Short and longer-term outcomes for women and their children according to planned mode of birth after previous caesarean section

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Abstract

Background: Policy supports offering pregnant women with previous caesarean section a choice between elective repeat caesarean section (ERCS) or planning a vaginal birth after previous caesarean (VBAC), provided they have no contraindications to VBAC. However, robust comprehensive information on the associated outcomes to counsel women is lacking. This thesis investigated short and longer-term outcomes for women and their children according to planned mode of birth after previous caesarean section (CS).

Methods: A structured literature review and three population-based cohort studies of term singleton births in Scotland to women with ≥1 previous CSs were conducted. Logistic, modified Poisson or Cox regression were used to investigate the association between planned mode of birth after previous CS and 1) short-term maternal and perinatal outcomes; 2) women's use of psychotropic medication in the first year postpartum; and 3) the child's risk of having a record of special educational needs (SENs).

Findings: Planned VBAC compared to ERCS was associated with an increased risk of the mother having uterine rupture (0.24% vs. 0.04%, adjusted odds ratio[aOR] 7.3, 95%CI 3.9-13.9), a blood transfusion (1.14% vs. 0.50%, aOR 2.3, 95%CI 1.9-2.8), puerperal sepsis (0.27% vs. 0.17%, aOR 1.8, 95%CI 1.3-2.7), and surgical injury (0.17% vs. 0.09%, aOR 3.0, 95%CI 1.8-4.8) as well as an increased risk of adverse perinatal outcomes including perinatal death, admission to a neonatal unit, resuscitation requiring drugs and/or intubation, and an Apgar score <7 at 5 minutes (7.99% vs. 6.37%, aOR 1.6, 95%CI 1.5-1.7). However, women who had a planned VBAC were more likely than those giving birth by ERCS to breastfeed at birth or hospital discharge (63.6% vs. 54.5%, adjusted risk ratio[aRR] 1.2, 95%CI 1.1–1.2), and at 6–8 weeks postpartum (43.6% vs. 34.5%, aRR 1.2, 95%CI 1.2–1.3). Planned VBAC compared to ERCS was also associated with a reduced risk of the mother being dispensed any psychotropic medication (adjusted hazard ratio[aHR] 0.85, 95%CI 0.78–0.92), an antidepressant (aHR 0.83, 95%CI 0.76–0.90), and at least two consecutive antidepressants (aHR 0.83, 95%CI 0.75–0.91) in the first year postpartum, but was associated with a similar risk of the child having a record of any SENs (19.24% vs. 17.63%, aRR 1.04, 95%CI 0.99-1.09) or specific types of SEN.

Conclusions: While planned VBAC compared to ERCS was associated with an increased risk of serious birth-related maternal and perinatal complications, the absolute risk of birth-related complications was small for either birth approach. Furthermore, little evidence was found to support an association between planned mode of birth after previous CS and SENs in childhood. However, further studies examining the longer-term effects are needed, including to establish the relationship with women's subsequent mental health. Overall, this thesis provides valuable information to help manage and counsel the increasing number of women with previous CS.

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Statement of contribution to work

I, Kathryn Fitzpatrick, confirm that the work presented in this thesis is my own. I conceptualised the research presented in this thesis, obtained the funding, gained the required approvals, cleaned the data, conducted all the analyses, and wrote the thesis. I am first author on three publications[1-3] arising from the studies described in Chapters 4-6. Professor Maria Quigley and Professor Jennifer Kurinczuk supervised the research, advised on study design, statistical analysis, and the interpretation of the thesis findings. They also provided feedback on the thesis and the arising manuscripts. Professor Sohinee Bhattacharya, a Senior Lecturer at the University of Aberdeen, provided methodological advice around conducting research on pregnancy and childbirth using routinely-collected health data. She also advised on the interpretation of the study findings presented in Chapter 4, and critically reviewed the manuscript[1] arising from the research described in this chapter. Professor Daniel Smith, an honorary consultant psychiatrist and now Chair of Psychiatry and Head of the Division of Psychiatry at the University of Edinburgh, was consulted about the study described in Chapter 5. He provided advice on the design of this study, the interpretation of the study findings, and critically reviewed the manuscript[2] based on the work presented in Chapter 5. The co-authors of the three arising publications[1-3] have all given their permission to include material from these publications in this thesis.

List of publications

Peer-reviewed publications arising from thesis research

Fitzpatrick KE, Kurinczuk JJ, Bhattacharya S, Quigley MA. Planned mode of delivery after previous cesarean section and short-term maternal and perinatal outcomes: A population-based record linkage cohort study in Scotland. **PLoS Medicine** 2019;16:e1002913.

Fitzpatrick KE, Quigley MA, Smith DJ, Kurinczuk JJ. Planned mode of birth after previous caesarean section and women's use of psychotropic medication in the first year postpartum: a population-based record linkage cohort study. **Psychological Medicine** 2021; 1-12. doi: 10.1017/S003329172995322

Fitzpatrick KE, Kurinczuk JJ, Quigley MA. Planned mode of birth after previous caesarean section and special educational needs in childhood: a population-based record linkage cohort study. **BJOG: An International Journal of Obstetrics and Gynaecology** 2021; https//doi.org/10.1111/1471-0528.16828

Other publications during DPhil

Fitzpatrick KE, van den Akker T., Bloemenkamp KWM., Deneux-Tharaux C., Kristufkova A., Li Z., Schaap TP., Sullivan EA., Tuffnell D., Knight M. Risk factors, management, and outcomes of amniotic fluid embolism: A multicountry, population-based cohort and nested case-control study. **PLoS Medicine** 2019;16:e1002962

Abbreviations

ACOG	American College of Obstetricians and Gynecologists
AHRQ	Agency for Healthcare Research and Quality
BDI	Beck Depression Inventory
b.f	Breastfeeding
BMI	Body mass index
BNF	British National Formulary
CS	Caesarean section
CHI	Community Health Index
CHSP-PS	Child Health Surveillance Programme Pre-School System
CI	Confidence interval
ECS	Elective caesarean section
EDD	Estimated Date of Delivery
eDRIS	electronic Data Research and Innovation Service
EPDS	Edinburgh postnatal depression scale
EPV	Events per variable
ERCS	Elective repeat caesarean section
GHQ-12	General health questionnaire-12
HR	Hazard ratio
ICD-9	International Classification of Diseases 9th revision
ICD-10	International Classification of Diseases 10th revision
IQR	Interquartile range
ISD	Information Services Division
IVF	In vitro fertilisation
NC	Not calculated because of low number of events
NCT	National Childbirth Trust
NHS	National Health Service
NICU	Neonatal intensive care unit
NRES	National Research Ethics Service
NRS	National Records of Scotland
NSS	National Services Scotland
NS-SEC	National Statistics Socio-Economic Classification
OPCS-3	Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures 3rd revision
OPCS-4	Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures 4th revision
OR	Odds ratio
PIS	Prescribing Information System
PPI	Patient and Public Involvement
RCOG	Royal College of Obstetricians and Gynaecologists
RECORD	Reporting of studies Conducted using Observational Routinely-collected Data
RCT	Randomised Controlled Trial
RR	Risk ratio
SENs	Special Educational Needs
SMR01	Scottish Morbidity Record General/Acute Inpatient and Day Case Dataset
SMR02	Scottish Morbidity Record Maternity Inpatient and Day Case Dataset
SSBID	Scottish Stillbirth and Infant Death Survey
TOLAC	Trial of labour after previous caesarean
VB	Vaginal birth
VBAC	Vaginal birth after previous caesarean

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1

INTRODUCTION

1.1 Chapter overview

The research presented in this thesis investigated the short and longer-term outcomes for women and their children according to planned mode of birth after previous caesarean section. This chapter provides the background and rationale for this research. An overview of caesarean section and birth after caesarean section is provided. The rationale for the research is described within the context of the limitations and evidence gaps highlighted with the current literature. The overall aim and specific objectives of the research are then presented along with the structure of the thesis.

1.2 Caesarean section

A caesarean section is a method of delivering a baby by making a surgical incision in the mother's abdomen and uterus (womb). It offers an alternative to vaginal birth. Caesarean sections were rarely performed before the 20th century as they usually resulted in the death of the mother. The procedure was considered an extreme measure, essentially performed to extract the infant from a dead or dying mother to try and save the infant's life or enable the infant to be buried separately from the mother. During the late 19th century and through the 20th century, however, medical advances such as the introduction of anaesthesia, advent of antiseptic techniques, suturing of the uterus, and adoption of low transverse uterine incisions, improved the safety and use of caesarean section[4,5].

1.2.1 Indications for caesarean section

Today caesarean sections are carried out for a variety of reasons (**Box 1**)[6-8]. While there are several absolute indications for caesarean, such as cord prolapse, major placenta praevia, and transverse lie where a caesarean is considered necessary to prevent death or serious harm to the mother and/or baby, most indications for caesarean are relative based on a more subjective assessment of what is thought to be safest for the mother and/or baby. A caesarean may also be performed at the request of the mother in the absence of any obstetric or medical reason. In high-income countries like the UK, common indications for performing a primary (first) caesarean include failure to progress, presumed fetal compromise/distress, and fetal malpresentation, while previous caesarean section is the main indication for performing a repeat caesarean[9-11].

Box 1. Indications for caesarean section

- Fetal malpresentation *(abnormal position of the fetal head relative to the mother's pelvis, such as breech presentation where the fetus presents 'bottom-down' in the uterus, or transverse lie where the fetus is positioned sideways in the uterus)*
- Multiple pregnancy
- Presumed *fetal compromise/distress (such as suspected intrauterine growth restriction or an abnormal fetal heart rate detected)*
- Cord prolapse *(where the umbilical cord drops ahead of the fetus through the woman's cervix)*
- Other fetal reasons
- Placenta praevia *(Low-lying placenta where the placenta is near to or covers the woman's cervix)*
- Placental abruption *(where the placenta comes away from the wall of the uterus)*
- Failure to progress *(where labour stalls or occurs too slowly)*
- Maternal conditions or other obstetric complications *(such as pre-eclampsia/eclampsia or uterine rupture)*
- Previous caesarean section
- Maternal request, in the absence of any obstetric or medical reason

1.2.2 Classification of caesarean section

Conventionally, caesarean sections are classified as either 'elective' or 'emergency' procedures. 'Elective' is used to refer to caesareans which are planned in advance and usually performed before labour begins, typically because they are recommended for an obstetric or medical indication or at the request of the mother. 'Emergency' caesareans refer to those which are unplanned taking place during labour or unexpectedly before labour begins due to unforeseen problems. Most emergency caesarean sections are performed around 1-2 hours after the decision is made, although some may need to be performed within 30 minutes of the decision. 'Planned' and 'unplanned' are often used interchangeably with 'elective' and 'emergency'. Various other ways of classifying caesarean sections have been proposed including classifications based on more detail of the degree of urgency for the caesarean section, the indication for the caesarean section, or the characteristics of the mother[12].

1.2.3 Risks and benefits of caesarean section

A caesarean section can prevent death or morbidity to the mother and/or baby in the presence of complications. Other benefits may include a reduced risk of the mother experiencing perineal and abdominal pain during or shortly after birth, as well as a reduced risk of vaginal injury, urinary incontinence or pelvic organ prolapse[8,13,14]. A caesarean may also offer a solution for women who continue to have a significant fear of childbirth despite appropriate support[15].

However, like other surgical procedures and despite medical advances, caesareans are still not without their risks particularly when performed as an emergency[16]. In the short-term caesarean section has been associated with an increased risk of the mother experiencing various complications such as haemorrhage, infection, and damage to the bowel, bladder, or ureter, as well as a longer hospital stay[8,13,17]. There is also a small risk of the baby being

cut during the surgery[18] and an increased risk with elective caesarean of the baby experiencing respiratory complications, particularly if the caesarean is performed before 39 weeks of gestation[19-21]. This has led to guidelines recommending that an elective caesarean should not be routinely performed before 39 weeks of gestation[8,22]. Women who have a caesarean may also find it more difficult to establish breastfeeding for reasons such as a delay in the onset of lactation or a disruption to mother-infant interaction which may follow a caesarean[23].

In the longer-term caesareans have been linked with an increased risk of various complications in future pregnancies, including abnormal placentation (such as placenta praevia), hysterectomy, uterine rupture, infertility, stillbirth, and prematurity[13,14,21,24,25]. Concerns have also been raised that caesarean section may adversely affect women's mental health by, for example, restricting perceived control over birth, violating expectations about childbirth, disrupting physiological hormonal processes, and leading to a more painful and difficult postnatal recovery[26,27]. There are also concerns that caesarean section may increase the child's risk of having various problems in childhood including obesity, allergic and allergy-related conditions, neurological and stress-related problems, autoimmune diseases, infections, and other immune system-related conditions[13,28,29]. Various possible biological mechanisms have been proposed for such effects. One potential mechanism is that whilst microbes from the mother's vaginal tract and perianal region are an important source of colonisation for infants born vaginally, microbes found on the skin surface and circulating in the hospital environment are a significant source of colonisation for infants born by caesarean, resulting in differences in the infant's microbiota composition that may persist at least into mid-childhood[30-34]. The exposure of babies born by caesarean to preoperative prophylactic antibiotics, recommended by UK guidelines since 2011[8], may contribute to these differences[35]. There is increasing evidence that an individual's microbiota plays a key role in the development and function of various physiological processes including immune defence, growth, digestion[36] and more recently brain

development and behaviour[37]. It has also been suggested that vaginal birth in contrast to caesarean without labour results in the fetus producing high levels of stress hormones. This is thought to be important for successful physiological transition and survival outside the uterine environment, not only promoting lung maturity but also influencing the development of the hypothalamic-pituitary-adrenal axis and the maturation of the immune system[13,38]. Mode of birth may also affect the future health and development of a child by influencing epigenetic regulation of gene expression[13,38]. As discussed in Chapter 3, it is also possible that caesarean may affect the health and development of a child by leading to birth at an earlier gestation and influencing the likelihood of breastfeeding.

1.2.4 Rates of caesarean section

Caesarean sections are now one of the most common surgical procedures performed, with many parts of the world, including the UK, having seen a sharp rise in their caesarean section rates in recent years (**Figure 1.1**) causing widespread concern[9,39-41]. Around 21% of all births globally in 2015 are thought to have occurred by caesarean, although caesarean rates continue to vary greatly both within and between countries and regions[42] The Latin American and Caribbean region had the highest caesarean section rate in 2015 (44.3%), followed by North America (32.0%), the Middle East and north Africa (29.6%), East Asia and the Pacific (28.8%), Eastern Europe and central Asia (27.3%), Western Europe (26.9%), South Asia (18.1%), Eastern and southern Africa (6.2%) and West and central Africa (4.1%)[42]. In the UK over 30% of all births in 2019/2020 occurred by caesarean section, with around 44% of caesarean's performed as an elective procedure[43-45].

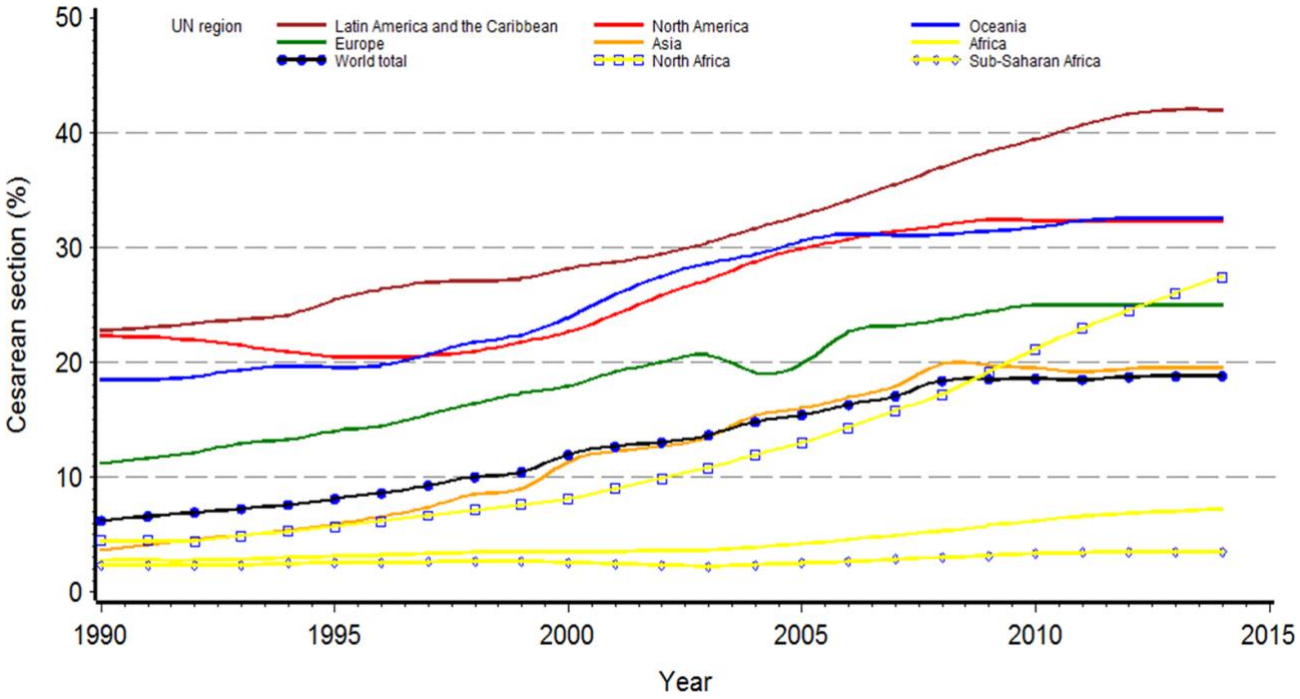


Figure 1.1. Global and regional trends in caesarean section rates, 1990-2014

Taken from Betrán et al, 2016[41], published CC-BY 4.0

Numerous reasons have been cited as possible explanations for the increasing rates of caesarean section in recent years including changes in the risk profile of the obstetric population (such as increased maternal age and pre-pregnancy weight), maternal request for caesarean in the absence of any obstetric or medical reasons, changes in clinical practice (such as the management of breech presentation, increased ability to detect problems antenatally and increased monitoring in labour), fear of litigation, and financial motivation to perform a caesarean section[46-48].

1.3 Birth after prior caesarean section

The rise in caesarean section rates has led to increasing numbers of women embarking upon a subsequent pregnancy with a history of previous caesarean section, estimated at around 95,000 women per year in the UK alone*. The management of such women,

*Estimated using national data on number of maternities and the average proportion of births to women with ≥1 previous caesarean sections observed in control women comparable in characteristic to the available national data on women giving birth in the UK, identified through the UK Obstetric Surveillance System in a series of UK-wide studies conducted over various time periods ranging from 2005-2014[49-53]

specifically whether they should give birth by planned caesarean, known as an elective repeat caesarean section (ERCS) or attempt a vaginal birth, known as a planned vaginal birth after previous caesarean (VBAC), also known as a trial of labour after previous caesarean (TOLAC), has long been a debated issue[54,55]. Whilst VBAC was common in Europe during the last century, before the 1980s Craigin's dictum "Once a caesarean, always a caesarean"[56] reflected the way most US obstetricians managed women with a history of prior caesarean. This reflected fears that the uterine scar from a previous caesarean may rupture during labour[57] potentially leading to serious consequences for the mother and/or baby[58-61]. For example, uterine rupture can cause maternal haemorrhage and result in hypoxic-ischaemic encephalopathy, a form of neonatal brain injury caused by oxygen deprivation and limited blood flow to the brain. In the 1980s, however, increasing concern over rising caesarean section rates and its associated morbidity and cost prompted the questioning of the necessity of routine ERCS and with endorsement from the American College of Obstetricians and Gynecologists (ACOG) led to a rise in the rate of planned VBAC[57,62,63].

Current policy consensus in many high-income countries supports offering pregnant women who have had previous caesarean section a choice between planned VBAC and ERCS providing they do not have contraindications to VBAC[8,22,64-66]. While most women are considered clinically eligible to plan a VBAC and success rates are generally thought to be high with around three-quarters of women in high-income settings achieving a vaginal birth[22,64], rates of planned VBAC reported in the literature vary widely from 28% to 82%[67]. Furthermore, reports suggesting that the risk of morbidity, particularly uterine rupture, associated with planned VBAC was higher than initially thought are believed to have contributed to a marked decline in planned VBAC rates in some countries in recent years[67-70]. The rate of ERCS is, in turn, a major determinant of the overall caesarean section rate[9,71,72].

1.4 Research rationale

Current clinical guidelines[8,22,64-66] advise that the increasing number of pregnant women who have had a previous caesarean section should be counselled about the risks and benefits of planned VBAC compared to ERCS to help them make an informed decision regarding this aspect of their maternity care. Furthermore, previous research suggests that although several factors may influence women's decisions about planned mode of birth after prior caesarean, many would find it helpful to have access to accurate, comprehensive and well-balanced information about the associated risks and benefits when making what is often viewed as a very difficult decision[73-76]. Recent legal developments in the UK also now require women to be informed of all risks they may consider to be important as well as their options when giving informed consent[77]. Having a clear understanding of the risks associated with planned mode of birth after previous caesarean also offers the potential to improve outcomes for women and children. For example, understanding the effect of planned mode of birth after previous caesarean on outcomes such as breastfeeding and women's mental health could help improve outcomes by informing the targeting of intervention strategies. A good understanding of the effects of planned mode of birth after previous caesarean is also useful to inform those involved in resource planning and policy development.

A comprehensive systematic review of the evidence concerning short and longer-term outcomes for women and their children born following planned VBAC compared with ERCS was published in 2010 by the US Agency for Healthcare Research and Quality (AHRQ)[67]. This review highlighted several significant limitations with the existing evidence. These included a lack of comparability between the comparison groups, with it often being unclear whether women included in the ERCS group were truly eligible to plan a VBAC, and reporting outcomes according to actual rather than intended mode of birth resulting in misclassification of women who intended ERCS but went into spontaneous labour before

their caesarean or women who intended planned VBAC but gave birth by caesarean. The review also identified a number of specific areas particularly lacking in robust evidence or any evidence at all, including the effect of planned VBAC compared to ERCS on the following outcomes: maternal haemorrhage, maternal infection, maternal surgical injury, breastfeeding initiation or continuation, mother's risk of pelvic floor dysfunction/perineal trauma, neonatal respiratory intervention/morbidity, hypoxic–ischaemic encephalopathy/asphyxia, neonatal sepsis, birth trauma, admission to a neonatal intensive care unit, and the child's neurological development. Also of note is that much of the literature identified by the AHRQ systematic review consisted of non-population-based cohort studies conducted in a single or small number of mainly tertiary or academic medical institutions. Such studies tend to suffer from several limitations such as limited generalisability and lack of statistical power. In addition, most of the studies identified in the review were conducted in North America, with just two UK-based studies which focused on a limited number of neonatal outcomes and were carried out, like many of the other identified studies, in the 1980's/1990's. The specific findings of the AHRQ review are described in more detail in Chapter 2.

Studies comparing the effects of mode of birth in the presence of specific complications, such as breech presentation[78], may not be applicable to the situation of birth after previous caesarean. Similarly, research conducted in the general obstetric population or women without a previous caesarean, where caesareans are usually performed because they are recommended for various obstetric or medical indications, may also not be applicable to birth after previous caesarean. This is because such research is more prone to the issue of confounding by indication, where complications may be a consequence of the underlying medical reasons that led to the need for the caesarean. By contrast, because policy consensus in many high-income countries supports offering women with previous caesarean section a choice about how to plan their birth if they do not have contraindications to VBAC, the decision to plan a caesarean in this context is likely to mainly

reflect maternal preference rather than specific medical indications such that confounding by indication will be less of an issue. Studies conducted in the presence of specific complications, the general obstetric population or women without a previous caesarean may also not be applicable to the situation of birth after prior caesarean as certain birth-related complications, such as uterine rupture, predominately only occur or are increased in women with a previous caesarean undergoing labour[79]. There is also evidence to suggest that the number of previous caesarean sections a woman has had can affect her likelihood of developing certain complications such as uterine rupture, haemorrhage, and needing a hysterectomy[49,79-81]. In any case much of the existing research, at least in the general obstetric population, has focused on the effects of actual mode of birth often without differentiating between planned and emergency caesarean[13,14]. Such research is of more limited value for counselling women about their birth options, as while women have the potential to choose their planned mode of birth, they cannot guarantee their actual mode of birth. The lack of evidence on the longer-term consequences of mode of birth on women and their children, in general and in the specific situation of planned VBAC compared to ERCS, has also been highlighted in UK guidelines[8,22]. This evidence gap and the need for methodologically rigorous studies of both the short and longer-term outcomes for women and their children born following planned VBAC compared to ERCS was further highlighted in a Cochrane review[82].

1.5 Research aim and objectives

The overall aim of the research presented in this thesis was to provide evidence-based information to help women make informed decisions with respect to planned mode of birth after previous caesarean section, by investigating the short and longer-term outcomes for women and their children according to planned mode of birth after previous caesarean section. The specific objectives were:

1) To review the evidence on the short and longer-term outcomes for women and their children following planned VBAC compared to ERCS in high-income settings.

2) To investigate the short-term maternal and perinatal outcomes associated with planned mode of birth after previous caesarean section among women giving birth to a singleton at term and considered clinically eligible to plan a VBAC.

3) To investigate the association between planned mode of birth after previous caesarean section and women's use of psychotropic medication in the first year postpartum as an indication of their subsequent risk of having mental health problems sufficiently severe as to require medication, among women giving birth to a singleton at term and considered clinically eligible to plan a VBAC.

4) To investigate the association between planned mode of birth after previous caesarean section and the child's risk of having a record of special educational needs (SENs) as a marker of adverse neurodevelopmental outcome(s), among singleton children born at term to women considered clinically eligible to plan a VBAC.

1.6 Organisation of component studies and structure of the thesis

This thesis is presented in seven chapters, including this introduction.

Chapter 2. Short and longer-term outcomes for women and their children following planned VBAC compared to ERCS: a literature review - describes a structured literature review of the evidence on the short and longer-term outcomes for women and their children

born following planned VBAC compared to ERCS, which in conjunction with describing the findings of the AHRQ systematic review of the evidence on outcomes associated with planned mode of birth after previous caesarean published in 2010[67], sought to address research objective 1. The limitations and gaps with the evidence that existed at the start of this thesis are highlighted.

Chapter 3. Study methods - provides a general description of the methods used to conduct three population-based cohort studies to address research objectives 2-4 in turn.

Chapter 4. Planned mode of birth after previous caesarean section and short-term maternal and perinatal outcomes: a population-based record linkage cohort study - describes the population-based cohort study conducted to address research objective 2.

Chapter 5. Planned mode of birth after previous caesarean section and women's use of psychotropic medication in the first year postpartum: a population-based record linkage cohort study - describes the population-based cohort study conducted to address research objective 3.

Chapter 6. Planned mode of birth after previous caesarean section and special educational needs in childhood: a population-based record linkage cohort study - describes the population-based cohort study conducted to address research objective 4.

Chapter 7. Overall discussion and conclusion – summarises the main findings from each study, the key strengths and limitations of the approach used, and includes a discussion of the implications for practice, policy, and future research in addition to providing recommendations around routinely-collected data.

2

SHORT AND LONGER-TERM OUTCOMES FOR WOMEN AND THEIR CHILDREN FOLLOWING PLANNED VBAC COMPARED TO ERCS: A LITERATURE REVIEW

2.1 Introduction and chapter overview

A number of systematic reviews of the evidence concerning the risks and benefits of planned VBAC compared to ERCS have been conducted[82-89], the most recent and comprehensive of which was published in 2010 by the US Agency for Healthcare Research and Quality (AHRQ)[67]. The AHRQ review summarised the literature between 1980 and September 2009 relating to women with a singleton pregnancy in developed countries who had undergone one or more previous caesarean sections. This chapter describes the main findings of the AHRQ systematic review. It also describes the methods and findings of a review that was carried out by the author of this thesis, of the literature that has been published since the AHRQ review as well as the literature that has been published since 1980 on outcomes not included in the AHRQ review. Given the number of outcomes considered it was not felt to be feasible in the time available to do this as a full systematic review. Instead, a structured review was conducted. The evidence that existed at the start of this thesis is highlighted along with what the limitations and gaps with the evidence were at this time.

2.2 Objective

The objective of this structured review, in conjunction with describing the findings of the AHRQ review, was to provide a comprehensive up-to-date understanding of the evidence on the short and longer-term outcomes for women and their children following planned VBAC compared to ERCS in high-income settings (research objective 1).

2.1 Structured literature review methods

2.1.1 Eligibility criteria

Studies were eligible for inclusion in this structured review if they included women with one or more prior caesarean sections and presented original data sufficient to compare outcomes for women and/or their children associated with planned VBAC versus ERCS.

Studies were excluded using similar criteria to those used in the AHRQ systematic review[67]. This included if they:

- had ten or fewer participants
- focused on women without a prior caesarean birth, nulliparous women, breech birth or women with particular conditions such gestational diabetes, human immunodeficiency virus, and preeclampsia
- exclusively focused on preterm (<37 weeks' gestation) birth, low birth weight, small for gestational age, multiple births, abortions, or antepartum stillbirths
- were non-English language papers
- were not conducted in a high income setting as defined by the World Bank (March 2017)
- were editorials or letters
- were available exclusively in abstract form
- were studies of animals or cadavers

When examining the outcomes perinatal or neonatal mortality, studies which did not exclude infants with known congenital or lethal anomalies from the analysis were also excluded as was done in the AHRQ systematic review[67].

2.1.2 Outcomes

The following maternal outcomes were considered:

- Mortality
- uterine rupture
- hysterectomy for complications resulting from birth
- haemorrhage
- blood transfusion
- infection
- surgical injury
- length of hospital stay
- breastfeeding
- pelvic floor dysfunction/perineal trauma
- mental health

Baby/child outcomes considered included:

- perinatal and neonatal mortality
- neonatal respiratory intervention/morbidity (including ventilation, intubation, need for oxygen, and transient tachypnoea of the newborn)
- hypoxic-ischaemic encephalopathy/asphyxia
- neonatal sepsis/infection
- birth trauma
- admission to a neonatal intensive care unit (NICU)
- low Apgar score (<7 or <4 at 5 minutes after birth)

- neurological development
- health problems in childhood (including obesity, cancer, infections, type-1 diabetes, asthma, and inflammatory bowel disease)

All of these outcomes are thought to have a plausible association with mode of birth[13,21,26-29,90,91], as outlined in Chapter 1, and are outcome measures that were considered to be important in relevant systematic reviews[67,82,92,93]. Representatives of various service user and voluntary groups in the perinatal field were also consulted and their views about what outcomes they considered to be important to women and their partners when deciding on mode of birth after previous caesarean section were considered when determining which outcome measures to include. This resulted in the addition of pelvic floor dysfunction/perineal trauma and maternal mental health as outcomes in this review. Further details of patient and public involvement in the research are described in section 3.2.11. Given the extensive evidence available on outcomes such as abnormal placentation and surgical complications in subsequent pregnancies[22], such outcomes were not included in this review.

2.1.3 Search strategy

MEDLINE, EMBASE and PsycINFO were searched for relevant studies. The search strategy used in the AHRQ systematic review[67] was updated and used to search for papers published since that review. Additional search strategies focusing on the outcomes not described in the AHRQ review (women's mental health and health problems in childhood) were also used to search for studies published from 1980 that included these outcomes (see **Appendix A** for search strategies). The references of all included papers and relevant systematic reviews were also reviewed to identify additional articles which may have been missed by the search strategies. Searches were initially performed in October 2016 and June 2017 to assess the evidence that existed at the start of this thesis. The evidence found

at the start of the thesis has been highlighted in blue in the Tables and Figures associated with this chapter. Searches were repeated in February 2021 to assess the evidence that existed by the end of this thesis.

2.1.4 Data extraction and analysis

Having first removed duplicates, the titles and abstracts of articles identified by the search strategies were screened against the eligibility criteria. The full texts of potentially eligible articles were then reviewed against the eligibility criteria. Data were extracted into a standardised form for each of the included studies. Where a study did not report a relative measure of effect (e.g. a risk ratio [RR] or odds ratio [OR]), this was calculated using the *csi* function in Stata 13 SE where there was sufficient information provided to do so. In situations where there was a small number (<5) of outcome events in a category, the penalized maximum likelihood estimation proposed by Firth (Stata add-in command *firthlogit*) was used to try and overcome the potential issue of sparse-data bias that can occur in maximum likelihood estimation[94]. As this was a structured rather than a systematic review, meta-analysis was not performed but forest plots were used to graphically display results.

2.2 Results

2.2.1 Structured review search results

Having removed duplicates, a total of 5,120 articles were identified, 4,898 of which were excluded after title and abstract screening (**Figure 2.1**). After reviewing the full text of the remaining articles, 45 were identified as meeting the eligibility criteria and were included in the structured review. This included two studies carried out as part of this thesis[1,2], described in Chapters 4 and 5. A total of 31 of the included studies were identified before conducting the studies carried out as part of this thesis by the searches performed at the

start of the thesis (literature up until June 2017). Two of the identified studies[95,96] reported on the same cohort and included some of the same outcomes, but both studies were included as they used slightly different inclusion criteria and had different comparison groups (one[95] compared planned VBAC with induction of labour vs. ERCS in women with two prior caesareans while the other[96] compared planned VBAC with spontaneous labour onset vs. ERCS in women with one prior caesarean).

