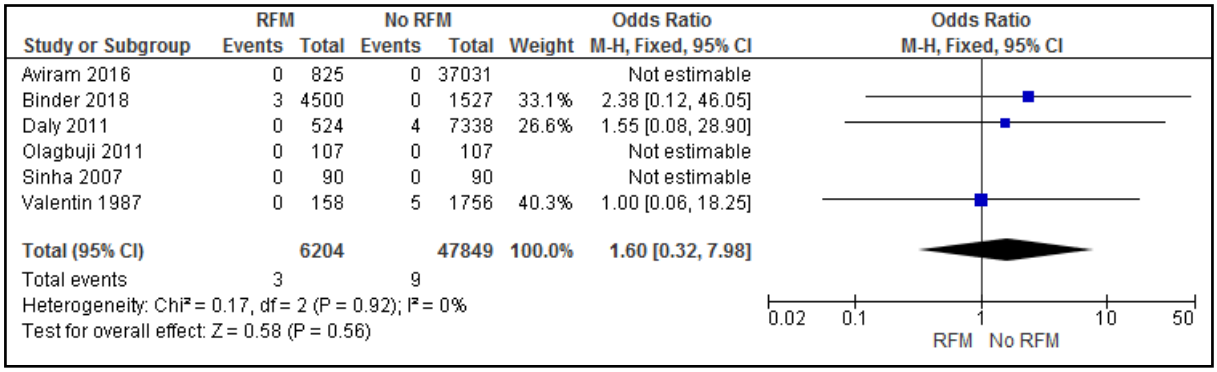


Figure K: Neonatal Death (Fixed Effect Model)

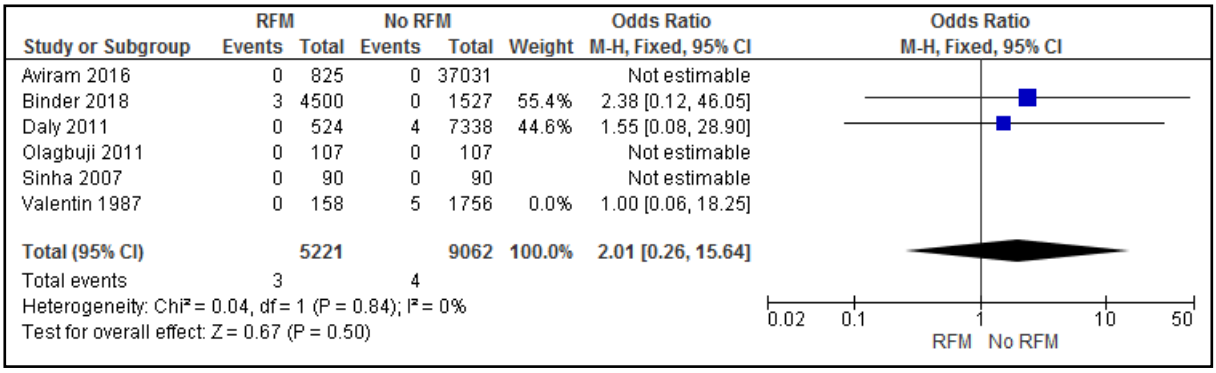


Figure L: Neonatal Death (Low Risk of Bias Studies)

Secondary Outcomes

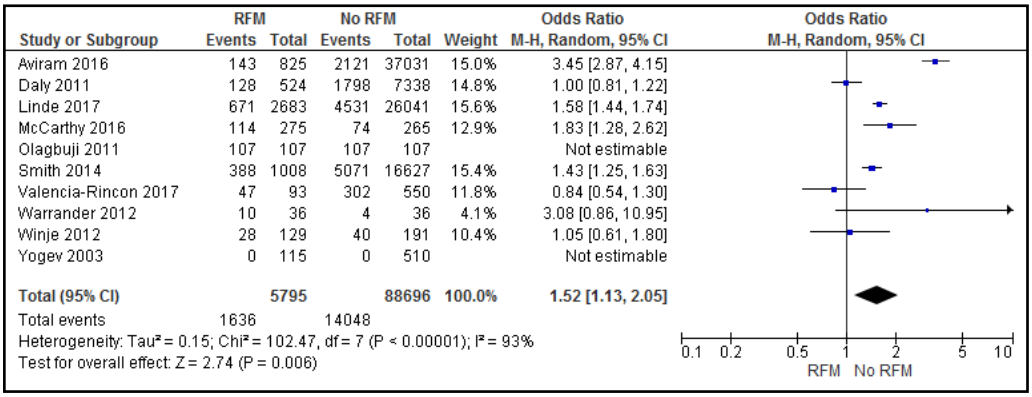


Figure M: Induction of Labour (Random Effects Model)

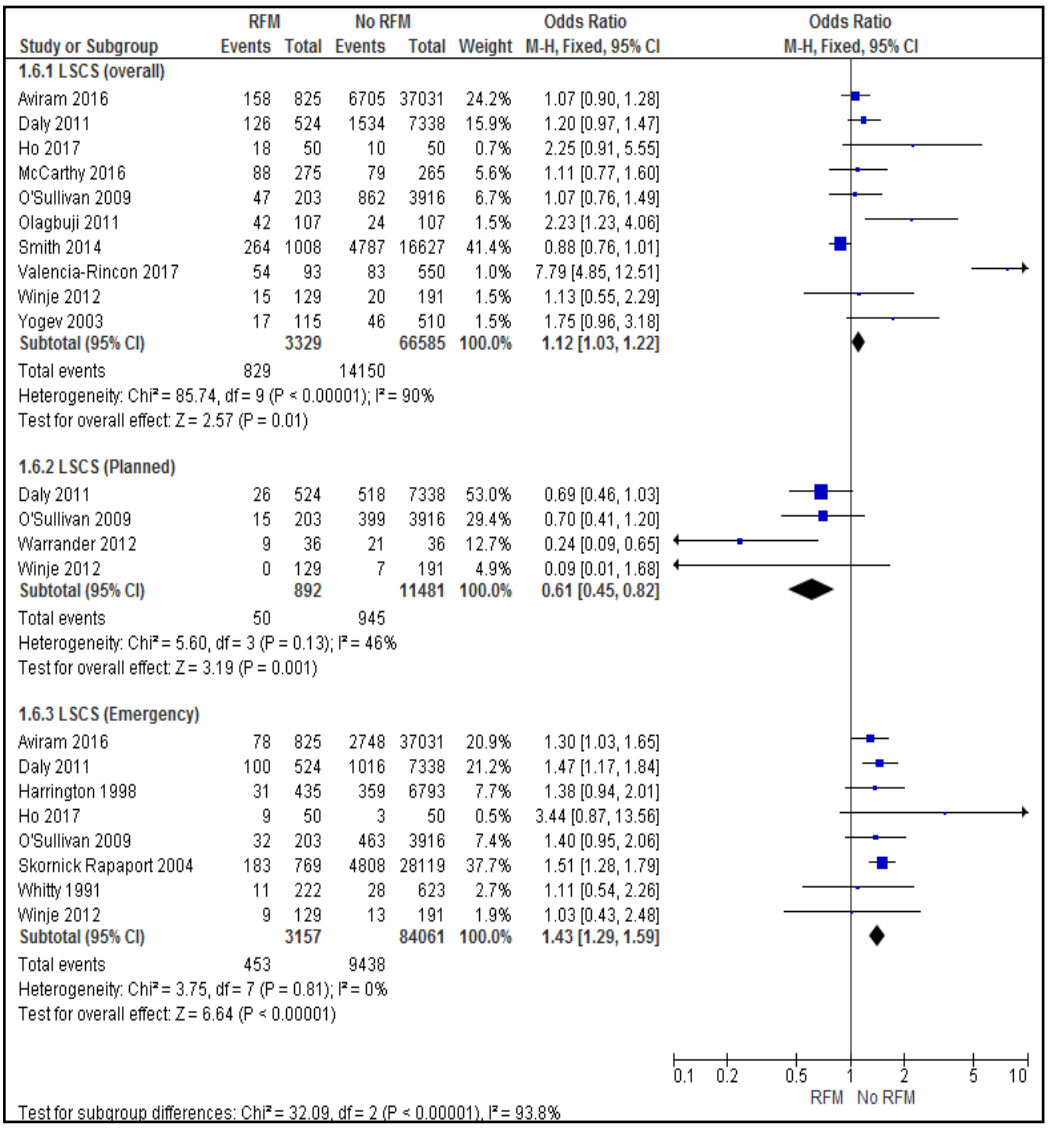


Figure N: Caesarean Section (CS overall, CS planned, CS Emergency)

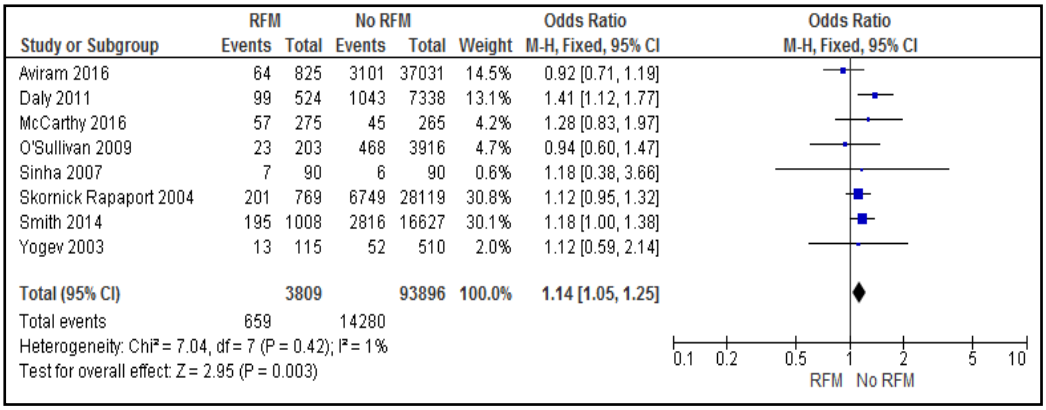


Figure O: Instrumental Birth

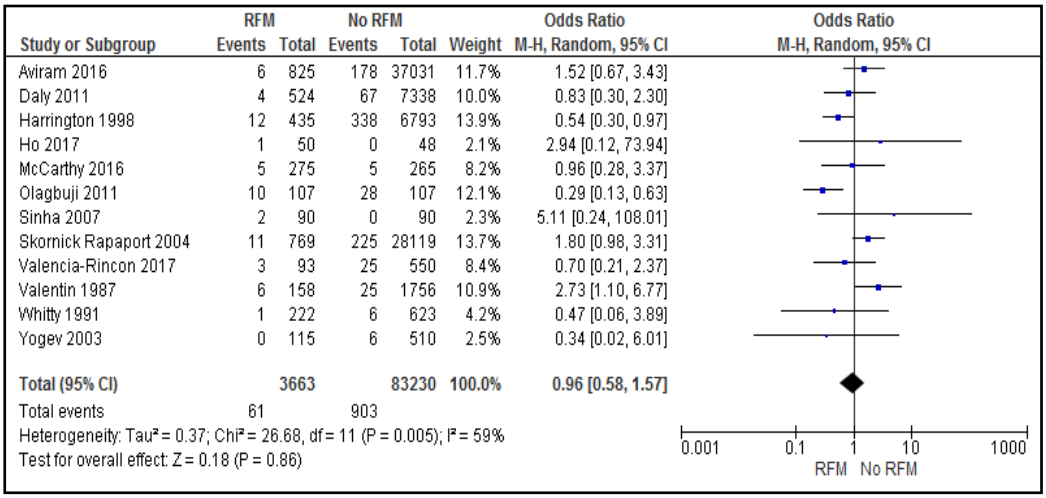


Figure P: Apgars <7 at 5 minutes at birth (Random effects model)

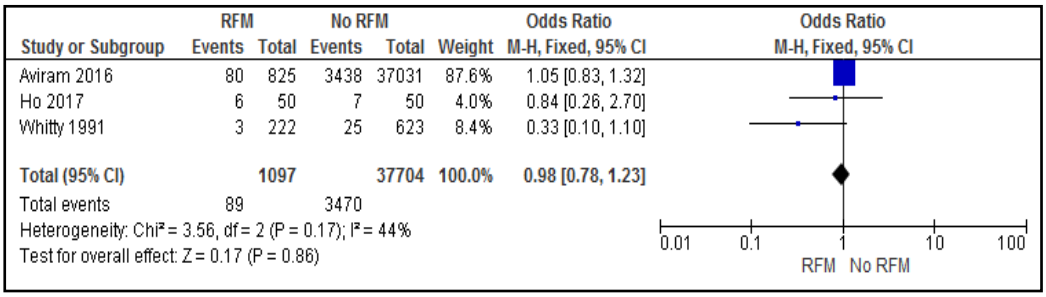


Figure Q: Meconium (Fixed effects model)

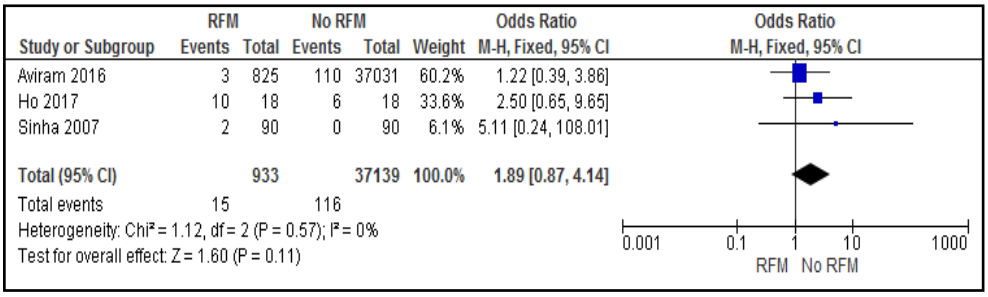


Figure R: Metabolic acidosis (Fixed effects model)