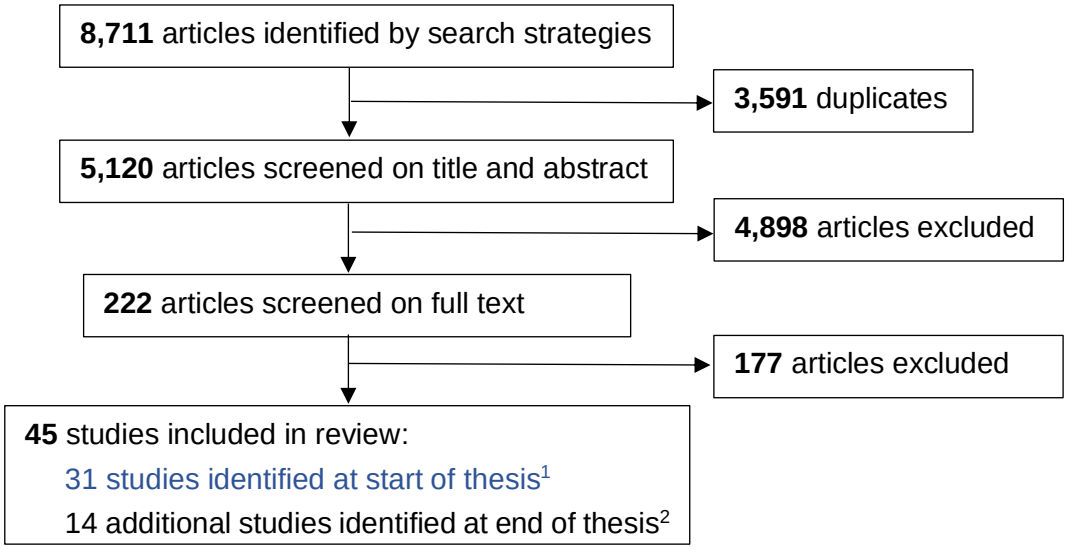


Figure 2.1. Flow diagram of study selection process

[1] Literature from October 2009-June 2017 for all outcomes apart from women's mental health and health problems in childhood, where literature from 1980-June 2017
[2] Literature from October 2009-February 2021 for all outcomes apart from women's mental health and health problems in childhood, where literature from 1980- February 2021

2.2.2 Characteristics of studies included in structured review

Table 2.1 summarises the characteristics of the studies included in the structured review. Studies varied greatly in the extent to which they attempted to exclude births to women with contraindications to VBAC (see **Tables B.1-B.15** in **Appendix B**). They also varied in the degree to which they adjusted for potential confounders (see **Tables B.1-B.15** in **Appendix B**), very few tested for effect modification between mode of birth and covariates, and before conducting the studies carried out as part of this thesis, none considered factors that may mediate any of the observed associations. Most of the studies reported data on more than

one outcome. Findings by outcome are described below and summarised in **Tables 2.2 and 2.3** along with the relevant AHRQ systematic review review[67] results where available.

Table 2.1. Characteristics of the studies included in the structured review

	Literature at start of thesis[1]	Literature at end of thesis[2]
Number of studies	31	45
Study design	- 2 RCTs[97,98], 1 of which nested in patient preference cohort study[98] - 28 cohort studies[54,95,96,99-123] - 1 case-control study[79] - 17 population-based[69,79,99,101,103-105,109-112,114,115,118,121-123] - 9 recruited subjects from a single centre[97,102,106,107,113,116,117,119,120] - 5 recruited subjects from multiple centres[95,96,98,100,108]	- 2 RCTs[97,98], 1 of which nested in patient preference cohort study[98] - 42 cohort studies[54,1,2,95,96,99-135] - 1 case-control study[79] - 26 population-based[1,2,69,79,99,101,103-105,109-112,114,115,118,121-123,125,126,128,130-132,134] - 13 recruited subjects from a single centre[97,102,106,107,113,116,117,119,120,124,129,133,135] - 6 recruited subjects from multiple centres[95,96,98,100,108,127]
Location	- 13 mainland Europe[99,102,103,105,107,108,113,115,119-123] - 7 United States[95,96,100,104,112,114,118] - 3 UK[79,110,111] - 3 Australia[69,98,101] - 2 Israel[106,117] - 1 Canada[109] - 1 Hong Kong[97] - 1 Taiwan[116]	- 18 mainland Europe[99,102,103,105,107,108,113,115,119-125,127-129] - 9 United States[95,96,100,104,112,114,118,131,132] - 5 UK[1,2,79,110,111] - 4 Australia[69,98,101,130] - 3 Israel[106,117,133] - 2 Canada[109,126] - 1 Hong Kong[97] - 1 Taiwan[116] - 2 Japan[134,135]
Recruitment period	Ranged from 1982-2015	Ranged from 1982-2019
Population characteristics	- 18 restricted to women or the children of women with 1 prior caesarean section[69,96-98,101,104-108,111,115-117,119-121,123] - 22 excluded multiple births[69,95-98,101,104-109,111-115,117-121] - 14 confined to women or the children of women delivered at term[69,96,98,106,107,109,111-116,120,121]	- 25 restricted to women or the children of women with 1 prior caesarean section[69,96-98,101,104-108,111,115-117,119-121,123,124,126-128,130,134,135] - 34 excluded multiple births[1,2,69,95-98,101,104-109,111-115,117-121,124,126-132,134,135] - 25 confined to women or the children of women delivered at term[1,2,69,96,98,106,107,109,111-116,120,121,124,126-132,134]
Sample size	Median of 17,395 subjects (range 50-1,833,407)	Median of 25,877 subjects (range 50-1,833,407)

[1] Literature from October 2009-June 2017 for all outcomes apart from women's mental health and health problems in childhood, where literature from 1980-June 2017

[2] Literature from October 2009-February 2021 for all outcomes apart from women's mental health and health problems in childhood, where literature from 1980- February 2021

Abbreviations: RCT, randomised control trial

Table 2.2. Maternal outcomes for planned VBAC vs. ERCS- summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)					Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Mortality	12	All studies: 4 per 100,000 (1-16 per 100,000) Term studies: 2 per 100,000 (0.4-10 per 100,000)	All studies: 13 per 100,000 (4-42 per 100,000) Term studies: 10 per 100,000 (2-43 per 100,000)	All studies: **Significantly reduced risk for planned VBAC, RR 0.33 (0.13-0.88)** Term studies: **Significantly reduced risk for planned VBAC, RR 0.27 (0.09-0.85)**	High	**Literature at start of thesis[1]**	6	Uncertain - Only 1 death in a woman who underwent an ERCS		
						Literature at end of thesis[2]	9	Uncertain – Only 4 deaths, all in women who underwent an ERCS		
Uterine rupture	4	0.47% (0.28–0.77%)	0.026% (0.009–0.082%)	**Significantly increased risk for planned VBAC, RR 20.74 (9.77-44.02)**	Moderate	**Literature at start of thesis[1]**	21	Ranged from 0.00%-3.10%	Ranged from 0.00%-0.80%	**10 studies found significantly increased risk for planned VBAC (1 just among women without prior VB), relative effect ranging from 1.39-243.98**; other predominately small studies found no difference or reported no cases
						Literature at end of thesis[2]	30	Ranged from 0.00%-4.76%	Ranged from 0.00%-2.92%	**15 studies found significantly increased risk for planned VBAC (1 just among women without prior VB), relative effect ranging from 1.39-243.98**; other predominately small studies found no difference or reported no cases

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Table 2.2. (continued). Maternal outcomes for planned VBAC vs. ERCS- summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)					Structured review			
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Hysterectomy	8	All studies: 0.17% (0.12–0.26%) Term studies: 0.14% (0.08-0.22%)	All studies: 0.28% (0.12–0.67%) Term studies: 0.16% (0.07-0.36%)	All studies: No significant difference, RR 0.65 (0.40-1.06) Term studies: No significant difference, relative effect not reported but states p-value=0.672	Moderate	**Literature at start of thesis[1]**	9	Ranged from 0.00%-0.11%	Ranged from 0.00%-0.37%	**1 study, the largest, found significantly increased risk for planned VBAC, relative effect ~1.2; 1 study found significantly reduced risk for planned VBAC (with spontaneous labour onset), relative effect 0.25**; other studies found no difference or reported no cases
						Literature at end of thesis[2]	15	Ranged from 0.00%-0.12%	Ranged from 0.00%-0.61%	**1 study, the largest, found significantly increased risk for planned VBAC, relative effect ~1.2; 1 study found significantly reduced risk for planned VBAC (with spontaneous labour onset), relative effect 0.25**; other studies found no difference or reported no cases
Haemorrhage	6	Insufficient data to evaluate risks			Low	**Literature at start of thesis[1]**	11	Ranged from 0.05%-17.46%	Ranged from 0.00%-16.79%	**6 studies found significantly increased risk for planned VBAC (1 just for major haemorrhage & 1 just among women without prior VB), relative effect ranging from 1.25-9.90; 1 study found significantly reduced risk for planned VBAC, relative effect 0.22**; other studies found no difference
						Literature at end of thesis[2]	18	Ranged from 0.05%-17.46%	Ranged from 0.00%-24.71%	**9 studies found significantly increased risk for planned VBAC (1 just for major haemorrhage & 1 just among women without prior VB), relative effect ranging from 1.25-9.90; 2 studies found significantly reduced risk for planned VBAC, relative effect ranging from 0.22-0.34**; other studies found no difference

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Table 2.2. (continued). Maternal outcomes for planned VBAC vs. ERCS- summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)					Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Blood transfusion	9	All studies: 0.9% (0.4–2.0%) Term studies: 0.7% (0.2–2.2%)	All studies: 1.2% (0.5–2.6%) Term studies: 0.5% (0.2–1.3%)	All studies: No significant difference, RR 0.81 (0.57-1.15) Term studies: **Significantly increased risk for planned VBAC, RR 1.30 (1.15-1.47)**	Moderate	**Literature at start of thesis[1]**	10	Ranged from 0.00%-3.23%	Ranged from 0.00%-5.00%	**3 of larger studies found significantly increased risk for planned VBAC (1 just among women without prior VB), relative effect ranging from 1.14-1.49**; other studies found no difference or reported no cases
						Literature at end of thesis[2]	17	Ranged from 0.00%-3.23%	Ranged from 0.00%-5.00%	**7 of larger studies found significantly increased risk for planned VBAC (1 just among women without prior VB), relative effect ranging from 1.14-3.73**; other studies found no difference or reported no cases
Maternal infection	10	4.6% (1.5–13.5%)	3.2% (1.3–7.3%)	No significant difference, relative effect not reported	Low	**Literature at start of thesis[1]**	9	Ranged from 0.02%-15.7%	Ranged from 0.0%-15.7%	**3 studies found significantly increased risk, relative effect ranging from 1.68-10.04, & 2 studies a significantly reduced risk for planned VBAC, relative effect ~0.2-0.5, for at least one of the infection outcomes they examined**; other studies found no difference
						Literature at end of thesis[2]	13	Ranged from 0.02%-15.7%	Ranged from 0.0%-15.7%	**5 studies found significantly increased risk, relative effect ranging from 1.19-10.04, & 3 studies a significantly reduced risk for planned VBAC (1 just among women without prior VB), relative effect ranging from 0.24-0.74, for at least one of the infection outcomes they examined**; other studies found no difference

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Table 2.2. (continued). Maternal outcomes for planned VBAC vs. ERCS- summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)					Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Surgical injury	4	Insufficient data to evaluate risks			Low	**Literature at start of thesis[1]**	6	Ranged from 0.00%-1.21%	Ranged from 0.00%-0.54%	**1 study, the largest, found ~3-fold significantly increased risk for planned VBAC (with spontaneous labour onset);** other predominately small studies found no difference or reported no cases
						Literature at end of thesis[2]	9	Ranged from 0.00%-2.86%	Ranged from 0.00%-2.92%	**The largest 2 studies found ~3-fold significantly increased risk for planned VBAC (with spontaneous labour onset);** other predominately small studies found no difference or reported no cases
Length of hospital stay	5	Mean of 2.55 days (2.34-2.76 days)	Mean of 3.92 days (3.56-4.29 days)	**Significantly reduced stay for planned VBAC,** relative effect not reported but states **p<0.001**	Not graded	**Literature at start of thesis[1]**	2	-	-	**1 study found median length of postnatal stay significantly shorter for planned VBAC** but no significant difference in % of women with postnatal stay >7days; other small study found no significant difference in % of women with stay >5 days
						Literature at end of thesis[2]	7	-	-	**5 studies found some evidence length of stay shorter for planned VBAC**: 2 found median length of postnatal stay significantly shorter for planned VBAC (1 with labour induction with a balloon catheter), although 1 of these studies found no significant difference in % of women with postnatal stay >7days & other reported no difference in median total admission time; another 2 studies found mean or median length of hospitalisation shorted for planned VBAC (1 with oxytocin induction); & a fifth study found planned VBAC associated with reduced likelihood of having a postnatal hospital stay >5 days, but only among women with prior VB. Two other small studies found no significant difference in % of women with prolonged hospitalisation (defined either as >5 or ≥7 days)

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Table 2.2. (continued). Maternal outcomes for planned VBAC vs. ERCS- summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)				Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Breastfeeding	0	No studies found so unable to evaluate effects			Insufficient	**Literature at start of thesis[1]**	1	65.1%	58.9%	**Women who had planned VBAC significantly more likely to initiate breastfeeding, relative effect 1.10**
						Literature at end of thesis[2]	2	Initiate breast-feeding ~65%; breastfeed at 6-8 weeks postpartum 43.6%	Initiate breast-feeding ~55-59%; breastfeed at 6-8 weeks postpartum 34.5%	**Women who had planned VBAC significantly more likely to initiate breastfeeding, relative effect 1.10-1.20 & more likely to breastfeed at 6-8 weeks postpartum, relative effect 1.20**
Pelvic floor dysfunction/ perineal trauma	0	No studies comparing planned VBAC vs. ERCS found so unable to evaluate effects			Not graded	**Literature at start of thesis[1]**	1	-Vulvar or perineal haematoma requiring evacuation: 0.16%	-Vulvar or perineal haematoma requiring evacuation: 0.09%	No significant difference found
						Literature at end of thesis[2]	1	Same as at the start of thesis		
Mental health		Outcome not included in review				**Literature at start of thesis[1]**	1	-EPDS median score (IQR): 34 weeks' gestation: 3.5 (0-9.3)	-EPDS median score (IQR): 34 weeks' gestation: 5 (0-9)	No significant differences found in EPDS, BDI or GHQ-12 scores

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Table 2.2. (continued). Maternal outcomes for planned VBAC vs. ERCS- summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)				Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Mental health continued	Outcome not included in review					**Literature at start of thesis[1]**	1	-EPDS median score (IQR): Post-birth: 1 (0-7) 3 months postnatal: 1 (0-6) 6 months postnatal: 0.5 (0-4) - BDI median score (IQR): 34 weeks' gestation: 4.5 (1-8) Post-birth: 2 (0-6) 3 months postnatal: 2 (0-6) 6 months postnatal: 0.5 (0-4)	-EPDS median score (IQR): Post-birth: 2 (0-7) 3 months postnatal: 2 (0-7) 6 months postnatal: 0 (0-4) - BDI median score (IQR): 34 weeks' gestation: 4.5 (2-9) Post-birth: 2 (0-6) 3 months postnatal: 2 (0-5.3) 6 months postnatal: 1.5 (0-4.8)	No significant differences found in EPDS, BDI or GHQ-12 scores

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Table 2.2. (continued). Maternal outcomes for planned VBAC vs. ERCS- summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)				Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Mental health continued	Outcome not included in review					**Literature at start of thesis[1]**	1	- GHQ-12 median score (IQR): 34 weeks' gestation: 1 (0-3) Post-birth: 0 (0-3) 3 months postnatal: 0 (0-2) 6 months postnatal: 0 (0-2)	- GHQ-12 median score (IQR): 34 weeks' gestation: 1 (0-3) Post-birth: 0 (0-2) 3 months postnatal: 0 (0-2) 6 months postnatal: 0 (0-1)	No significant differences found in EPDS, BDI or GHQ-12 scores
						Literature at end of thesis[2]	2	-EPDS median score (IQR): 34 weeks' gestation: 3.5 (0-9.3) Post-birth: 1 (0-7) 3 months postnatal: 1 (0-6) 6 months postnatal: 0.5 (0-4)	-EPDS median score (IQR): 34 weeks' gestation: 5 (0-9) Post-birth: 2 (0-7) 3 months postnatal: 2 (0-7) 6 months postnatal: 0 (0-4)	1 study found no significant differences in EPDS, BDI or GHQ-12 scores; other study found **women who had planned VBAC significantly less likely to be dispensed any psychotropic medication, an antidepressant & at least 2 consecutive antidepressants in 1st year postpartum**

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Table 2.2. (continued). Maternal outcomes for planned VBAC vs. ERCS- summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)				Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Mental health continued	Outcome not included in review					**Literature at end of thesis[2]**	2	- BDI median score (IQR): 34 weeks' gestation: 4.5 (1-8) Post-birth: 2 (0-6) 3 months postnatal: 2 (0-6) 6 months postnatal: 0.5 (0-4) - GHQ-12 median score (IQR): 34 weeks' gestation: 1 (0-3) Post-birth: 0 (0-3) 3 months postnatal: 0 (0-2) 6 months postnatal: 0 (0-2)	- BDI median score (IQR): 34 weeks' gestation: 4.5 (2-9) Post-birth: 2 (0-6) 3 months postnatal: 2 (0-5.3) 6 months postnatal: 1.5 (0-4.8) - GHQ-12 median score (IQR): 34 weeks' gestation: 1 (0-3) Post-birth: 0 (0-2) 3 months postnatal: 0 (0-2) 6 months postnatal: 0 (0-1)	1 study found no significant differences in EPDS, BDI or GHQ-12 scores; other study found **women who had planned VBAC significantly less likely to be dispensed any psychotropic medication, an antidepressant & at least 2 consecutive antidepressants in 1st year postpartum**

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Table 2.2. (continued). Maternal outcomes for planned VBAC vs. ERCS- summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)				Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Mental health continued	Outcome not included in review					**Literature at end of thesis[2]**	2	- Dispensed any psychotropic medication, rate per 100 person-years: 10.58 - Dispensed an antidepressant, rate per 100 person-years: 8.84 - Dispensed at least 2 consecutive prescriptions for an antidepressant, rate per 100 person-years: 6.43 - Dispensed a hypnotic &/or anxiolytic, rate per 100 person-years: 2.66 - Dispensed an antipsychotic &/or related drug, rate per 100 person-years: 0.27	- Dispensed any psychotropic medication, rate per 100 person-years: 13.18 - Dispensed an antidepressant, rate per 100 person-years: 11.36 - Dispensed at least 2 consecutive prescriptions for an antidepressant, rate per 100 person-years: 8.55 - Dispensed a hypnotic &/or anxiolytic, rate per 100 person-years: 3.10 - Dispensed an antipsychotic &/or related drug, rate per 100 person-years: 0.17	1 study found no significant differences in EPDS, BDI or GHQ-12 scores; other study found **women who had planned VBAC significantly less likely to be dispensed any psychotropic medication, an antidepressant & at least 2 consecutive antidepressants in 1st year postpartum**

Abbreviations: AHRQ, Agency for Healthcare Research and Quality; BDI, Beck depression inventory; CI, confidence interval; EPDS, Edinburgh postnatal depression scale; ERCS, elective repeat caesarean section; GHQ-12, general health questionnaire-12; IQR, interquartile range; RR, risk ratio; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

[1] Literature from October 2009-June 2017 for all outcomes apart from mental health, where literature from 1980-June 2017

[2] Literature from October 2009-February 2021 for all outcomes apart from mental health, where literature from 1980- February 2021

Table 2.3. Baby/child outcomes for planned VBAC vs. ERCS - summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)					Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Perinatal mortality	5	1.3 per 1,000 (0.6-3.0 per 1,000)	0.5 per 1,000 (0.1-3.8 per 1,000	**Significantly increased risk for planned VBAC, RR 1.82 (1.24-2.67)**	Moderate	**Literature at start of thesis[1]**	3	Ranged from 0.0-3.8 per 1,000	Ranged from 0.0-1.0 per 1,000	**1 study, the largest, found ~5-6-fold significantly increased risk of intrapartum stillbirth & death within 7 days of birth for planned VBAC;** other rather small studies found no difference or reported no cases
						Literature at end of thesis[2]	5	Ranged from 0.0-3.8 per 1,000	Ranged from 0.0-1.0 per 1,000	**The largest 3 studies found ~5-7-fold significantly increased risk of perinatal mortality for planned VBAC (1 for intrapartum stillbirth & death within 7 days of birth, 1 for intrapartum stillbirth & death within 4 weeks of birth & other for intrapartum stillbirth, death within 4 weeks of birth, time of death unknown & pre-labour stillbirths after 39 weeks' gestation);** other rather small studies found no difference or reported no cases
Neonatal mortality	6	1.1 per 1,000 (0.6-2.0 per 1,000)	0.6 per 1,000 (0.2-1.5 per 1,000)	**Significantly increased risk for planned VBAC, RR 2.06 (1.35-3.13)**	Moderate	**Literature at start of thesis[1]**	8	Ranged from 0.0-3.0 per 1,000	Ranged from 0.0-1.0 per 1,0000	**2 studies found ~2-fold significantly increased risk for planned VBAC (1 for asphyxia associated neonatal death, other for death within 7 days of birth);** other studies found no difference or reported no cases
						Literature at end of thesis[2]	11	Ranged from 0.0-3.0 per 1,000	Ranged from 0.0-1.0 per 1,0000	**3 studies found ~1.4-2-fold significantly increased risk for planned VBAC (1 for asphyxia associated neonatal death, 1 for death within 7 days of birth & other for neonatal death where time period not defined);** other studies found no difference or reported no cases

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Table 2.3. (continued). Baby/child outcomes for planned VBAC vs. ERCS - summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)					Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Neonatal respiratory intervention/ morbidity	4 (3 reported on bag-&-mask ventilation, 2 on intubation & 3 on transient tachypnoea of the newborn)	- Bag-&-mask ventilation: 5.4% (3.5-7.6%) - Intubation for meconium: 11.5% - Transient tachypnoea of the newborn: 3.6% (0.9-8.0%)	- Bag-&-mask ventilation: 2.5% (1.6-3.6%) - Intubation for meconium: 1.5% - Transient tachypnoea of the newborn: 4.2% (1.9-7.3%)	- Bag-&-mask ventilation: **Significantly increased risk for planned VBAC, risk difference 2.5% (95% CI 0.72-5.0%)** - Intubation for meconium: **Significantly increased risk for planned VBAC**, relative effect not reported but states p≤0.001 - Transient tachypnoea of the newborn: No significant difference, risk difference -0.83% (95% CI -3.35-1.7%)	Low	**Literature at start of thesis[1]**	7 (4 reported on ventilation, 1 on intubation & 2 on transient tachypnoea of the newborn)	-Ventilation: Ranged from 0.08%-2.54% -Intubation: 0.82% -Transient tachypnoea of the newborn: Ranged from 0.66%-2.69%	-Ventilation: Ranged from 0.16%-2.29% -Intubation: 1.18% -Transient tachypnoea of the newborn: Ranged from 1.10%-2.99%	-Ventilation: **2 studies found ~1.1-1.2-fold significantly increased risk for planned VBAC**; other studies found no difference -Intubation: The 1 rather small study found no significant difference -Transient tachypnoea of the newborn: **1 study found significantly reduced risk for planned VBAC (with spontaneous labour onset), relative effect 0.59;** other found no significant difference
						Literature at end of thesis[2]	11 (7 reported on ventilation, 3 included intubation & 3 on transient tachypnoea of the newborn)	-Ventilation: Ranged from 0.08%-2.54% -Intubation: 0.65%-2.00% -Transient tachypnoea of the newborn: Ranged from 0.66%-2.69%	-Ventilation: Ranged from 0.16%-2.29% -Intubation: 0.3%-1.4% -Transient tachypnoea of the newborn: Ranged from 1.10%-2.99%	-Ventilation: **4 studies found ~1.1-1.2-fold significantly increased risk for planned VBAC** (1 for ventilation with endotracheal intubation or continuous positive air-way pressure);other studies found no difference -Intubation: **2 largest studies reported ~1.5-6-fold significantly increased risk for planned VBAC** (1 for ventilation with endotracheal intubation excluding ventilation requiring continuous positive air-way pressure; & 1 for resuscitation requiring drugs &/or intubation); 1 rather small study found no significant difference -Transient tachypnoea of the newborn: **1 study found significantly reduced risk for planned VBAC (with spontaneous labour onset), relative effect 0.59;** other studies found no significant difference

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Table 2.3. (continued). Baby/child outcomes for planned VBAC vs. ERCS - summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)				Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Hypoxic–ischaemic encephalopathy/ asphyxia	3	Insufficient data to evaluate risks			Low	**Literature at start of thesis[1]**	8 (5 reported on hypoxic-ischaemic encephalopathy/ asphyxia& 5 on cord pH<7)	- Hypoxic-ischaemic encephalopathy/ asphyxia: Ranged from 0.00%-0.25% - Cord pH <7: 0.28%-6.32%	Hypoxic-ischaemic encephalopathy/ asphyxia: Ranged from 0.00%-0.21% - Cord pH <7: 0.00%-8.81%	Hypoxic-ischaemic encephalopathy/asphyxia: All 5 predominately small studies found no significant difference - Cord pH <7: **1 small study found significantly reduced risk for planned VBAC, relative effect 0.7**; other small studies found no significant difference
						Literature at end of thesis[2]	13 (7 reported on hypoxic-ischaemic encephalopathy/ asphyxia, 6 on cord pH<7, 1 on cord pH<7.10 & 1 on cord pH<7.15)	- Hypoxic-ischaemic encephalopathy/ asphyxia: Ranged from 0.00%-0.25% - Cord pH <7: 0.28%-6.32% -Cord pH < 7.10: 5.9% -Cord pH < 7.15: 7.93%	Hypoxic-ischaemic encephalopathy/ asphyxia: Ranged from 0.00%-0.27% - Cord pH <7: 0.00%-8.81% -Cord pH <7.10: 3.7% -Cord pH < 7.15: 1.27%	Hypoxic-ischaemic encephalopathy/asphyxia: All 7 predominately small studies found no significant difference - Cord pH <7: **1 small study found significantly reduced risk for planned VBAC, relative effect 0.7**; other small studies found no significant difference -Cord pH <7.10: The 1 small study found no significant difference -Cord pH <7.15: The **1 small study found ~5-fold increased risk for planned VBAC with oxytocin labour induction**

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Table 2.3. (continued). Baby/child outcomes for planned VBAC vs. ERCS - summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)				Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Neonatal sepsis/ infection	3	Insufficient data to evaluate risks			Low	**Literature at start of thesis[1]**	3	Ranged from 0.24%-5.30%	Ranged from 0.09%-3.11%	**1 study found significantly increased risk for planned VBAC, relative effect 1.72**; other studies found no difference
						Literature at end of thesis[2]	4	Ranged from 0.00%-5.30%	Ranged from 0.00%-3.11%	**1 study found significantly increased risk for planned VBAC, relative effect 1.72**; other studies found no difference or reported no cases
Birth trauma	2	Insufficient data to evaluate risks			Low	**Literature at start of thesis[1]**	7	Ranged from 0.00%-0.51%	Ranged from 0.00%-0.18%	**4 largest studies found significantly increased risk for planned VBAC (1 just among women without prior VB), relative effect ranging from 3.12-12.5**; other rather small studies found no difference or reported no cases
						Literature at end of thesis[2]	7	Same as at the start of thesis		
Admission to neonatal intensive care unit	8	Insufficient data to evaluate risks			Low	**Literature at start of thesis[1]**	10	Ranged from 0.00%-18.7%	Ranged from 0.00%-13.6%	**3 studies found a significantly increased risk for planned VBAC (1 just among women without prior VB), relative effect ranging from 1.12-1.9; 1 study found significantly reduced risk for planned VBAC relative effect 0.89**; other predominately smaller studies found no difference
						Literature at end of thesis[2]	17	Ranged from 0.00%-18.7%	Ranged from 0.00%-13.6%	**6 studies found a significantly increased risk for planned VBAC (1 just among women without prior VB), relative effect ranging from 1.12-6.2; 3 studies found significantly reduced risk for planned VBAC relative effect ranging from 0.55-0.89**; other predominately smaller studies found no difference

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Table 2.3. (continued). Baby/child outcomes for planned VBAC vs. ERCS - summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)					Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Low Apgar score	4 (3 reported on Apgar score <7 at 5 minutes & 1 on Apgar score <4 at 5 minutes)	- Apgar score <7 at 5 minutes: Ranged from 1-1.5% - Apgar score <4 at 5 minutes: 0.68%	- Apgar score <7 at 5 minutes: Ranged from 0-1% - Apgar score <4 at 5 minutes: 0.44%	- Apgar score <7 at 5 minutes: relative effect not reported but states no study found a significant difference - Apgar score <4 at 5 minutes: **Significantly increased risk for planned VBAC** relative effect not reported but states **p-value=0.02**		**Literature at start of thesis[1]**	11 (9 reported on Apgar score <7 at 5 minutes & 4 on Apgar score <4 at 5 minutes)	- Apgar score <7 at 5 minutes: Ranged from 0.00%-3.17% - Apgar score <4 at 5 minutes: 0.03%-0.37%	- Apgar score <7 at 5 minutes: Ranged from 0.00%-3.00% - Apgar score <4 at 5 minutes: 0.00%-0.14%	- Apgar score <7 at 5 minutes: **4 studies found significantly increased risk for planned VBAC, relative effect ranging from 1.46-5.4**; other predominately smaller studies found no significant difference or reported no cases - Apgar score <4 at 5 minutes: **2 largest studies found significantly increase risk for planned VBAC (1 just among women without prior VB), relative effect ranging from 2.13-8.85**; other studies found no difference
						Literature at end of thesis[2]	19 (17 reported on Apgar score <7 at 5 minutes & 5 on Apgar score <4 at 5 minutes)	- Apgar score <7 at 5 minutes: Ranged from 0.00%-3.17% - Apgar score <4 at 5 minutes: 0.03%-0.37%	- Apgar score <7 at 5 minutes: Ranged from 0.00%-3.00% - Apgar score <4 at 5 minutes: 0.00%-0.14%	- Apgar score <7 at 5 minutes: **7 studies found significantly increased risk for planned VBAC, relative effect ranging from 1.46-5.4**; other predominately smaller studies found no significant difference or reported no cases - Apgar score <4 at 5 minutes: **3 largest studies found significantly increase risk for planned VBAC (1 just among women without prior VB & 1 just among infants born to "high-risk" women), relative effect ranging from 2.13-8.85**; other studies found no difference

Table continued overleaf

Table 2.3. (continued). Baby/child outcomes for planned VBAC vs. ERCS - summary of main findings of AHRQ systematic review and this structured review

Maternal outcome	AHRQ systematic review (Literature from 1980-September 2009)				Structured review				
	Number of studies	Pooled absolute effect (95% CI)		Pooled relative effect for planned VBAC vs. ERCS (95% CI)	Strength of evidence		Number of studies	Absolute effect		Relative effect for planned VBAC vs. ERCS
		Planned VBAC	ERCS					Planned VBAC	ERCS	
Neuro-development	3	Insufficient data to evaluate risks			Insufficient	**Literature at start of thesis[1]**	1	-Learning disability: 2.9% -Cerebral palsy: 0.2%	-Learning disability:2.9% -Cerebral palsy: 0.1%	No significant differences found
						Literature at end of thesis[2]	1	Same as at the start of thesis (note study described in Chapter 6 not included as was under review & not published at time the literature review was updated)		
Childhood health problems	Outcome not included in review					**Literature at start of thesis[1]**	1	- Obesity at age 5 years: 9.5% - Salbutamol inhaler prescription at age 5 years: 8.9% - Type 1 diabetes: 0.5% - Cancer: 0.3% - Hospitalisation with asthma ≤ 30 months of age: 0.9% - Hospitalisation with asthma > 30 months of age: 2.6% - Hospitalisation with inflammatory bowel disease: 0.2%	- Obesity at age 5 years: 12.1% - Salbutamol inhaler prescription at age 5 years: 9.3% - Type 1 diabetes: 0.4% - Cancer: 0.2% - Hospitalisation with asthma ≤ 30 months of age: 0.9% - Hospitalisation with asthma > 30 months of age: 2.7% - Hospitalisation with inflammatory bowel disease: 0.2%	No significant differences found
						Literature at end of thesis[2]	1	Same as at the start of thesis		

Abbreviations: AHRQ, Agency for Healthcare Research and Quality; CI, confidence interval; ERCS, elective repeat caesarean section; RR, risk ratio; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

[1] Literature from October 2009-June 2017 for all outcomes apart from health problems in childhood, where literature from 1980-June 2017

[2] Literature from October 2009-February 2021 for all outcomes apart from health problems in childhood, where literature from 1980- February 2021

2.2.3 Maternal outcomes

2.2.3.1 Mortality

The AHRQ systematic review[67] reported that although rare, the risk of maternal mortality was significantly lower for planned VBAC compared to ERCS: pooled estimates from 12 cohort studies of women who gave birth at any gestational age, mainly conducted in the United States, 4 per 100,000 for planned VBAC vs. 13 per 100,000 for ERCS, unadjusted risk ratio [uRR] 0.33, 95% confidence interval [CI] 0.13-0.88, with similar results found when the analysis was limited to the four studies of women who gave birth at term (**Table B.1** in **Appendix B**). Most studies identified by the AHRQ review were carried out in a single or small number of institutions. However, the strength of evidence overall was regarded to be high, with consistent results between studies and a good level of precision in the estimate of effect.