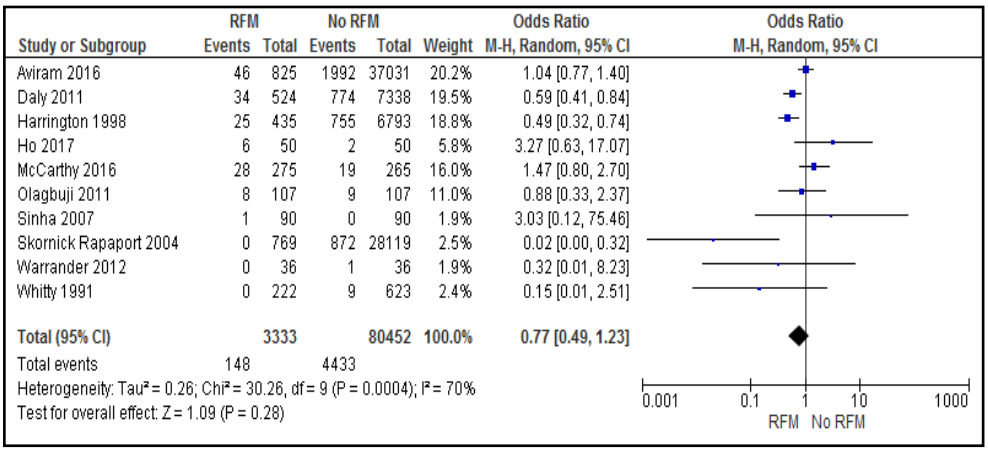


Figure S: Admission to NICU (Random effects model)

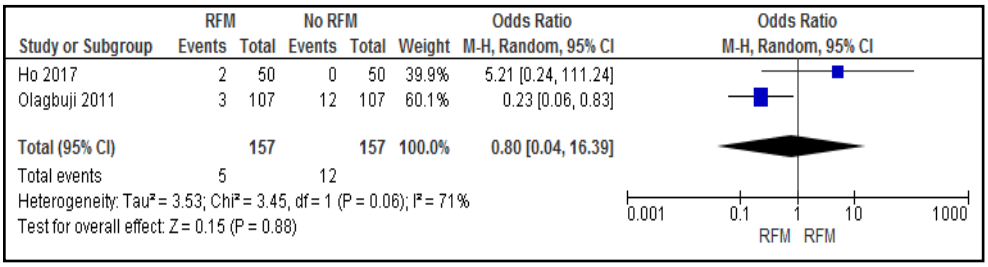


Figure T: Birthweight <2500g (Random Effects Model)

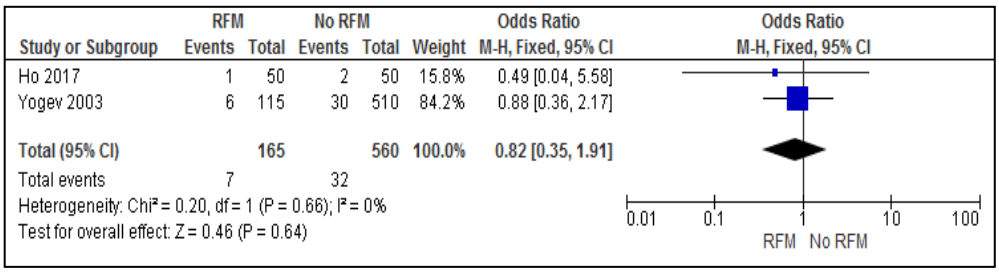


Figure U: Birthweight ≥4000g

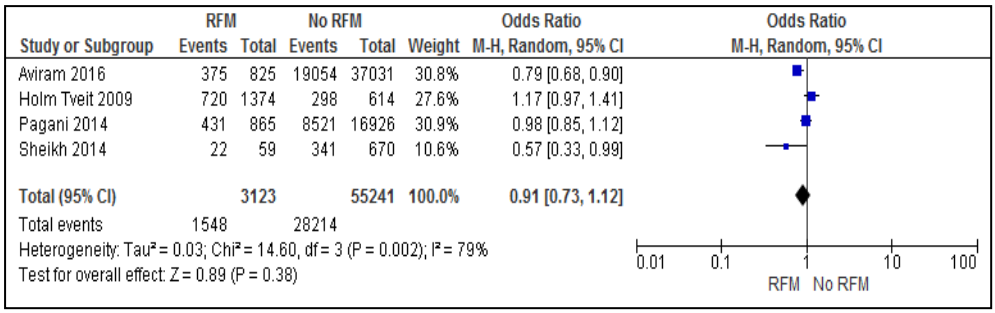


Figure V: Gender Male (Random Effects Model)

Appendix 7 Publication Bias (Analysis of Funnel Plots)

Publication Bias (Funnel Plot Analysis)

When ten or more studies contributed to the analyses, funnel plots were inspected for evidence of asymmetry and possible publication bias.

A funnel plot for parity (17 studies) was conducted. The funnel plot for parity (17 studies) is asymmetrical and therefore publication bias is possible. Visual inspection of a funnel plot (figure 6) showed a gap in the middle and bottom left and right of the plot suggesting that some smaller studies with large effects may be underrepresented.

Funnel plots for stillbirth, preterm birth, SGA, Apgar score <7 at 5 mins and admission to NICU were relatively symmetrical indicating minimal publication bias or small study effect. The funnel plot for induction of labour was visually asymmetrical possibly due to two studies having no events in either group. Publication bias cannot be out ruled.

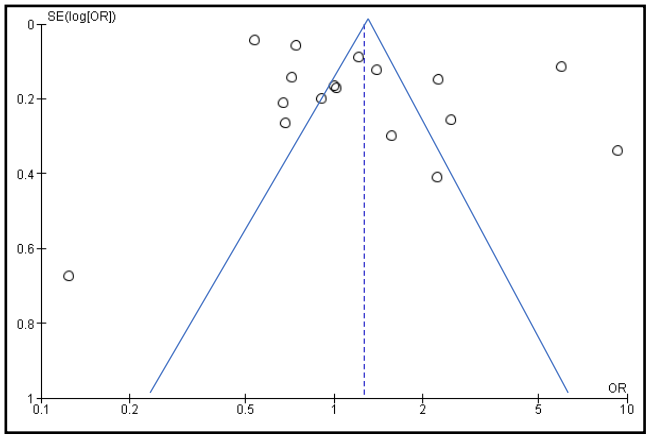


Figure 1: Funnel Plot analysis Parity (17 studies)

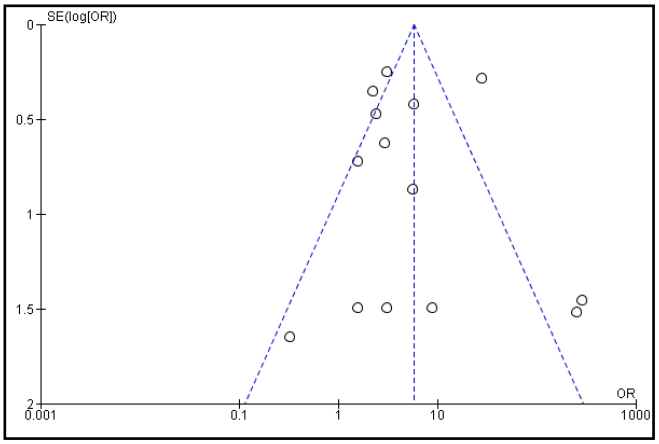


Figure 2: Funnel Plot analysis Stillbirth (15 studies)

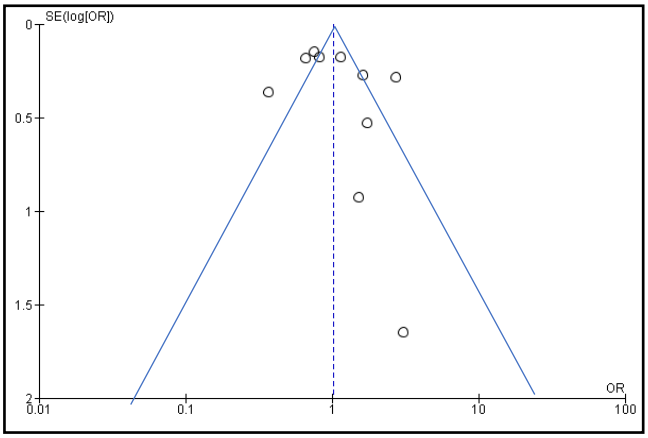


Figure 3: Funnel Plot analysis Preterm Birth (10 studies)

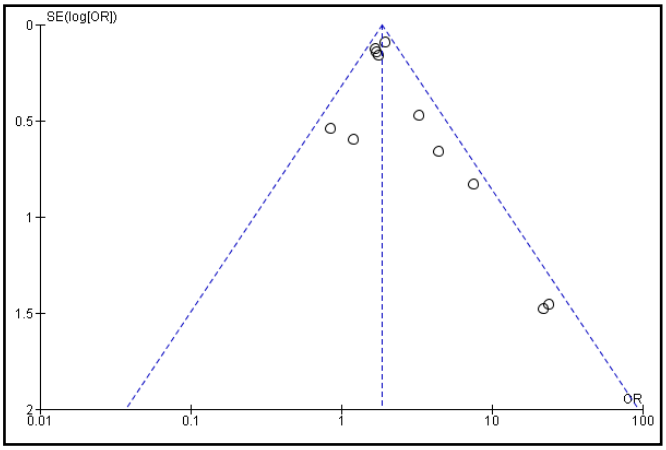


Figure 4: Funnel Plot analysis Small for Gestational Age (12 studies)

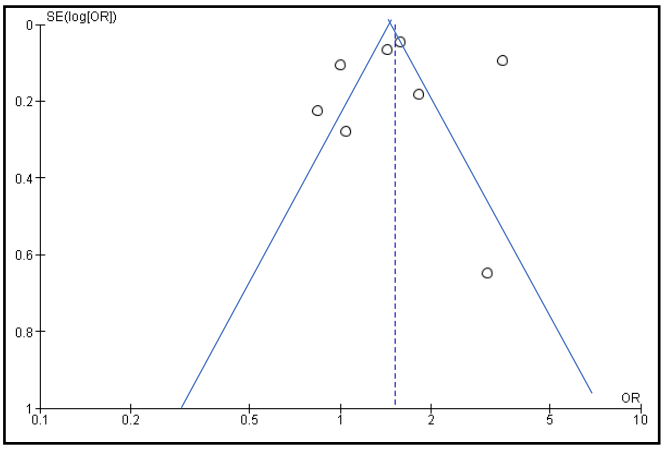


Figure 5: Funnel Plot Analysis Induction of Labour (10 studies)

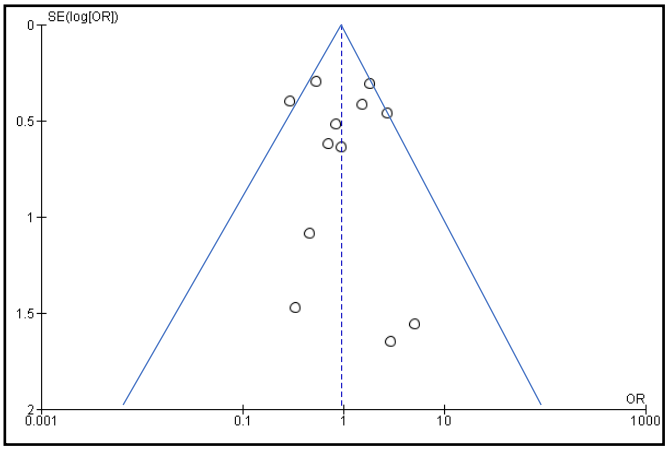


Figure 6: Funnel Plot Analysis Apgars <7 at 5 mins (12 studies)

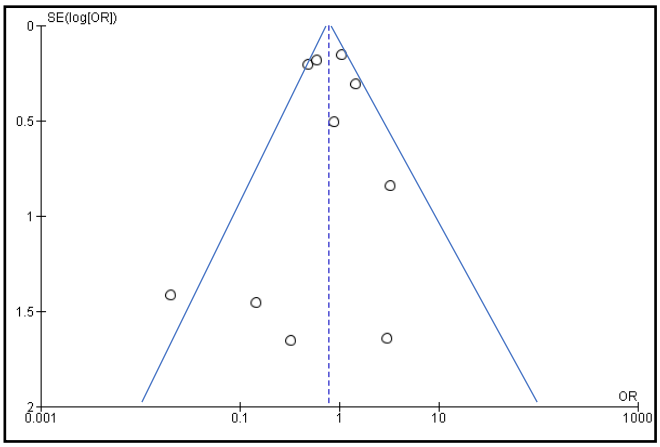


Figure 7: Funnel Plot Analysis Admission to NICU (10 studies)

Appendix 8 STROBE Statement

STROBE Statement—Checklist of items that should be included in reports of *case-control studies.*

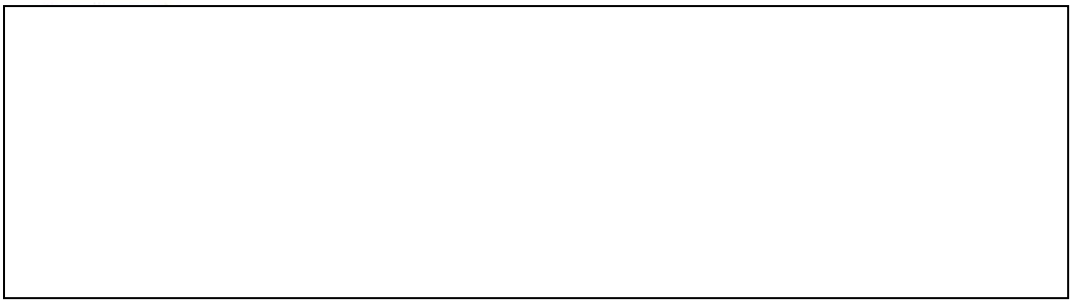
	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 75 Section 3.7
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 78 Section 4.2
Methods			
Study design	4	Present key elements of study design early in the paper	Page 82 Section 4.4.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 90 Section 4.7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	Page 96 Section 4.10
		(*b*) For matched studies, give matching criteria and the number of controls per case	Not applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 100 Section 4.12
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 102 Section 4.13
Bias	9	Describe any efforts to address potential sources of bias	Page 88
Study size	10	Explain how the study size was arrived at	Page 98 Section 4.11
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 108
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pages 108-113 Section 4.16
		(*b*) Describe any methods used to examine subgroups and interactions	Page 114 Section 4.1.6.4
		(*c*) Explain how missing data were addressed	Page 107 Section 4.1.5.3
		(*d*) If applicable, explain how matching of cases and controls was addressed	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially	Pages 121-123 Section 5.2

		eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	Pages 121-123 Section 5.2
		(c) Consider use of a flow diagram	Page 124 Figure 5.3
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 123 Section 5.3
		(b) Indicate number of participants with missing data for each variable of interest	Page 126 Table 5.1
Outcome data	15*	Report numbers in each exposure category, or summary measures of exposure	Page 126 Table 5.1
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 132, Table 5.6, Page 140
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 146 Section 5.12
Discussion			
Key results	18	Summarise key results with reference to study objectives	Chapter 6
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 183 Section 6.6
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Chapter 6
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 183 Section 6.6
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Not applicable

*Give information separately for cases and controls.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

Appendix 9 Letter of Approval from Chief Executive Officer Consultant Obstetrician



Re: Lorraine Carroll-Trinity College Dublin Doctoral Student

Dear Lorraine,

I am writing to you to express my support in undertaking your research study: *'Reduced Fetal Movements in Pregnancy: A matched case-control study of risk factors, pregnancy, birth and neonatal outcomes'* as part of Postgraduate Doctoral Studies at Trinity College Dublin and give my permission to for you to access the hospital.

Appendix 10 Director of Midwifery Approval Letter

Lorraine Carroll <carroll@tcd.ie>

Permission to access hospital for research study

2 messages

[redacted]

19 March 2019 at 21:02

I hope you are well and somehow getting back to normal after recent tragic events.

As you are aware I am currently pursuing a postgraduate doctoral degree with the School of Nursing and Midwifery, Trinity College Dublin. Professor Valerie Smith and Dr Louise Gallagher are my supervisors. You may recall that I briefly discussed with you my chosen topic of reduced fetal movements in pregnancy. To date I have been concentrating on a systematic review and meta-analysis of risk factors, pregnancy, birth and neonatal outcomes associated with reduced fetal movements in pregnancy. Further details can be found at this link: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=82685

This is now nearing completion and pointing towards the need for more robust studies on risk factors and outcomes associated with reduced fetal movements in pregnancy.

With this in mind, I now wish to seek permission from you and [redacted] to access the [redacted] to conduct a prospective matched case-control study to further investigate risk factors and outcomes associated with reduced fetal movements in pregnancy.

Subject to your and [redacted] approval to access the hospital, I plan to set up a meeting very soon with potential stakeholders to decide on best course for setting up the study and subsequently apply for ethical approval. I would be delighted if you could also be involved.

I wish to take this opportunity to thank you for your continued support.

With warm regards,
Lorraine Carroll

Lorraine Carroll

[redacted]

20 March 2019 at 10:59

[redacted]
Cc: "carroll@tcd.ie" <carroll@tcd.ie>

Dear Lorraine

Yes I am very supportive it's a really important topic

Very happy to lend any help I can.!

Best wishes

[redacted]

Appendix 11 Clinical Research Ethics Committee Approval Letter

[redacted]

PRIVATE AND CONFIDENTIAL

Ms. Lorraine Carroll

[redacted]

Wednesday 15th May 2019

Re: Reduced Fetal Movements in Pregnancy: A case control study of risk factors, pregnancy, birth and neonatal outcomes
Our ref:(EC 19. 2019)

Dear Ms. Carroll,

The above study was considered by the Research Ethics Committee a[redacted] on Monday 13th May 2019. I am pleased to inform you that it has received ethical approval.

Best of luck with the study.

Kind regards,

Yours sincerely,

[redacted]

Chairman,
Ethics Research Committee

Appendix 12 University Research Ethical Approval Letter

Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

Lorraine Carroll
School of Nursing and Midwifery
24 D'Olier Street,
Dublin 2

5th June 2019

Study title:
Risk factors for and outcomes associated with reduced fetal movements in pregnancy

Dear Lorraine,

I am pleased to inform you that your study has been granted ethical approval from the School of Nursing and Midwifery Research Ethics Committee.

Yours sincerely,

Maria Brenner

Prof Maria Brenner
Chair of School of Nursing and Midwifery Research Ethics Committee

Scoil an Altranais agus an Chnáimhseachais
Dámh na nEolaíochtaí Sláinte,
Coláiste na Tríonóide,
Baile Átha Cliath,
Ollscoil Átha Cliath,
24 Sráid D'Olier.
Baile Átha Cliath 2, Éire.

School of Nursing and Midwifery
Faculty of Health Sciences,
Trinity College Dublin,
The University of Dublin,
24 D'Olier Street,
Dublin 2, Ireland.

+353 1 8962692
nursing.midwifery@tcd.ie
nursing-midwifery.tcd.ie

Appendix 13 Gatekeeper Monthly Data Extraction Excel Sheet

Women presenting to ED with Reduced Fetal Movements (RFM)			
Hospital ID	**Date of RFM**	**Gestation[a]**	**Notes[b]**

Notes:

a Gestation on admission to ED

b e.g., twins, less than 24 weeks gestation or less than 18 years old

Appendix 14 Study Data Extraction Form

Study ID:

Research Title:	**Reduced fetal movements in pregnancy: an assessment of risk factors and pregnancy, birth, fetal and neonatal outcomes**	
Investigators:	Ms. Lorraine Carroll, Professor Valerie Smith (TCD), Dr Louise Gallagher (TCD),	
Woman's Details	Date of Birth	d d m m y y y y
	Ethnic Group	Irish ☐
		Irish Traveller ☐
		Any other white background ☐
		Black or Black Irish ☐
		Any other black background ☐
		Asian or Asian Irish ☐
	Other, *please specify*	_____
Study Data	BMI (kg/m²) at booking	☐
	Did the woman cigarette smoke at booking?	Yes ☐ No ☐ Unknown
Previous Pregnancy History *(tick all that apply)*	None	☐
	Previous miscarriage	☐
	Previous Stillbirth (≥24 weeks gestation)	☐
	Previous Caesarean Section	☐
Previous Medical History	Did the woman have any of the following medical conditions before being pregnant?	Diabetes ☐
		Hypertension ☐
		Epilepsy ☐

Study ID:

Current Pregnancy	Parity	☐ ☐
	Conception *(tick one)*	Spontaneous ☐ Assisted ☐ Not reported ☐
	EDD by Ultrasound	d d m m y y y y
	Anterior Postion of Placenta (U/S) at anomaly scan	Yes ☐ No ☐
	Congenital anomaly seen on Ultrasound	Yes ☐ No ☐
Reduced Fetal Movements (RFM) Episode Data	Reason for referral	Reduced fetal movements ☐ or Absent movements ☐
	Gestation at 1st presentation with reduced/absent movements	Weeks ☐ days
	Date of 1st presentation with RFM/absent fetal movements	d d m m y y y y
	How many times did the woman present to the hospital with reduced or absent fetal movements during this pregnancy? *(tick one)*	One ☐ Two ☐ Three or more ☐
Complications of this current pregnancy *(tick all that apply)*	None	☐
	Gestational hypertension	☐
	Chronic hypertension	☐
	Pre-eclampsia	☐
	Small Gestational Age/IUGR/FGR	☐
	Gestational Diabetes	☐
	Oligohydramnios	☐
	Polyhydramnios	☐
	Antenatal bleeding	☐
Labour Events	Onset of Labour *(tick one)*	Spontaneous ☐ Induced ☐ Elective Casearean Section ☐
	Provide reason for induction/Elective LSCS	_____
	Date of Delivery	d d m m y y y y

Study ID:

Labour events	Mode of Birth *(tick one)*	Spontaneous Vaginal Birth ☐ Ventouse ☐ Forceps ☐ Casearean Section ☐
	If caesarean section (tick one)	Emergency not in labour ☐ Emergency in labour ☐
	Reason for caesarean section	☐
Neonatal Outcome	Neonatal Outcome *(tick one)*	Liveborn ☐ Neonatal Death ☐ Stillbirth ☐
	Gestational age at birth	weeks ☐ days ☐
	Birthweight (kgs)	☐☐.☐☐
	Apgar score at 5 minutes	☐
	Gender of infant	Male ☐ Female ☐
Neonate admitted to NICU/SCBU	Neonate admitted to NICU	Yes ☐ No ☐
	Date of admission to NICU/SCBU	d d m m y y y y
	Reason for admission to NICU/SCBU	_____
	Date of discharge from NICU/SCBU	d d m m y y y y
	Discharged	Home ☐ To another hospital ☐ Neonatal Death ☐
	Date of Neonatal Death *(if applicable)*	d d m m y y y y
	Reason for neonatal death	☐

Appendix 15 Sample size calculation

Hi Lorraine,

We had a think about your study and a look at your figures and discussed them with [redacted]

He mentioned it may be better to do an unmatched study and then control for age, etc in the analysis. If you were going to match he would recommend only matching on one thing or the study will become difficult to recruit for but also to analyse.

If you were going to do an unmatched study with samples selected on the basis of RFM:

- based on an alpha of 0.05
- power of 0.80 doing
- 1:1 study (cases:controls)
- basing this on a prevalence of stillbirth of 0.5%,
- OR of 3.86 (based on your systematic review)

Your sample size would be **920 in each group**.

I'm unsure by the methods if you will need to add a proportion for loss to follow up, or if you expect to have complete records for all of those that present with RMF? will you be talking to these mothers/getting consent or is it after they give birth you will gather the data?

Just for your ethics you will probably need to include how you will sample the controls too (e.g. is it a data extraction query you can run that will include all mothers with the exception of those with RMF, and then will randomly sample them?)

If you do want to match we will need to add in the correlation effect, which refers to how the prevalence of stillbirth, RMF and age correlate - for this we would need figures looking at the prevalence of stillbirth and RMF. Depending on how the two correlate we may need more information regarding age.
If there is a correlation (which there probably will be to some extent) your sample size is likely to increase from the above figure (there is a chance it would go down if correlation was low but from what you outlined in the background it seems like the two would be related).

If you have different figures you would like us to use (the stillbirth prevalence, or a different odds ratio) let me know and I can re-run the numbers,or if you want to set up a time to meet again?

Thanks,

[redacted]

Public Health SpR
CSTAR Fellow
University College Dublin

Study sample size

18 April 2019 at 08:07

Hi Lorraine,

I re-ran your sample size for an unmatched prospective study using the 1:2 ratio and this is the sample size output:

We are planning a study of independent cases and controls with 2 control(s) per case. Prior data indicate that the failure rate (i.e. stillbirth prevalence) is 0.005. If the true relative risk (OR) of failure for experimental subjects relative to controls is 3.86, we will need to study 631 experimental subjects and 1262 control subjects to be able to reject the null hypothesis that this relative risk equals 1 with probability (power) 0.8. The Type I error probability associated with this test of this null hypothesis is 0.05.

I also noticed in your sample size calculations you used a prevalence of stillbirth of 0.4%, so ran this too in case that is a better prevalence to use, which gives this output:

We are planning a study of independent cases and controls with 2 control(s) per case. Prior data indicate that the failure rate (stillbirth) among controls is 0.004. If the true relative risk (OR) of failure for experimental subjects relative to controls is 3.86, we will need to study 791 experimental subjects and 1582 control subjects to be able to reject the null hypothesis that this relative risk equals 1 with probability (power) 0.8. The Type I error probability associated with this test of this null hypothesis is 0.05.

for info, the sample size using the 0.4% prevalence with a 1:1 study is 1154 in each group.

I could meet you today at 12, or any time between 2.30 and 4pm if that suits?

Appendix 16 Study Update

[redacted]

Reduced Fetal Movements (RFM) Study Update

10 messages

Lorraine Carroll <lorraine.carroll@ucd.ie> 24 June 2020 at 21:07
To: Lorraine Carroll <lorraine.carroll@ucd.ie>

[redacted]

Dear All,

Just a brief update on the reduced fetal movements case-control study in progress. A huge thank you to Gillian and Fionnuala who have continued to provide this data in these unprecedented times.

You may be interested to note that overall numbers of women presenting to ED department fell in March (highly probable due to COVID19 restrictions) however the percentage of women attending with RFM did not change. There seems to be an increase in the percentage of women attending from April to May (see attached).

We are on target for eligible women with RFM to the study, 500 (up to 31st May). 860 required in total. Therefore I anticipate that we should reach sample size by the end of September.

Next steps include running MN-CMS reports for RFM and No RFM group (Jan-March). Thank you Fionnuala.

Thank you again for your support with this study, I really appreciate it.

Please contact me if you have queries regarding this update,

Stay well and safe,
Lorraine

Lorraine Carroll

[redacted]

Reduced Fetal Movement Study Update 24_6_2020.pdf
290K

[redacted] 25 June 2020 at 08:27

Hi Lorraine,

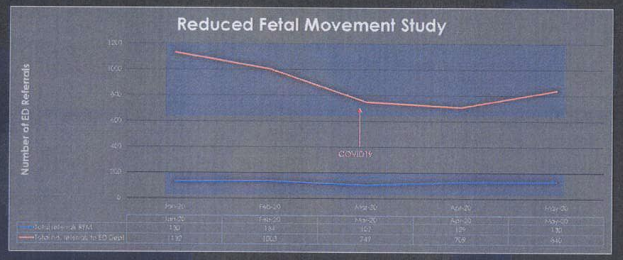
That is fantastic. I wonder would the increase in attendances for RFM's be a combination of anxiety due to Covid but also less contact with midwives/ doctors due to less attendances in OPD during the previous month...