At the start of this thesis, six studies[96,98,107,109,112,117] (two population-based, five of women who gave birth at term, none conducted in the UK) involving a median of 7,859 women (range 2,345-685,137) were identified since the AHRQ review as reporting on maternal mortality in relation to planned VBAC and ERCS (**Table B.1** in **Appendix B**). Only one maternal death occurred in a woman who underwent an ERCS. By the end of this thesis a further three studies[127,129,134] (one population-based, all of women who gave birth at term, none conducted in the UK) were identified as reporting on the risk of maternal mortality associated with planned VBAC and ERCS (**Table B.1** in **Appendix B**). A summary of the findings of all nine identified studies is presented in **Table 2.2**.

2.2.3.2 Uterine rupture

In the AHRQ review[67], the risk of uterine rupture was found to be significantly higher for women undergoing a planned VBAC compared to those having an ERCS: pooled estimates from four cohort studies that used an anatomical definition of uterine rupture that excluded asymptomatic dehiscence, all conducted in North America, 0.47% for planned VBAC vs.

0.026% for ERCS, uRR 20.74, 95% CI 9.77-44.02 (**Table B.2** in **Appendix B**). These summary results were largely driven by a single study conducted in the United States, where the incidence of uterine rupture was much higher than those reported in the other studies. Also of note, only one of the studies included in the AHRQ meta-analysis was population-based. The AHRQ review also reported that the risk of rupture associated with any induction of labour method was 1.5% at term and 1% at any gestational age while the risks associated with specific induction methods were 1.1% for oxytocin, 2% for prostaglandin E_2 and 6% for misoprostol. However, the review highlighted that there was imprecision and inconsistency in these results among the studies.

At the start of this thesis, 21 studies[79,95,96,98-102,106-109,112,113,116,117,119-123] (eight population-based, ten of women who gave birth at term) were identified since the AHRQ review as reporting on uterine rupture in relation to planned VBAC and ERCS (**Table B.2** in **Appendix B**). Uterine rupture was variably defined amongst these studies and the reported absolute risk of rupture varied from 0.00%-3.10% for planned VBAC and 0.00%-0.80% for ERCS. Ten of the studies[79,96,99,101,109,112,120-123], including the one UK based study[79], reported an increased risk of uterine rupture for planned VBAC compared to ERCS (relative effect ranging from 1.39-243.98), with the highest risks generally apparent when labour was induced and/or augmented. However, one of the studies reported that the risk was only significantly elevated among women without a prior vaginal birth[109]. The remaining predominately small studies found no significant difference in the risk of this outcome for planned VBAC compared to ERCS[95,98,102,107,108,117,119] or reported no cases at all of uterine rupture[100,106,113,116] (**Figure 2.2,** with the literature identified at the start of thesis highlighted in blue). By the end of this thesis, a further nine studies[1,124,126,127,129,131,133-135] (four population-based, seven of women who gave birth at term) including one study carried out as part of this thesis[1] (described in Chapter 4) were identified as reporting on the risk of uterine rupture associated with planned VBAC and

ERCS (**Table B.2** in **Appendix B**; **Figure 2.2**). A summary of the findings of all 30 identified studies is presented in **Table 2.2**.

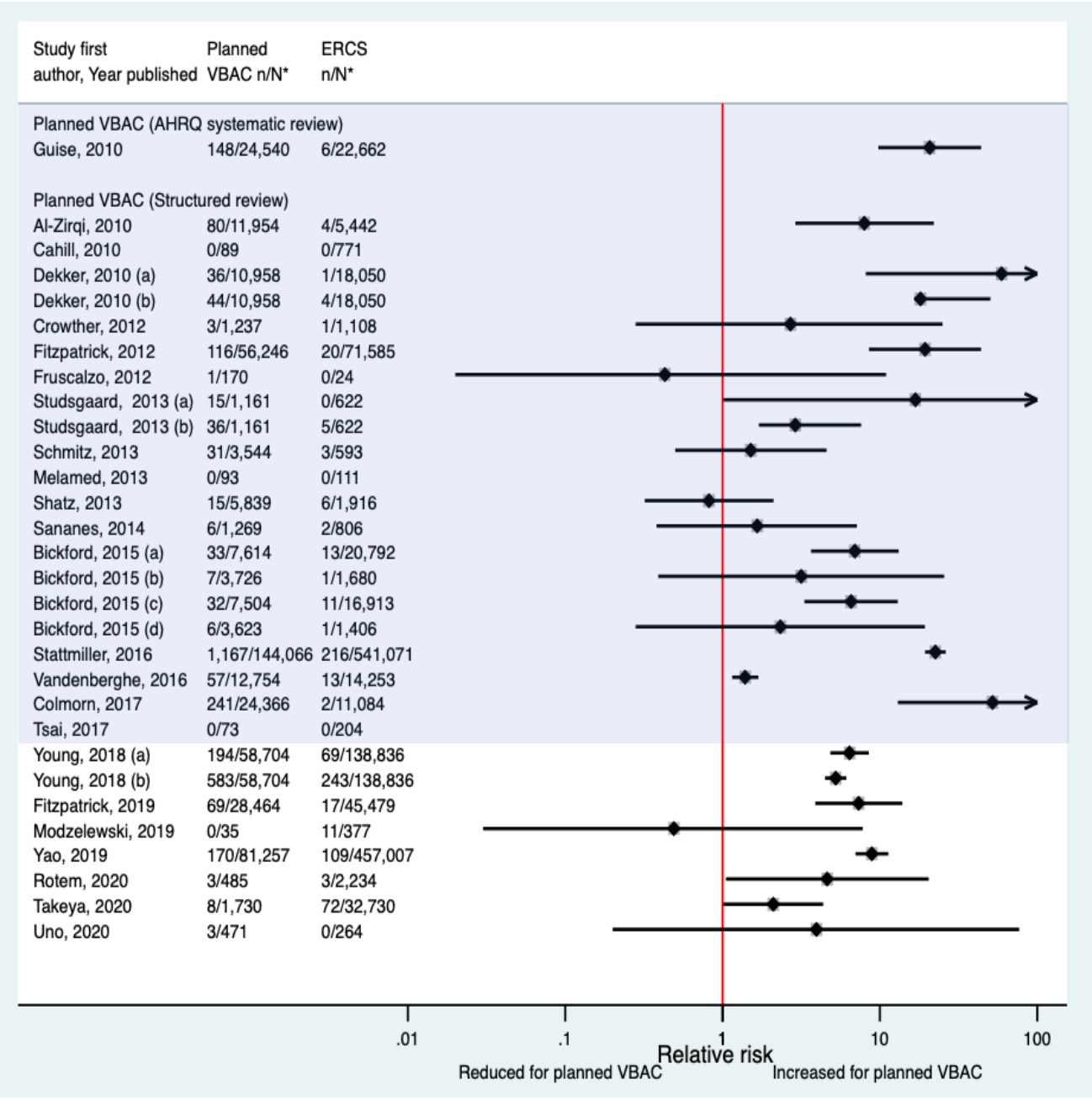


Figure 2.2. Risk of uterine rupture for planned VBAC vs. ERCS

Figure continued overleaf

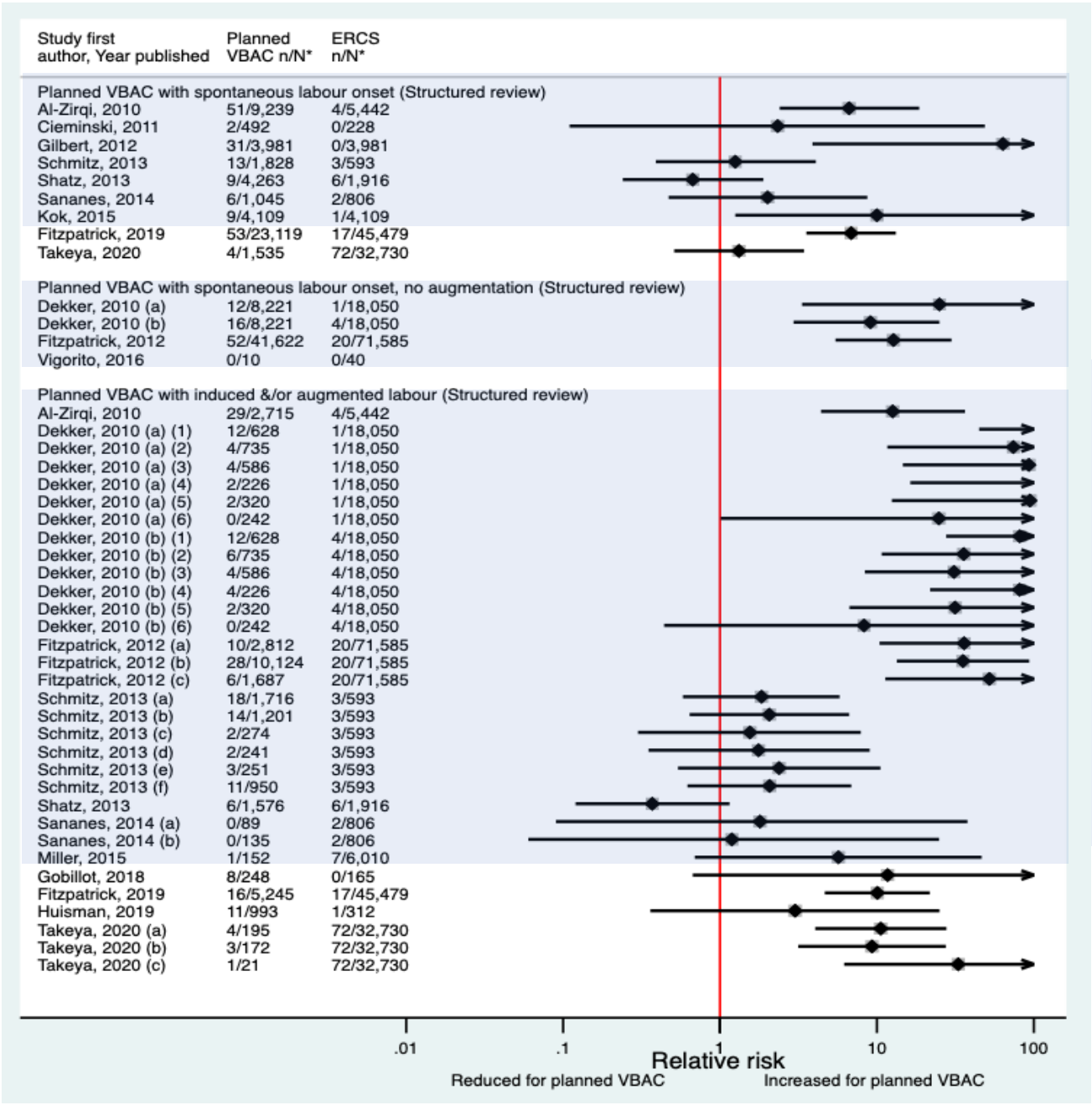


Figure 2.2 (continued). Risk of uterine rupture for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Dekker, 2010 (a) – Outcome: complete uterine rupture, (b) – Outcome: partial uterine rupture, (1) – planned VBAC with spontaneous onset of labour, augmentation with oxytocin, (2) – planned VBAC with induced labour onset, oxytocin only, (3) – planned VBAC with induced labour onset, prostaglandins only, (4) – planned VBAC with induced labour onset, oxytocin & prostaglandins, (5) – planned VBAC with induced labour onset, no oxytocin or prostaglandins, (6) – planned VBAC with induced labour onset, unspecified method; Studsgaard, 2013 (a) – Outcome: complete uterine rupture, (b) – Outcome: incomplete uterine rupture; Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB; Young, 2018 (a) – Outcome: uterine rupture not including dehiscence, (b) – Outcome: uterine rupture including dehiscence; Fitzpatrick, 2012 (a) – planned VBAC where labour induced with prostaglandin & oxytocin not used in labour, (b) – planned VBAC where laboured without prostaglandin induction but oxytocin used in labour, (c) – planned VBAC where labour induced with prostaglandin & oxytocin used in labour; Schmitz, 2013 (a) – planned VBAC with induction or augmentation of labour, (b) – planned VBAC with oxytocin only, (c) – planned VBAC with prostaglandins only, (d) – planned VBAC with prostaglandins & oxytocin, (e) – planned VBAC where labour induced with oxytocin, (f) – planned VBAC where labour augmented with oxytocin; Sananès, 2014 (a) – planned VBAC where labour induced with oxytocin & amniotomy, (b) – planned VBAC where induced with Foley catheter; Takeya, 2020 (a) – planned VBAC with induction or augmentation of labour, (b) – planned VBAC with induction or augmentation of labour with oxytocin, (c) – planned VBAC with induction or augmentation of labour with any prostaglandins with or without oxytocin

Literature at the start of this thesis is highlighted in blue

Abbreviations: AHRQ, Agency for Healthcare Research and quality; CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

2.2.3.3 Hysterectomy

A hysterectomy, the surgical removal of a woman's womb, is usually performed shortly after birth as a life-saving procedure to manage intractable obstetric haemorrhage. Such hysterectomies are often referred to as a peripartum hysterectomy. The AHRQ review[67] reported that the risk of hysterectomy did not differ significantly between planned VBAC and ERCS: pooled estimates from eight cohort studies of women who gave birth at any gestational age, all conducted in North America, 0.17% for planned VBAC vs. 0.28% for ERCD, uRR 0.65, 95% CI 0.40-1.06 (**Table B.3** in **Appendix B**). However, significant heterogeneity was identified among the included studies, which could not be explained by differences in study setting (university or community hospital), gestational age, number of prior caesarean sections, and previous caesarean uterine incision type.

At the start of this thesis, nine studies[95,96,98,109,110,112,113,117,123] (four population-based, five of women who gave birth at term) were identified since the AHRQ review as reporting on the risk of hysterectomy associated with planned VBAC and ERCS (**Table B.3** in **Appendix B**). The absolute risk of hysterectomy in these studies varied from 0.00%-0.11% for planned VBAC and 0.00-0.37% for ERCS. Of the eight studies where cases of hysterectomy occurred, six[95,98,109,110,117,123] including the one UK based study[110] found no significant difference in the risk of hysterectomy for planned VBAC compared to ERCS, while one study[96] reported a reduced risk of hysterectomy for planned VBAC (with spontaneous labour onset) and one[112] (the largest study) reported a higher risk for planned VBAC (**Figure 2.3**). By the end of this thesis, a further six studies[1,124,126,129,131,134] (four population-based, all of women who gave birth at term) including one study carried out as part of this thesis[1] (described in Chapter 4) were identified as reporting on the risk of hysterectomy associated with planned VBAC and ERCS (**Table B.3** in **Appendix B**; **Figure 2.3**). A summary of the findings of all 15 identified studies is presented in **Table 2.2**.

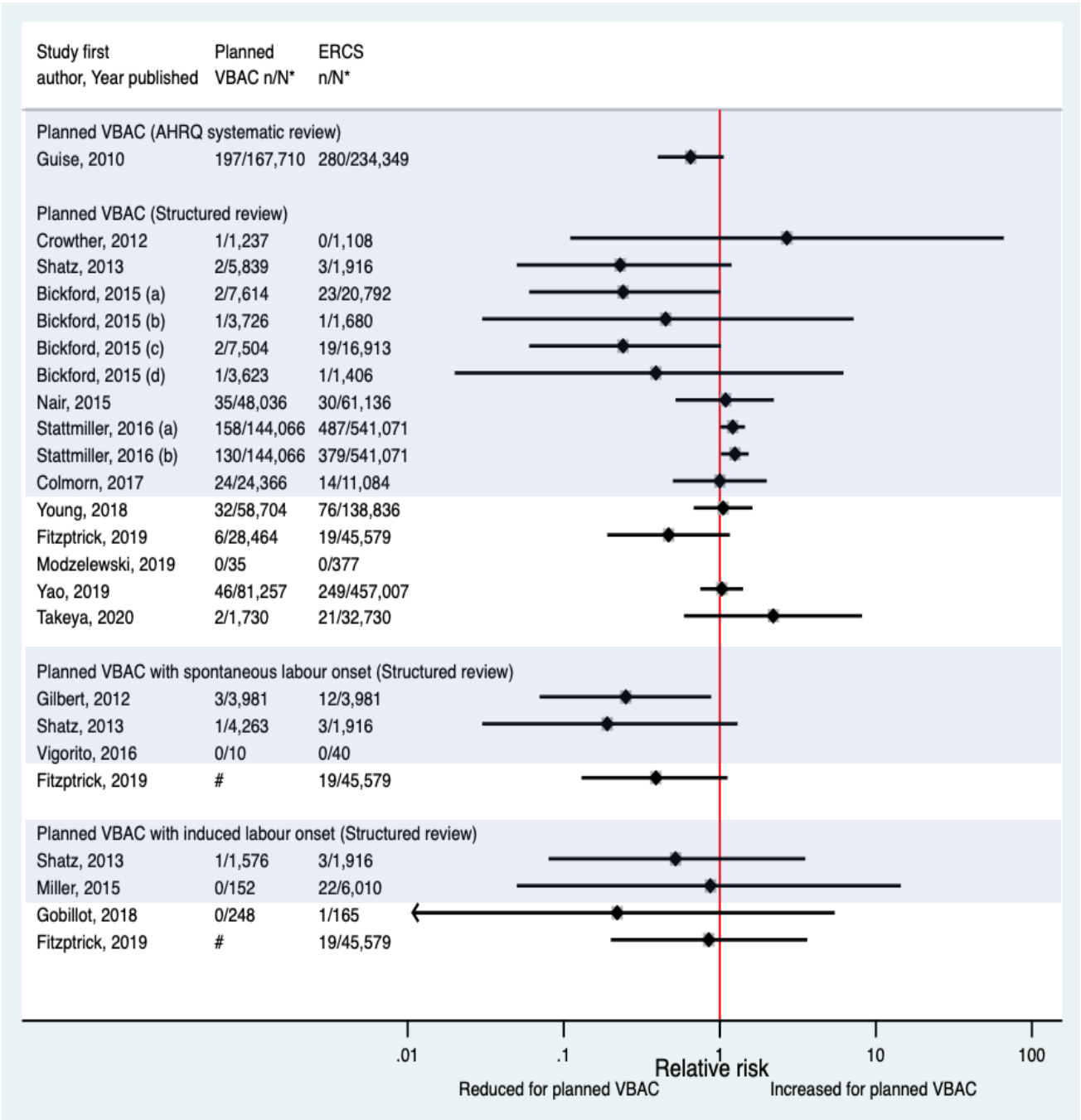


Figure 2.3. Risk of hysterectomy for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB; Stattmiller, 2016 (a) - Outcome: hysterectomy, (b) - Outcome: severe postpartum haemorrhage requiring hysterectomy

- numbers have not been shown to protect against potential disclosure risks

Literature at the start of this thesis is highlighted in blue

Abbreviations: AHRQ, Agency for Healthcare Research and quality; CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

2.2.3.4 Haemorrhage

The six studies identified in the AHRQ review[67] in general reported an increased occurrence of haemorrhage with ERCS compared to planned VBAC, with risks of haemorrhage for ERCS ranging from 0.3% to 29%, although none of the studies found a statistically significant difference. Most of the studies identified by the AHRQ review were conducted in a single centre. Furthermore, the strength of evidence on haemorrhage overall was considered low because studies variably and imprecisely defined and reported haemorrhage. No pooled analysis was therefore conducted and the AHRQ review concluded that there was insufficient data to evaluate the risks and more studies were needed to understand the true relationship.

At the start of this thesis 11 studies[98,106,107,109,110,112,116,117,119-121] (four population-based, eight of women who gave birth at term) were identified since the AHRQ review as reporting on the occurrence of haemorrhage for planned VBAC and ERCS (**Table B.4** in **Appendix B**). These studies variably defined haemorrhage and reported absolute risks ranged from 0.05%-17.46% for planned VBAC and 0.00%-16.79% for ERCS. Six of the studies[98,109,112,117,120,121] reported an increased risk of haemorrhage for planned VBAC compared to ERCS (relative effect ranging from 1.25-9.90), although for one of these studies[98] the risk was only significantly higher for major haemorrhage and for another of the studies[117] the risk was only significantly elevated for planned VBAC with induced labour onset. The risk of haemorrhage was significantly reduced for planned VBAC compared to ERCS in another study[105], while no significant difference in risk was found in the other four studies[106,107,110,116,119], including the one UK based study[110] (**Figure 2.4**). By the end of this thesis, a further seven studies[124,126,127,129,130,133,134] (three population-based, six of women who gave birth at term, none conducted in the UK) were identified as reporting on the risk of haemorrhage associated with planned VBAC and ERCS (**Table B.4** in **Appendix B**; **Figure 2.4**). A summary of the findings of all 18 identified studies is presented in **Table 2.2**.

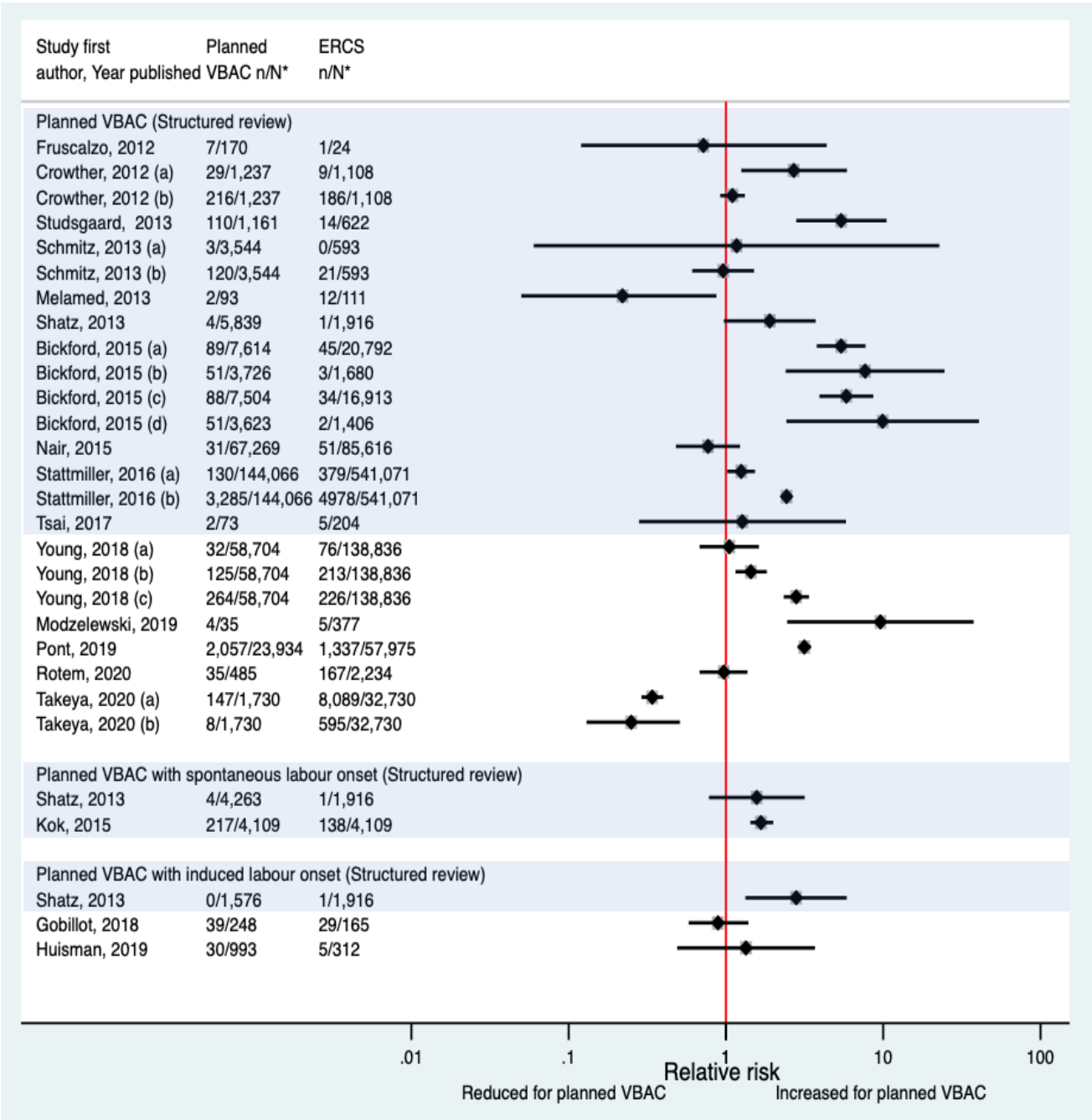


Figure 2.4. Risk of haemorrhage for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Crowther, 2012 (a) – Outcome: blood loss ≥1,500mL &/or requiring blood transfusion, (b) – Outcome: blood loss >500ml; Schmitz, 2013 (a) – Outcome: surgery (compression sutures, artery ligation & hysterectomy) for postpartum haemorrhage, (b) – Outcome: prostaglandins for postpartum haemorrhage; Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB; Stattmiller, 2016 (a) - Outcome: severe postpartum haemorrhage requiring hysterectomy, (b) - Outcome: severe postpartum haemorrhage; Young, 2018 (a) – Outcome: postpartum haemorrhage requiring hysterectomy, (b) – Outcome: postpartum haemorrhage requiring procedures to control bleeding, (c) – Outcome: postpartum haemorrhage requiring blood transfusion; Takeya, 2020 (a) – Outcome: Haemorrhage, defined as ≥1000ml, (b) – Outcome: Haemorrhage, defined as ≥2000ml

Literature at the start of this thesis is highlighted in blue

Abbreviations: CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

2.2.3.5 Blood transfusion

The risk of requiring a blood transfusion was found to be significantly elevated for planned VBAC compared to ERCS in the AHRQ review[67] when only the studies of women who gave birth at term rather than any gestational age were considered: pooled estimates from four term studies, all conducted in North America, 0.7% for planned VBAC vs. 0.5% for ERCD, uRR 1.30, 95% CI 1.15-1.47 (**Table B.5** in **Appendix B**).

At the start of this thesis ten studies[95,100,103,109,112,113,117,119,121,123] (five population-based, four of women who gave birth at term, none conducted in the UK) were identified since the AHRQ review as reporting on the occurrence of blood transfusion in relation to planned VBAC and ERCS (**Table B.5** in **Appendix B**). Reported absolute risks of blood transfusion in these studies varied from 0.00%-3.23% for planned VBAC and 0.00%-5.00% for ERCS. No cases of blood transfusion occurred in one small study[119], while three of the larger studies[103,109,112] reported an elevated risk of blood transfusion for planned VBAC compared to ERCS (relative effect ranging from 1.14-1.49). However, for one of the studies[109], the elevated risk was only apparent among women without a prior vaginal birth. The remaining six studies[95,100,113,117,121,123] found no significant difference between planned VBAC and ERCS (**Figure 2.5**). By the end of this thesis, a further seven studies[1,124,126,129-131,133] (four population-based, six of women who gave birth at term) including one study carried out as part of this thesis[1] (described in Chapter 4) were identified as reporting on the risk of blood transfusion associated with planned VBAC and ERCS (**Table B.5** in **Appendix B**; **Figure 2.5**). A summary of the findings of all 17 identified studies is presented in **Table 2.2**.

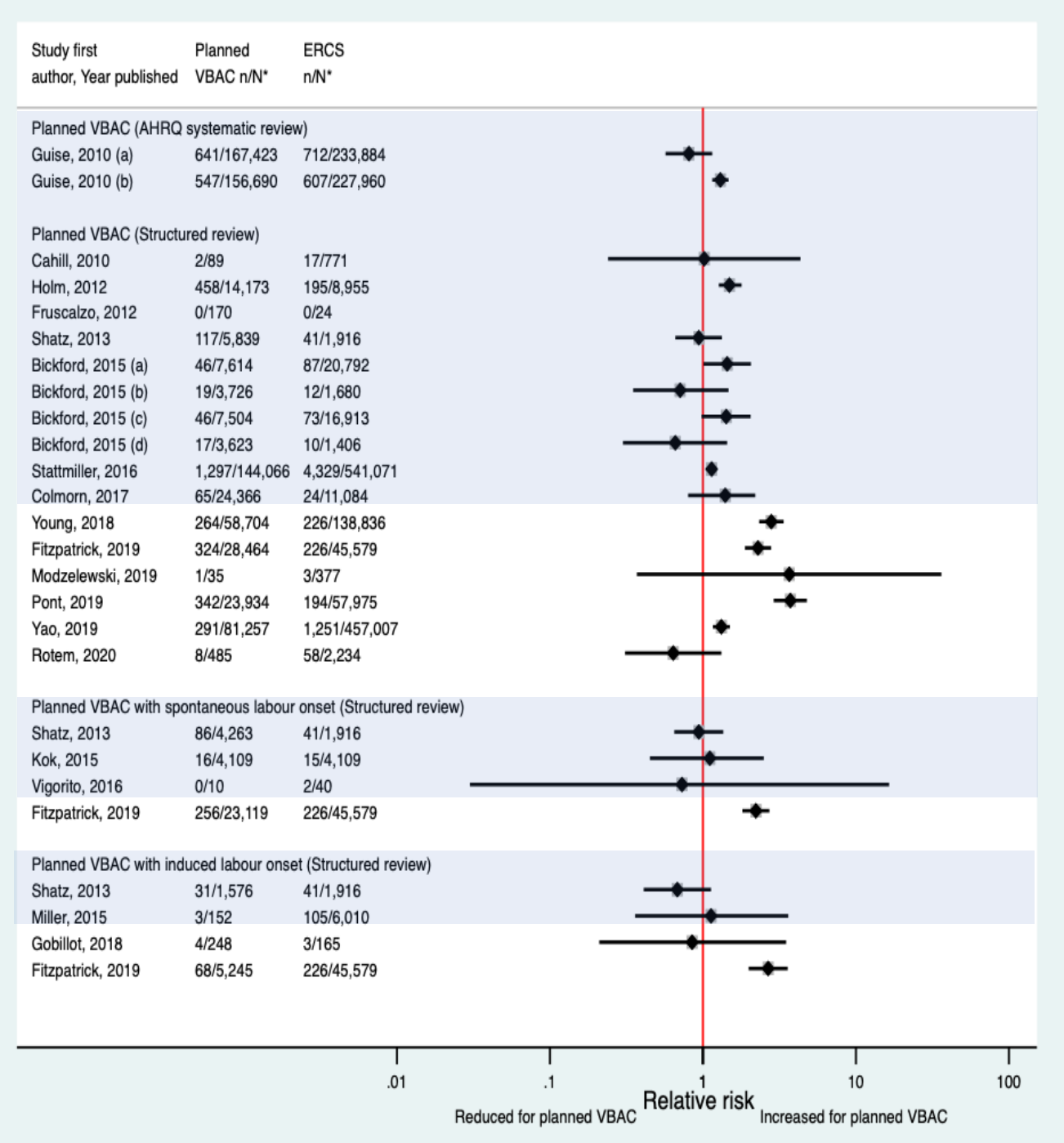


Figure 2.5. Risk of blood transfusion for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Guise, 2010 (a) - risk in women who gave birth at any gestational age, (b) - Risk in women who gave birth at ≥ 37 weeks' gestation; Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB

Literature at the start of this thesis is highlighted in blue

Abbreviations: AHRQ, Agency for Healthcare Research and quality; CS – caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

2.2.3.6 Maternal infection

The AHRQ review[67] reported no significant difference in the risk of maternal infection (all definitions) between planned VBAC and ERCS: pooled estimates from ten cohort studies, mainly single centre studies conducted in the United States, 4.6% for planned VBAC vs. 3.2% for ERCD, relative effect or p-value not given (**Table B.6** in **Appendix B**). However, significant heterogeneity was identified among the studies included. When specific infections reported by the studies included in the AHRQ review were examined, mixed results were found. Six studies investigated endometritis in relation to planned VBAC and ERCS. Overall, endometritis was reported to be increased with planned VBAC compared to ERCS, with risks of endometritis ranging from 0.8 to 30% for planned VBAC and 1.2% to 18% for ERCS. The risk of chorioamnionitis was also found to be higher with planned VBAC compared to ERCS in the two studies that assessed this. The risk of fever on the other hand was found to be significantly reduced with planned VBAC compared to ERCS (pooled estimates from ten studies: 6.5% vs. 7.2%, uRR 0.63, 95% CI 0.43-0.91), although there was significant heterogeneity among the studies. The risk of wound infection was also reported to be higher for ERCS in two studies, although one study found a higher risk of this outcome for planned VBAC. However, the study reporting a higher risk of wound infection with planned VBAC was confined to women weighing more than 136 kilograms, making it difficult to compare this study with the others. Overall, the AHRQ review regarded the strength of evidence on maternal infection to be low because of the variability in how infection was defined and because the evidence was considered to be indirect and to have a high risk of bias.