Thanks for update,

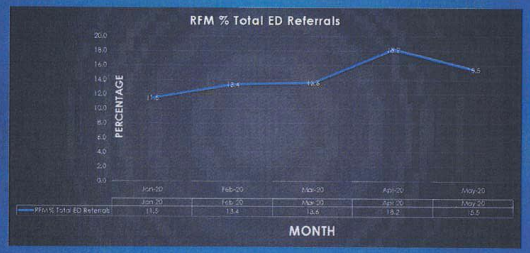
Reduced Fetal Movement Study Update

JUNE 2020

Trend in Referrals with RFM



RFM % of Total ED Referrals (Jan-May 2020)



Eligibility Update

Month	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Totals
Total referrals with RFM	130	134	102	129	130	625
Ineligible for inclusion (total)	7	10	7	8	14	46
Eligible for inclusion	123	124	95*	121	116	579
Total Repeat RFM referrals						79
Total number of women enrolled						500

*COVID 19 Restrictions commenced

Total Sample Size Calculation for RFM Group =860

Appendix 17 Study Excel Sheet Monthly Data

Month	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Totals
Total referrals	130	134	102	129	130	137	115	129	112	**1118**
***Ineligible* for inclusion (total)**	7	10	8	9	14	10	16	7	6	87
Twins	1	2	1	3	4	1	1	0	0	13
<24 weeks	6	8	6	6	10	9	13	7	6	71
<18 years	0	0	1	0	0	0	2	0	0	3
Eligible for inclusion	123	124	94	120	116	127	99	122	106	**1031**
No. with repeat referrals in month only	5	7	5	7	11	3	8	4	2	52
With repeat referrals from prev months		10	5	15	14	19	9	10	16	98
Total Repeat referrals										150
Total women included	**118**	**107**	**84**	**98**	**91**	**105**	**82**	**108**	**88**	**881**
Total *No RFM* required (randomise)	236	214	168	196	182	210	164	216	176	**1762**
As per FB singleton hospital births	580	550	579	607	599	608	643	597	601	**5364**
***Ineligible* for inclusion (total)**	16	10	9	9	17	17	14	10	13	**115**
Twins	16	10	9	9	16	17	14	10	13	**114**
<24 weeks	0	0	0	0	0	0	0	0	0	**0**
<18 years	0	0	0	0	1	0	0	0	0	**1**
Total no. referrals to ED Dept	1132	1003	749	709	840	887	994	998	888	8200
Total referrals RFM	130	134	102	129	130	137	115	129	112	**1118**
RFM % Total ED Referrals	11.5	13.4	13.6	18.2	15.5	15.4	11.6	12.9	12.6	13.6

Appendix 18 Summary of original variables created and data dictionary

Project Title: Reduced fetal movements in pregnancy: an assessment of risk factors and pregnancy, birth, fetal and neonatal outcomes								
Investigators & Affiliations: Lorraine Carroll								
Col	Abbrev	Full Name of Variable	Definition of Variable	Source(s)	Type of Variable		Level of Measurement	Coding Option
					Qualitative / Quantitative	Categorical Discr / Contin		
A	ID	Study ID	No. assigned	Assigned	Numeric	N/A	N/A	
B	Study Group							1=No RFM 2=RFM
C	DOB	Date of Birth	Self explanatory		Date	Date	N/A	Type in as dd-mm-yyyy
D	Ethnicity	Ethnicity	Self explanatory		Qualitative	Categorical	Nominal	1=Irish, 2=Any other white background, 3=African 4=Chinese 5=Any other Black background, 6=Any other Asian background, 7=Other including mixed background, 8=Irish Traveller, 9= Not known 99=missing
E	BMI	Body Mass Index	Self explanatory		Quantitative	Continuous	Interval	Type in, 999=Unknown
F	Smoking	Smoking	Cigarette smoking		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
G	Parity	Parity	Obstetric history		Quantitative	Continuous	Interval	Type in e.g. 1.0, 1.1, 1.3 99=missing
H	PH_Misc	Pregnancy History-Miscarriage	Previous miscarriage		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
I	No_Misc	Number of Miscarriages	Number of Miscarriages		Quantitative	Continuous	Interval	Type in
J	PH_IUD	Pregnancy History-Stillbirth	Previous IUD		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
K	PH_NND	Pregnancy History-Neonatal Death	Previous NND		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
L	PH_CS	Previous Caesarean Section	Previous LSCS		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
M	PMH_BP	Medical History-Hypertension	History hypertension		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
N	PMH_DM	Medical History-Diabetes	History diabetes		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
O	PMH_Epilepsy	Medical History-Epilepsy	History epilepsy		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
P	Conception	Conception	Conception		Qualitative	Categorical	Nominal	1= Spontaneous, 2= Assisted, 3= Not reported, 9=Missing
Q	EDD	Expected Date of Delivery	Date		Date	Date	N/A	Type in as dd-mm-yyyy, 999=Unknown
R	Ant_Placenta	Anterior Placenta	Location of placenta		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
S	Cong_Anomaly	Congenital Anomaly	congenital anomaly		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
T	Gest_BP	Gestational Hypertension	occuring in pregnancy		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
U	Chron_BP	Chronic Hypertension	occuring in pregnancy		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
V	Pre_Eclamp	Pre-Eclampsia	occuring in pregnancy		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown

Coll	Abbrev	Full Name of Variable	Definition of Variable	Source(s)	Type of Variable		Level of Measurement	Coding Option
					Qualitative / Quantitative	Categorical Discr / Contin		
W	SGA	Small for Gestational Age	occuring in pregnancy		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
X	Gest_DM	Gestational Diabetes	occuring in pregnancy		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
Y	Oligo	Oligohydramnios	occuring in pregnancy		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
Z	Poly	Polyhydramnios	occuring in pregnancy		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
AA	APH	Antenatal Bleeding	occuring in pregnancy		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
AB	LOnset	Labour Onset	Onset of Labour		Qualitative	Categorical	Nominal	1=Spontaneous, 2=Induced, 3=Pre Labour C-Section, 99=Missing
AC	IOL_Reason	Reason for Induction of Labour/LSCS	Self explanatory					? Dropdown in MN-CMS report
AD	INF_DOB	Date of Delivery of Infant	Date		Date	Date	N/A	Type in as dd-mm-yyyy
AE	Mode_Birth	Mode of Birth	Self explanatory		Qualitative	Categorical	Nominal	1=SVD, 2=Operative Birth, 3=Caesarean Section 4=Spontaneous Breech 99=missing
AF	Instr_Type	Operative Type	Type of Instrumental		Qualitative	Categorical	Nominal	1=Ventouse 2=Forceps 3=Ventouse/Forceps
AG	CS_type	Type of Caesarean Section	Self explanatory		Qualitative	Categorical	Nominal	1=Category 1, 2=Category 2, 3=Category 3, 4=Category 4
AG	CS_Reason	Reason for Caesarean Section			Qualitative	Categorical	Nominal	As per Dropdown in MN-CMS report
AH	INF_Out	Neonatal Outcome	Outcome at birth		Qualitative	Categorical	Nominal	1=Liveborn, 2=Neonatal Death, 3=Stillborn, 9=Missing
AI	Gest_Birtha	Gestation at birth	Self explanatory		Quantitative	Continuous	Interval	Type in
AK	INF_Wgt	Birthweight (kgs)	Kgs		Quantitative	Continuous	Interval	Type in
AL	Apgar5	Apgars at 5 minutes	Apgar score 5mins		Quantitative	Continuous	Interval	Type in
AM	Gender	Infant Gender	Self explanatory		Qualitative	Categorical	Nominal	1=Male, 2=Female, 9=Unknown
AN	ADM_NICU	Admission to NICU	Self explanatory		Qualitative	Categorical	Nominal	1=No, 2=Yes, 9=Unknown
AP	NICU_Reason	Reason for admission to NICU	Self explanatory		Qualitative	Categorical	Nominal	Type in ? Dropdown list in MN-CMS
AU	Date_RFM	Date of RFM	Date		Date	Date	N/A	Type in dd-mm-yyyy
AV	Gest_RFM	Gestation of 1st presentation RFM	Self explanatory		Quantitative	Continuous	Interval	Type in (e.g. 37+4 = 37.4)
AX	No_RFM	Number of RFM referrals	Self explanatory		Qualitative	Categorical	Nominal	1=1, 2=2, 3=3 or more, 9=Missing

Appendix 19 List of new variables created and recategorised for analysis

List of variables created for analysis

Label	New Variable name	Description	Categories
Age	Age	Maternal age was calculated by using the transform function-date and time wizard in SPSS, computing the difference between the date of infant birth and date of birth of the mother	Age (in years)
BMI	BMI_IOTF	BMI was recategorised from a scale variable into categorical variable by using the 'transform into different variable' function in SPSS	1. BMI <18.5 2. BMI ≥18.5-24.99 3. BMI ≥25-29.99 4. BMI ≥30-39.99 5. BMI ≥40 99. Not reported
Infant Weight	INF_Wgt_Kgs	Infant weight was recategorised from grams to kgs by using the Transform-compute variable function in SPSS INF_weight/100	
Gestation of 1st presentation with RFM	Gest_RFMa	Gestation of 1st presentation with RFM was calculated by: 1. computing the difference (days) between Expected date of birth and date of RFM (=X days) 2. Subtracting 280 days - X days 3. Using a formula to convert days into weeks and days (INT((L2)/7&"weeks"&IF(MOD(L2,7)=0,"",","&MOD(L2,7)&"days")	

Variables recoded and recategorised

Label	Original Categories	New Variable name	Recoded categories
Age	Age (in years)	Age_groups	1. <20 years 2. 20-24 years 3. 25-29 years 4. 30-34 years 5. 35-39 years 6. ≥40 years
Age groups recategorised	1. <20 years 2. 20-24 years 3. 25-29 years 4. 30-34 years 5. 35-39 years 6. ≥40 years	Age_Groups_recat	1. Up to 24 years 2. 25-29 years 3. 30-34 years 4. 35-39 years 5. ≥40 years
Ethnicity	1. Irish 2. Any other white background 3. African 4. Chinese 5. Any other black background 6. Any other Asian background 7. Other including mixed background 8. Irish Traveller 99. Missing/not reported	Ethnicity	1. Irish/White/ Traveller 2. Asian/Chinese 3. African/Black 4. Other ethnicity 99. Missing/not reported
Parity Group	Parity (scale)	Parity_2	1. Nulliparous 2. Multiparous 999. Missing
Number of Miscarriages	scale	No_Misc_2	0. None 1. 1 miscarriage 2. 2 miscarriages 3. ≥3 miscarriages
Gestation at birth (weeks)	scale	Gest_birth_b	1. Preterm 2. Term birth 3. Postterm birth

Variables recoded and recategorised

Label	Original Categories	New Variable name	Recoded categories
Mode of birth	1. SVB 2. Assisted birth 3. Caesarean section 4. Spontaneous breech	Mode_Birth2	1. Spontaneous vaginal birth 2. assisted birth 3. caesarean section
Infant weight	Infant weight (grams)	INF_Wgt_Groups	1. <500g 2. 500-999g 3. 1000g-1499g 4. 1500-1999g 5. 2000g-2499g 6. 2500g-2999g 7. 3000g-3499g 8. 3500g-3999g 9. 4000g-4499g 10.4500g-4999g 11. ≥5000g
Infant weight	Infant weight groups	INF_Wgt_Groups3	1. ≤2500g 2. >2500g-<3500g 3. ≥3500g-<4000g 4. ≥4000g 9999. Not reported/missing
Apgars at 5 minutes	Apgar5 (scale)	Apgar_5_Group	0. Apgars 0 1. Apgars 7-10 2. Apgars 1-6
Gestation RFM	Gestation RFM (scale)	Gest_RFM_Cat	1. RFM ≤36 weeks gestation 2. RFM ≥37 weeks gestation
Number of referrals with RFM	scale	No_RFM_group	0. No RFM 1. 1 2. 2 3. ≥3

Appendix 20 Study Site Data Privacy Statement

Data Privacy Statement

At The [redacted], we take your privacy seriously. It is important that you know exactly what we do with personal information that you and others provide to us, why we gather it and what it means to you. Our Privacy Statement is being provided to you in line with our obligations under the General Data Protection Regulation (**GDPR**), which came into force on 25th May 2018. GDPR together with applicable Irish legislation amends existing data protection law and place enhanced accountability and transparency obligations on organisations when using your information. [redacted] is a quality oriented organisation and is determined to develop and improve the services it provides to women, babies and their families. The GDPR introduces changes which will give you greater control over your personal information. To download our full Privacy Statement please click here.

Everyone working for [redacted] has a legal duty to keep personal information about you confidential. This document explains why we ask for your personal information, how that information will be used and how you can access your information.

Who are we

[redacted] specialises in the provision of obstetrics, gynaecology and neonatal services.

[redacted]

Information that we collect

"Personal data" means any information about an individual from which that person can be identified. There are instances where we invite or request individuals to provide us with their personal data, including through our website (Privacy Policy & Cookies – [redacted] Website). In addition, individuals may volunteer their personal data to us by various means of communication, e.g. by telephone, email or via our website.

Some of the ways we collect information from / about you are:-

- Referral letter received by us
- Telephone call from a GP or other third party
- Registration form completed and sent in to our central booking office
- Attendance at a clinic or emergency room
- Admission to the hospital
- Insurance form completed.

In providing our services, we may also receive personal data, including sensitive personal data, indirectly. Categories of such personal data include names, addresses, contact information and other information that is relevant to the provision of our services.

How we use personal data we collect

We will only use your personal data for the purposes and legal bases set out in the table below. It is important that your health records are accurate and up-to-date as they will help make sure that any staff looking after you are able to provide you with the care that you require.