At the start of this thesis a total of nine studies[95,96,98,100,109,110,112,117,119] (three population-based, four of women who gave birth at term) were identified since the AHRQ review as reporting on some form of maternal infectious morbidity (**Table B.6** in **Appendix B**). The type of infection reported amongst these studies varied widely and the criteria for infection was often not defined. Considering all definitions, absolute risks of infection ranged from 0.02%-15.7% for planned VBAC and 0.00%-15.7% for ERCS. Two of the studies[96,112] found that when

compared to ERCS, planned VBAC was associated with an increased risk of all maternal infection outcomes they examined. Another study[117] found that planned VBAC with induced labour onset was associated with a significantly increased risk of one of the infection outcomes examined, whilst planned VBAC with spontaneous labour onset was associated with a significantly reduced risk of another of the infection outcomes examined when compared to ERCS. Another of the studies[109] reported a reduced risk of infection for planned VBAC compared to ERCS for two out of the three infection outcomes they examined, while the remaining five studies[95,98,100,110,119], including the one UK-based study[110], reported no significant difference (**Figure 2.6**). Considering the specific type of infection, of the three studies identified at the start of this thesis that reported on endometritis, one[96] found an increased risk of this outcome for planned VBAC compared to ERCS (adjusted odds ratio [aOR] 1.75, 95% CI 1.33-2.33) while the others[95,117] reported no significant difference (**Figure 2.7**). At the start of this thesis one study[112] was identified as reporting on chorioamnionitis, finding the risk of this to be significantly higher risk for planned VBAC compared to ERCS (aOR 10.04, 95% CI 9.26-10.90). The risk of fever was found to be significantly reduced for planned VBAC compared to ERCS in one[72] of the three studies[100,117,119] identified at the start of this thesis that examined this outcome, although only among women who had a planned VBAC with spontaneous labour onset (uRR 0.52, 95% CI 0.31-0.87; **Figure 2.8**). Wound infection was found to be significantly reduced for planned VBAC compared to ERCS in the one study[109] identified at the start of this thesis that examined this outcome (uRR as low as 0.26, 95% CI 0.15-0.48 in women with 1-2 prior caesarean sections and ≥1 prior vaginal birth). Considering puerperal sepsis, while one study (the largest)[112] found this to be significantly increased for planned VBAC compared to ERCS (aOR 1.99, 95% CI 1.18-3.34), the other two studies[109,110] identified at the start of this thesis including the one UK based study[110] found no significant difference (**Figure 2.9**). The risk of puerperal infection was examined in two studies identified at the start of this thesis, with one[109] reporting a significantly reduced risk of this outcome for planned VBAC (uRR as low as 0.24, 95% CI 0.10-0.57 in women with 1-2 prior

caesarean sections and ≥1 prior vaginal birth) and the other[112] (the largest study) reporting a significantly increased risk for planned VBAC (aOR 1.68, 95% CI 1.52-1.86; **Figure 2.10**).

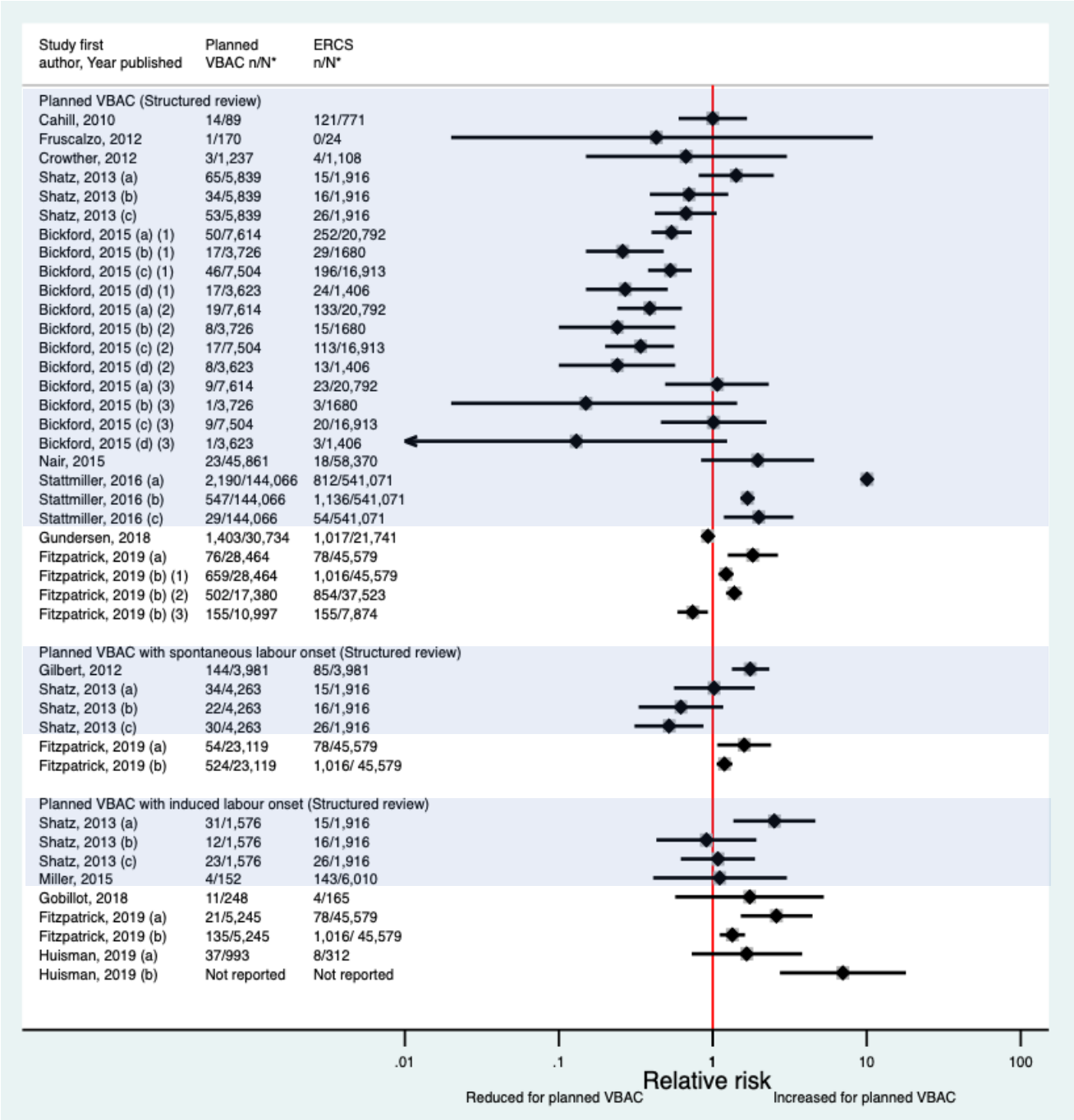


Figure 2.6. Risk of any type of maternal infection for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Shatz, 2013 (a) – Outcome: postpartum infection, (b) – Outcome: endometritis, (c) – Outcome: fever; Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB, (1) – Outcome: obstetric surgical wound infection, (2) – Outcome: puerperal infection, (3) – Outcome: puerperal sepsis; Statmiller, 2016 (a) – Outcome: chorioamnionitis, (b) – Outcome: major puerperal infection, (c) – Outcome: puerperal sepsis; Shatz, 2013 (a) – Outcome: infection, (b) – Outcome: Endometritis, (c) – Outcome: Fever; Fitzpatrick, 2019 (a) – Outcome: puerperal sepsis, (b) – Outcome: other puerperal infection, (1) – Risk in women with ≥ 1 prior CSs, (2) – Risk in women with ≥ 1 prior CSs & no prior VB, (3) – Risk in women with ≥ 1 prior CSs & ≥ 1 prior VB; Huisman, 2019 (a) - Outcome: postpartum infection, defined as treated urinary tract infection, endometritis, pneumonia, wound infection or other unspecified suspected maternal infection (defined as fever of ≥38^{0}C during labour or fetal tachycardia and start of broad-spectrum intravenous antibiotics for suspected infection), (b) – Outcome: fever during labour, defined as temperature ≥38^{0}C

Literature at the start of this thesis is highlighted in blue. Abbreviations: CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

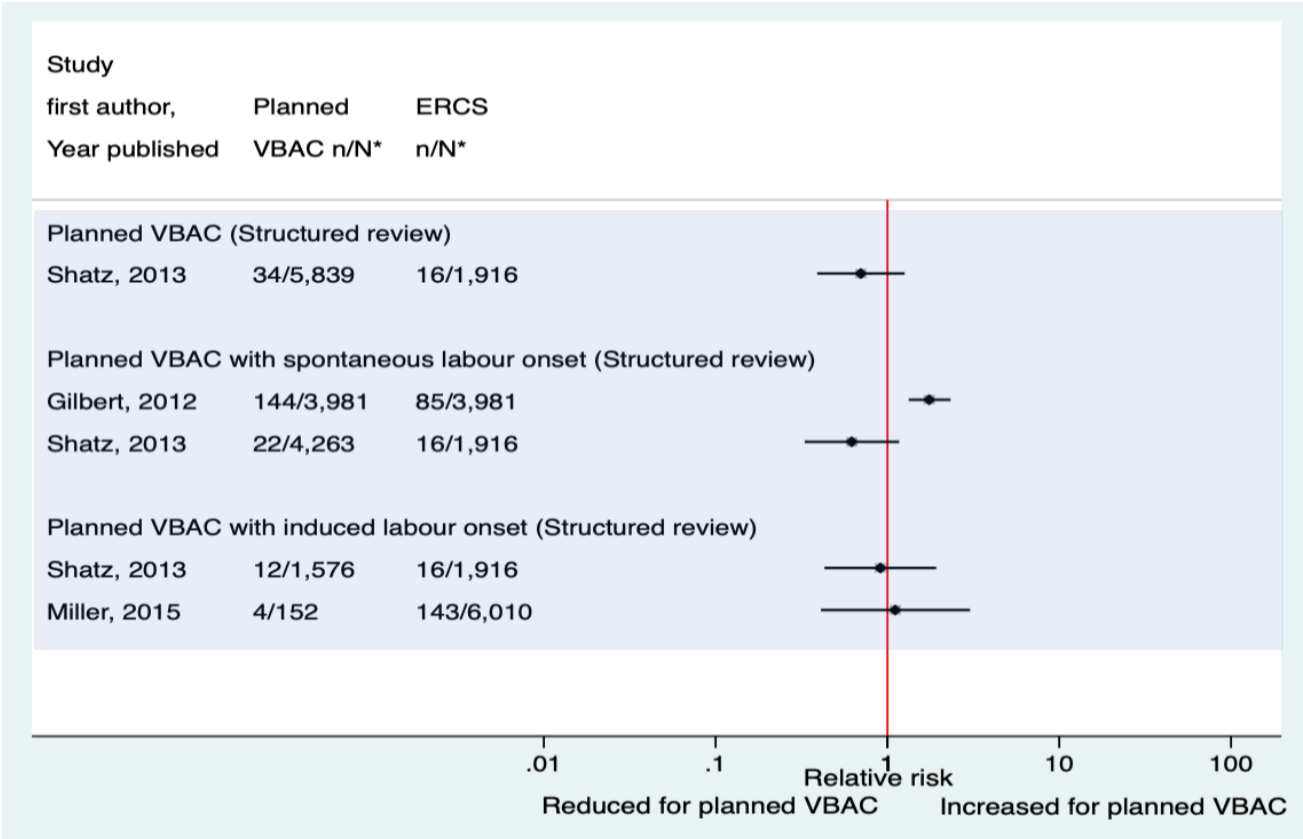


Figure 2.7. Risk of endometritis for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Literature at the start of this thesis is highlighted in blue. Abbreviations: ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean

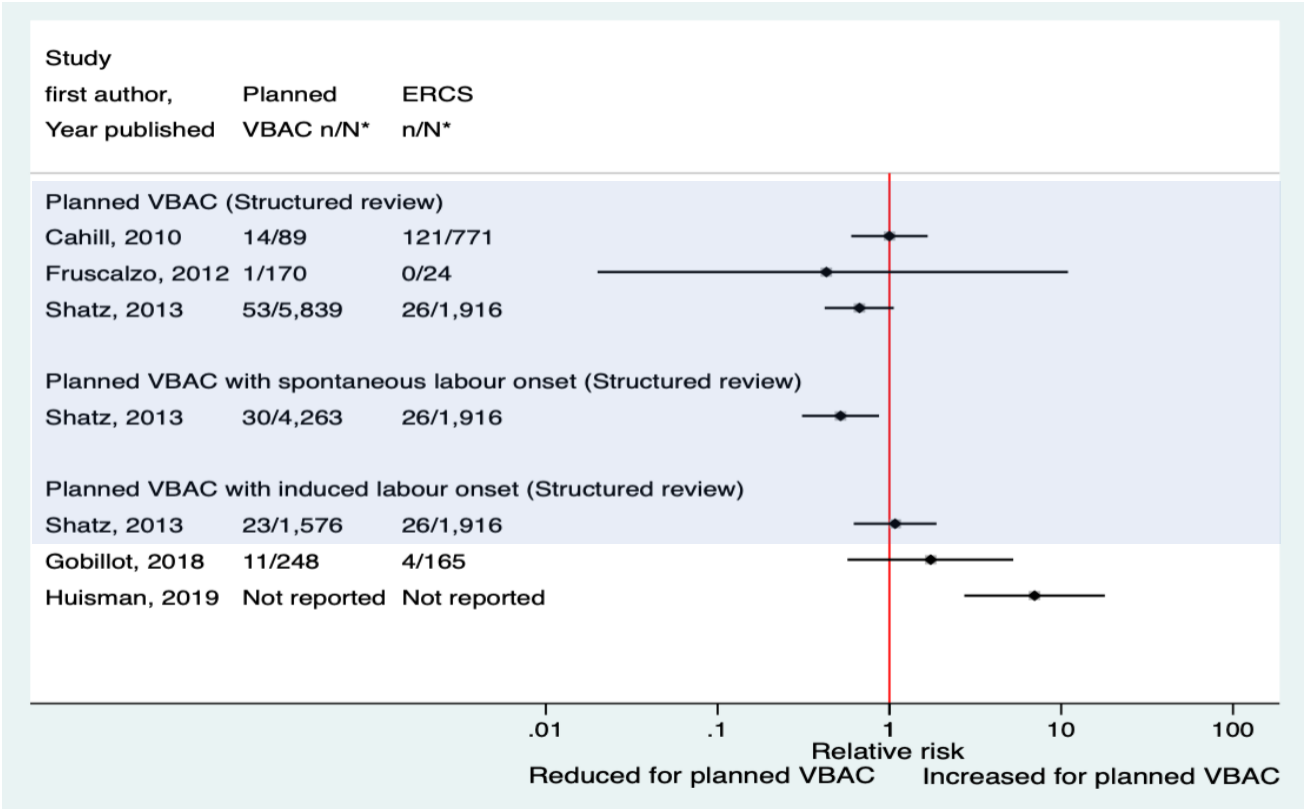


Figure 2.8. Risk of fever for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Literature at the start of this thesis is highlighted in blue. Abbreviations: ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean

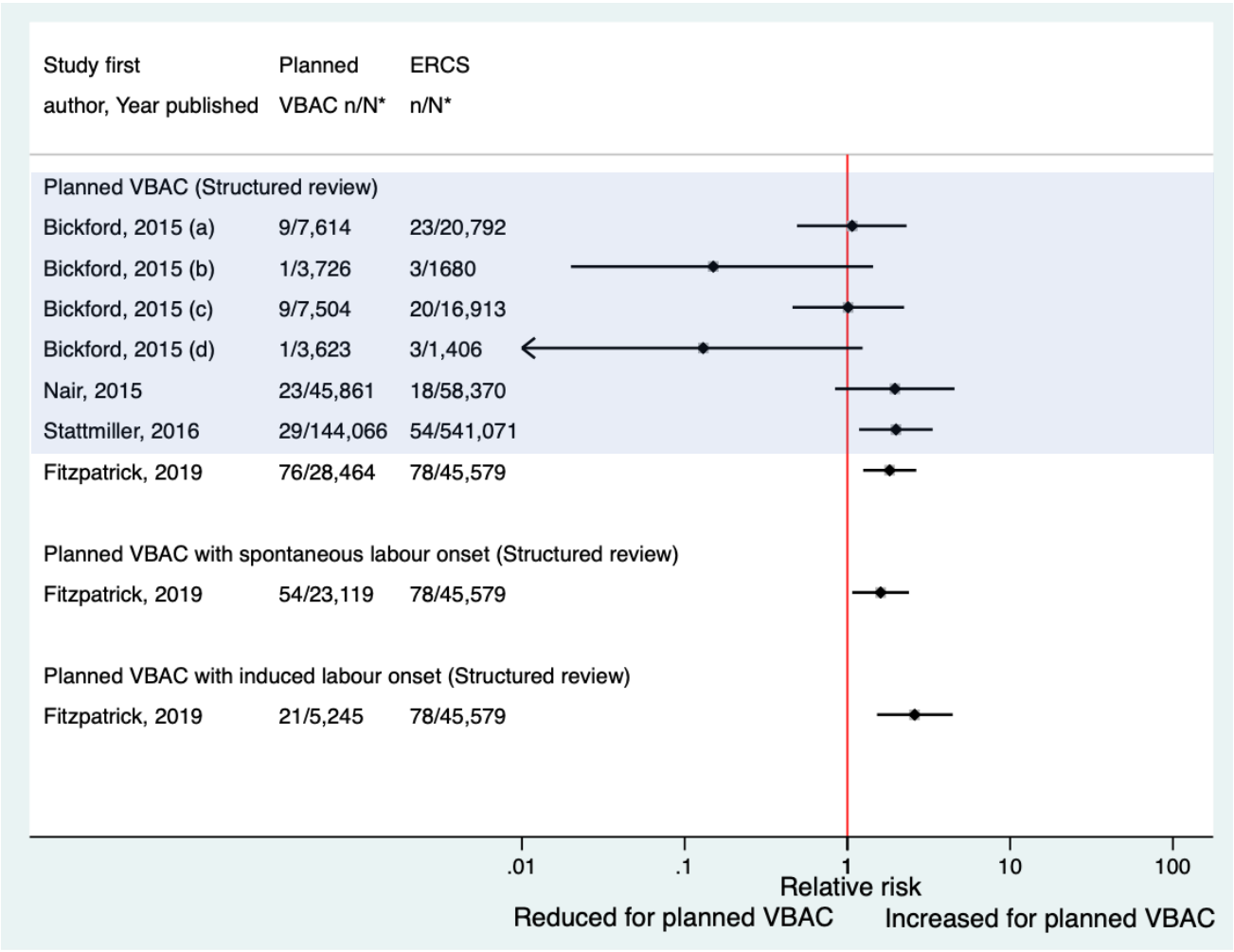


Figure 2.9. Risk of puerperal sepsis for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB

Literature at the start of this thesis is highlighted in blue. Abbreviations: CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

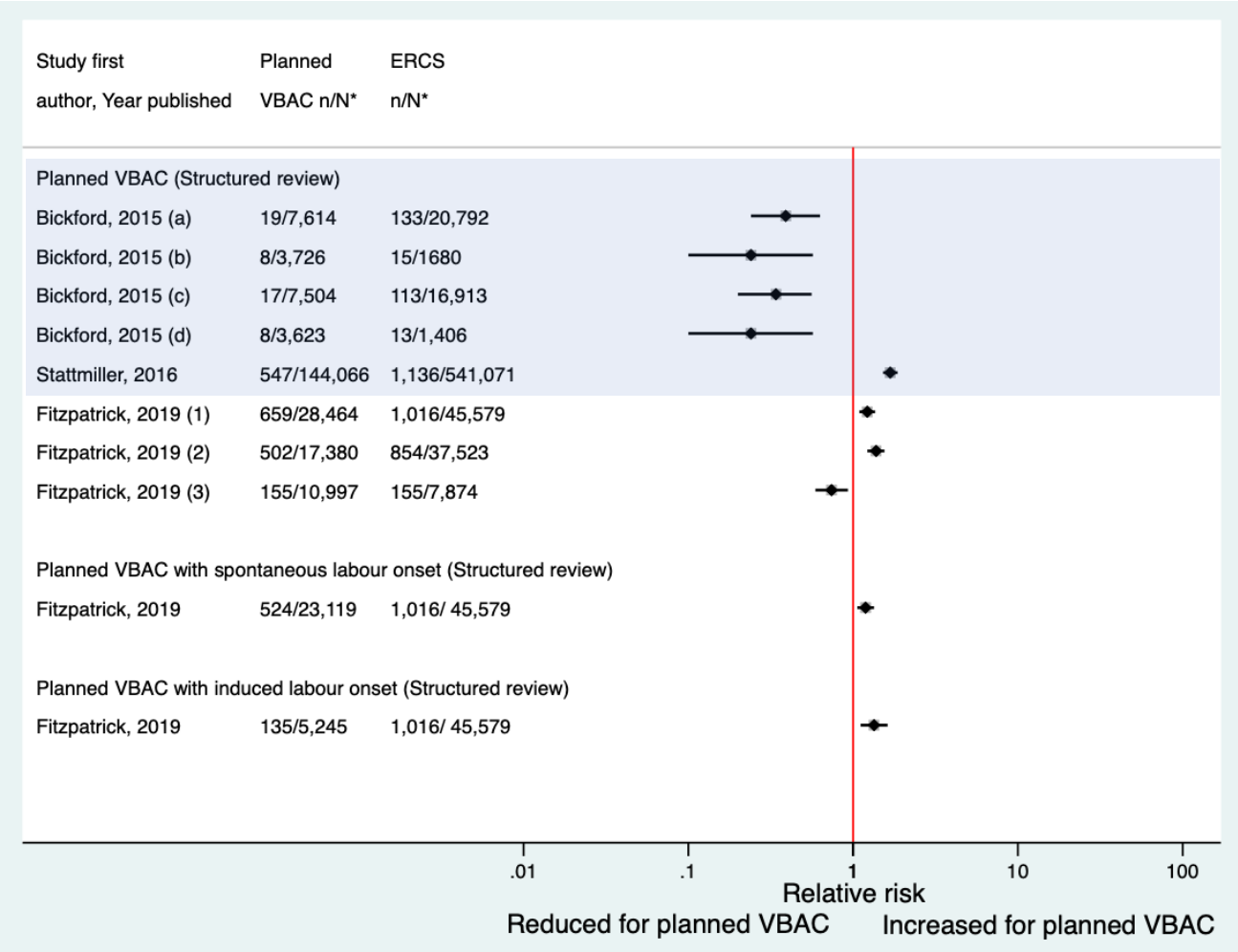


Figure 2.10. Risk of puerperal infection for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB; Fitzpatrick, 2019 (1) – Risk in women with ≥ 1 prior CSs, (2) – Risk in women with ≥ 1 prior CSs & no prior VB, (3) – Risk in women with ≥ 1 prior CSs & ≥ 1 prior VB

Literature at the start of this thesis is highlighted in blue. Abbreviations: CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

By the end of this thesis, a further four studies[1,124,125,127] (two population-based, three of women who gave birth at term) including one study carried out as part of this thesis[1] (described in Chapter 4) were identified as reporting on some form of maternal infectious morbidity associated with planned VBAC and ERCS (**Table B.6** in **Appendix B**; **Figure 2.6 & Figures 2.8-2.10**). A summary of the findings of all 13 identified studies is presented in **Table 2.2**.

2.2.3.7 Surgical injury

Surgical injury was variably defined by the four studies identified in the AHRQ review[67] and while most of the studies suggested there was no significant difference in the risk of this outcome for planned VBAC compared to ERCS, the strength of evidence was regarded as poor with there considered to be insufficient data to determine the risk.

The definition of surgical injury used by the six predominately small studies[95,96,98,100,106,107] (none population-based, four of women who gave birth at term, none conducted in the UK) identified since the AHRQ review at the start of this thesis (**Table B.7** in **Appendix B**) also varied and reported absolute risks of this outcome among the six studies ranged from 0.00%-1.21% for planned VBAC and 0.00%-0.54% for ERCS. Only one of the studies (the largest)[96] found a significant difference in the risk of surgical injury between planned VBAC and ERCS, reporting around a three-fold increased risk for planned VBAC (with spontaneous labour onset) (**Figure 2.11**). By the end of this thesis, a further three studies[1,124,129] (one population-based, all of women who gave birth at term) including one study carried out as part of this thesis[1] (described in Chapter 4) were identified as reporting on the risk of surgical injury associated with planned VBAC and ERCS (**Table B.7** in **Appendix B**; **Figure 2.11**). A summary of the findings of all nine identified studies is presented in **Table 2.2**.

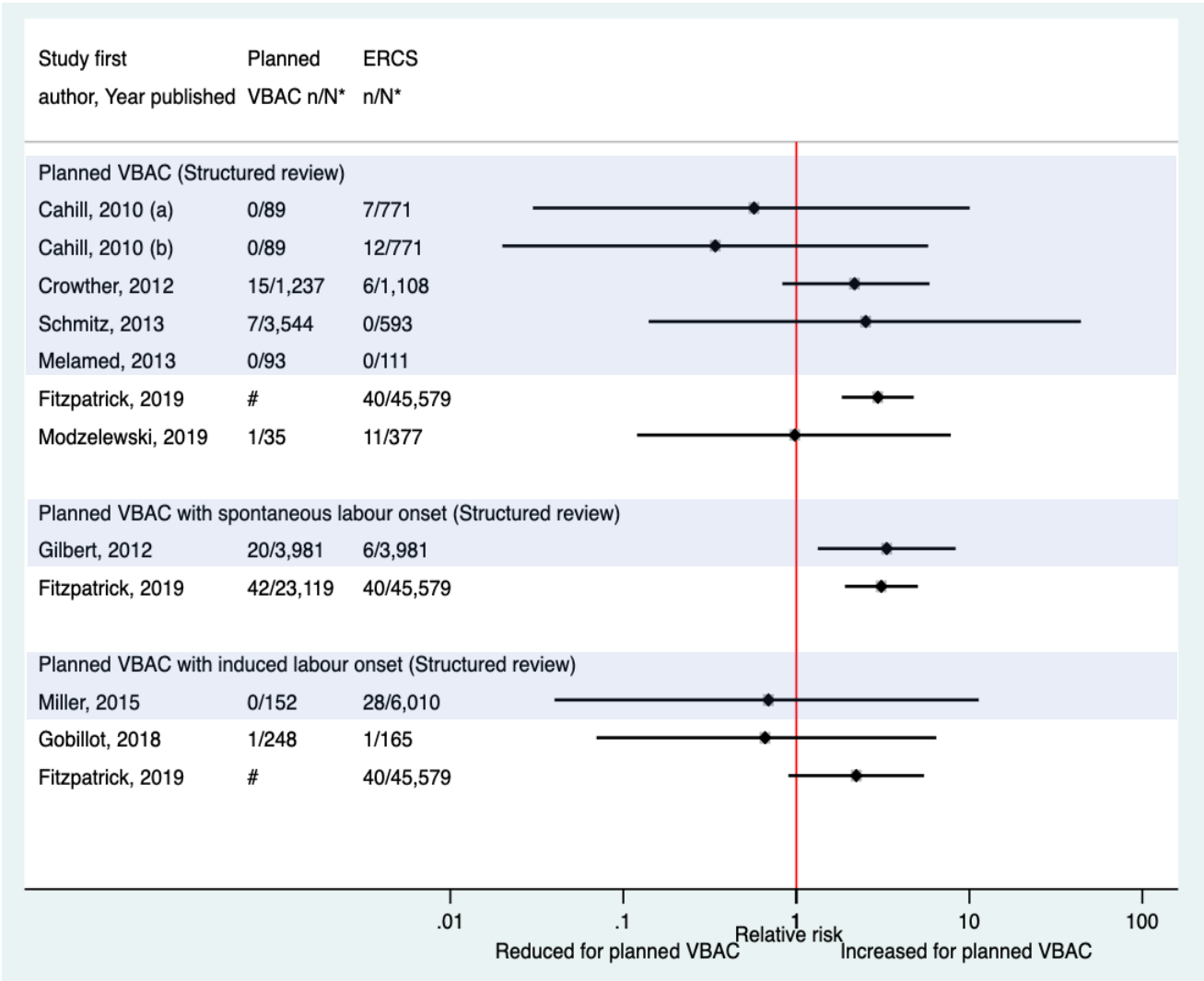


Figure 2.11. Risk of maternal surgical injury for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Cahill, 2010 (a) – Outcome: surgical injury, (b) – Outcome: bladder injury

- numbers have not been shown to protect against potential disclosure risks

Literature at the start of this thesis is highlighted in blue

Abbreviations: ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean

2.2.3.8 Length of hospital stay

The AHRQ review[67] reported that planned VBAC was associated with a shorter length of hospital stay than ERCS: pooled estimates from five cohort studies, all conducted in the United States, mean of 2.55 days for planned VBAC vs. mean of 3.92 days for ERCS, p<0.001, although there was significant heterogeneity between the studies.

At the start of this thesis only two studies[98,106] were identified since the AHRQ review as reporting on the length of hospital stay. One of these studies was conducted in Australia and

reported that although the median length of postnatal stay was shorter for planned VBAC compared to ERCS (4 vs. 5 days, p<0.001), there was no significant difference in the proportion of women with a postnatal stay longer than seven days[98]. The other, a small single centre study of just over 200 women, found no significant difference in the proportion of women with a hospital stay longer than five days[106]. By the end of this thesis a further five studies[1,124,127,132,133] (two population-based, four of women who gave birth at term) including one study carried out as part of this thesis[1](described in Chapter 4) were identified as reporting on the length of hospital stay in relation to planned VBAC and ERCS. A summary of the findings of all seven identified studies is presented in **Table 2.2**.

2.2.3.9 Breastfeeding

The AHRQ review[67] identified no studies that examined the effect of planned VBAC compared to ERCS on breastfeeding initiation or continuation. At the start of this thesis a population-based study conducted in one state of the United States involving 31,511 women[118] was the only study identified since the AHRQ review that investigated the effects of mode of birth after previous caesarean section on breastfeeding. This study reported that among women with one or more previous caesarean sections who gave birth to a live singleton infant at 20-42 weeks' gestation, those giving birth by successful VBAC and those giving birth by caesarean section following an unsuccessful planned VBAC were both more likely to initiate breastfeeding than women giving birth by ERCS (66.6% vs. 58.9%, adjusted OR 1.42, 95% CI 1.30-1.56 and 61.3% vs. 58.9%, aOR 1.15, 95% CI 1.01-1.31 respectively). The study did not report the risks for planned VBAC compared to ERCS but estimating this from the data provided suggests that women who had a planned VBAC were significantly more likely to initiate breastfeeding than women who gave birth by ERCS (65.1% vs. 58.9%, uRR 1.10, 95% CI 1.08-1.13). By the end of this thesis, one further study, a study carried out as part of this thesis[2] (described in Chapter 4), was identified as reporting on the effect of planned VBAC compared to ERCS on breastfeeding.

2.2.3.10 Pelvic floor dysfunction/perineal trauma

The AHRQ review[67] only identified two studies that investigated the effect of VBAC on perineal trauma (damage in the area between the vagina and anus). One of these studies found that women who had a VBAC in their second birth had an OR of 5.46 (95% CI 3.69-8.08) for anal sphincter tears (third- and fourth-degree episiotomy extensions and lacerations) compared to women with a previous vaginal birth having a second vaginal birth. By comparison, the OR for primiparous women who had a vaginal birth was 4.08 (95% CI 3.16-5.28). The second study reported the prevalence of third- or fourth-degree perineal lacerations following episiotomy to be 34% in women who had a VBAC, but no comparisons were made.

At the start of this thesis only one study[98] was identified since the AHRQ review as reporting on the effect of planned VBAC compared to ERCS on perineal trauma. This study, which included a total of 2,345 Australian women, reported that the risk of vulvar or perineal haematoma requiring evacuation was not significantly different for planned VBAC and ERCS (0.16% vs. 0.09%, adjusted risk ratio [aRR] 1.79, 95% CI 0.16-20). Like the AHRQ review, no studies were identified that investigated the effect of planned VBAC compared to ERCS on the risk of urinary or faecal incontinence. By the end of this thesis, no further studies were identified that investigated the effect of planned VBAC compared to ERCS on pelvic floor dysfunction/perineal trauma. However, a number of studies[136-140] (not included in this structured review) were identified that reported on the risk of obstetric anal sphincter injury in women who had a VBAC compared to primiparous women who had a vaginal birth, with most[136,137,139,140] reporting an increased risk of this outcome in the women who had a VBAC. A study carried out as part of this thesis[2] (described in Chapter 4) described the absolute risk of third- or fourth-degree perineal tears in women who had a planned VBAC.

2.2.3.11 Mental health

As maternal mental health was not included as an outcome in the AHRQ review[67], the current structured review searched the literature for relevant studies as far back as 1980. At the start

of this thesis only one study[97] investigating the effect of planned VBAC compared to ERCS on women's mental health-related outcomes was identified, a small randomised controlled trial of 291 women with one prior lower segment caesarean section and a singleton pregnancy recruited from a single University-affiliated tertiary referral unit in Hong Kong. This study used psychometric tests during pregnancy up until six months postpartum to measure woman's anxiety, depression, and general psychological wellbeing, reporting no significant differences in these measures between women who were randomised to planned VBAC compared to planned ERCS. By the end of this thesis, one further study, a study carried out as part of this thesis[2] (described in Chapter 5), was identified as reporting on the effect of planned VBAC compared to ERCS on women's mental health.

2.2.4 Baby/Child outcomes

2.2.4.1 Perinatal and Neonatal mortality

The AHRQ review[67] reported that although rare, the risk of perinatal mortality (defined as deaths occurring at 20 weeks' gestation or more up to 28 days after birth excluding congenital or lethal anomalies) was significantly higher for planned VBAC compared to ERCS: pooled estimates from five cohort studies, one conducted in the UK, all of infants who were born at term, 1.3 per 1,000 vs. 0.5 per 1,000, uRR 1.82, 95% CI 1.24-2.67 (**Table B.8** in **Appendix B**).

At the start of this thesis three studies[98,109,117] (one population-based, none conducted in the UK) were identified since the AHRQ review as reporting on perinatal mortality excluding congenital or lethal anomalies (**Table B.8** in **Appendix B**). One[117] of these studies did not restrict their study population to term born infants or attempt to take account of gestational age. The definition of perinatal mortality varied slightly amongst the three studies and absolute risks of this outcome ranged from 0-0.3.8 per 1,000 for planned VBAC and 0-1.0 per 1,000 for ERCS. A significant difference between planned VBAC and ERCS was only apparent in one of the studies[109] (the largest), where the risk of intrapartum stillbirth or early (≤7 days of birth)

neonatal death was found to be elevated around 5-6-fold among infants born to women without a prior vaginal birth who had a planned VBAC (**Figure 2.12**). At the end of this thesis a further two studies[1,128] (both population-based and restricted to infants who were born at term) including one study carried out as part of this thesis[1] (described in Chapter 4) were identified as reporting on perinatal mortality excluding congenital or lethal anomalies in relation to planned VBAC and ERCS (**Table B.8** in **Appendix B**; **Figure 2.12**). A summary of the findings of all five identified studies is presented in **Table 2.3**.