Purpose (s) for Processing	Legal Basis
Communicating with you or other persons in the course of our business	To support our legitimate interests in managing our business and providing services to you provided such interests are not overridden by the rights and interests of the data subjects concerned
Providing our services to you and managing our business	As above
Maintaining and operating our website	As above
Processing of job applications	(a) To perform or enter into a contract with the data subject (b) To support our legitimate interests in managing our business and providing services to you provided such interests are not overridden by the rights and interests of the data subjects concerned (c)
For the prevention and detection of fraud, money laundering and other crimes or for the purposes of responding to a binding request from a public authority or court	To comply with our legal obligations
Transferring information to third parties, including to our own service providers	(a) To support our legitimate interests in managing our business and providing services you provided such interests are not overridden by the rights and interests of the data subjects concerned (b) To comply with our legal obligations (c) To protect vital interests

We will store your personal data only for as long as necessary for the purposes for which it was collected; as required by law or regulatory guidance to which we are subject, and for the exercise or defence of legal claims that may be brought by or against us.

In line with best practice the NMH references the HSE Retention Policy with regard to the recommended retention period for medical data to satisfy the requirements of the GDPR

Disclosure of your information

We may disclose your personal data to:

- A third party who provides a service to us
- A public authority in the event that we are required to do so by law
- A prospective seller or buyer of any our business or assets
- A third party where we are under a duty to disclose or share your personal data in order to comply with any legal obligation
- A third party where it is necessary to protect the vital interests of the data subject or another natural person
- A third party where necessary for our legitimate business interests to protect the rights, property, or safety of NMH, our customers, or others
- Your registered GP

Some of the ways we may share your information with your consent is as follows:

- With another Hospital
- With a third party representative
- With your next of kin
- For non-anonymised research
- With your insurance company

Research: Anonymised data is used as a basis for clinical audit and for research purposes. The [redacted]. Research projects are approved by the [redacted]esearch Ethics Committee.

Anonymised data is shared with the National Treatment Purchase Fund (NTPF).

Some personal data is also shared as follows and may be applicable to you:

- General Registrars Office – for the purposes of birth registration
- Cancer Research
- Infectious Diseases
- IBTS
- HPO
- PHN – Public Health Nurses
- Child protection
- Department of Social Welfare (where legislation permits)
- Congenital Anomaly Register
- An Garda Siochana (where legislation permits)

When other organisations are involved in your care we may need to share details about you to enable us to work together for your benefit. Information will only be shared with them if they have genuine need for it and where possible we will ask for your consent on this.

Your rights

You have the right to request access to, rectification, or erasure of your personal data, or restriction of processing or object to processing of your personal data, as well as the right to data portability. In

each case, these rights are subject to restrictions as laid down by law. The following is a summary of your rights:

- **The right of access** enables you to receive a copy of your personal data
- **The right to rectification** enables you to correct any inaccurate or incomplete personal data we hold about you
- **The right to erasure** enables you to ask us to delete your personal data in certain circumstances
- **The right to restrict processing** enables you to ask us to halt the processing of your personal data in certain circumstances
- **The right to object** enables you to object to us processing your personal data on the basis of our legitimate interests (or those of a third party).
- **The right to data portability** enables you to request us to transmit personal data that you have provided to us, to a third party without hindrance, or to give you a copy of it so that you can transmit it to a third party, where technically feasible.

You have the right to lodge a complaint with the Data Protection Authority, in particular in the Member State of your residence, place of work or place of an alleged infringement, if you consider that the processing of your personal data infringes the GDPR.

If you wish to exercise any of these rights, please contact us (see Contact Us below). We will respond to your request within one month. That period may be extended by two further months where necessary, taking into account the complexity and number of requests. We will inform you of any such extension within one month of receipt of your request. We may request proof of identification to verify your request. We have the right to refuse your request where there is a basis to do so in law, or if it is manifestly unfounded or excessive, or to the extent necessary for important objectives of public interest.

Can I access my information

Under the Data Protection Act 2018 / GDPR you have a right to obtain a copy / access any electronic or manual information that the NMH holds about you. The hospital will provide you with a copy of your personal data held by the hospital on request free of charge within 30 days from the date you make the access request.

In certain circumstances access to your records may be limited, e.g. if it is felt to be in your best interest or for the protection of others.

If you would like a copy of your personal data, please write in to the Data Protection Officer enclosing a copy of your photo ID (proof of identity) with your signed (Data Protection Subject Access Request Form - Appendix A) request to:

Data Protection Officer,

We are unable to accept access requests via telephone or text message.

Contact us

Questions, comments, requests and complaints regarding this Privacy Statement and the personal data we hold are welcome and should be addressed to [redacted] or send in writing to the [redacted]. All requests will be dealt with promptly and efficiently.

If you would like to know more about how we use your information or for any reason you do not wish to have your information used in any of the ways described, please speak to the health professionals concerned with your care.

We reserve the right to change this Privacy Statement from time to time at our sole discretion. If we make any changes, we will post those changes on our website. However, if we make material changes to this Privacy Statement, we will notify you by means of a prominent notice on the website prior to the change becoming effective. Please review this Privacy Statement periodically for updates.

Further guidance about data protection can be obtained from the Data Protection Commissioners website at www.dpc.ie or www.gdprandyou.ie

14/01/2019

Appendix 21 Systematic Review Update

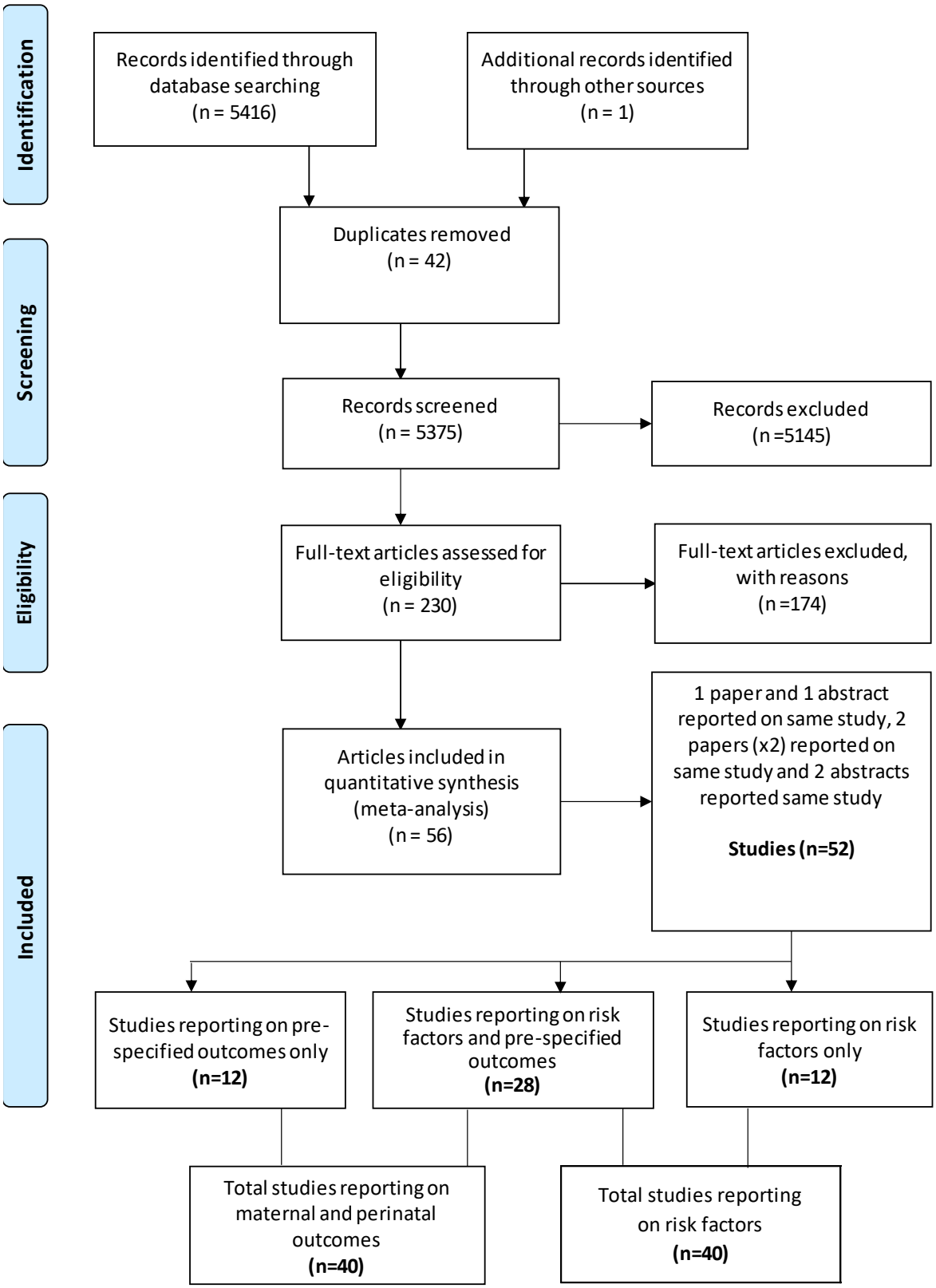


Figure 1 PRISMA flow chart updated systematic review

Table 1 Characteristics of included studies

Lead Author & Year	Setting (Country)	Study Design	Study Period	Data Collection Methods	Inclusion/Exclusion Criteria	Definition of RFM	Timing of RFM (gestation)	RFM (n)	No RFM (N)
Akelsson 2019	Sweden	prospective population-based cohort	Jan 2014 - Dec 2014	Questionnaire and birth register	women who sought care due to decreased or altered fetal movements	decreased or altered fetal movements	≥28 weeks gestation	2683	26041
Bradford 2019	New Zealand	case-control	Feb 2012 - Dec 2015	Interviews	Cases were women who had experienced a singleton late stillbirth (≥28 weeks' gestation). Controls were women with ongoing singleton non-anomalous pregnancies randomly selected from hospital booking lists	Maternal perception	Not specified	145	588
Christou 2019	Afghanistan	Prospective population-based	2010	Questionnaire	Women aged 12-49 years, births within the last three years	Maternal perception	Not specified	162	13672
Eshragi 2020	Iran	prospective cohort	Not reported	Not reported	singleton pregnancy, ≥37 weeks gestation and persistent reduced fetal movement	Persistent reduced fetal movement	>37 weeks'	150	150
Heazell 2018	UK	Case -Control	April 2014 - March 2016	interviewer-administered questionnaire	Women with a singleton, stillbirth at or after 28 weeks gestation without congenital anomaly. Controls were women with an ongoing pregnancy	changes in strength and frequency FM in the last two weeks prior to stillbirth	≥28 weeks'	86	875
Greenberg 2021	New York	retrospective case-control	Jan 2017-Dec 2017	Not reported	Women who presented with RFM	Not reported	>24 weeks	112	112
Inukollu 2021	India	Prospective Case-Control	Sept 2018-Aug 2019	not specified	pregnant women presenting with RFM after 30 weeks' gestation matched with controls with no RFM	Maternal sujective feeling of RFM	>30 weeks'	100	100
Levy 2020	Israel	Retrospective	Jan 2009 - July 2019	medical records	singleton deliveries≥37 gestational weeks, isolated complaint of RFM,	Maternal perception	≥37 weeks	2762	10576
Radestad 2021	Sweden	observational	Oct 2016-Jan 2018	pregnancy register	pregnant women with a singleton pregnancy with RFM	maternal perception	>32 weeks	2059	37806
Saglam 2021	Turkey	Case control matched	Sept 2018 - Jan 2020	Medical records	Women who complained of RFM in a singleton pregnancy after 32 weeks	Maternal perception	> 32 weeks'	42	126
Sterpu 2020	Sweden	Retrospective cohort	Jan 2016 - Dec 2017	medical records	All singleton pregnancies presenting with RFM after 22 gestational weeks'	Maternal perception	> 22 weeks'	3243	11944
Turner 2021	Australia	Retrospective cohort	2009 - 2019	hospital database	Women with a single fetus without a known congenital anomaly presenting with RFM	Maternal perception	>28 weeks'	8821	92776
Zamstein 2019	Israel	Retrospective cohort	1991 - 2014	Databases	maternal complaint of DFM during advanced stages of pregnancies	Maternal perception	advanced stages of pregnancy	439	243243

Table 2 Quality Assessment of Included Studies

Lead Author & Year	Study Participation	Study Attrition	Risk Factor Management	Outcome Measurement	Study Confounding	Statistical Analysis & Presentation
Akelsson 2019	Low	Low	Low	Moderate	Moderate	Low
Bradford 2019	Moderate	Low	Moderate	Low	Low	Low
Christou 2019	Low	Low	High	Low	Low	Low
Eshragi 2020	Moderate	Low	Moderate	Low	Moderate	Low
Heazell 2018	Moderate	High	Low	Low	Low	Low
Ho 2018	Low	Low	Low	Low	Low	Low
Inukollu 2021	Low	Low	Low	Low	Low	Low
Levy 2020	Moderate	High	Low	Low	Moderate	Low
Radestad 2021	Low	Low	Low	NA	Low	Low
Saglam 2021	Moderate	Moderate	High	High	Moderate	Low
Sterpu 2020	Low	Low	Low	Low	Low	Low
Turner 2021	Low	Low	Low	Moderate	Low	Low
Zamstein 2019	Low	Low	Low	Low	Low	Low

Appendix 22 Forest Plots Updated Systematic Review

Risk Factors for RFM

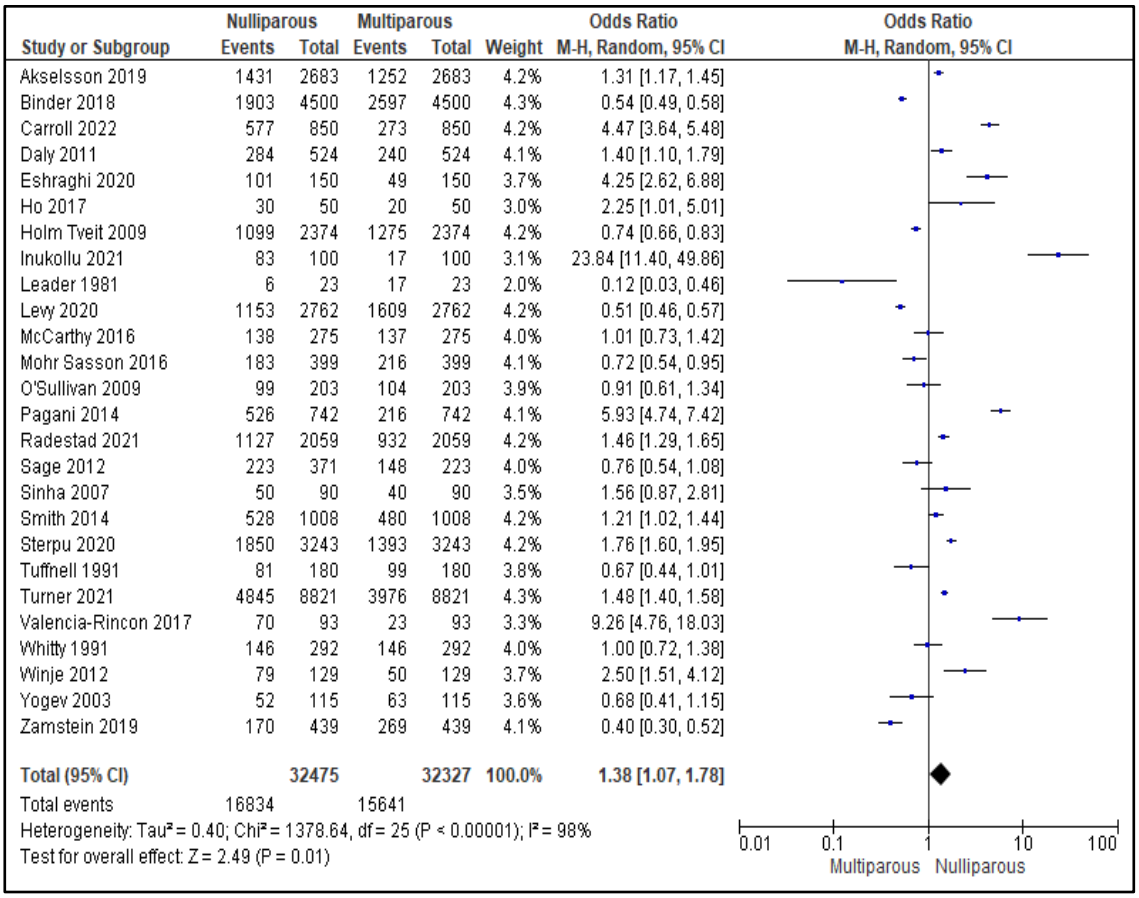


Figure A: Parity

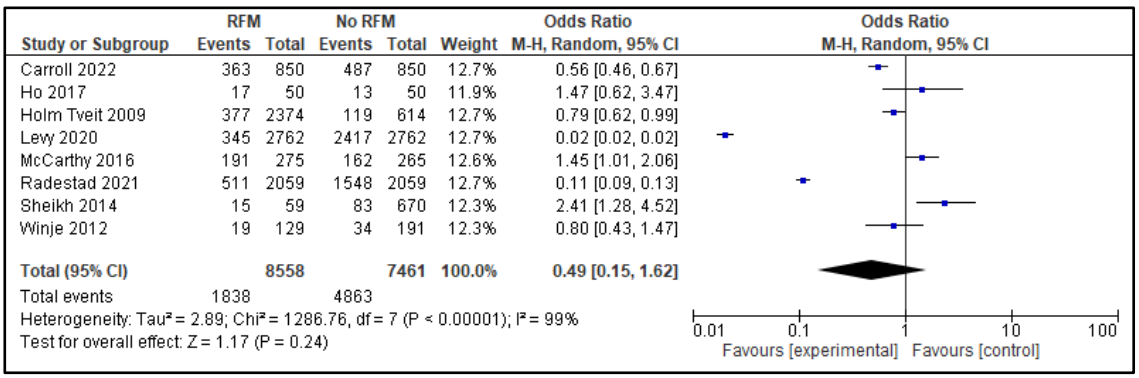


Figure B: Maternal age >35 years

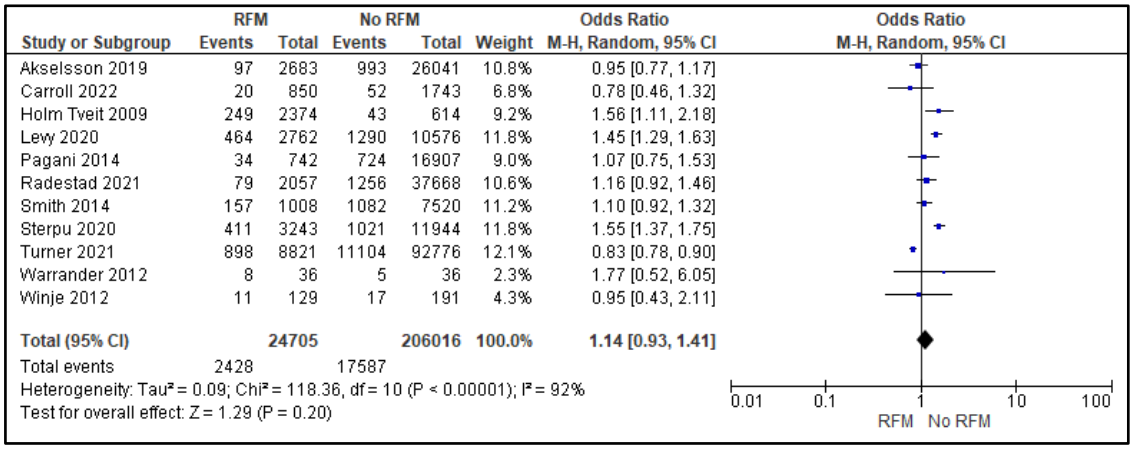


Figure C: Smoking

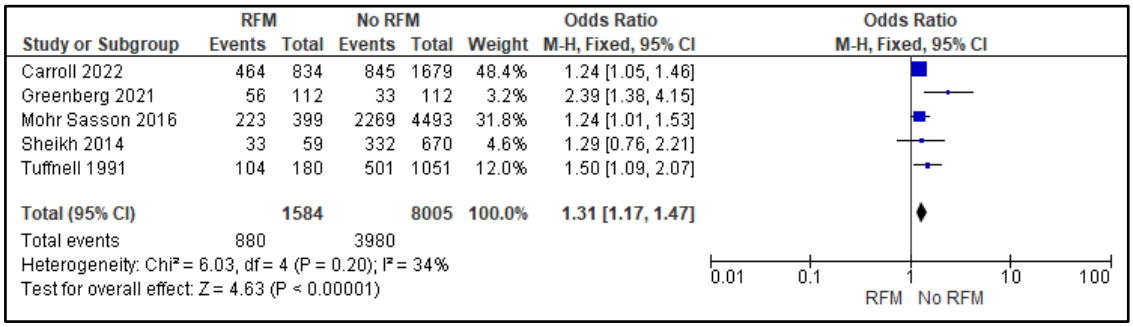


Figure S: Anterior Placenta

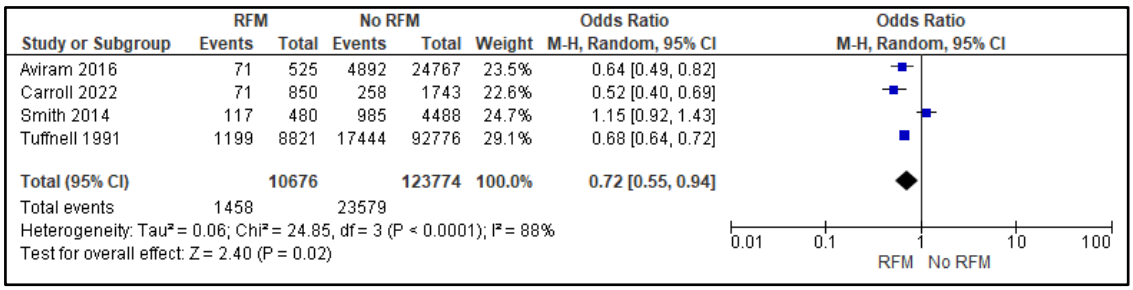


Figure E: Previous caesarean section

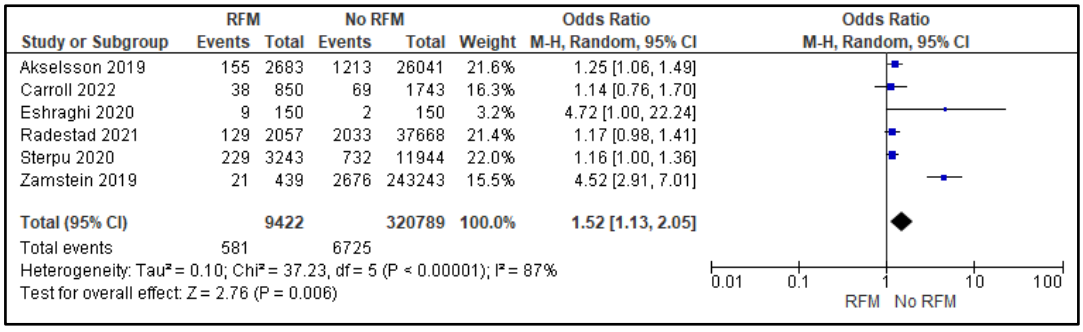


Figure F: Assisted conception

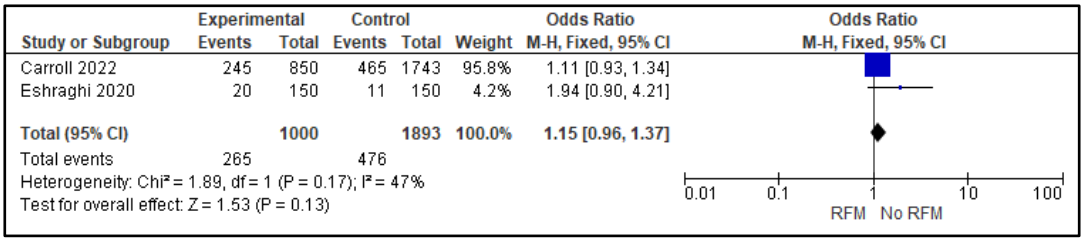


Figure G: Previous history of miscarriage

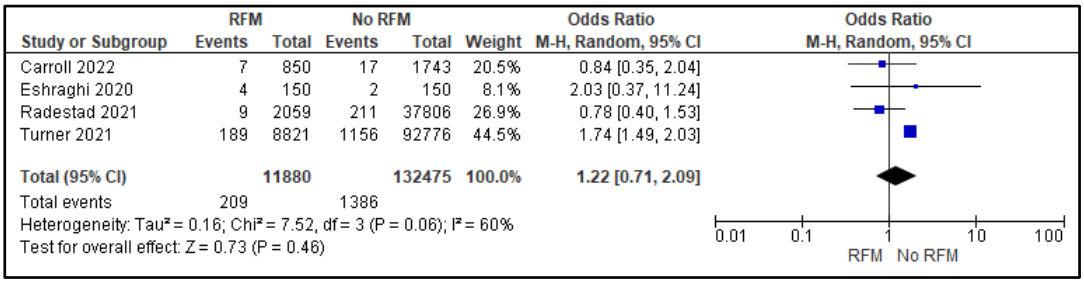


Figure H: Previous stillbirth

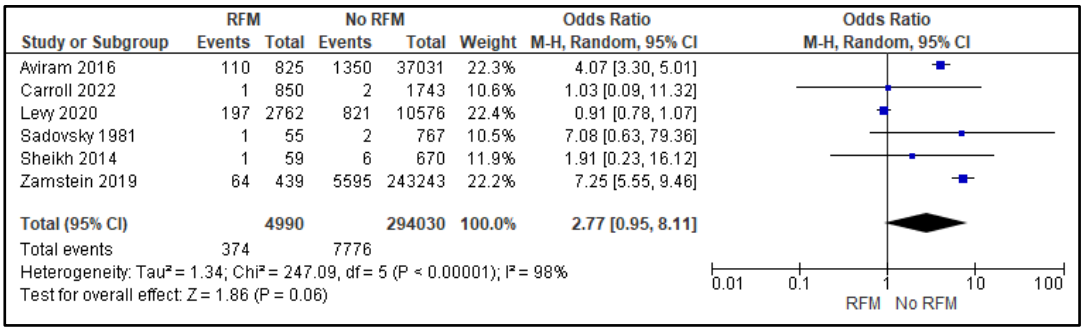


Figure I: Oligohydramnios

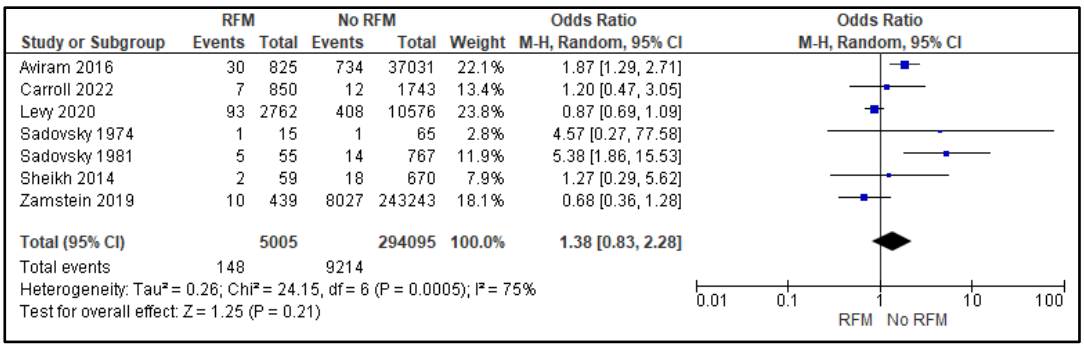


Figure J: Polyhydramnios

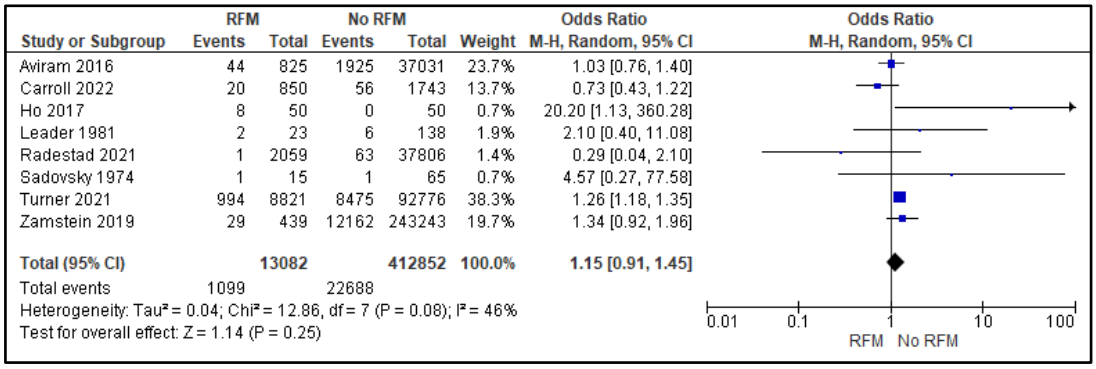


Figure K: Diabetes

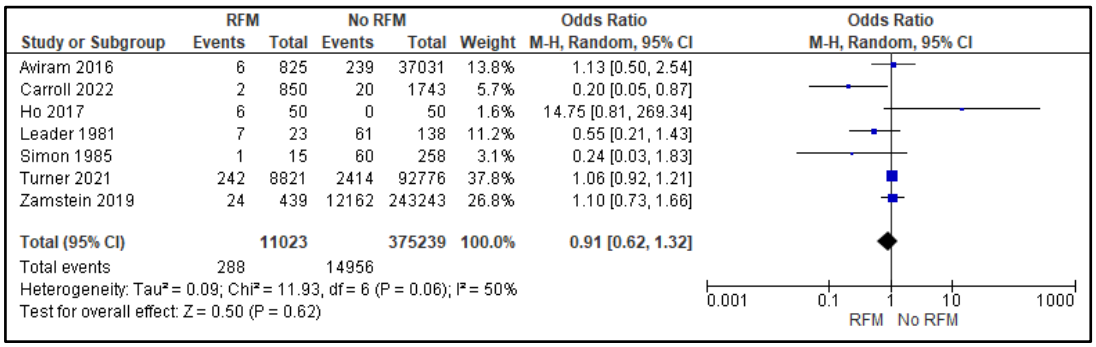


Figure L: Gestational hypertension

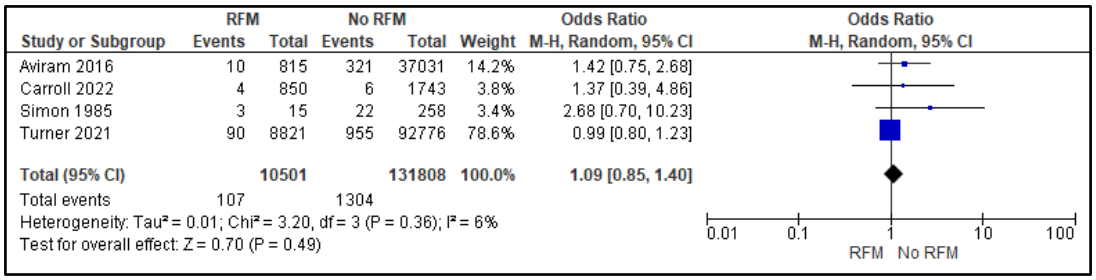


Figure M: Chronic hypertension

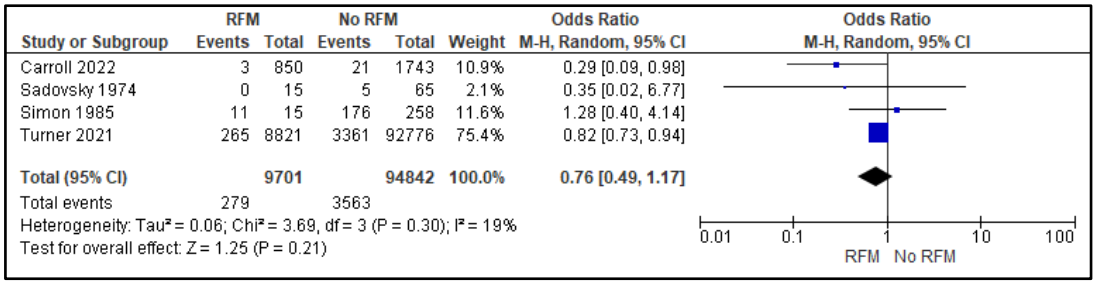


Figure N: Preeclampsia

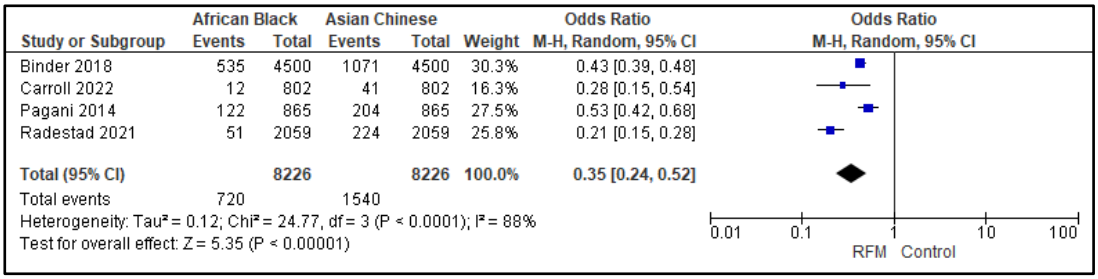


Figure O: Ethnicity African/Black versus Asian/Chinese

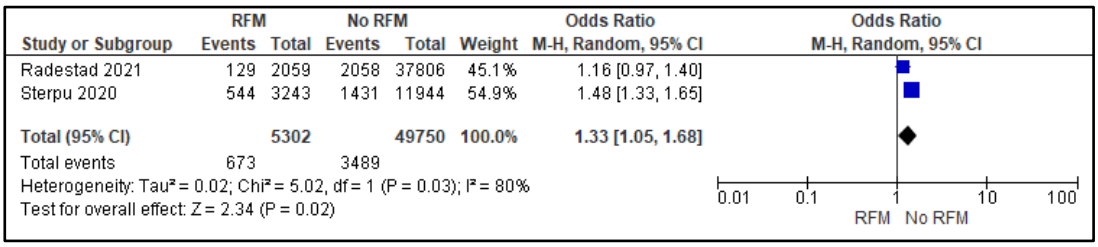


Figure P: History of psychiatric illness

Appendix 23 Forest Plots Updated Systematic Review

Pregnancy, birth and neonatal outcomes

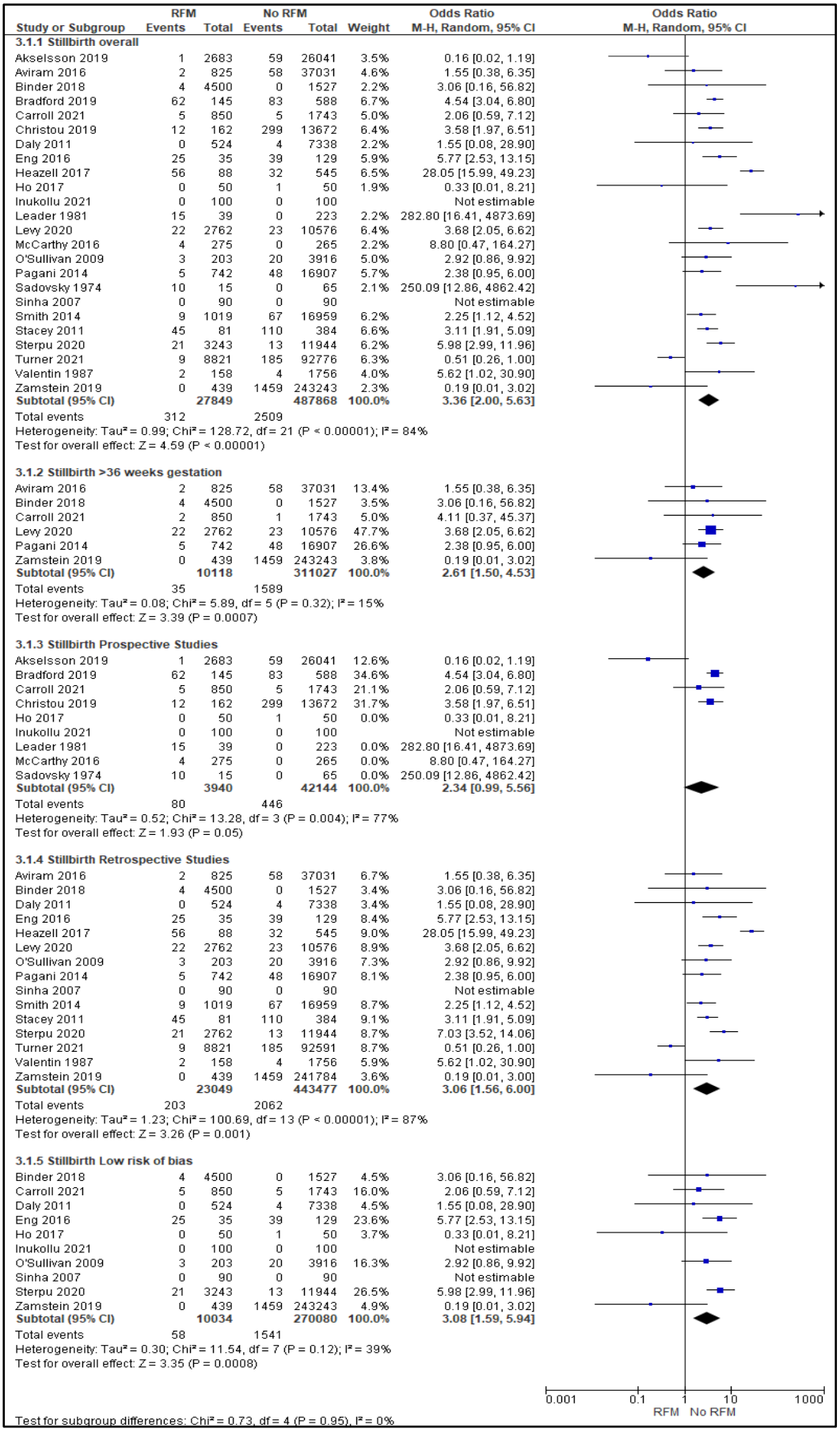