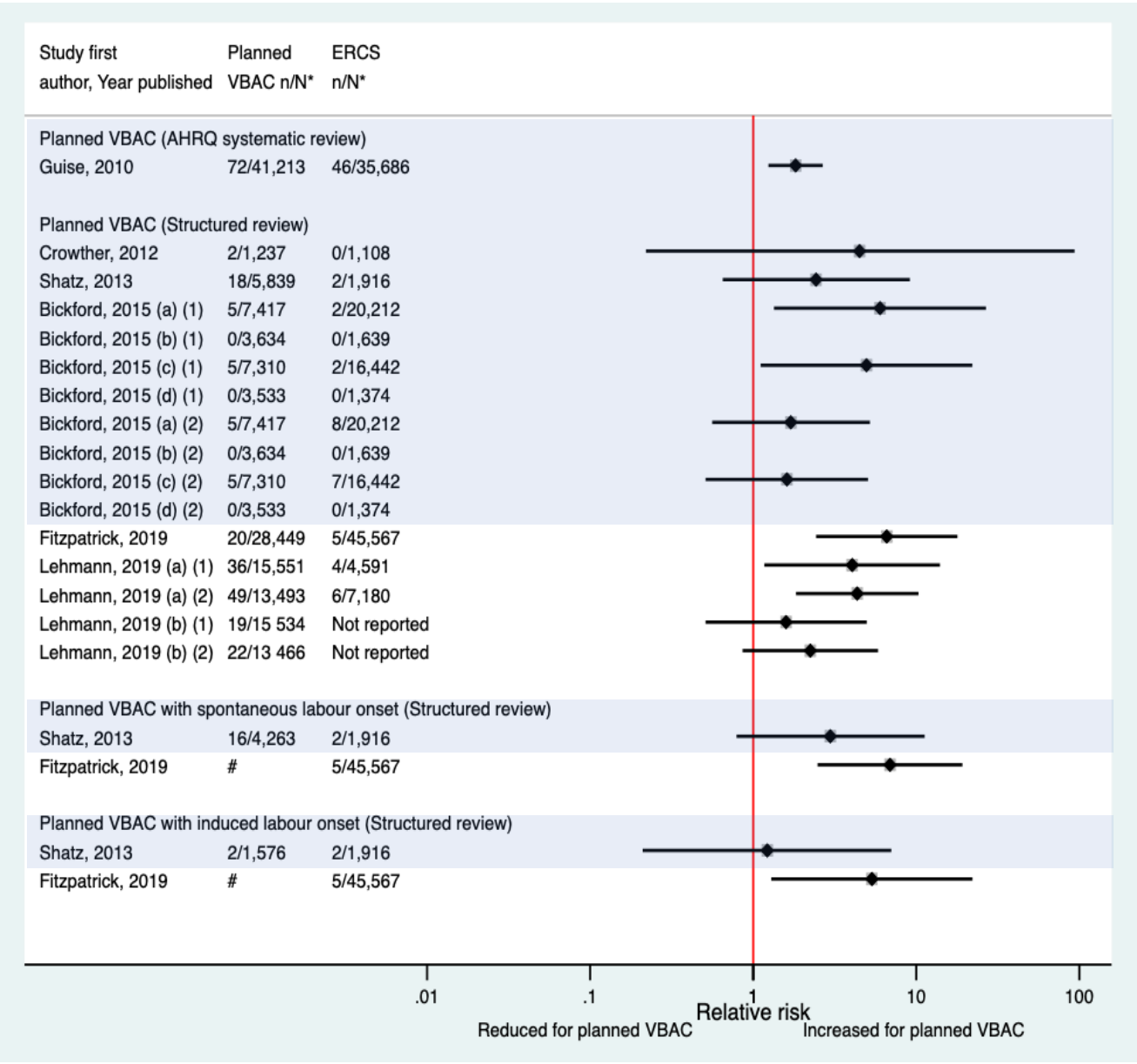


Figure 2.12. Risk of perinatal mortality for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB, (1) – Outcome: intrapartum stillbirth or death at ≤ 7 days of birth, (2) – Outcome: intrapartum stillbirth or death up to 28 days of birth; Lehmann (a) – Outcome: Intrapartum stillbirth, death within 28 days of birth, time of death unknown and pre-labour stillbirths delivered after 39 weeks' gestation, (b) – Outcome: Intrapartum stillbirth, death within 28 days of birth, & time of death unknown, (1) – Risk in "low-risk" women, (2) Risk in "high-risk" women

- numbers have not been shown to protect against potential disclosure risks

Literature at the start of this thesis is highlighted in blue

Abbreviations: AHRQ, Agency for Healthcare Research and quality; CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

The AHRQ review[67] also reported that the risk of neonatal mortality (defined as deaths occurring in the first 28 days after birth excluding congenital or lethal anomalies) at term was low but significantly increased for planned VBAC compared to ERCS: pooled estimates from six cohort studies, two conducted in the UK, 1.1 per 1,000 vs. 0.6 per 1,000, uRR 2.06, 95% CI 1.35-3.13 (**Table B.9** in **Appendix B**).

At the start of this thesis eight studies[96,98,104,109,114,115,117,121] (five population-based, none conducted in the UK) were identified as reporting on neonatal mortality excluding congenital or lethal anomalies since the AHRQ review (**Table B.9** in **Appendix B**). Only one[117] of these studies did not restrict their study population to term born infants or attempt to take account of gestational age. Neonatal mortality was not defined in three of the studies[96,104,117] while definitions varied amongst the other studies. Absolute risks of neonatal mortality ranged from 0-3.0 per 1,000 for planned VBAC and 0-1.0 per 1,000 for ERCS with only two of the studies reporting a significant difference in the risk between planned VBAC and ERCS; both of these studies reported around a two-fold increased risk of neonatal mortality for planned VBAC, although for one the studies[104] the elevated risk was only apparent for asphyxia associated neonatal death rather than all cause neonatal death and for the other study[115] the increased risk was confined to early (≤7 days of birth) rather than late (8-28 days of birth) neonatal death (**Figure 2.13**). At the end of this thesis a further three studies[126,129,131] (two population-based, all restricted to infants who were born at term, and none conducted in the UK) were identified as reporting on neonatal mortality excluding congenital or lethal anomalies in relation to planned VBAC and ERCS (**Table B.9** in **Appendix B**; **Figure 2.13**). A summary of the findings of all 11 identified studies is presented in **Table 2.3**.

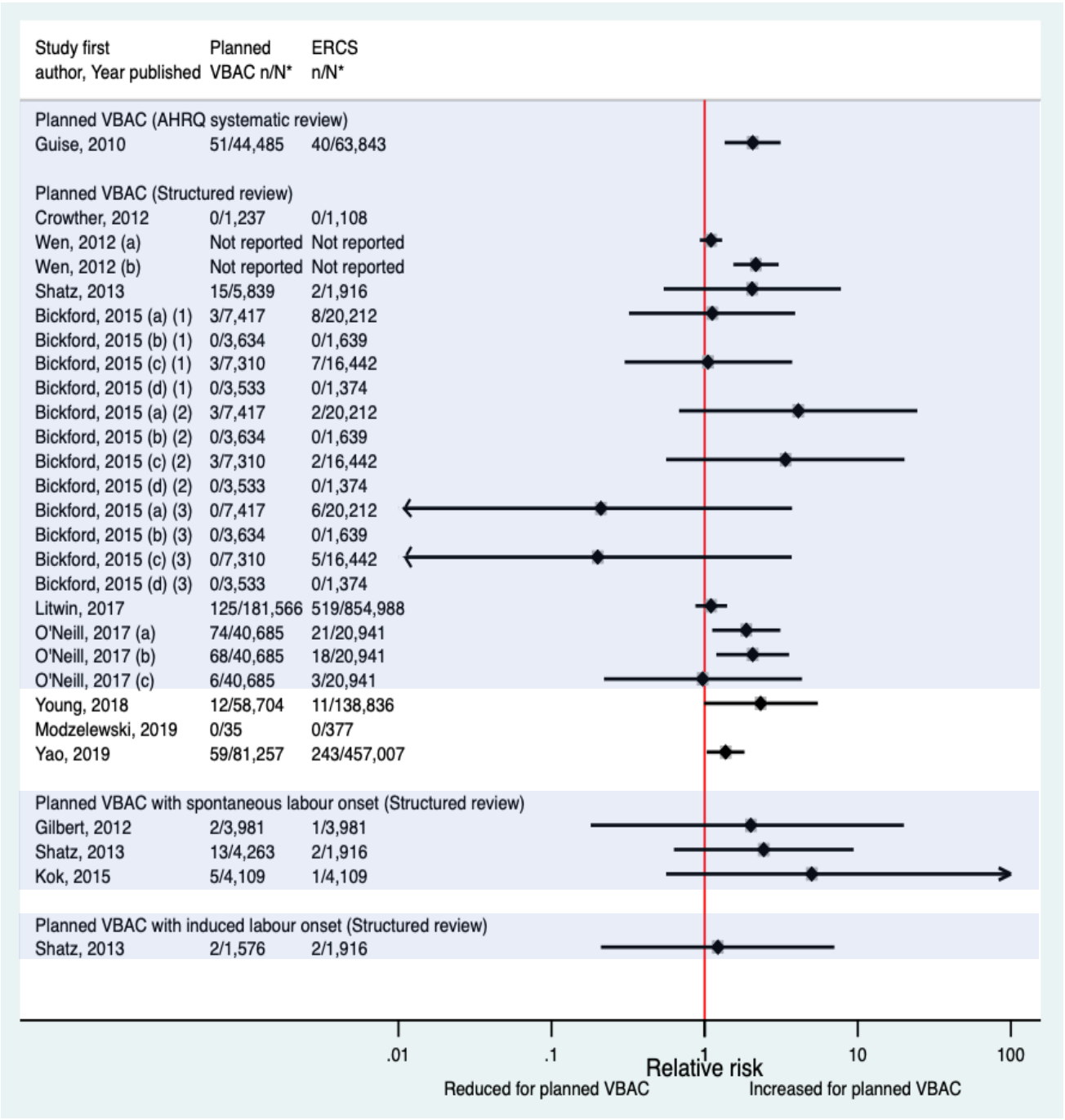


Figure 2.13. Risk of neonatal mortality for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Wen, 2012 (a) – Outcome: all cause neonatal death, (b) – Outcome: asphyxia associated neonatal death; Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB, (1) – Outcome: death at ≤ 28 days of birth, (2) – Outcome: death at ≤ 7 days of birth, (3) – Outcome: death at 8-28 days of birth; O'Neill, 2017 (a) – Outcome: death at ≤ 28 days of birth, (b) – Outcome: death at ≤ 7 days of birth, (c) – Outcome: death at 8-28 days of birth

Literature at the start of this thesis is highlighted in blue

Abbreviations: AHRQ, Agency for Healthcare Research and quality; CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

2.2.4.2 Neonatal respiratory intervention/morbidity

The AHRQ review[67] reported that the risk of an infant receiving bag-and-mask ventilation (an intervention to deliver oxygen to an infant struggling to breathe) was significantly increased for planned VBAC compared to ERCS: pooled estimates from three studies of infants born at term, 5.4% vs. 2.5%, risk difference 2.5%, 95% CI 0.72-5% (**Table B.10** in **Appendix B**). The risk of intubation (inserting a tube into airway) for meconium-stained amniotic fluid (where the baby's poo passes into the amniotic fluid during labour or birth potentially causing breathing problems in the infant) was also found to be greater for planned VBAC compared to ERCS (11.5% vs. 1.5%, p≤0.001) in the two studies identified in the AHRQ review that investigated this. However, the risk of transient tachypnoea of the newborn (a short-lived breathing problem) was reported to not differ significantly for planned VBAC compared to ERCS (pooled estimates from three studies of infants born at term: 3.6% vs. 4.2%, risk difference -0.83%, 95% CI -3.35-1.7%), although there was significant heterogeneity between the studies. All of the studies identified by the AHRQ review were conducted in North America and none were population-based. Overall, the AHRQ review regarded the strength of evidence on neonatal respiratory intervention/morbidity to be low, with few studies, a lack of precision in estimates and inconsistency in results.

At the start of this thesis a total of seven studies[96,98,104,107,109,114,121] (four population-based, none conducted in the UK) were identified as reporting on some form of neonatal respiratory intervention/morbidity since the AHRQ review (**Table B.10** in **Appendix B**). One of the studies[104] did not confine their study population to term infants, although did conduct a sub-group analysis on "low-risk" women which excluded those who gave birth preterm. Four of the studies[98,104,109,114] investigated the need for some form of ventilation, reporting absolute risks ranging from 0.08%-2.54% for planned VBAC and 0.16%-2.29% for ERCS. Two of these studies found an increased risk of this outcome for planned VBAC compared to ERCS, although for one of the studies[104] the increased risk was only apparent among women considered to be "low-risk" and the other[114] did not find any significant difference when

ventilation >6 hours was considered. The other two studies[98,109] reported no significant difference in the risk of ventilation between planned VBAC and ERCS (**Figure 2.14**). The need for intubation (reason unspecified) was not found to be significantly different for planned VBAC compared to ERCS in the single rather small study that investigated this[107], while the single study that examined the need for oxygen found this to be significantly lower for planned VBAC compared to ERCS[109] (uRR as low as 0.27, 95% CI 0.12-0.63 among infants born to women with 1 prior caesarean section and ≥1 prior vaginal birth). Two studies with similar sample sizes that both used propensity score methods to identify planned VBAC and ERCS groups which were comparable on multiple baseline characteristics, reported mixed results in terms of the risk of transient tachypnoea of the newborn for planned VBAC (with spontaneous labour onset) compared to ERCS: one[121] found a reduced risk of this outcome for the planned VBAC group (aOR 0.59, 95% CI 0.36-1.0) and the other[96] found no significant difference.

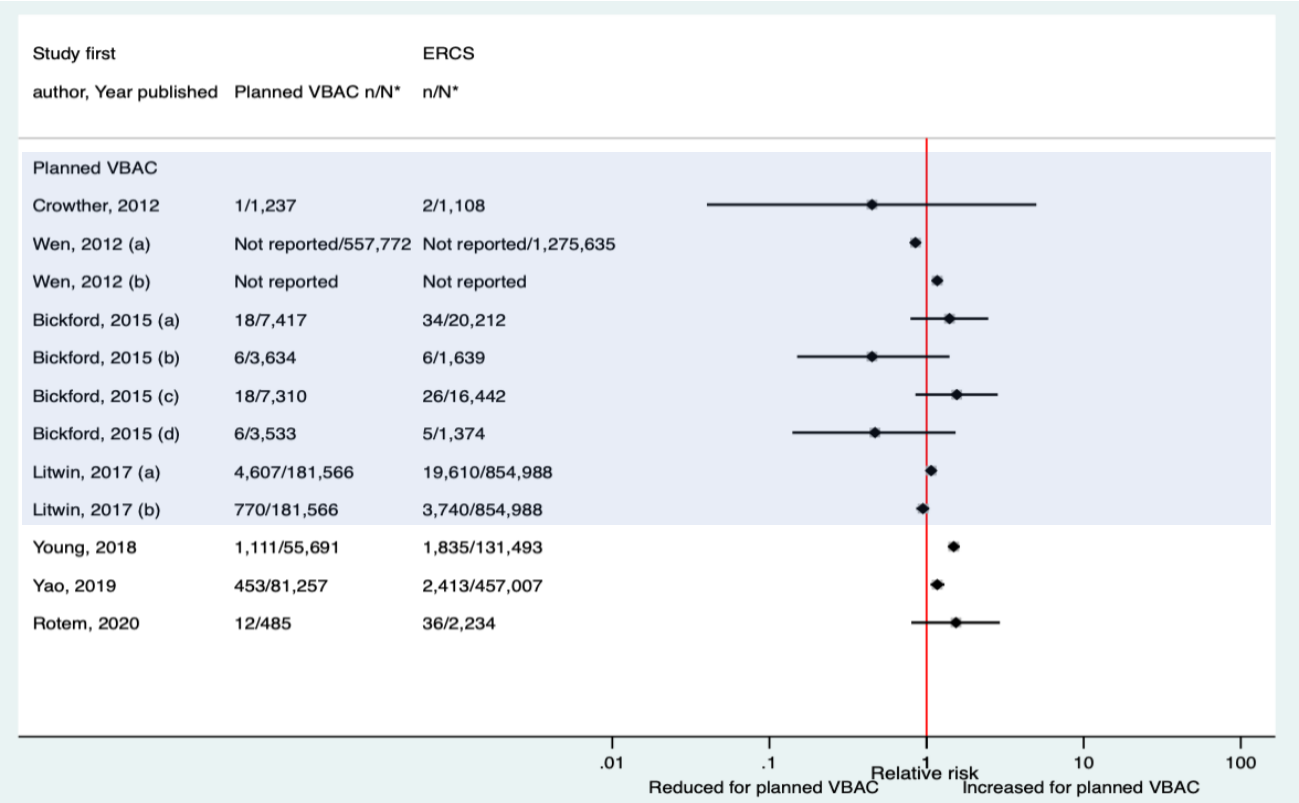


Figure 2.14. Risk of neonatal ventilation for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group
Wen, 2012 (a) – Risk in total study population, (b) – Risk in infants born to "low-risk" women without pre-existing medical problems, pregnancy complications, preterm birth or an infant with low birth weight or congenital anomaly
Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB
Litwin, 2017 (a) – Outcome: assisted ventilation, (b) – Outcome: assisted ventilation > 6 h
Literature at the start of this thesis is highlighted in blue
Abbreviations: CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

At the end of this thesis a further four studies[1,126,131,133] (three population-based, three restricted to infants who were born at term) were identified including one study carried out as part of this thesis[1] (described in Chapter 4) as reporting on some form of neonatal respiratory intervention/morbidity in relation to planned VBAC and ERCS (**Table B.10** in **Appendix B**; **Figure 2.14**). A summary of the findings of all 11 identified studies is presented in **Table 2.3**.

2.2.4.3 Hypoxic-ischaemic encephalopathy/ asphyxia

The three studies identified in the AHRQ review[67], all of which were conducted in North America, suggested that there was no significant difference in the risk of hypoxic–ischaemic encephalopathy (neonatal brain injury caused by oxygen deprivation and limited blood flow to the brain, sometimes referred to as asphyxia) for planned VBAC compared to ERCS in infants born at term. However, the review considered there to be insufficient data to assess the true risk, with the strength of evidence regarded as low due to variability in how hypoxic–ischaemic encephalopathy/asphyxia was defined and a limited number of studies.

At the start of this thesis eight predominately small studies[95,96,98,107-109,117,120] (one population-based, none conducted in the UK) were identified as attempting to investigate hypoxic-ischaemic encephalopathy or asphyxia since the AHRQ review (**Table B.11** in **Appendix B**). Three of these studies[95,108,117] did not restrict their study population to term infants and made no attempt to control for gestational age. Five of the studies[95,96,98,109,117] reported on hypoxic-ischaemic encephalopathy/asphyxia without defining it, with all finding no significant difference in the risk of this outcome between planned VBAC and ERCS (**Figure 2.15**). Of the five studies[96,98,107,108,120] that investigated the proportion of infants with a cord pH of <7 shortly after birth (an indication of hypoxic–ischaemic encephalopathy/asphyxia), one[108] found this to be significantly reduced for planned VBAC compared to ERCS (except where planned VBAC had induced labour onset) while the others reported no significant difference (**Figure 2.16**). The one study[98] that reported on cord blood base deficit of ≥12mmol/l found there to be no significant difference in this measure for planned VBAC compared to ERCS. At the end of this

thesis a further five predominately small studies[124,127,129,133,135] (none population-based, three restricted to infants who were born at term, and none conducted in the UK) were identified as reporting on hypoxic-ischaemic encephalopathy or asphyxia in relation to planned VBAC and ERCS (**Table B.11** in **Appendix B**; **Figure 2.15** & **Figure 2.16**). A summary of the findings of all 13 identified studies is presented in **Table 2.3**.

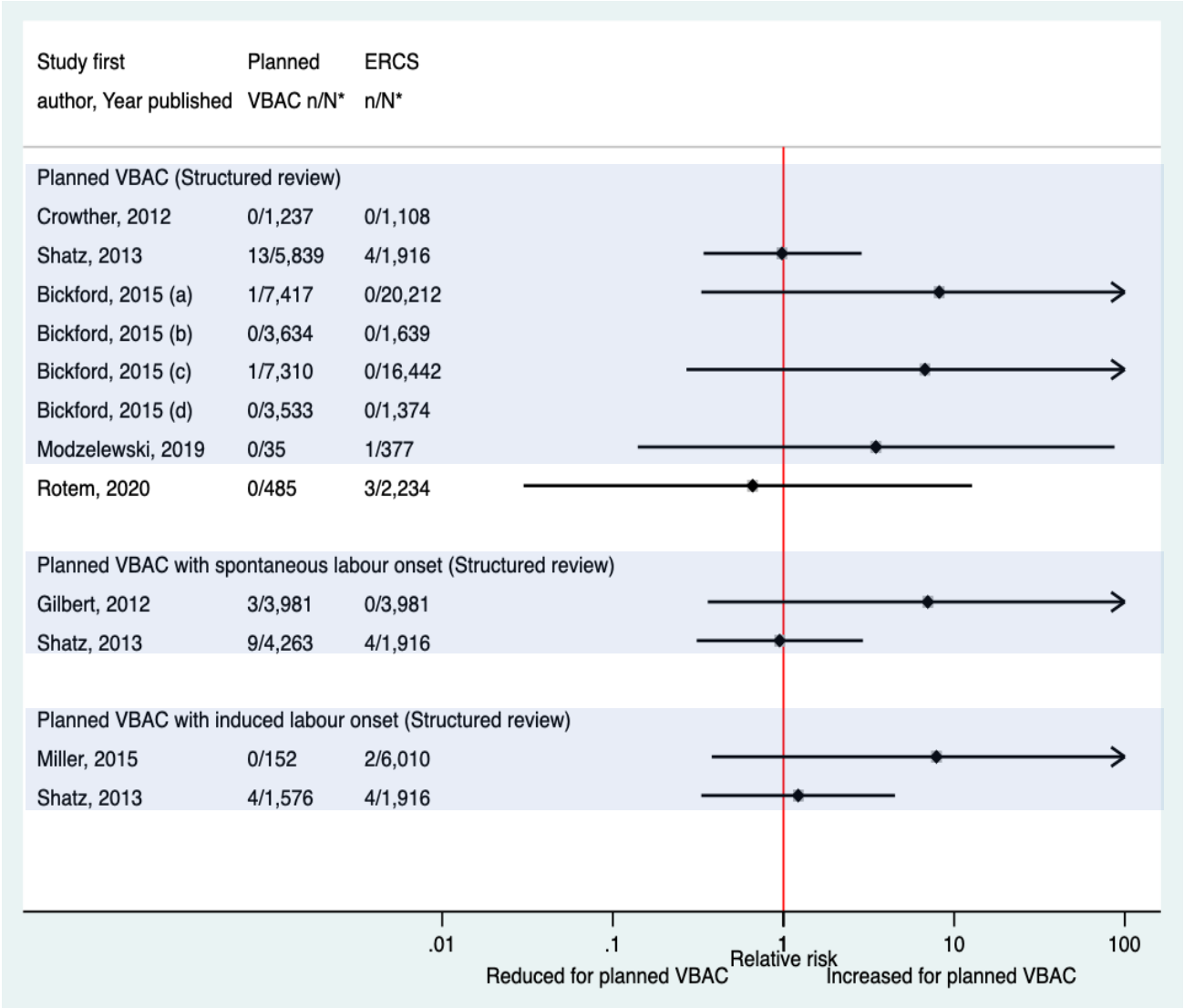


Figure 2.15. Risk of hypoxic–ischaemic encephalopathy/asphyxia for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group
Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB
Literature at the start of this thesis is highlighted in blue

Abbreviations: CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

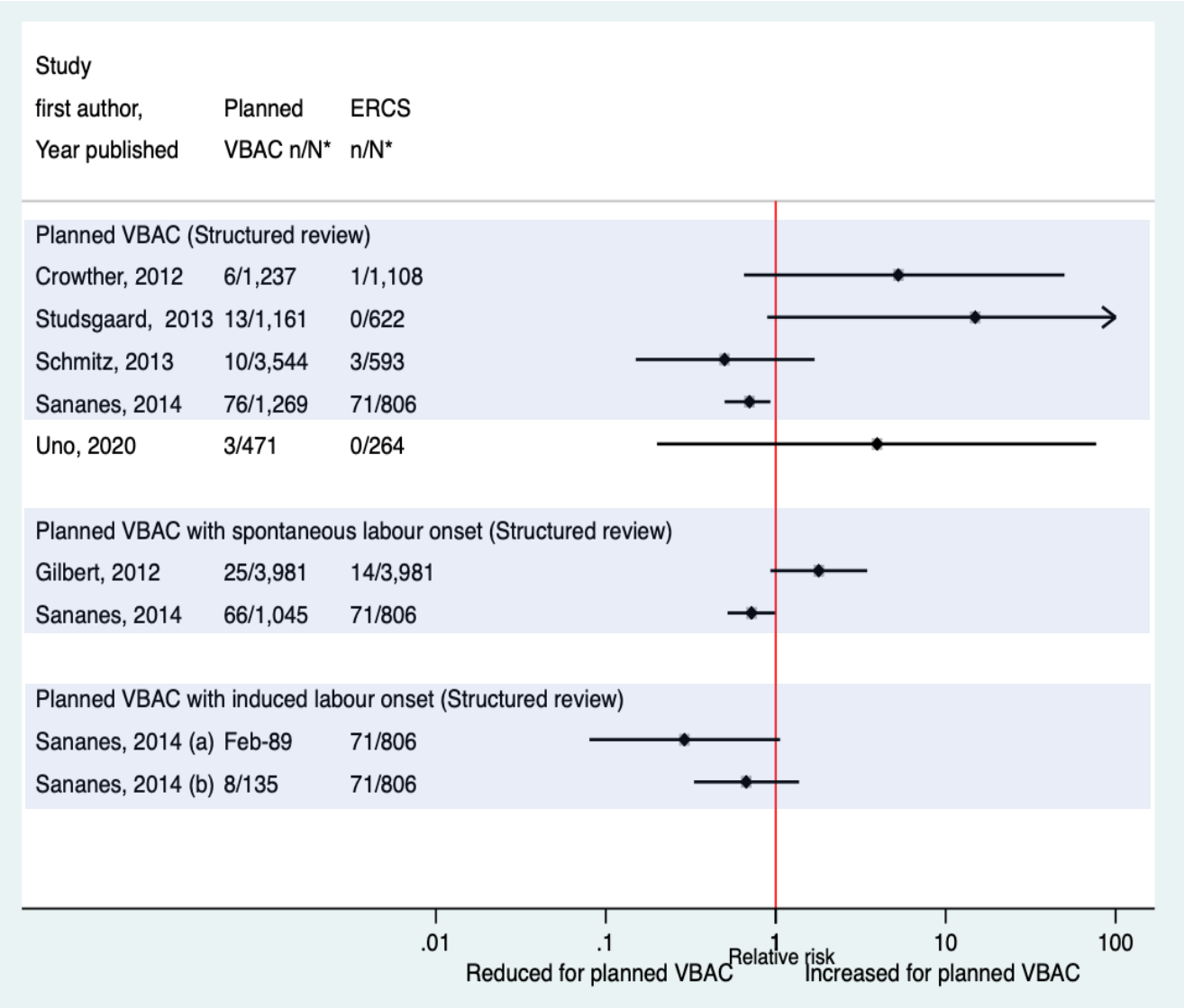


Figure 2.16. Risk of cord pH <7 for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Sananès, 2014 (a) - planned VBAC with induction of labour with oxytocin and amniotomy, (b) – planned VBAC with induction of labour with foley catheter

Literature at the start of this thesis is highlighted in blue

Abbreviations: ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean

2.2.4.4 Neonatal sepsis/infection

The AHRQ review[67] identified three studies that investigated sepsis in infants born at term (**Table B.12** in **Appendix B**), reporting that only one of the studies evaluated 'proven' sepsis (positive blood culture), finding no significant difference between infants born following VBAC and those born by caesarean after a failed attempt at a planned VBAC. All the studies identified by the AHRQ review were conducted in the United States and none were population-based. Overall, there was thought to be insufficient data to evaluate the true risk of sepsis in relation to mode of birth after previous caesarean, with the strength of evidence regarded as

low because studies were inconsistent and imprecise in how they defined sepsis and due to a limited number of studies.

At the start of this thesis three studies[96,98,121] (one population-based, none conducted in the UK) were identified as reporting on neonatal sepsis/infection since the AHRQ review (**Table B.12** in **Appendix B**). All restricted their study population to infants born at term. Absolute risks of neonatal sepsis/infection ranged from 0.24%-5.30% for planned VBAC and 0.09%-3.11% for ERCS amongst the three studies. One of the studies[96] grouped suspected and confirmed sepsis (without defining it), finding an increased risk of this outcome for planned VBAC compared to ERCS (aOR 1.72, 95% CI 1.39-2.17). The other two studies considered 'proven' systemic infection[98] and neonatal infection[121] (neither defined) respectively, with both reporting no significant difference between planned VBAC and ERCS. At the end of this thesis one further study[129] (a small single-centre study conducted in Poland) was identified as reporting on neonatal sepsis/infection (**Table B.12** in **Appendix B**). A summary of the findings of all four identified studies is presented in **Table 2.3**.

2.2.4.5 Birth trauma

The AHRQ review[67] reported that the two studies it identified on birth trauma (injury to a baby during labour or birth such as cuts or fractures), both of which were conducted in the United Sates, suggested that this outcome may be increased for planned VBAC compared to ERCS at term. However, the review authors considered there to be insufficient data to assess the true relationship, with few studies giving an overall low strength of evidence in this area.

Of the seven studies[98,104,106,109,114,117,121] (four population-based, none conducted in the UK) identified at the start of this thesis that investigated birth trauma since the AHRQ review (**Table B.13** in **Appendix B**), only one[117] did not restrict their study population to term born infants or attempt to take account of gestational age. The definition of birth trauma used by the seven studies varied and absolute risks ranged from 0.00%-0.51% for planned VBAC and 0.00%-

0.18% for ERCS. While the four largest studies[104,109,114,121] reported an increased risk of birth trauma for planned VBAC compared to ERCS (relative effect ranging from 3.12-12.5), the remaining rather small studies reported no significant difference[98,117] or no cases at all of birth trauma[106] (**Figure 2.17**). However, one of the studies found that the risk was only significantly elevated among women without a prior vaginal birth[109]. No other studies were identified as reporting on birth trauma in relation to planned VBAC and ERCS by the end of this thesis.

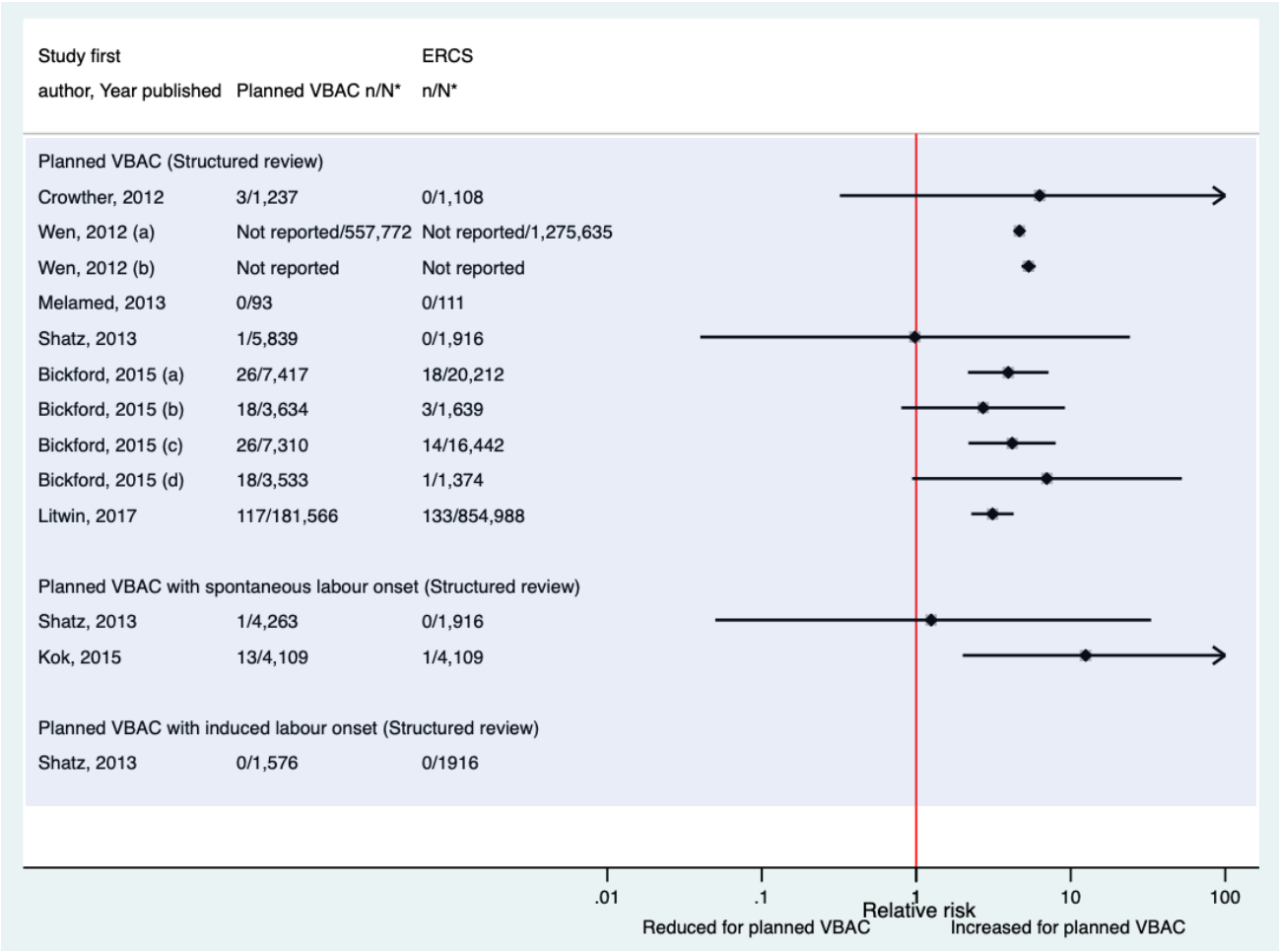


Figure 2.17. Risk of birth trauma for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Wen, 2012 (a) – Risk in total study population, (b) – Risk in infants born to "low-risk" women without pre-existing medical problems, pregnancy complications, preterm birth or an infant with low birth weight or congenital anomaly; Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB

Literature at the start of this thesis is highlighted in blue

Abbreviations: CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

2.2.4.6 Admission to NICU

A baby may need to be admitted to a specialist neonatal unit for extra care after they are born. Babies can be admitted to a neonatal intensive care unit (NICU) for several reasons, such as when they have an infection or a difficult birth. Most of the eight studies identified by the AHRQ review[67] reported no significant difference between planned VBAC and ERCS in the proportion of term infants admitted to the NICU. However, there was considered to be insufficient data to assess the true relationship, with the strength of evidence regarded as low due to variable and imprecise measures. For example, none of the studies defined the NICU admission criteria which, amongst other factors, can determine the significance of NICU admission. The review stated that improvements could be made in this area if future studies described the NICU admission criteria, the reason for admission, and the care provided following admission. Also of note, all the studies identified by the AHRQ review were conducted in North America and none were population-based.

Of the ten studies[69,95,98,106,107,109,113,114,119,120] (three population-based, none conducted in the UK) identified at the start of this thesis that examined NICU admission since the AHRQ review (**Table B.14** in **Appendix B**), three[95,113,119] did not confine their study population to term born infants and made no attempt to control for gestational age. None of the studies described the NICU admission criteria, the reason for admission was only reported in one study[109], and only one study[98] gave any information regarding the length of stay. Absolute risks of NICU admission varied from 0.00%-18.7% for planned VBAC and 0.00%-13.6% for ERCS and studies reported mixed results when risks were compared for planned VBAC and ERCS. While one study found a reduced risk[69] (unadjusted odds ratio (uOR) 0.89, 95% CI 0.83-0.97), three studies[109,114,120] reported an elevated risk of NICU admission for planned VBAC compared to ERCS (relative effect ranging from 1.12-1.9), although in one of these studies[109] the increased risk was confined to infants born to women who had not had a prior vaginal birth. The other six predominately smaller studies reported no significant difference between planned VBAC and ERCS[95,98,106,107,113,119] (**Figure 2.18**).

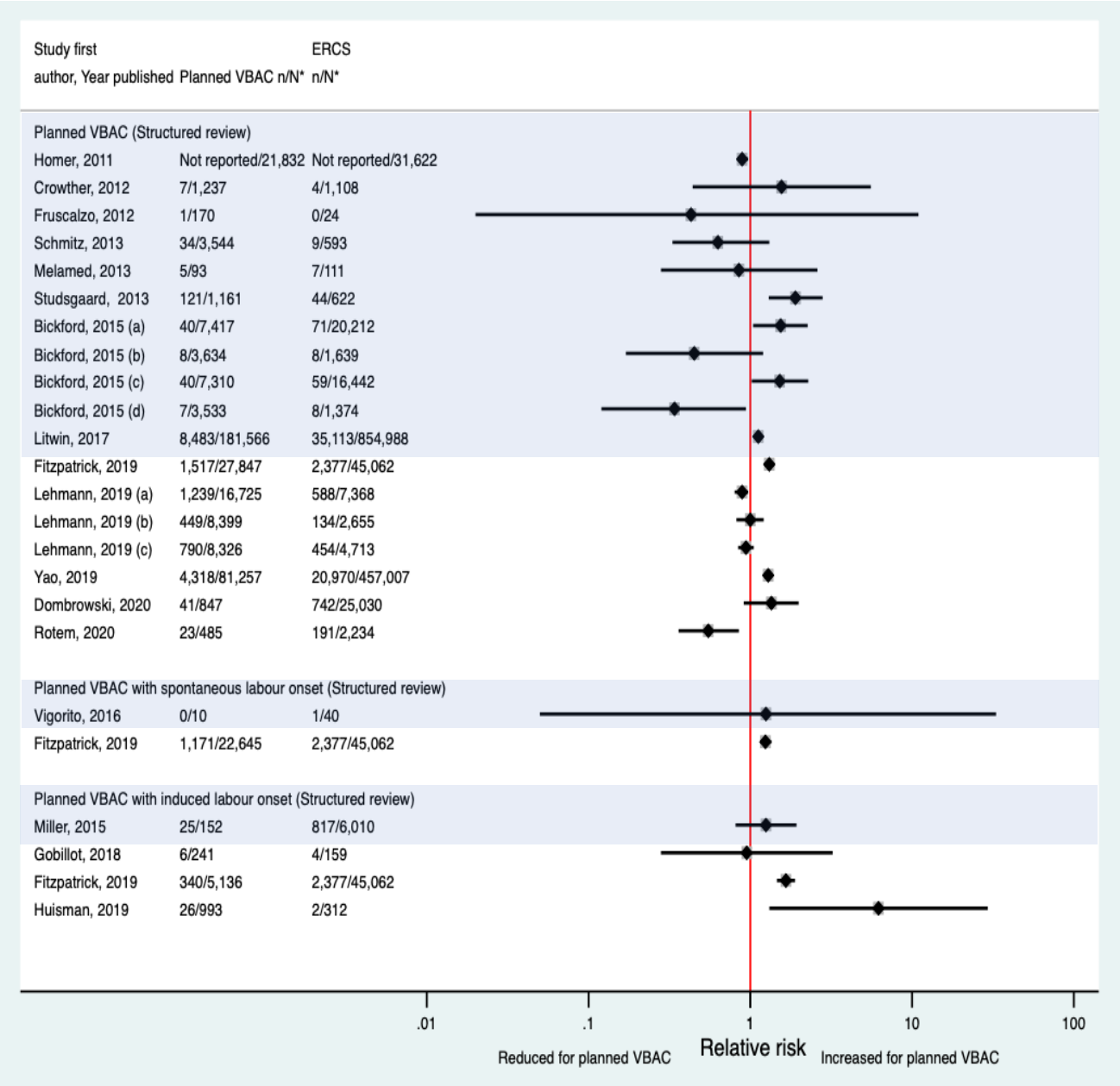


Figure 2.18 Risk of NICU admission for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB; Lehmann, 2019 (a) – Risk in all of study population, (b) – Risk in "low-risk" women, (c) – Risk in "high-risk" women

Literature at the start of this thesis is highlighted in blue

Abbreviations: CS, caesarean section; ERCS, elective repeat caesarean section; NICU, neonatal intensive care unit; VBAC, vaginal birth after previous caesarean; VB, vaginal birth

At the end of this thesis a further seven studies[1,124,127,128,131-133] (four population-based, six restricted to infants who were born at term) were identified including one study carried out as part of this thesis[1] (described in Chapter 4) as reporting on NICU admission in relation to planned VBAC and ERCS (**Table B.14** in **Appendix B**; **Figure 2.18**). A summary of the findings of all 17 identified studies is presented in **Table 2.3**.

2.2.4.7 Apgar score

The Apgar score is a way of quickly assessing the health of a baby shortly after birth. It can help medical staff to decide if a baby needs extra care. A score of ≥7 out of 10 at 5 minutes after birth is considered normal. A score of <7 at 5 minutes after birth is considered as low, particularly if it is <4, and may indicate that a baby needs extra care. The AHRQ review[67] identified four cohort studies that investigated Apgar score in infants born at term to women who underwent planned VBAC compared to ERCS. Three of these studies reported on the proportion of infants who had a 5-minute Apgar score of <7, with all finding no significant difference between the infants in the planned VBAC compared to the ERCS group. The other study, the only population-based and UK-based study, reported on the proportion of infants with a 5-minute Apgar score of <4, finding this to be significantly higher in the planned VBAC compared to the ERCS group (**Table B.15** in **Appendix B**).

At the start of this thesis 11 studies[95,98,104-107,109,114,117,120,121] (five population-based, none conducted in the UK) were identified since the AHRQ review as reporting on Apgar score in relation to infants born by planned VBAC versus ERCS (**Table B.15** in **Appendix B**). Two of these studies[95,107] did not restrict their study population to term born infants or attempt to take account of gestational age. Of the nine studies that reported on the proportion of infants with a 5-minute Apgar score of <7, absolute risks of this outcome ranged from 0.00%-3.17% for planned VBAC and 0.00%-3.00% for ERCS, with four of the studies[104,105,114,121] finding an elevated risk associated with planned VBAC compared to ERCS (relative effect ranging from 1.46-5.4). However, for one of the studies[105] the increased risk was only apparent for the overall study population and for infants born to women who had certain indications for their first caesarean, with the risk reported to vary greatly according to indication for the first caesarean. The remaining predominately smaller studies reported no significant difference[95,98,117,120] or reported that there were no infants in their study with an Apgar score of <7 at 5 minutes[106] (**Figure 2.19**). Of the four studies[98,107,109,114] that reported on the proportion of infants with a 5-minute Apgar score of <4, absolute risks of this outcome ranged

from 0.03%-0.37% for planned VBAC and 0.00%-0.14% for ERCS with only the two largest studies[109,114] findings a significantly higher risk for planned VBAC compared to ERCS (**Figure 2.20**). However, one of these studies[109] reported that the risk was only significantly elevated among women without a prior vaginal birth.

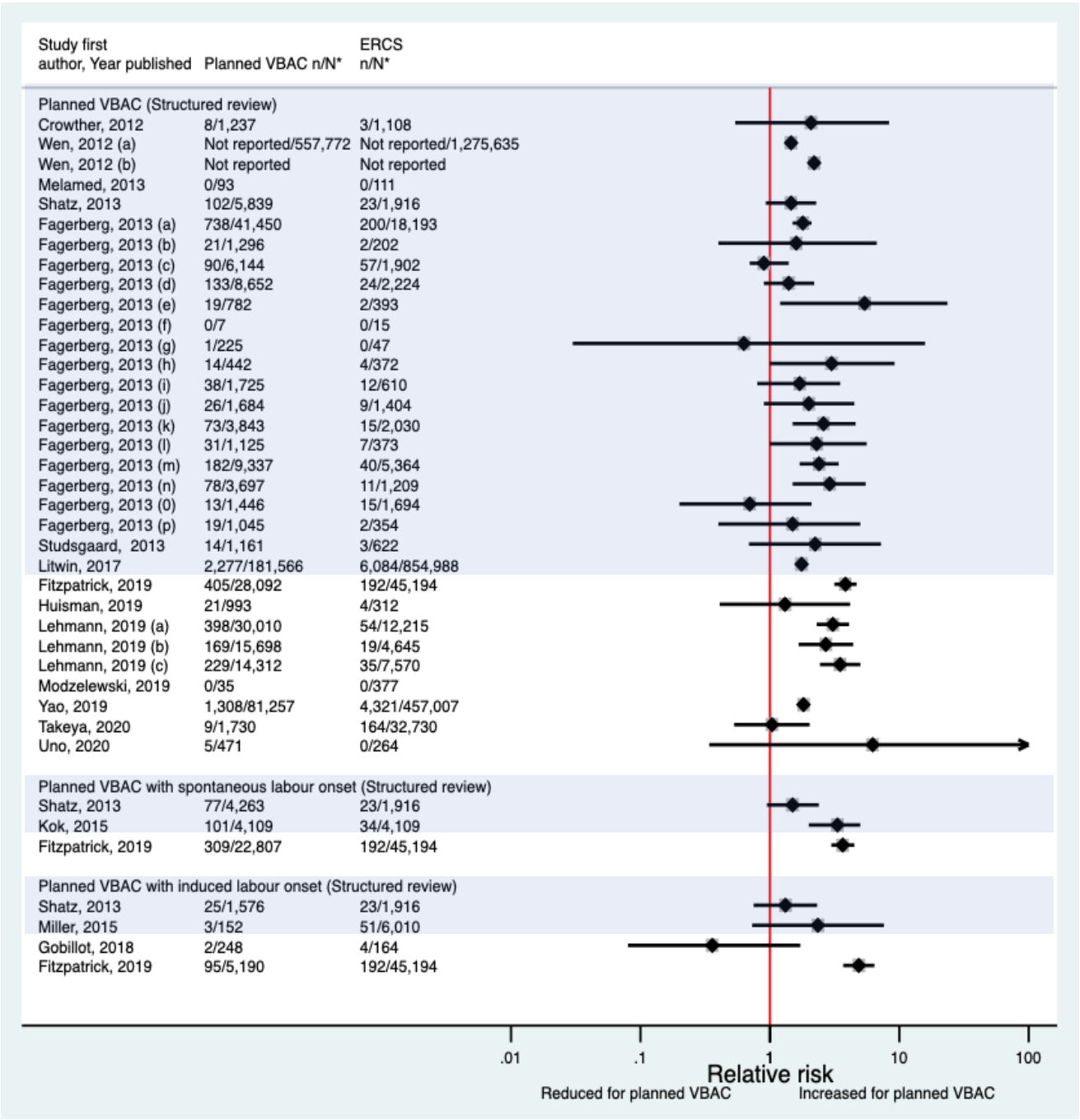


Figure 2.19. Risk of Apgar score <7 at 5 minutes after birth for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Wen, 2012 (a) – Risk in total study population, (b) – Risk in infants born to "low-risk" women without pre-existing medical problems, pregnancy complications, preterm birth or an infant with low birth weight or congenital anomaly; Fagerberg, 2013 (a) – Risk in all women with one prior CS, (b) – Risk in women whose indication for first CS multiple gestation, (c) – Risk in women whose indication for first CS preterm birth, (d) – Risk in women whose indication for first CS breech or other malpresentation ≥37 weeks' gestation, (e) – Risk in women whose indication for first CS significant congenital malformation, (f) – Risk in women whose indication for first CS rupture of uterus, (g) – Risk in women whose indication for first CS placenta praevia, (h) – Risk in women whose indication for first CS diabetes mellitus/gestational diabetes, (i) – Risk in women whose indication for first CS small for gestational age/suspected intrauterine growth restriction, (j) – Risk in women whose indication for first CS large for gestational age/suspected large for gestational age/birth weight>4500g, (k) – Risk in women whose indication for first CS prolonged pregnancy ≥42 weeks' gestation, (l) – Risk in women whose indication for first CS severe pregnancy complications/severe maternal disease, (m) – Risk in women whose indication for first CS complications during labour/birth, (n) – Risk in women whose indication for first CS fetal distress/death unexplained by indications above, (o) – Risk in women whose indication for first CS no indication listed above/mild conditions not classified elsewhere, (p) – Risk in women who had no diagnosis available for indication for first CS; Lehmann, 2019 (a) – Risk in all of study population, (b) – Risk in "low-risk" women, (c) – Risk in "high-risk" women

Literature at the start of this thesis is highlighted in blue

Abbreviations: CS, caesarean section; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean

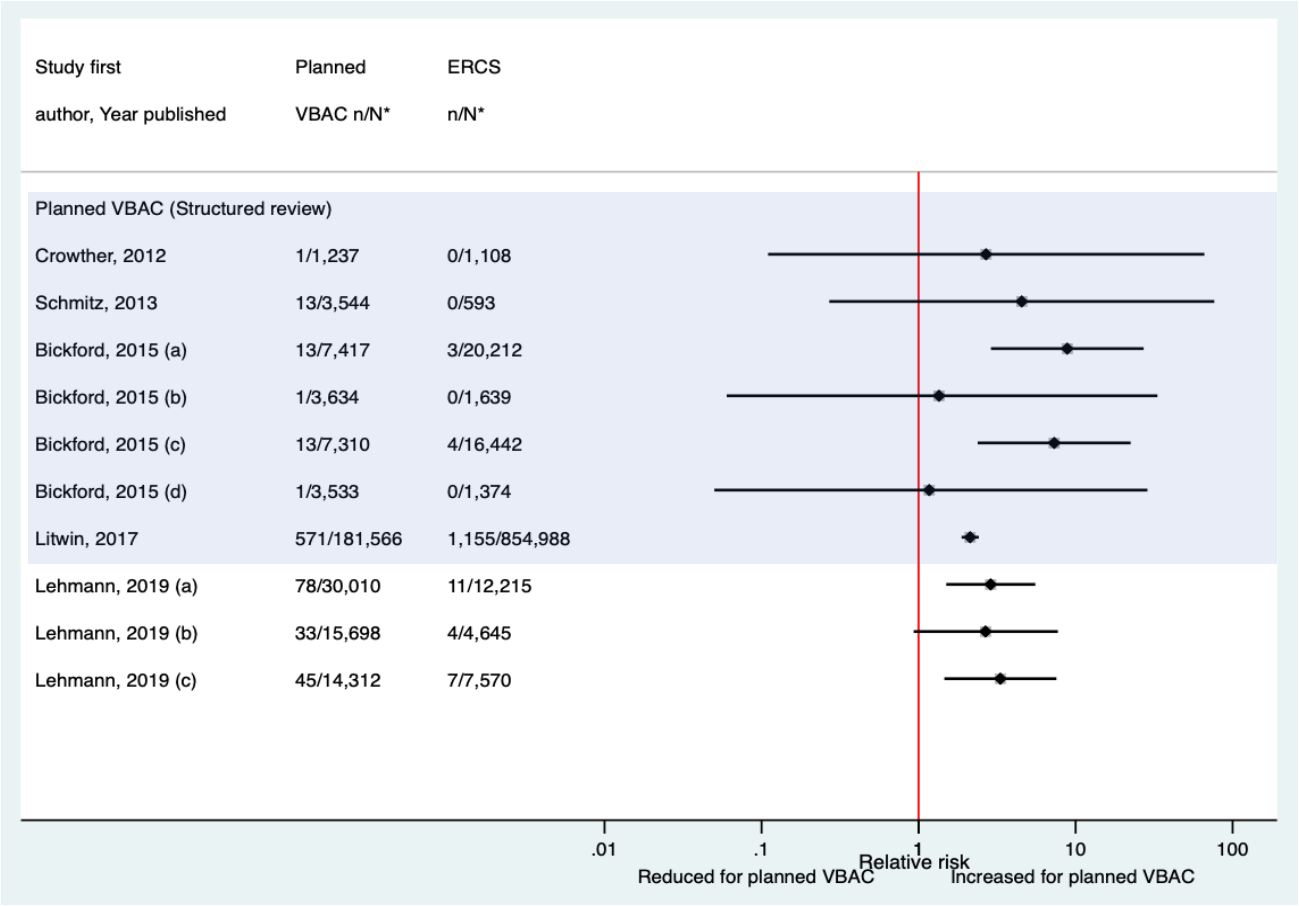


Figure 2.20. Risk of Apgar score <4 at 5 minutes after birth for planned VBAC vs. ERCS

* n=number in group with the outcome, N=Total number in group

Bickford, 2015 (a) – Risk in women with 1-2 prior CSs only, (b) – Risk in women with 1-2 prior CSs & ≥ 1 prior VB, (c) – Risk in women with 1 prior CS only, (d) – Risk in women with 1 prior CS & ≥ 1 prior VB; Lehmann, 2019 (a) – Risk in all of study population, (b) – Risk in "low-risk" women, (c) – Risk in "high-risk" women

Literature at the start of this thesis is highlighted in blue

Abbreviations: caesarean section, CS; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean; VB, vaginal birth.

At the end of this thesis a further eight studies[1,124,127-129,131,134,135] (four population-based, seven restricted to infants who were born at term) were identified including one study carried out as part of this thesis[1] (described in Chapter 4) as reporting on Apgar score at 5 minutes in relation to planned VBAC and ERCS (**Table B.15** in **Appendix B**; **Figure 2.19** & **2.20**). A summary of the findings of all 19 identified studies is presented in **Table 2.3**.

2.2.4.8 Neurodevelopment

The AHRQ review[67] found no studies that assessed the effect of planned VBAC compared to ERCS on the child's neurological development. At the start of this thesis a single population-based study conducted in Scotland[111] was the only study identified since the AHRQ review

that investigated this. This study reported that there was no significant difference in the risk of learning disability or cerebral palsy among singleton school-aged children born at term following a planned VBAC compared to an ERCS, although this study did find an increased risk of learning disability associated with repeat caesarean section after an unsuccessful VBAC compared to successful VBAC (3.7% vs. 2.3%, aOR 1.64, 95% CI 1.17-2.29). However, the analysis of these outcomes was limited to children born in just two health boards (n=8,218) due to poor coverage and lack of consistent use across Scotland of the system used to ascertain the relevant outcomes. As acknowledged by the authors, this limited the power of this study to detect clinically important effects in this area. At the time of updating this literature review in February 2021, a study carried out as part of this thesis (described in Chapter 6) that investigated the effect of planned VBAC compared to ERCS on the child's risk of having special educational needs (SENs, a marker of adverse neurodevelopmental outcome) was under review (published in July 2021[3]) and no other relevant studies were found.

2.2.4.9 Health problems in childhood

The AHRQ review[67] did not include childhood health problems and so the current structured review searched the literature for relevant studies that included this outcome as far back as 1980. This identified just one study, a population-based study of second-born singleton children born at term conducted in Scotland[111]. This study found no significant difference in the risk of various adverse childhood health outcomes between planned VBAC and ERCS, including obesity at age 5 years, salbutamol inhaler prescription (proxy for asthma) at age 5 years or type 1 diabetes mellitus, cancer, hospitalisation with asthma or hospitalisation with inflammatory bowel disease, where follow-up time was up to 21 years. On the other hand, the risk of hospitalisation with asthma, but not the other health outcomes, was found to be significantly raised for children born by repeat caesarean section after an unsuccessful VBAC and for children born by ERCS when compared to those born by VBAC (adjusted hazard ratio (aHR) 1.18, 95% CI 1.05-1.33 and aHR 1.24, 95% CI 1.09-1.42 respectively). The power of the study was considered adequate to examine common outcomes such as obesity, although

a fifth of children were missing data on obesity, which as the authors acknowledged, may have biased these findings.

2.3 Discussion

This review suggests that whilst adverse outcomes are rare for either birth approach, when compared to ERCS, there is some evidence that planned VBAC is associated with a lower risk of maternal mortality, a shorter length of hospital stay, and a higher likelihood of breastfeeding, but also an increased risk of maternal complications such as uterine rupture, as well as a higher risk of perinatal/neonatal mortality and some types of neonatal morbidity. While this review provides valuable insight into the associated outcomes of planned VBAC and ERCS for women and their children, several limitations and gaps with the evidence were apparent.

Key limitations highlighted in the AHRQ systematic review[67] were still evident with much of the subsequent literature, including questionable comparability between the groups (including women in the ERCS group who were not eligible to attempt planned VBAC) and inferring intended mode of birth from actual mode of birth resulting in misclassification of women who intended ERCS but went into spontaneous labour before their caesarean or women who intended planned VBAC but gave birth by caesarean. Due to no or few studies, inadequate or variable outcome definition, inconsistency in results between studies or a lack of precision in estimates of effect, a particular lack of robust evidence was apparent, at least at the start of this thesis, for a whole range of outcomes. This included the following outcomes: maternal haemorrhage, maternal infection, breastfeeding initiation or continuation, maternal pelvic floor dysfunction/perineal trauma, women's mental health, neonatal respiratory intervention/morbidity, hypoxic–ischaemic encephalopathy/asphyxia, neonatal sepsis, admission to a neonatal intensive care unit, child's neurological development, and health problems in childhood. Evidence on the longer-term outcomes for women and their children was particularly sparse.

Much of the literature identified by the AHRQ systematic review[67] consisted of non-population-based cohort studies conducted in a single or small number of mainly tertiary or academic medical institutions. Such studies tend to suffer from several limitations such as limited generalisability and lack of statistical power. Although more population-based studies have been conducted since the AHRQ review much of the literature still consists of rather small studies that are likely to lack statistical power, particularly given the rarity of many of the outcomes considered. Although a large randomised controlled trial would arguably be the gold standard methodology for assessing the effects of planned VBAC compared to ERCS, most of the literature also still consists of non-randomised studies with only two small trials identified. One of these trials included around 300 women and only investigated the effects on women's psychological health[97], while only 22 women consented to randomisation of planned mode of birth in the other trial[98]. The latter study suggests that a large randomised controlled trial in this area is unlikely to be feasible as few women are likely to consent to participate. Consequently, high quality observational studies offer the best opportunity to further inform the evidence in this area. Unfortunately, in the existing observational studies risk estimates were often not adjusted, or only minimally adjusted, for confounding factors such that any observed effects may be due to differences between the planned VBAC and ERCS groups. Furthermore, studies seldom investigated what factors may modify any effects of mode of birth and before conducting the studies carried out as part of this thesis, none considered what factors may mediate any observed associations. Knowing whether there are certain subgroups (such as women without a prior vaginal birth) who have an increased or reduced risk of experiencing an adverse effect of mode of birth would be useful for the counselling of pregnant women with a prior caesarean. Additionally, knowing whether a potential association between mode of birth and longer-term child developmental outcomes is mediated through a factor amenable to intervention such as breastfeeding would potentially help inform the development and targeting of interventions.

Further limitations with the existing literature included the fact that most of the studies did not distinguish between whether planned VBAC was attempted with or without labour induction and/or augmentation. This distinction is important as labour induction/augmentation in women with previous caesarean has been associated with an increased risk of certain complications such as uterine rupture as well as a reduced likelihood of achieving a successful VBAC[141-145]. It has also been suggested that synthetic oxytocin used for labour induction and/or augmentation may reach the neonate's brain and desensitize oxytocin receptors, possibly leading to adverse neurodevelopmental effects[146]. Another limitation with the literature includes the fact that the recruitment period of many of the studies extended back to the 1980s or 1990s. Findings from such studies may not be relevant to current populations owing to advances in obstetric and neonatal care and changes in clinical practice and maternal characteristics[9,147,148] since this time. Some studies were also limited by the fact that they did not restrict their study population to singleton and/or term births and made no attempt to control for plurality and/or gestational age. Women with a singleton pregnancy at term who have a history of previous caesarean section are the main group of women UK guidelines[8,22] recommend are candidates for planned VBAC or ERCS and should be counselled about both options. Furthermore, the risk of adverse outcomes is likely to differ between singleton and multiple births[149,150], and between term and non-term births[151,152]. It is also worth noting that before conducting the studies carried out as part of this thesis very few studies had been conducted in the UK, with the UK-based studies that did exist focusing on just a limited range of outcomes. Studies conducted outside of the UK may have limited generalisability to the UK setting because of differences in population characteristics and clinical practice.

Although this review included a comprehensive range of outcomes, it is important to highlight that it did not consider all possible outcomes. Most significantly, it did not include complications in subsequent pregnancies. As mentioned in Chapter 1, caesareans have been linked to an increased risk of various complications in future pregnancies. The latest Royal College of Obstetricians and Gynaecologists (RCOG) guidelines[22] state that there is considerable data

in particular to show that repeated ERCS is associated with an increased risk of placenta praevia, morbidly adherent placenta, and surgical complications such as hysterectomy in subsequent pregnancies/births.

In summary, while this review provides valuable insight into the outcomes potentially associated with planned VBAC and ERCS for women and their children, several limitations and gaps with the evidence were apparent. This included a lack of comparability between the comparison groups, with it often being unclear whether women included in the ERCS group were clinically eligible to have a planned VBAC. Many studies also did not adequately consider or investigate the influence of covariates on the associations between planned mode of birth and the outcomes studied. Furthermore, although many studies have reported the risk of uterine rupture associated with planned VBAC and the risk of maternal morbidity such as placental abnormalities in subsequent pregnancies associated with ERCS, at least before conducting the studies carried out as part of this thesis, contemporary, adequately powered, population-based studies comparing a wider range of outcomes for women and their children of planned VBAC versus ERCS were limited. Evidence on the longer-term outcomes for women and their children was particularly sparse.

3

STUDY METHODS

3.1 Introduction and chapter overview

As described in the literature review (Chapter 2), although a large randomised controlled trial would arguably be the gold standard methodology for assessing the effects of planned mode of birth after previous caesarean section, a previous study[98] suggests that such a trial is unlikely to be feasible as few women are likely to consent to participate. Consequently, high quality observational studies offer the best opportunity to further inform evidence in this area. This chapter provides a general description of the methods used to conduct three population-based cohort studies, with subsequent chapters providing methodological detail specific to each study. The objective of the first study was to investigate the short-term maternal and perinatal outcomes associated with planned mode of birth after previous caesarean section among women giving birth to a singleton at term and considered clinically eligible to plan a VBAC (research objective 2). The objective of the second study was to investigate the association between planned mode of birth after previous caesarean section and women's use of psychotropic medication in the first year postpartum as an indication of their subsequent risk of having mental health problems sufficiently severe as to require medication, among women giving birth to a singleton at term and considered clinically eligible to plan a VBAC (research objective 3). The objective of the third study was to investigate the association between planned mode of birth after previous caesarean section and the child's risk of having a record of special educational needs (SENs) as a marker of adverse neurodevelopmental outcome(s), among women giving birth to a singleton at term and considered clinically eligible to plan a VBAC (research objective 4).

3.2 Methods

3.2.1 Study design and data sources

The three population-based cohort studies were conducted by linking a number of Scottish national datasets detailed in **Table 3.1**. In brief, these included: the National Records of Scotland (NRS) live births and stillbirths data compiled from birth registrations; the Scottish Morbidity Record Maternity Inpatient and Day Case (SMR02) and General/Acute Inpatient and Day Case (SMR01) datasets of all hospital inpatient and day case discharges from obstetric and acute specialities, respectively, in the National Health Services (NHS) Scotland; NRS deaths dataset compiled from death registrations; Scottish Stillbirth and Infant Death Survey (SSBID) data; Child Health Surveillance Programme Pre-school System (CHSP-PS) data on child health reviews carried out on pre-school children in Scotland; Prescribing Information System (PIS) data on medicines that are prescribed and dispensed in the community in Scotland; Pupil Census data on children attending publicly funded schools in Scotland; and the Community Health Index (CHI) dataset, a register of all individuals in NHS Scotland. These datasets constitute routinely-collected data, that is data collected for administrative and clinical purposes without specific *a priori* research questions in mind[153].