Figure A: Stillbirth

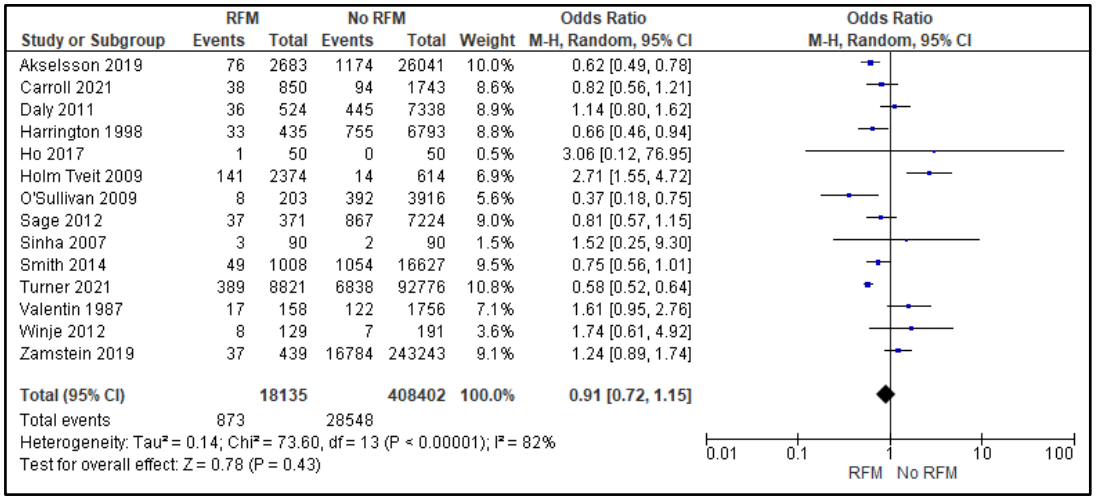


Figure B: Preterm Birth

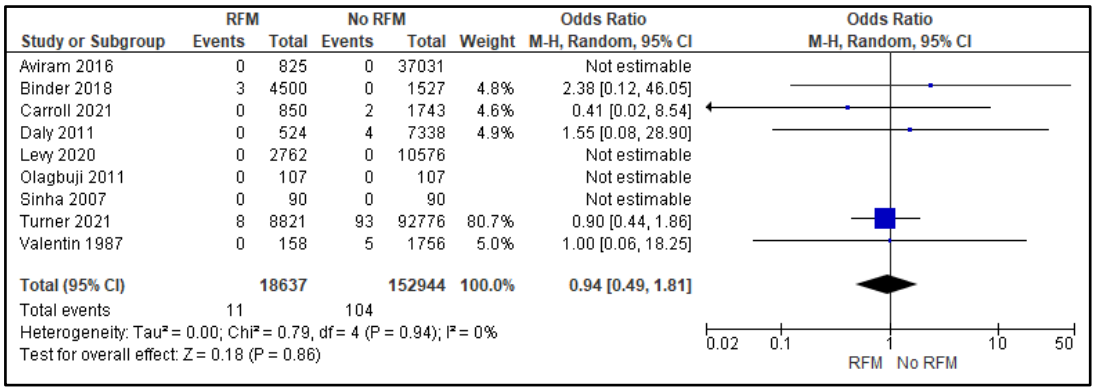


Figure C: Neonatal Death

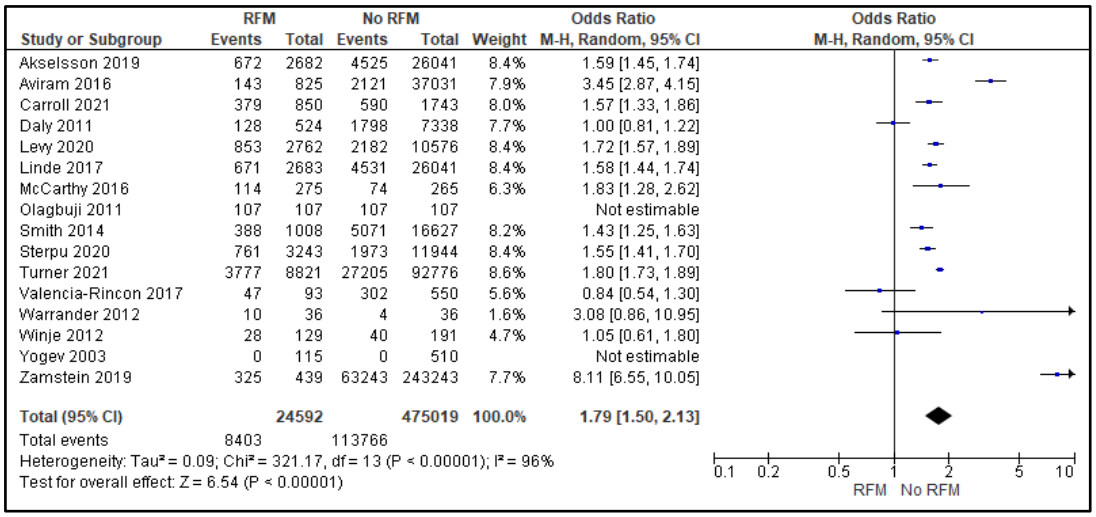


Figure D: Induction of Labour

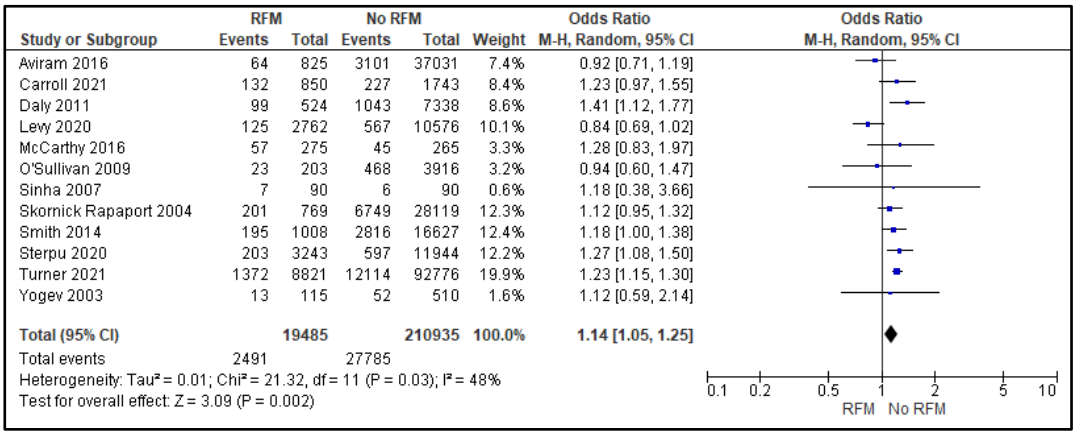


Figure E: Assisted Birth

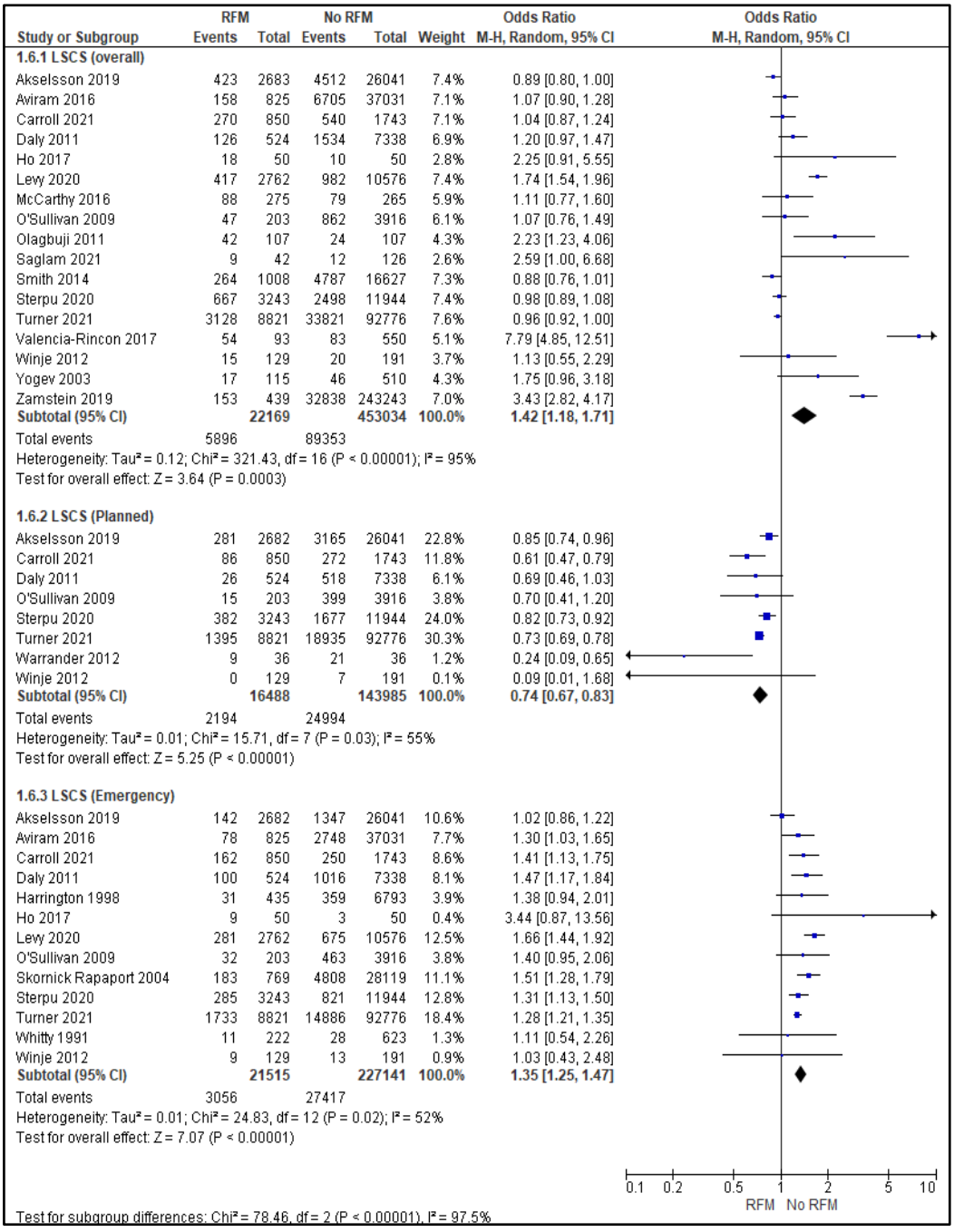


Figure F: Caesarean Section

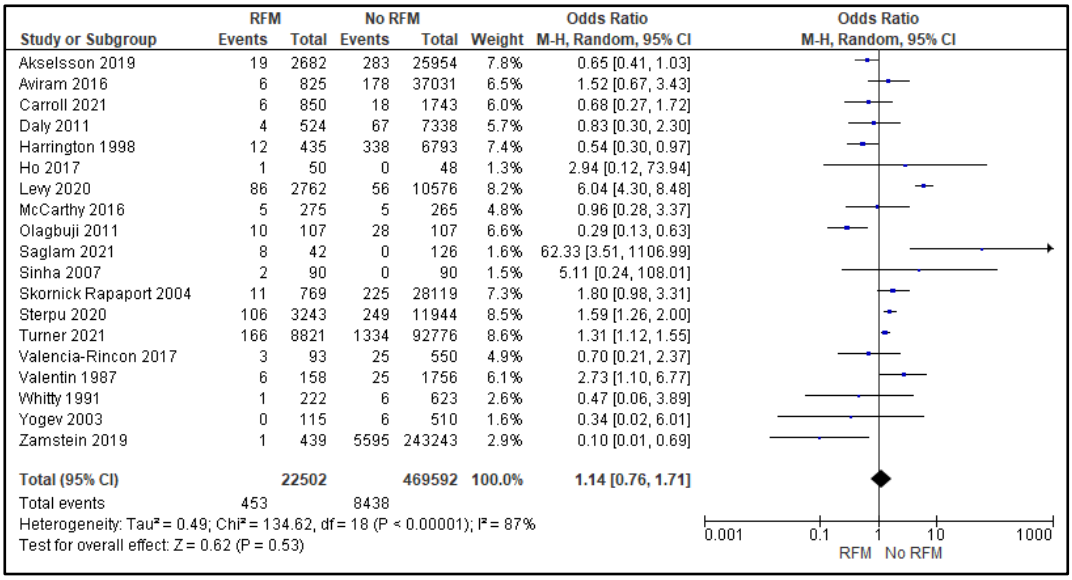


Figure G: Apgar Score less than 7 at 5 minutes of age

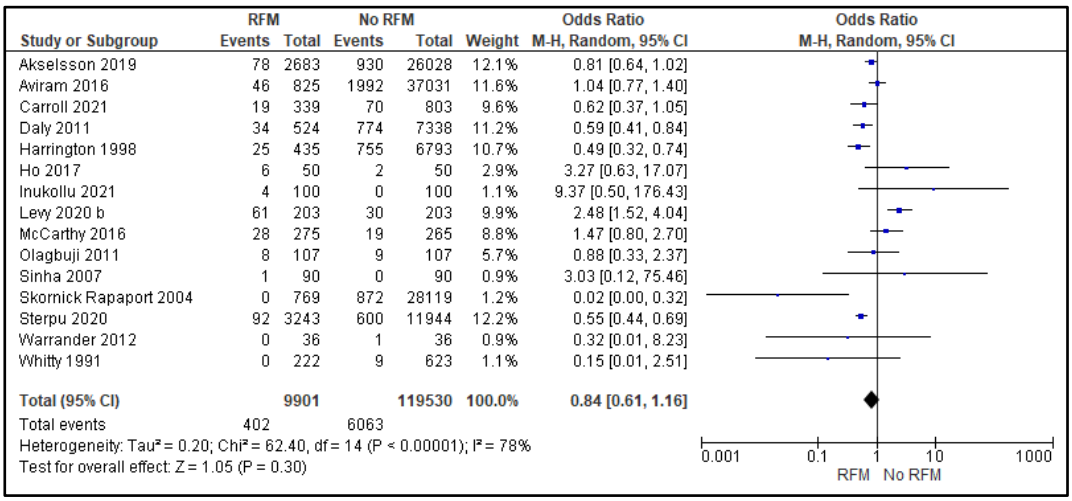


Figure H: Admission to NICU

Appendix 24 Poster Presentation

The impact of COVID-19 on attendance for reduced fetal movements during pregnancy

Carroll L[1 2], Byrne F[3], Canty G[3], Gallagher L[1] and Smith V[1]

Introduction

The World Health Organisation (WHO) declared a global pandemic on the 11th of March 2020. The Irish government subsequently imposed the first national lockdown to curb the spread of COVID-19 between March-May 2020. Concerns were raised about whether women during pregnancy were fearful of accessing maternity services during the lockdown, and the possible impacts this could have on maternal and fetal wellbeing.

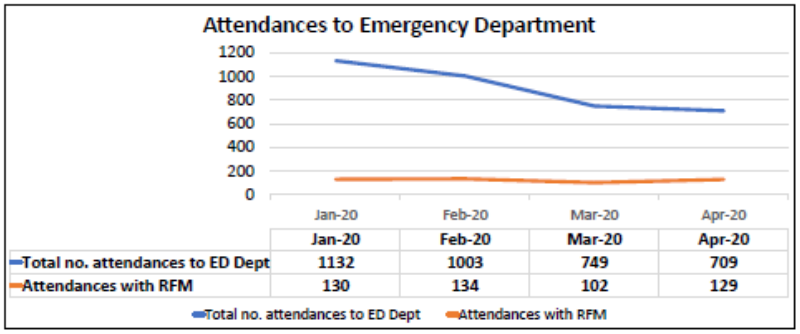
Objective

We sought to determine the impact of the first pandemic-related national lock-down on attendances for reduced fetal movements (RFM) during pregnancy in a large urban maternity unit in Ireland.

Methods

This study is a secondary analysis of data collected as part of a larger study examining outcomes in women with RFM in pregnancy. All women with a singleton pregnancy, presenting to the emergency department (ED) of the [redacted] with a primary presentation of perceived reduced fetal movements after 24 weeks' gestation were eligible for inclusion. Participants included in this sub-study represented pre-COVID (01-Jan to 29-Feb 2020) and during-COVID (01-Mar to 30 April 2020) groups.

Results



	Jan-20	Feb-20	Mar-20	Apr-20
Total no. attendances to ED Dept	1132	1003	749	709
Attendances with RFM	130	134	102	129

	PRE-COVID period (01-Jan to 29-Feb 2020)	DURING-COVID period (01-Mar to 30 April 2020)	Difference
Overall ED attendances	2135	1458	-37%
Attendances with RFM	264 (12.4%)	231 (15.8%)	12.4% versus 15.8%, z -2.97, p<0.003

Conclusions

Although fewer women overall attended the ED during the first national lockdown, a decrease in the numbers of women presenting with RFM was not observed. Conversely, proportionate to total attendances, the proportion attending with RFM increased during COVID. This suggests, while COVID will have deterred some pregnant women attending the ED, it did not adversely influence women with RFM from attending. Given the seriousness of RFM for adverse pregnancy outcomes, including stillbirth, this finding will be reassuring to maternity care providers.

-000-