Table 3.1. Data sources

Data source	Description of data source	Completeness & quality of data source	Study one - short-term maternal & perinatal outcomes	Study two - women's use of psychotropic medication	Study three - Special educational needs in childhood
			Time period of data source used for analysis		
National Records of Scotland (NRS) live births & stillbirths	Mainly socio-demographic information about all live births & stillbirths occurring in Scotland complied from birth registrations, with registration within 21 days of birth mandated by law. Available for linkage from 1981	Compiled from birth registrations, with registration mandated by law & subject to various quality checks[154], considered to give most accurate measure of number of live & stillbirths in Scotland with data quality regarded as high[155]	2002-2015	2010-2015	2002-2011
Scottish Morbidity Record Maternity Inpatient & Day Case dataset (SMR02)	Data on all inpatient & day case discharges from obstetric specialities in National Health Service (NHS) Scotland, including information on maternal & infant characteristics, clinical management & obstetric complications. Available for linkage from 1981	Although not mandatory, SMR02 has had a national coverage of around 98% of all births in NRS since the late 1970s, with some of the shortfall due to data about home births & at non-NHS hospitals not being available from SMR02[155]. Data subject to regular quality assurance checks. Latest quality assurance assessment found that 15 of the 21 hard-coded variables assessed, (including mode of birth, induction of labour, estimated gestation, birth weight, diabetes, neonatal indicator, first feed given, feed on discharge, mother's height, weight at booking & smoking status at booking) matched the information found in the medical records in 90% or more of the records sampled. Four variables were found to be between 80-89% accurate (including presentation at birth) with only two variables (ethnic group & transfer of responsibility midwife to consultant) recorded with less than 80% accuracy[156]	1981-2016 (deliveries in study period 2002-2015 to eligible women & all their previous pregnancy records going back to 1981 & any subsequent postnatal records up until 2016)	1981-2016 (deliveries in study period 2010-2015 to eligible women & all their previous pregnancy records going back to 1981 & any subsequent postnatal records up until 2016)	1981-2011 (deliveries in study period 2002-2011 to eligible women & all their previous pregnancy records going back to 1981 & any subsequent postnatal records up until 2012)
Scottish Morbidity Record General/ Acute Inpatient & Day case dataset (SMR01)	Demographic & clinical data on all hospital inpatient & day case discharges from acute specialties (non-obstetric & non-psychiatric) in NHS Scotland. Available for linkage from 1981	Estimated completeness 99%. Data subject to regular quality assurance checks. Latest quality assurance assessment found that the main condition & main operation/procedure were 89% & 94% accurate respectively[157]	2002-2016	2010-2016	2002-2012
NRS deaths	Data on all deaths occurring in Scotland from 1981 compiled from death registrations, with registrations within 8 days of death mandated by law	Compiled from death registrations, with registration mandated by law & subject to various quality checks[154], considered to be complete & of high quality	2002-2016	2010-2016	2002-2016

Table continued overleaf

Table 3.1 (continued). Data sources

Data source	Description of data source	Completeness & quality of data source	Study one - short-term maternal & perinatal outcomes	Study two - women's use of psychotropic medication	Study three - child's risk of special educational need
			Time period of data source used for analysis		
Scottish Stillbirth & Infant Death Survey (SSBID)	Additional data on all stillbirths & infant deaths from 1985-2012 that were registered with NRS (previously called General Register Office for Scotland)	100% complete compared to NRS deaths[158]. Cause of stillbirth or neonatal death classified using clinical information from local coordinators & pathologists with accuracy of classification dependent on amount of information available. Classification performed by single medically qualified individual, ensuring consistency in classification[158]	2002-2010	-	-
Child Health Surveillance Programme Pre-School System (CHSP-PS)	Data on child health reviews carried out on pre-school children in Scotland	CHSP-PS introduced in 1991, although NHS boards implemented system in phased roll out increasing coverage over time. 10 of the 14 Boards participating in 2001/2002 & all Boards participating by 2010/11. This is reflected in the estimates of data completeness, with around 80% of all live births in NRS in 2001/2002 thought to have had their second (~6-8 weeks of age) review, increasing to around 92% in 2015/2016[159]. Quality of information recorded on infant feeding reported as high[159]	2002-2016	2010-2016	2002-2012
Prescribing Information System (PIS)	Data on all medicines that are prescribed & dispensed in the community in Scotland. Also includes prescriptions written in hospitals that are dispensed in the community. Available for linkage from 2009	Contains 100% of NHS Scotland prescriptions dispensed within community & claimed for payment by a pharmacy contractor. Does not contain data on prescriptions dispensed but not claimed (thought to be very unlikely) or prescriptions prescribed but not submitted for dispensing by a patient (estimated to be ~6% of all prescriptions issued to patients)[160]. Routine monthly quality checks performed on random sample of 5% of prescription payments demonstrating consistent accuracy of at least 98%[160]	-	2009-2016	-
Pupil census	Annual census conducted near the start (September) of every school year of all children who are attending publicly funded schools in Scotland, including local authority maintained or grant-aided primary, secondary & special schools. Available for linkage from 2007	Contains data on all children attending publicly funded schools in Scotland (~96% of all pupils in Scotland)[161]. Data subject to various quality assurance checks & is generally considered to be of high quality[162]	-	-	2007-2016
Community Health Index (CHI) database	Register of all individuals in NHS Scotland		-	2009-2016	-

All data linkages were undertaken by a third party under contract to the Information Services Division (ISD) Scotland, now part of Public Health Scotland. In the case of the health data, linkages were carried out using exact matching of the mother or child's CHI number, a unique ten-digit person identifier used in Scotland and present in all the health datasets. Such deterministic linkage produces few false matches (where records belonging to different individuals are linked), as different individuals are unlikely to have the same identifier. As the education sector uses a different unique identifier to the health sector, linkage of the education (pupil census) to the health data was instead performed using probabilistic matching techniques. This involved using a number of common person identifiers (date of birth, sex, home postcode) to derive the likelihood of records belonging to the same individual, a method which has previously been shown to be 99% accurate for singleton births[163]. The linked data with the personal identifiers removed and study specific unique identifiers added was made available to the author of this thesis by remote access to the National Services Scotland (NSS) National Safe Haven. The NSS National Safe Haven is a secure environment in which data can be accessed and analysed by researchers. Any outputs from the safe haven are checked by research co-ordinators at ISD Scotland to ensure they comply with NSS disclosure control guidance and policies before being released to researchers.

3.2.2 Data cleaning, checking and preparation

The coverage, completeness, and quality of most routinely-collected Scottish data is considered to be very high, with some of the data sources containing statutorily collected data and many of the data sources undergoing regular quality assurance checks as outlined in **Table 3.1**. However, prior to analysis extensive data cleaning, checking and preparation was undertaken on the data received. The data providers made the data available as 21 separate CSV files which were imported into StataMP version 14 or 16. Variables in all the datasets were initially checked to see if they contained values consistent with the available data dictionaries provided by the data providers. Any missing or invalid data were recoded to

missing in Stata, string variables were converted into numeric variables where appropriate, and date variables were changed into a consistent format. Each of the datasets were checked for duplicate records and de-duplicated where required. The data were reshaped to long (e.g. one record per hospital admission) or wide (e.g. one record per mother or baby) format as required. The different datasets were merged using the study-specific unique identifiers added by the data providers. Variables were created to identify the study population, exposures, outcomes, and covariates for each of the studies as detailed in subsequent sections of this chapter or the methods sections of the next three chapters. This required careful consideration of the most appropriate way to identify data items of interest from the information available, with all relevant hard coded fields often considered together with diagnosis and/or procedure codes to try to minimise misclassification. In the SMR01 and the SMR02 datasets diagnoses are recorded using the International Classification of Diseases 9th (ICD-9) or 10th revision (ICD-10). Procedures performed during an episode of day case or inpatient care are coded using the Office of Population Censuses and Survey Classification of Surgical Operations and Procedures 3rd (OPCS-3) or 4th revision (OPCS-4). Further details about the data cleaning, checking and preparation undertaken are provided below with the key steps taken to clean, check and prepare the SMR02 data summarised in **Figure 3.1**.

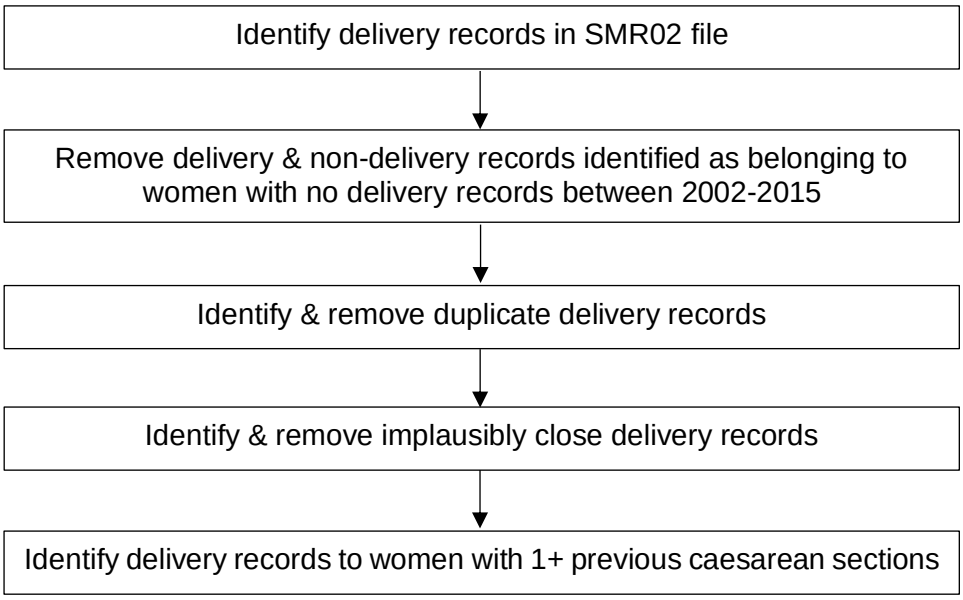


Figure 3.1. Key steps taken to clean, check and prepare SMR02 data

3.2.2.1 Identifying delivery records in SMR02

An SMR02 record is generated each time a woman is discharged from an episode of day case or inpatient care in any of the obstetric specialities in NHS Scotland, including both delivery and non-delivery admissions. On the advice of ISD Scotland delivery episodes in SMR02 were initially identified as records which had a date of delivery present or a code for "delivered" in the condition on discharge field or a code of '0' in the condition on discharge field in addition to a valid baby birth weight, with all other records marked as non-delivery episodes. While a code of '0' in the condition on discharge field is not a valid code, according to ISD Scotland 99% of records with this code relate to women who died in childbirth. Records identified as non-delivery episodes were then checked to see if they contained valid data suggesting a delivery had occurred (valid mode of birth present or valid data relating to a baby present). The small number of non-delivery episodes (n=14 records) containing data suggesting a delivery had occurred were checked against the woman's other records in SMR02 and against the woman's NRS live and stillbirth records. Either no corresponding NRS record was found or an NRS record with a child date of birth within 31 days of the record was found but the woman already had a delivery record in SMR02 that better matched the date of birth of the particular NRS record. All non-delivery records were therefore kept as non-delivery records.

Delivery episodes in SMR02 were also checked to see if they contained valid data suggesting a delivery had occurred and all did. Delivery episodes in SMR02 which did not have a code for "delivered" in the condition on discharge field (n=42 records) were then checked against the woman's other records in SMR02 and against the woman's NRS live and stillbirth records. Where no corresponding NRS record was found or an NRS record with a child date of birth within 31 days of the record was found but the woman already had a delivery record in SMR02 that better matched the date of birth of the particular NRS record, the record was recoded as a non-delivery episode relating to the particular condition on discharge field value (n=13 records). Delivery episodes were additionally checked to see if they had codes suggesting a miscarriage (spontaneous abortion) or a termination of pregnancy in either the type of abortion

field or management of abortion field, had an ICD-9 or ICD-10 code for miscarriage or termination of pregnancy (630-639, O00-O08) or had a gestational age at birth suggestive of a miscarriage or termination of pregnancy (<24 weeks of gestation). The small number of delivery records (n=17 records) containing data suggesting a miscarriage or termination of pregnancy had occurred were checked against the woman's NRS live and stillbirth records. If an NRS record with a child date of birth within 31 days of the record was not found, then the record was recoded as a non-delivery episode relating to a miscarriage or termination of pregnancy (n=6 records). Having performed the above steps, all SMR02 records (delivery and non-delivery) identified as belonging to women with no delivery records in any of the study periods (2002-2015) were discarded.

3.2.2.2 Duplicate delivery records in SMR02

Apparent duplicate delivery records in SMR02 were identified as delivery episodes that had the same motherID and the same date of delivery and were not identified as records relating to multiples (i.e. twins, triplets, or higher order multiples). If the records were identified as relating to multiples, the data was reformatted into one delivery record per multiple birth rather than per child of a multiple birth. Around 0.3% (n=633) of the remaining delivery episodes in the SMR02 file appeared to be duplicates. The number of apparent duplicate delivery records ranged from 1 (i.e. 2 records with same motherID and same date of delivery) to 3 (i.e. 4 records with same motherID and same date of delivery), with 1 being the most common.

Apparent duplicate delivery records were compared on the following key fields: previous caesarean sections, parity, mode of birth, baby birth weight, baby gender, number of births in pregnancy, and gestational age at birth. If the apparent duplicate records did not differ in value on any of these key fields (either exactly match, both missing or missing in one record and not the other), the records were considered to be duplicates and the record with the least missing data was kept and the other(s) discarded having first copied over any missing data to the more complete record. This was the case for around 73% of the apparent duplicate records. If the

apparent duplicate records differed in value on one or more of these key fields, the records were cross-checked against the woman's NRS live birth and stillbirth records and the most complete record that best matched the NRS information was kept, and the other record(s) discarded. If the records equally matched the NRS information, the records were compared against the woman's other records in SMR02 and the most complete record that was most consistent in terms of parity, previous caesarean section and mode of birth value to the woman's other records in SMRO2 was kept, and the other record(s) discarded. If the records equally matched the woman's other records in SMR02 or the woman did not have any other records in SMR02 to compare against, the most complete record was kept and the other record(s) discarded.

3.2.2.3 Implausibly close delivery records in SMR02

Having first removed duplicate delivery records and reformatted records relating to multiples as one delivery record per multiple birth rather than per child of a multiple birth, implausibly close delivery records in SMR02 were identified as delivery records which had the same motherID and the interval between the delivery dates was <169 days (<24 weeks). Such records were cross checked against the woman's NRS live and stillbirth records and the record that best matched a child date of birth in the woman's NRS records was retained and the other record discarded. In the very small number of cases where the records both equally matched to a child date of birth in the woman's NRS records, the record that was most consistent in terms of parity, previous caesarean section, mode of birth, and height value to the woman's other records in SMR02 was kept and the other record discarded. Instances where the inter-pregnancy interval (interval between the delivery dates minus gestational age at birth) was <28 days were also identified and checked against the woman's NRS live and stillbirth records. If one of the records matched a child date of birth in the woman's NRS records and the other did not, the matching record was retained and the other record discarded. In total, 68 delivery records were discarded having been identified as implausibly close.

3.2.2.4 Identifying delivery records to women with one or more previous caesareans sections in SMR02

In SMR02, births to women with one or more previous caesarean sections can be identified as delivery episodes that have a previous caesarean section field value of one or more. They can also be identified as delivery episodes to women who have at least one previous delivery episode in SMR02 in which the mode of birth is recorded as caesarean section (code 7 or 8) and/or a caesarean section operation code (OPCS-4: R17-R18, R251; OPCS-3: 764-766, 769) is present. Of the previous publications that have used SMR02 data to identify births to women with prior caesarean section[111,164-167], most did not state how they did this. The quality assurance exercise of SMR02 data published in 2010[168] reported that for the previous caesarean section and mode of birth fields, the information recorded in SMR02 matched the information found in the medical records in 98% and 87% of the records assessed respectively. However, the main issue identified with mode of birth was not related to the recording of caesarean birth. Instead, most unmatched records were caused by mode of birth being wrongly recorded as '0' (normal, spontaneous vertex vaginal delivery, occipito-anterior) rather than the correct code of '1' (cephalic vaginal delivery with abnormal presentation of the head at delivery). Based on this data and following discussions with ISD Scotland, it was decided to use all available data in SMR02 to identify births to women with prior caesarean section.

Births to women with one or more previous caesarean sections were therefore identified in the SMR02 as:

> delivery episodes that had a previous caesarean section field value of one or more
>
> OR
>
> delivery episodes to women who had at least one previous delivery episode in SMR02 in which the mode of birth was recorded as caesarean section (code 7 or 8) and/or a caesarean section operation code (OPCS-4: R17-R18, R251; OPCS-3: 764-766, 769) was present, using SMR02 records going back as far as 1981.

3.2.2.5 Additional data validation

Various other internal as well as external data validation approaches were used as outlined below.

1) The consistency between the previous caesarean section field in the delivery records and the information in the previous delivery records for identifying delivery records to women with one or previous caesarean sections was examined as reported in **Appendix C**.

2) The proportion of births identified to women with one or more previous caesarean sections using the method outlined in the above section was compared with available UK rates from the literature as reported in **Appendix C**.

3) The number of previous caesarean sections according to the previous caesarean section field was cross-checked against the mode of birth and operation codes information in the previous delivery records. Where this was found to be less than the number of previous caesarean sections observed to date, it was overwritten with the higher number. Also, if the previous caesarean section field was missing, the number of previous caesarean sections was derived from the number of previous caesarean sections observed to date.

4) The parity field was cross-checked with the number of previous delivery records observed to date. Where the parity value was found to be less than the number of previous delivery records observed to date, it was overwritten with the higher number.

5) The consistency in the reporting of some common data items (multiple birth status, gender of child, and whether pregnancy ended in a live or a stillbirth) between SMR02 and NRS live and stillbirths was assessed as reported in **Appendix C**. For the very small proportion of records which were discordant on any of these fields, the value in

the NRS live and stillbirth record was used as this was felt to be the most reliable data source.

6) Implausible data combinations, such as duration of labour recorded as '0' and code for 'vaginal delivery' in mode of birth field, were checked to see if they were rare.

7) Values of maternal height, weight at booking and body mass index (BMI) at booking were compared with published values[53,169]. Maternal height values <120 cm and >200 cm, weight of mother at booking values <32kg and >180 kg and maternal BMI at booking values ≤15 and >80 kg/m2 were considered to be implausible based on the published values. If height was missing or implausible, it was set to the median value observed in the woman's other records in SMR02. Implausible values of maternal weight or BMI at booking were set to missing.

8) Implausible birth weights for gestational age were identified as those more than twice the interquartile range (IQR) below and above the first and third quartile, respectively, using sex-specific birth weight for gestational age centiles as reported by Bonellie et at[28]. Implausible values were set to missing.

9) Values of maternal age were compared with published values[52]. None of the values were considered to be implausible based on the published values, so all values were retained.

10) If a child appeared in more than one pupil census, the consistency in the recording of a child's ethnicity between the pupil censuses was examined. Where a child had a different known ethnic group value recorded in different census years, it was set to the child's most frequently recorded ethnic group value, having first recoded ethnicity into a smaller number of less specific groups.

11) The characteristics of the derived study populations were compared to the available data about the characteristics of women who gave birth after previous caesarean section reported in previous UK studies as reported in **Appendix C**.

12) Several sensitivity analyses were conducted for each of the studies as described in sections 3.2.9, 4.3.5, 5.3.5, and 6.3.5.

3.2.3 Study populations

The eligibility criteria for each study in turn can be found in the methods section of subsequent chapters (sections 4.3.1, 5.3.1, 6.3.1). Each of the studies used the most consistent and contemporary time period of births possible at the time the data was requested. However, the time period of births included in each of the studies varies, largely reflecting the differing availability of the datasets used in the studies and how much follow-up time was needed (**Figure 3.2**). For example, for study two the prescription data was available for the period 2009-2016 when it was requested, so this study was confined to births between 2010-2015 to facilitate the identification of women who had psychotropic medication dispensed in the one year before and after birth. Similarly, for study three, the pupil census data was available for 2007-2016 at the time it was requested, so this study was limited to births between 2002-2011 to allow follow-up data for at least one year when the child was primary school age. Only singleton births at term (37-41 completed weeks' gestation) to women with previous caesarean section were included in each of the studies, as this is the main group UK guidelines[8,22] recommend as candidates for planned VBAC or ERCS and should be counselled about both options. Furthermore, the risk of adverse outcomes is likely to differ between singleton and multiple births[149,150], and between term and non-term births[151,152]. The methods used to link the education to the health data outlined in section 3.2.1 also do not allow for accurate linkage of same sex multiples living at the same address.

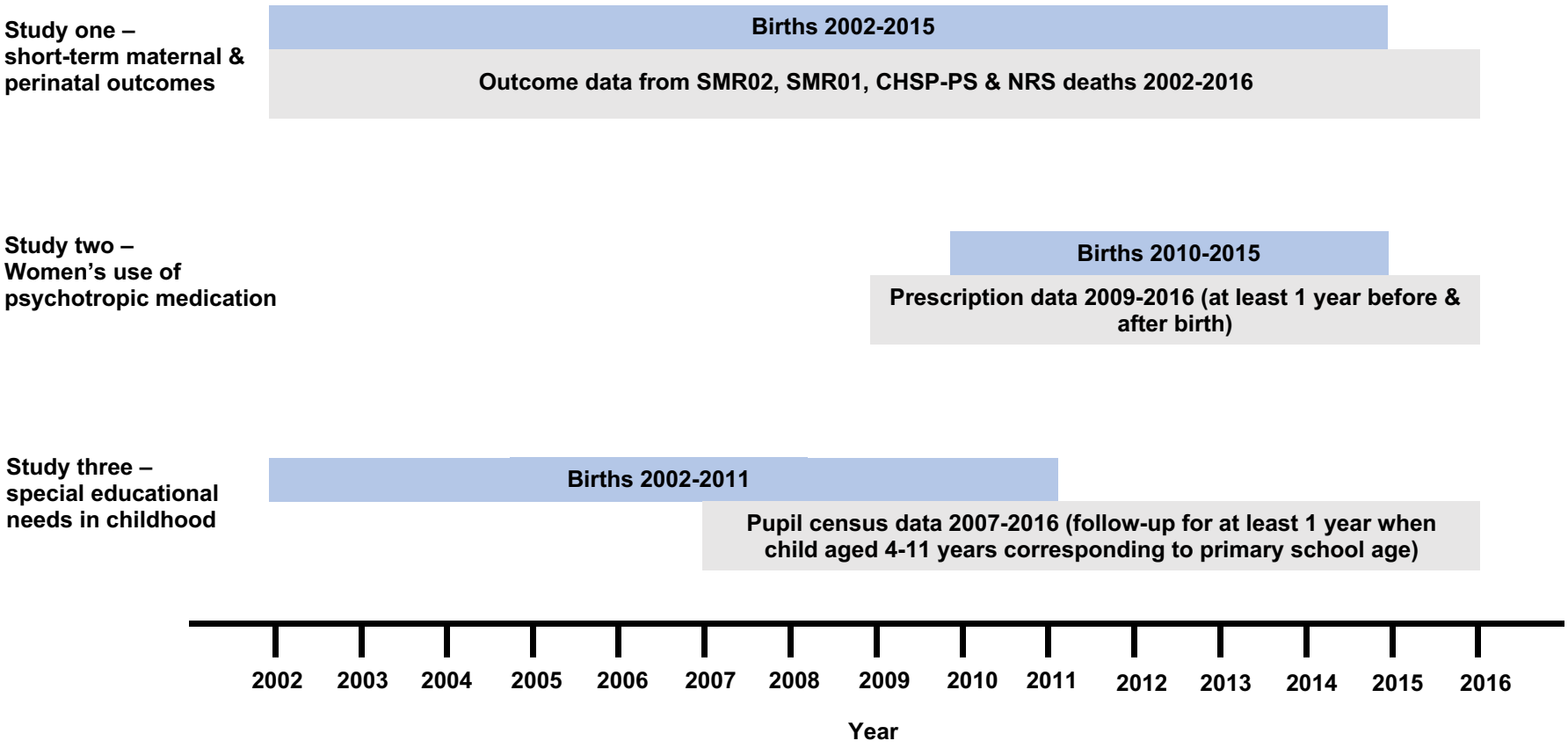


Figure 3.2. Study time periods

Abbreviations: CHSP-PS, Child Health Surveillance Programme Pre-School System; National Records of Scotland (NRS); SMR01, Scottish Morbidity Record General/Acute Inpatient & Day case dataset; SMR02, Scottish Morbidity Record Maternity Inpatient & Day Case Dataset

3.2.4 Exposure variables

Table 3.2 details the data sources, codes and database fields used to identify the exposures of interest. The primary exposure in each study was planned mode of birth after previous caesarean, with planned VBAC (birth vaginally or by non-elective caesarean section with a duration of labour of ≥1 hour) compared to ERCS (birth by elective caesarean, defined by ISD Scotland as a caesarean performed during the day with both the patient and staff fully prepared).

Analyses were also performed according to whether planned VBAC was attempted with or without labour induction (including surgical and/or medical induction) compared to ERCS. For comparative purposes, analyses were additionally conducted according to actual mode of birth after previous caesarean, comparing actual VBAC (birth vaginally), in-labour non-elective caesarean section (birth by non-elective caesarean with a duration of labour of ≥1 hour), and ERCS.

Table 3.2. Data sources, codes and database fields used to identify exposures

Exposures	Data source	Database fields/codes
Elective repeat caesarean section (ERCS)	SMR02	Code for elective caesarean section in mode of delivery field (7) in women with ≥1 previous caesarean sections
Planned vaginal birth after previous caesarean section (planned VBAC)	SMR02	Code for vaginal delivery in mode of delivery field (0, 1, 2, 3, 4, A, B, C, D or E) OR code for non-elective caesarean section in mode of delivery field (8) AND duration of labour field ≥1 hour in women with ≥1 previous caesarean sections
Planned VBAC without labour induction	SMR02	Criteria for Planned VBAC AND code for none in induction of labour field (0)
Planned VBAC with labour induction	SMR02	Criteria for Planned VBAC AND code for induction of labour using ARM, oxytocics, ARM & oxytocics, prostaglandins, prostaglandins & ARM, prostaglandins & oxytocics, prostaglandins & ARM & oxytocics or other method in induction of labour field (1-8). Surgical induction defined as using ARM to induce labour & medical induction defined as using oxytocics &/or prostaglandins to induce labour.
Actual vaginal birth after previous caesarean section (VBAC)	SMR02	Code for vaginal delivery in mode of delivery field (0, 1, 2, 3, 4, A, B, C, D or E) in women with ≥1 previous caesarean sections
In-labour non-elective repeat caesarean section	SMR02	Code for non-elective caesarean section in mode of delivery field (8) AND duration of labour field ≥1 hour in women with ≥1 previous caesarean sections

Abbreviations: ARM, artificial rupture of membrances; SMR02, Scottish Morbidity Record Maternity Inpatient & Day Case Dataset

3.2.5 Outcomes

The outcomes investigated in each study are briefly listed below with a detailed description provided in the methods section of subsequent chapters (sections 4.3.3, 5.3.3, 6.3.3). All of the outcomes were predetermined by considering what outcomes are thought to have a plausible association with mode of birth[13,21,26-29,90,91] as outlined in Chapter 1, what outcomes were considered in relevant systematic reviews[67,82,92,93], the existing evidence on outcomes following planned VBAC compared to ERCS, and what data were available. Representatives of various service user and voluntary groups in the perinatal field were also consulted and their views about what outcomes they considered to be important to women and their partners when deciding on mode of birth after previous caesarean were considered when determining which outcome measures to investigate. Further details of patient and public involvement in the research are described in section 3.2.11.

Study one – short-term maternal & perinatal outcomes

Maternal outcomes: uterine rupture, blood transfusion, peripartum hysterectomy, puerperal sepsis, other puerperal infections, surgical injury, length of postnatal hospital stay, overnight readmission to hospital within 42 days of giving birth, any breastfeeding at birth or hospital discharge, exclusive breastfeeding, and any breastfeeding (exclusive or mixed breast and formula) at around 6-8 weeks after birth. The absolute risk of third- or fourth- degree perineal tears was also described among those who had a planned VBAC.

Perinatal outcomes: intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs and/or intubation, and Apgar score of <7 at 5 minutes after birth. A composite outcome comprising any of these adverse perinatal outcomes was also examined.

Study two – woman's use of psychotropic medication

The primary outcome was time to first dispensed prescription for any psychotropic medication within the first year postpartum, including antidepressant drugs used to treat a range of affective symptomatology including depressive disorders, anxiety disorders and mixed symptomatology; hypnotics, used to treat insomnia; anxiolytics, used to treat anxiety; and drugs in psychoses and related disorders. Secondary outcomes included time to first dispensed prescription within the first year postpartum for specific categories of psychotropic medications.

Study three – special educational needs (SENs) in childhood

The primary outcome was any record of SENs and secondary outcomes were specific type of SEN, with children classified as having a record of SENs if it was recorded in any pupil census year when they were aged 4-11 years and attending a primary or special school.

3.2.6 Covariates

Table 3.3 details the data sources, codes and database fields used to identify the covariates of interest in each study. The rationale for adjusting for particular covariates in the analyses is described in the next section.

Table 3.3. Data sources, codes and database fields used to identify the covariates considered in each study

Covariates	Data source	Database fields/codes	Outcome analyses in which covariate included
Year of birth	SMR02	Date of delivery field in current pregnancy *(Treated as a continuous variable in analyses)*	All outcomes
Socio-demographic			
Maternal age (years)	SMR02	Derived from mother's date of birth & date of delivery in current pregnancy *(Treated as a continuous variable in analyses but grouped into following categories for descriptive purposes: <25, 25-29, 30-34, 35-39, ≥40)*	All outcomes
Mother's country of birth	NRS live & stillbirths	Mother's Country of Birth field in current pregnancy *(Categorised as: UK, Non-UK)*	All outcomes
Marital status/ registration type	NRS live & stillbirths	Parents married indicator field in current pregnancy *(Categorised as: Married or joint registration/same address, Joint registration/different address, Sole registration)*	All outcomes
Socio-economic status	NRS live & stillbirths	Socio-economic status of mother if sole registered birth or highest of mother or father's socio-economic status for births registered inside marriage or jointly registered by both parents outside marriage. Socio-economic status defined by National Statistics Socio-Economic Classification (NS-SEC) based on occupation & employment status *(Categorised as: Managerial/professional, Intermediate, Routine/manual, Other)*	All outcomes
Child's ethnicity	Pupil Census	Ethnic background field. If child in more than one pupil census & had different known ethnic group value recorded in different census years, set to the child's most frequently recorded ethnic group value *(Categorised as: White, Asian, African/Caribbean/Black/Mixed/Other)*	All study 3 outcomes
Maternal medical & pregnancy-related			
Number of previous caesarean sections	SMR02	Previous caesarean sections field in current pregnancy. Number of previous caesarean sections according to previous caesarean sections field was cross-checked against woman's previous delivery records in SMR02. Where this was found to be less than the number of previous caesarean sections observed to date (14% of eligible births in studies 1 & 3, 15% of eligible births in study 2), it was overwritten with the higher number. Also, if the previous caesarean sections field was missing (0.2% of eligible births in studies 1 & 2, 0.3% of eligible births in study 3), number of previous caesarean sections was derived from the number of previous caesarean sections observed to date. *(Treated as a continuous variable in analyses but grouped into following categories for descriptive purposes: 1, ≥2)*	All outcomes

Table continued overleaf

Table 3.3. (continued). Data sources, codes and database fields used to identify the covariates considered in each study

Covariates	Data source	Database fields/codes	Outcome analyses in which covariate included
Any prior vaginal birth	SMR02	Derived from parity (number of previous pregnancies resulting in either a live birth or stillbirth) & number of previous caesarean sections in current pregnancy. Woman's previous delivery records were also examined for evidence of any prior vaginal births. *(Categorised as: No, Yes)*	All outcomes
Any previous stillbirth or neonatal death	SMR02	Derived from previous stillbirths & previous neonatal deaths fields in current pregnancy. *(Categorised as: No, Yes)*	All study 2 outcomes
Inter-pregnancy interval (months)	SMR02	Derived from interval between date of delivery of current pregnancy & date of delivery of previous delivery minus gestational age at delivery of current pregnancy/birth *(Treated as a continuous variable in analyses but grouped into following categories for descriptive purposes: <12, 12-23, ≥24)*	All outcomes
Smoked at booking	SMR02	Booking smoking history field in current pregnancy *(Categorised as: No, Yes)*	All outcomes
Maternal BMI at booking (kg/m^2)	SMR02	Derived from height & weight of mother at booking fields in current pregnancy. Maternal height values < 120 cm & > 200 cm, weight of mother at booking values < 32kg & > 180 kg & maternal BMI at booking values ≤15 & >80 kg/m2 were considered to be implausible based on published values[53,169]. If height was missing or implausible, it was set to the median value observed in the woman's other records in SMR02. Implausible values of maternal weight or BMI at booking were set to missing. *(Treated as a continuous variable in analyses but grouped into following categories for descriptive purposes: <25, 25-29.9, ≥30)*	All outcomes
Hypertensive disorder	SMR02	Antenatal or delivery episodes of current pregnancy with an ICD-10 code for pre-existing or gestational hypertensive disorder (O10-O11, O13-O16, I10) *(Categorised as: No, Yes)*	The following maternal outcomes in study 1: blood transfusion, length of postnatal hospital stay, readmission to hospital within 42 days of birth; all perinatal outcomes in study 1; & all study 2 & 3 outcomes
Diabetes mellitus	SMR02	Antenatal or delivery episodes of current pregnancy with a code for pre-existing or gestational diabetes mellitus in diabetes field (1-3) OR an ICD-10 code for pre-existing or gestational diabetes mellitus (O24, E10-E11) *(Categorised as: No, Yes)*	The following maternal outcomes in study 1: puerperal sepsis, other puerperal infection, length of postnatal hospital stay, readmission to hospital within 42 days of birth; all perinatal outcomes in study 1; & all study 2 & 3 outcomes
Pre-labour rupture of membranes	SMR02	Antenatal or delivery episodes of current pregnancy with an ICD-10 code for premature rupture of membranes (O42) *(Categorised as: No, Yes)*	The following maternal outcomes in study 1: puerperal sepsis, other puerperal infection, length of postnatal hospital stay, readmission to hospital within 42 days of birth; all perinatal outcomes in study 1; & all study 3 outcomes

Table continued overleaf

Table 3.3 (continued). Data sources, codes and database fields used to identify the covariates considered in each study

Covariates	Data source	Database fields/codes	Outcome analyses in which covariate included
Infant-related			
Sex of child	NRS live births & stillbirths	Sex field in current pregnancy (*Categorised as: Male, Female)*	Breastfeeding outcomes in study 1, all perinatal outcomes in study 1, & all study 3 outcomes
Gestational age at birth (weeks)	SMR02	Estimated gestation field in current pregnancy (containing number of completed weeks of gestation as judged by the clinician, usually on the basis of ultrasound) or if missing (0.05% of eligible births in study 1, 0.04% of eligible births in study 3) derived from date of delivery & date of last menstrual period fields *(Treated as a continuous variable in analyses but grouped into following categories for descriptive purposes: 37-38, 39-41)*	Breastfeeding outcomes in study 1, all perinatal outcomes in study 1, & all study 3 outcomes
Birth weight centile	SMR02	Derived from gestational age at birth, birth weight & gender of child in current pregnancy using sex-specific birth weight for gestational age centiles as reported by Bonellie et at[170]. Implausible birth weights for gestational age were identified as those more than twice the interquartile range below & above the first & third quartile, respectively, using the sex-specific birth weight for gestational age centiles reported by Bonellie et at[170]. Implausible values were set to missing. *(Categorised as: 10-90th, <10th, >90th)*	Breastfeeding outcomes in study 1, all perinatal outcomes in study 1, & all study 3 outcomes
Other			
Adverse perinatal outcome (Study 2 included intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation or Apgar score <7 at 5 minutes. Study 3 included same as above except intrapartum stillbirth or neonatal death)	NRS deaths & SMR02	Study 2: code for intrapartum stillbirth or death within four weeks of current birth in period of death field (2-6), code for admitted in neonatal indicator field (1-2), code for bag & mask with drugs, intubation for intermittent positive pressure ventilation with/without drugs or drugs only in resuscitation field (3-6), or <7 in Apgar score field of current pregnancy Study 3: same as above except did not include intrapartum stillbirth or death within four weeks of birth *(Categorised as: No, Yes)*	None, provided only for descriptive information in studies 2 & 3

Table continued overleaf

Table 3.3 (continued). Data sources, codes and database fields used to identify the covariates considered in each study

Covariates	Data source	Database fields/codes	Outcome analyses in which covariate included
Maternal intrapartum or postpartum complication (Study 2 included uterine rupture, peripartum hysterectomy, blood transfusion, puerperal sepsis, other puerperal infection, surgical injury – damage to bowel, bladder or ureter requiring surgical repair, third- or fourth-degree perineal tear, or overnight readmission to hospital within 42 days of birth. Study 3 included same as above except overnight readmission to hospital within 42 days of birth)	SMR02 & SMR01	Study 2: Delivery episode of current pregnancy with an ICD-10 code for uterine rupture (O710-O711); OPCS-4 code for hysterectomy (Q071-Q075, Q08, R251) within 6 weeks of delivery date of current pregnancy; Delivery episode of current pregnancy with an OPCS-4 code for blood transfusion (X331-X333, X337-X339, X341); ICD-10 code for puerperal sepsis (O85) within 6 weeks of delivery date of current pregnancy; ICD-10 code for other puerperal infections (O86) within 6 weeks of delivery date of current pregnancy; OPCS-4 code for any of the following within 6 weeks of delivery date of current pregnancy: total excision of colon & rectum, total excision of colon, extended excision of right hemicolon, other excision of right hemicolon, excision of transverse colon, excision of left hemicolon, excision of sigmoid colon, other excision of colon, exteriorisation of caecum, other exteriorisation of colon, subtotal excision of colon, exteriorisation of colon, repair of anus, other operations on the anal sphincter to control continence, excision of ureter, urinary diversion, replantation of ureter, other connection of ureter, repair of ureter, incision of ureter, other open operations on ureter,therapeutic nephroscopic operations on ureter, therapeutic ureteroscopic operations on ureter, other therapeutic endoscopic operations on ureter, percutaneous ureteric stent procedures, total excision of bladder, partial excision of bladder, enlargement of bladder, other repair of bladder or open drainage of bladder (H04-H11, H14-H15, H29, H32, H50, H57, M18-M23, M25-M27, M29, M33-M38); Delivery episode of current pregnancy with a code for third- or fourth-degree tear in *tears* field (3 or 4) OR ICD-10 code for third- or fourth-degree perineal laceration during delivery (O702-0703) OR OPCS-4 code for repair of obstetric laceration of perineum & sphincter of anus or repair of obstetric laceration of perineum & sphincter & mucosa of anus (R322, R325); or women readmitted to hospital within 42 days of delivery of current pregnancy, excluding planned transfers & readmissions of <1 day. Planned transfers identified as episodes where difference between the admission date of the episode & the discharge date of previous episode <0 OR is between 0-1 day AND either admission from/type of admission is a transfer or discharged to/type of discharge of previous episode is a transfer. Maternal deaths within delivery episode were excluded, identified using discharge type 40-43 (death). Women with a postnatal hospital stay >42 days also excluded. Study 3: same as above except did not include overnight readmission to hospital within 42 days of birth *(Categorised as: No, Yes)*	None, provided only for descriptive information in studies 2 & 3
Any breastfeeding at 6-8 week review	CHSP-PS	Method of feeding at 6-8 week review breast milk only or mixed breast & formula milk *(Categorised as: No, Yes)*	All study 2 & 3 outcomes

Abbreviations: BMI, body mass index; CHSP-PS, Child Health Surveillance Programme Pre-School System; ICD-10, International Classification of Diseases 10th revision; NRS, National Records of Scotland; OPCS-4, Office of Population Censuses & Surveys Classification of Surgical Operations & Procedures 4th revision; SMR01, Scottish Morbidity Record General/Acute Inpatient & Day case dataset; SMR02, Scottish Morbidity Record Maternity Inpatient & Day Case Dataset

3.2.7 Statistical analysis

The characteristics of the primary exposure groups (planned VBAC and ERCS) were first compared using descriptive statistics. To investigate the association between the exposures and each outcome, logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for rare binary outcomes (affecting <10% of population); modified Poisson regression[171] was used to estimate risk ratios (RRs) and 95% CIs for common binary outcomes, recognising that ORs do not give a good approximation of the RR when the outcome is common[172]; and Cox proportional hazards regression was used to allow for follow-up time and take account of censoring where appropriate (study two).

All models were adjusted for year of birth to account for any temporal changes ("base model"). To examine the relative influence of socio-demographic, maternal medical and obstetric-related factors on the association between the exposure variables and outcome in question, models were adjusted in a hierarchical fashion. Model A was adjusted for *a priori* socio-demographic factors; model B was additionally adjusted for *a priori* maternal medical and pregnancy-related factors; models assessing breastfeeding outcomes and the risk of adverse perinatal and child outcomes were additionally adjusted for *a priori* infant-related factors as detailed in **Table 3.3** (model C). The variables included in these models were determined *a priori* based on pre-existing hypotheses or evidence on what factors are thought to potentially explain or confound any association between the exposure and outcome in question[67,79,142,173,174-179], having also considered what data were available. A conceptual framework of how the factors might influence the relationship between planned mode of birth after previous caesarean and the outcomes considered is outlined in **Figure 3.3**. As explained in the footnote of **Figure 3.3**, arrows are shown at both ends of the line between planned mode of birth and infant-related factors as gestational age is a potential confounder and a potential mediator in that gestational age may influence planned mode of birth but planned mode of birth may also influence gestational age. Earlier gestational age at birth, even at term,

is in turn a risk factor for adverse perinatal[19-21] and child outcomes[178,180], and may also influence the likelihood of breastfeeding[181].

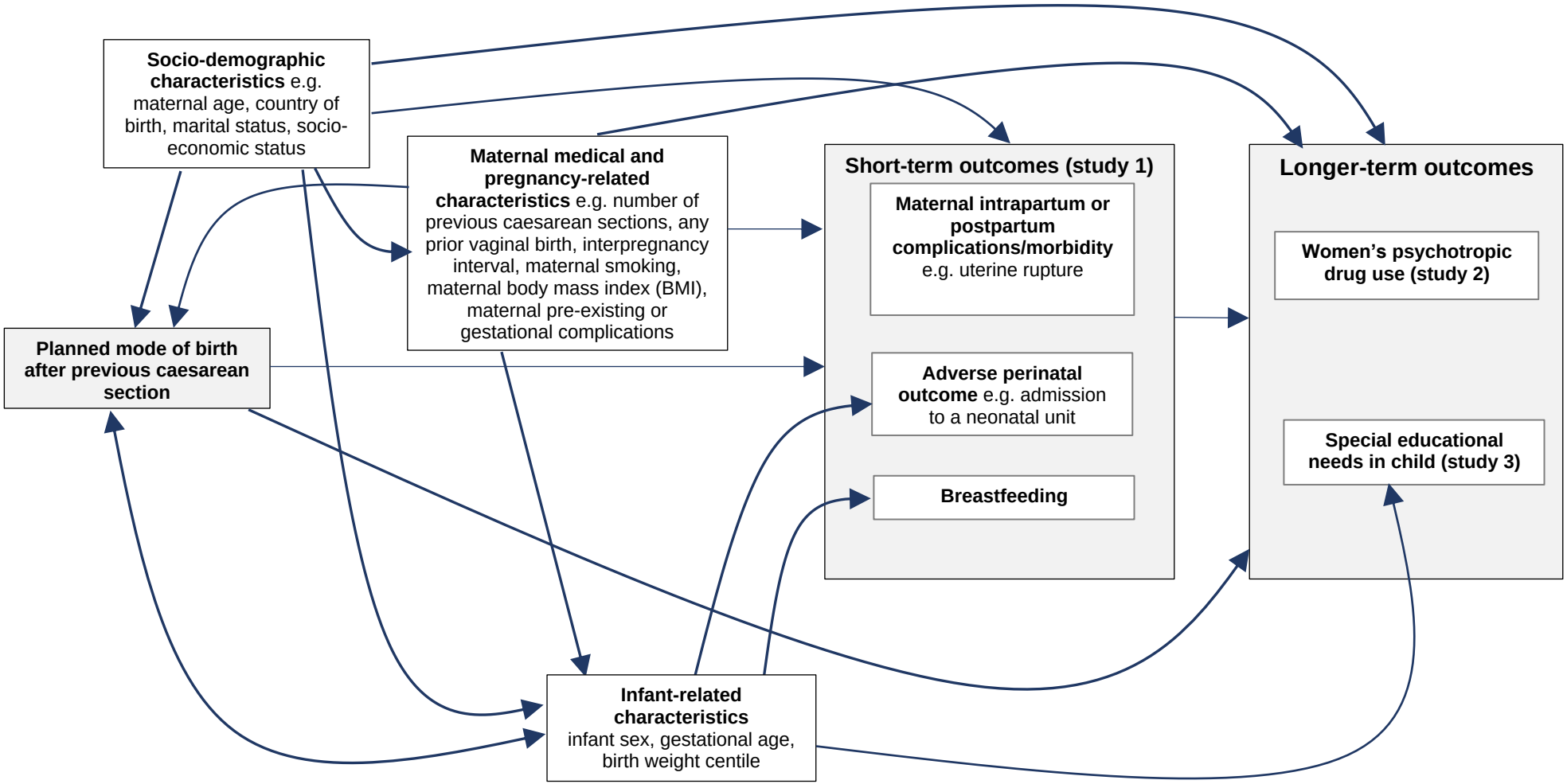


Figure 3.3. Conceptual framework of how socio-demographic, maternal medical and pregnancy-related and infant-related factors* might influence the relationship between planned mode of birth after previous caesarean and the short and longer-term outcomes considered

Note, arrows are shown at both ends of line between planned mode of birth & infant-related factors as gestational age is considered as a potential confounder & a potential mediator in that gestational age may influence planned mode of birth (e.g. if a woman has not gone into spontaneous labour by 40-41 weeks' gestation she may choose an ERCS rather than risk a planned VBAC with induction of labour) but planned mode of birth may also influence gestational age (since 2004, UK guidelines[8,22] have recommended that an ERCS should be performed from 39 weeks' gestation, which typically results in women having an ERCS giving birth at an earlier gestational age compared to women awaiting spontaneous onset of labour). Earlier gestational age at birth, even at term, in turn is a risk factor for adverse perinatal[19-21] & child outcomes[178,180] & may also influence the likelihood of breastfeeding[181].

*Note only factors which were measured in the data available are shown

In studies two and three, breastfeeding may also be on the causal pathway. As demonstrated by study one (Chapter 4), the exposures are associated with a woman's likelihood of breastfeeding[1] and breastfeeding may in turn influence a woman's likelihood of being dispensed psychotropic medication as well as the child's risk of having a record of SENs. An association between breastfeeding and psychotropic medication use may arise through concerns around the safety of psychotropic medication for the breastfed baby[182], or possibly through unmet breastfeeding expectations[183]. Breastfeeding may affect a child's likelihood of having SENs by influencing the child's neurodevelopment through several possible mechanisms, including through differences in the composition of breast and formula milk or differences in maternal-infant interactions[31,184-186]. To examine any effects of the exposures that were not mediated through breastfeeding, additional analyses were performed in studies two and three adjusting for whether the mother breastfed (exclusively or mixed) around 6-8 weeks postpartum (model C for study two and model D for study three). Adjustments were only performed when there was considered to be a sufficient number of outcome events to do so. There is a rule of thumb suggesting there should be at least ten outcome events per variable coefficient (EPV) in the model. However, this rule is based on weak evidence[187] and it has been suggested the rule can be relaxed to 5-9 EPV, particularly to allow adequate control of confounding[188]. Thus, this less conservative criteria of at least 5 EPV was applied.

Categorical covariates were fitted in the models using the categories shown in **Table 3.3**. Continuous covariates were investigated for evidence of departure from linearity in the models for each outcome using fractional polynomials, a method that involves fitting multiple power transformations of the continuous variable including the following powers: -2, -1, -0.5, 0, 1, 2, and 3[189]. Continuous variables with insufficient evidence of nonlinearity were treated as continuous linear terms when adjusting for them in the analysis, whereas those showing evidence of nonlinearity were fitted using the best-fitting power

transformation of the variable. Several covariates were investigated *a priori* as potential effect modifiers of the relationship between the exposure and outcomes examined as detailed in the methods section of subsequent chapters (sections 4.3.4, 5.3.4, 6.3.4). Effect modification was examined by the addition of interaction terms to the full regression models. The Cox regression assumption that the hazard ratio (HR) is constant over time, known as the proportional hazards assumption, was assessed in study two (Chapter 5) using Schoenfeld residuals and visually using log-log plots.

For all studies, robust standard errors were used to account for the lack of independence in the data of women who had more than one eligible birth in the study period. All p-values were two-sided with the significance level set at <0.05, except for tests of departure from linearity and interaction tests, where the significance level was set at <0.01 to allow for multiple testing. All analyses were conducted in StataMP version 14 or 16 (Statacorp, College Station, USA). The studies are reported as per the REporting of studies Conducted using Observational Routinely-collected Data (RECORD) guideline[153].

3.2.8 Missing data

The proportion of the study population which had missing data for one or more of the covariates included in the fully adjusted models was 38.6% for study one, 24.7% for study two and 55.6% for study three (see footnotes of **Tables 4.3, 5.3 and 6.3** for details). The characteristics of those with missing data differed from those with complete data, suggesting the data were not missing completely at random. Excluding those with missing data from the analysis (complete case analysis) would therefore potentially introduce bias as well as reduce study power. For each study, partially observed covariates were therefore imputed using multiple imputation, an approach involving fitting a statistical model to the observed data to estimate values for the missing data. Multiple values are imputed for each missing observation, resulting in multiple complete datasets. The analysis model of interest

(substantive model) is then fitted to each of the complete datasets and the results combined using Rubin's rules. When there appeared from the complete case analysis to be evidence of non-linear covariate effects or effect modification, a multiple imputation method using a recently developed extension to the chained equations approach was used[190]. This was to ensure missing covariate values were imputed from imputation models that were compatible with the analysis models. Otherwise, multiple imputation using the normal chained equations method was used. The imputation models included all covariates and the outcome of interest or, when the analysis model of interest was a Cox model (study two, Chapter 5), included all covariates, the event indicator, and Nelson-Aalen estimator of the cumulative hazard[191]. The number of imputations performed ranged from 30 to 55 depending on the study, determined on the basis of the suggested rule of thumb that the number of imputations should be at least equal to the percentage of incomplete cases[192].

3.2.9 Sensitivity analyses

Three sensitivity analyses were conducted for all three studies. First, a complete case analysis for each outcome studied was performed. Second, recognising that the criterion used to define planned mode of birth could misclassify some women who planned ERCS but went into labour before their scheduled caesarean date, analyses were repeated restricting the study populations to births at 39 or more weeks of gestation. Since 2004, this is the gestational age UK guidelines have recommended to conduct an ERCS[8,22]. Third, E-values were calculated to quantify the minimum strength of association that an unmeasured confounder would need with both the exposure and a given outcome to fully explain any observed associations between the exposure and outcomes conditional on the measured covariates[193]. Study specific additional sensitivity analyses conducted are outlined in the methods section of subsequent chapters (sections 4.3.5, 5.3.5, 6.3.5).

3.2.10 Sample size

There are around 55,000 births per year in Scotland. It was estimated there would be approximately 5,500 births per year eligible for primary analyses. This estimate was derived assuming around 13% of births during the study periods are to women who have previously given birth by caesarean. This is based on the average rate observed in control women comparable in characteristics to the available national data on women giving birth in the UK identified through the UK Obstetric Surveillance system in a series of UK-wide studies conducted over various time periods ranging from 2005-2014[49-53]. The estimate also assumed that 97% of births are singletons and 91% of singletons are born at term[194]. It was also based on excluding births to women with potential contraindications to VBAC, estimated at 12% of births[195]. **Table 3.4** shows examples of the effect sizes that could be detected with 80% power and 5% significance level, assuming 44% of eligible women plan VBAC[79].

Table 3.4. Effect sizes for example outcomes

Examples of outcomes	Estimated sample size	Estimated prevalence in ERCS group	Least extreme relative risk detectable for planned VBAC if planned VBAC has protective effect	Least extreme relative risk detectable for planned VBAC if planned VBAC has harmful effect
Mother – peripartum hysterectomy	77,000[a]	0.05%[110]	0.27	2.13
Mother – antidepressant medication	33,000[b]	12%[196]	0.92	1.09
Child – any special educational needs	55,000[c]	15%[d]	0.94	1.06
Child – special educational needs attributed to autistic spectrum disorder	55,000[c]	2%[d]	0.84	1.18

[a] using 14 years of birth data (study period 2002-2015)
[b] using 6 years of birth data (study period 2010-2015)
[c] using 10 years of birth data (study period 2002-2011)
[d] estimated using aggregate special educational needs data from pupil census years 2007-2016 received from the Scottish Government Educational Analytical Services

3.2.11 Patient and public involvement

The National Perinatal Epidemiology Unit at the University of Oxford has strong links with service user and voluntary groups in the perinatal field. The author of this thesis used these links to seek patient and public involvement (PPI) in this research. Input was obtained from PPI representatives from the Birth Trauma Association, NCT (formerly the National

Childbirth Trust), the Maternal Mental Health Alliance as well as the co-leads on Parent, Patient and Public Involvement at the NIHR Policy Research Unit in Maternal and Neonatal Health and Care. One face-to-face and one virtual meeting was held, supplemented by discussions over email. PPI representatives first advised on the proposed research plan when the author of this thesis was developing the funding application for the research. The PPI representatives considered the research to be important to women and their families and were supportive of the proposed research plan and keen to engage with the research. The views of the PPI representatives on what outcomes they considered to be important when deciding on mode of birth after previous caesarean were considered to help ensure the research addressed relevant information needs of women and their partners faced with this decision. This resulted in pelvic floor dysfunction/perineal trauma and maternal mental health being added as outcomes in the literature review (Chapter 2). This also resulted in the addition of third- or fourth- degree perineal tears as an outcome in study one, and focusing in study two on women's mental health using the proxy of women's use of psychotropic medication. The progress and results of the studies were discussed with the PPI representatives, who also advised on the interpretation and communication of the findings. This included producing, with the help of the PPI representatives, a plain English one page summary and a plain English longer leaflet of the research findings, copies of which can be found in **Appendix G**. A webpage about the research was also created on the National Perinatal Epidemiology Unit's website (https://www.npeu.ox.ac.uk/birth-after-previous-caesarean), where copies of the lay documents of the research findings can also be found.

3.2.12 Approvals

The Oxford Research and Development Services reviewed the studies regarding the need for UK National Research Ethics Service (NRES) approval and advised that this approval was not required (see letter from Ms H House in **Appendix C**) as the studies involved the

analysis of anonymised secondary data sources. However, approval for the studies, including the required data linkage, was obtained from the Scottish Public Benefit and Privacy Panel for Health and Social care (application number 1516-0196; **Appendix C**) and the Scottish Government Education Analytical Services. An NSS electronic Data Research and Innovation Service (eDRIS) user agreement and a data sharing agreement with the Scottish Government Education Analytical Services were also signed.

3.2.13 Challenges

I experienced lengthy delays in getting access to the linked Scottish national datasets I required. I first received some of the data nine months after obtaining the necessary approvals but there were errors in the way the data had been extracted by the data providers. It took a further eight months to obtain a correct version of most of the data I required and a further ten months to obtain a correct version of all the data. While I was able to develop some preparatory STATA analysis files while waiting for the data, these delays together with a reduced capacity to work because of added caring responsibilities due to the Coronavirus (COVID-19) pandemic-related school closures, did have a negative impact on my planned timelines.

4

PLANNED MODE OF BIRTH AFTER PREVIOUS CAESAREAN SECTION AND SHORT-TERM MATERNAL AND PERINATAL OUTCOMES: A POPULATION-BASED RECORD LINKAGE COHORT STUDY

4.1 Introduction and chapter overview

The literature review (Chapter 2) revealed that robust comprehensive information on the outcomes for women and their children of planned VBAC compared to ERCS to counsel eligible women about this choice was lacking. This chapter describes the first population-based cohort study conducted to address some of the limitations that were apparent with the existing evidence. The research presented in this chapter has been published in PLoS Medicine[1].

4.2 Objective

The objective of this study was to investigate the short-term maternal and perinatal outcomes associated with planned mode of birth after previous caesarean section among

women giving birth to a singleton at term and considered clinically eligible to plan a VBAC (research objective 2).

4.3 Methods

4.3.1 Study population

The data sources, codes and database fields used to identify the population for this study are detailed in **Table 4.1**. The study population included singleton term (37-41 completed weeks' gestation) births in Scotland, UK, between 1st January 2002 and 31st December 2015 to women with a history of one or more previous caesarean sections. As described in section 3.2.2.4 and **Table 4.1**, births to women with one or more previous caesarean sections were identified in the SMR02 as delivery episodes that had a previous caesarean section field value of ≥1 or delivery episodes to women who had ≥1 previous delivery episode in which the mode of birth was recorded as caesarean section and/or a caesarean section operation code was present, using SMR02 records going back as far as 1981.

Births to women not considered clinically eligible to have a planned VBAC based on UK guidelines[8,22] were excluded. Women with any of the following were thus excluded: non-cephalic presentation at birth, placenta praevia, abdominal pregnancy, known or suspected disproportion of maternal and/or fetal origin, tumour of corpus uteri, or birth by pre-labour non-elective caesarean section. Births to women who had an antepartum stillbirth were also excluded as vaginal birth is usually recommended in this situation[197]. Stillbirths missing time of death in relation to birth (i.e. whether occurred antepartum or intrapartum), births missing mode of birth or gestational age at birth, births by non-elective caesarean section with missing information about duration of labour, and instances in which the number of previous caesarean sections was greater than a woman's recorded parity were also excluded.

Table 4.1. Data sources, codes and database fields used to identify the study one population

	Data source	Database fields/codes
Inclusion criteria		
≥1 previous caesarean sections	SMR02	Previous caesarean sections field ≥1 OR at least one previous delivery with a code for caesarean section in mode of delivery field (7 or 8) &/or an OPCS-4 or OPCS-3 code for caesarean section (R17-R18, R251, 764-766, 769), using SMR02 records going back as far as 1981
Singleton birth	NRS live births & stillbirths	Numbirths field=1
Term birth	SMR02	Gestation at birth 37-41 completed weeks according to Estimated gestation field (containing number of completed weeks of gestation as judged by the clinician, usually on the basis of ultrasound) OR according to gestation derived from date of delivery & date of last menstrual period fields if Estimated gestation missing (0.05% of eligible births)
Exclusion criteria		
Non-cephalic presentation	SMR02	Delivery episodes with a code for breech or shoulder in presentation at delivery field (4 or 6) OR a code for breech delivery or breech extraction in mode of delivery field (5 or 6) OR an ICD-10 code for breech delivery or breech extraction (O801, O830-O831) OR an OPCS-4 code for breech delivery or breech extraction (R19-R20) OR an ICD-10 code for maternal care for malpresentation of fetus (0320-0322, 0326-0329)
Placenta praevia	SMR02	Delivery episodes with an ICD-10 code for placenta praevia (O440-O441)
Abdominal pregnancy	SMR02	Delivery episodes with an ICD-10 code for delivery of or maternal care for viable fetus in abdominal pregnancy (O833, O367)
Known or suspected disproportion of maternal &/or fetal origin	SMR02	Delivery episodes with an ICD-10 code for maternal care for known or suspected disproportion (O33)
Tumour of corpus uteri	SMR02	Delivery episodes with an ICD-10 code for maternal care for tumour of corpus uteri (O341)
Pre-labour non-elective caesarean section	SMR02	Code for non-elective caesarean section in mode of delivery field (8) AND duration of labour field=0
Antepartum stillbirth	NRS stillbirths	Code for antepartum stillbirth in period of death field (1)

Abbreviations: ICD-10, International Classification of Diseases 10th revision; NRS, National Records of Scotland; OPCS-3, Office of Population Censuses & Surveys Classification of Surgical Operations & Procedures 3rd revision OPCS-4, Office of Population Censuses & Surveys Classification of Surgical Operations & Procedures 4th revision; SMR02, Scottish Morbidity Record Maternity Inpatient & Day Case Dataset

4.3.2 Exposure variables

The exposures of interest are detailed in section 3.2.4. In brief, the primary exposure of interest was planned mode of birth after previous caesarean section with planned VBAC (birth vaginally or by non-elective caesarean section with a duration of labour of ≥1 hour) compared to ERCS (birth by elective repeat caesarean). Analyses were also performed according to whether planned VBAC was attempted with or without labour induction compared to ERCS and according to actual mode of birth after previous caesarean section (actual VBAC, in-labour non-elective repeat caesarean section or ERCS).

4.3.3 Outcomes

The following predetermined maternal outcomes as defined in **Table 4.2** were investigated: uterine rupture, blood transfusion, peripartum hysterectomy, puerperal sepsis, other puerperal infections, surgical injury, length of postnatal hospital stay, overnight readmission to hospital within 42 days of giving birth, any breastfeeding at birth or hospital discharge, exclusive breastfeeding, and any breastfeeding (exclusive, or mixed breast and formula) at around 6-8 weeks after birth. The absolute risk of third- or fourth- degree perineal tears was also described among those who had a planned VBAC. Women who died before discharge or were not discharged within 42 days of giving birth were excluded from the analysis of maternal overnight readmission to hospital. Intrapartum stillbirths were excluded from the analysis of breastfeeding at birth or hospital discharge, and intrapartum stillbirths and neonatal deaths (deaths within four weeks of birth) were excluded from the analysis of breastfeeding at around 6-8 weeks after birth.

The following predetermined perinatal outcomes as defined in **Table 4.2** were investigated: intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs and/or intubation, and Apgar score of <7 at 5 minutes after birth. A composite outcome comprising any of these adverse perinatal outcomes was also examined. Deaths due to congenital abnormalities were excluded from all perinatal outcomes, and all intrapartum stillbirths were excluded from the analysis of neonatal unit admission, resuscitation, and Apgar score.

Table 4.2. Data sources, codes and database fields used to identify the study one outcomes

	Data source	Database fields/codes
Maternal outcomes		
Uterine rupture	SMR02	Delivery episodes with an ICD-10 code for uterine rupture (O710-O711) *(Categorised as: No, Yes)*
Peripartum hysterectomy	SMR02 & SMR01	OPCS-4 code for hysterectomy (Q071-Q075, Q08, R251) within 6 weeks of delivery date *(Categorised as: No, Yes)*
Blood transfusion	SMR02	Delivery episodes with an OPCS-4 code for blood transfusion (X331-X333, X337-X339, X341) *(Categorised as: No, Yes)*
Puerperal sepsis	SMR02 & SMR01	ICD-10 code for puerperal sepsis (O85) within 6 weeks of delivery date *(Categorised as: No, Yes)*
Other puerperal infection	SMR02 & SMR01	ICD-10 code for other puerperal infections (O86) within 6 weeks of delivery date *(Categorised as: No, Yes)*
Surgical injury (Damage to bowel, bladder or ureter requiring surgical repair)	SMR02 & SMR01	OPCS-4 code for any of the following within 6 weeks of delivery date: total excision of colon & rectum, total excision of colon, extended excision of right hemicolon, other excision of right hemicolon, excision of transverse colon, excision of left hemicolon, excision of sigmoid colon, other excision of colon, exteriorisation of caecum, other exteriorisation of colon, subtotal excision of colon, exteriorisation of colon, repair of anus, other operations on the anal sphincter to control continence, excision of ureter, urinary diversion, replantation of ureter, other connection of ureter, repair of ureter, incision of ureter, other open operations on ureter,therapeutic nephroscopic operations on ureter, therapeutic ureteroscopic operations on ureter, other therapeutic endoscopic operations on ureter, percutaneous ureteric stent procedures, total excision of bladder, partial excision of bladder, enlargement of bladder, other repair of bladder or open drainage of bladder (H04-H11, H14-H15, H29, H32, H50, H57, M18-M23, M25-M27, M29, M33-M38) *(Categorised as: No, Yes)*
Third- or fourth-degree perineal tear	SMR02	Delivery episodes with a code for third- or fourth-degree tear in tears field (3 or 4) OR ICD-10 code for third- or fourth-degree perineal laceration during delivery (O702-0703) OR OPCS-4 code for repair of obstetric laceration of perineum & sphincter of anus or repair of obstetric laceration of perineum & sphincter & mucosa of anus (R322, R325) *(Categorised as: No, Yes)*
Length of postnatal hospital stay (days)	SMR02 & SMR01	Derived from date of delivery & latest date of discharge of the continuous inpatient stay, with continuous inpatient stays identified as episodes where the difference between the discharge date of the episode & the admission date of the next episode is less than 0 OR is between 0-1 day AND either the discharged to/type of discharge of the episode is a transfer or the admission from/type of admission of the next episode is a transfer. *(Categorised as: ≤5, >5)*
Overnight readmission to hospital within 42 days of giving birth	SMR02 & SMR01	Women readmitted to hospital within 42 days of giving birth, excluding planned transfers & readmissions of less than one day. Planned transfers identified as episodes where the difference between the admission date of the episode & the discharge date of the previous episode is less than 0 OR is between 0-1 day AND either the admission from/type of admission is a transfer or the discharged to/type of discharge of the previous episode is a transfer. Maternal deaths within the delivery episode were excluded, identified using discharge type 40-43 (death). Women with a length of postnatal hospital stay >42 days were also excluded. *(Categorised as: No, Yes)*

Table continued overleaf

Table 4.2 (continued). Data sources, codes and database fields used to identify the study one outcomes

	Data source	Database fields/codes
Any breastfeeding at birth or hospital discharge	SMR02	Code for breast only or mixed (breast & formula) in first feed given (immediately following birth) or feed on discharge fields (1 or 4) *(Categorised as: No, Yes)*
Exclusive breastfeeding at 6-8 week review	CHSP-PS	Method of feeding at 6-8 week review breast milk only *(Categorised as: No, Yes)*
Any breastfeeding at 6-8 week review	CHSP-PS	Method of feeding at 6-8 week review breast milk only or mixed breast & formula milk *(Categorised as: No, Yes)*
Perinatal outcomes		
Intrapartum stillbirth or neonatal mortality	NRS deaths or SSBID in sensitivity analysis	Code for intrapartum stillbirth or death within four weeks of birth in period of death field (2-6). Deaths from congenital anomalies were excluded, identified from NRS deaths data as deaths with a primary cause of death ICD-10 code for congenital malformations, deformations & chromosomal abnormalities (Q00-Q99) & in SSBID as deaths with a paediatric classification code for congenital anomaly (1-7) *(Categorised as: No, Yes)*
Admission to a neonatal unit	SMR02	Neonatal indicator field. A neonatal unit defined by ISD Scotland as a nursery in which accommodation, equipment, staffing, spacing, temperature, & other support facilities are such as to permit the care of babies who require a level of care above that associated with healthy babies. *(Categorised as: No, Yes)*
Resuscitation requiring drugs &/or intubation	SMR02	Code for bag & mask with drugs, intubation for intermittent positive pressure ventilation with/without drugs or drugs only in resuscitation field (3-6) *(Categorised as: No, Yes)*
Apgar score at 5 minutes after birth	SMR02	Apgar score field *(Categorised as: <7, ≥7)*

Abbreviations: CHSP-PS, Child Health Surveillance Programme Pre-School System; ICD-10, International Classification of Diseases 10th revision; ICD, Information Services Division; NRS, National Records of Scotland; OPCS-4, Office of Population Censuses & Surveys Classification of Surgical Operations & Procedures 4th revision; SMR01, Scottish Morbidity Record General/Acute Inpatient & Day Case Dataset; SMR02, Scottish Morbidity Record Maternity Inpatient & Day Case Dataset; SSBID, Scottish Stillbirth & Infant Death Survey

4.3.4 Statistical analysis

The statistical analyses are detailed in section 3.2.7. In brief, associations between the exposures and outcomes were examined using logistic regression to estimate ORs and 95% CIs where the outcome was rare (affecting <10% of population), and modified Poisson regression[171] to estimate RRs and 95% CIs where the outcome was common[172]. All models were adjusted for year of birth. Models were then sequentially adjusted for *a priori* covariates as described in section 3.2.7, with a detailed description of the covariates found in section 3.2.6. Categorical covariates were fitted in the models using the categories shown in **Table 3.3**. Linearity of continuous covariates was investigated using fractional

polynomials as described in section 3.2.7. Several covariates including maternal age, number of previous caesarean sections a woman had, whether the woman had any prior vaginal births, inter-pregnancy interval, and maternal BMI were investigated *a priori* as potential effect modifiers of the relationship between the primary exposure and outcomes based on pre-existing hypotheses or evidence of what factors are thought to plausibly be effect modifiers[67,89,109,198]. Effect modification was explored by adding interaction terms to the full models. Multiple imputation was used to impute partially observed covariates as described in section 3.2.8.

4.3.5 Sensitivity analyses

In addition to conducting the three sensitivity analyses described in section 3.2.9 (complete case, repeating analyses restricted to births at ≥39 weeks' gestation, and calculating E-values), an additional sensitivity analysis was carried out in which intrapartum stillbirths and neonatal deaths, excluding deaths from congenital abnormalities, were identified using the Scottish Stillbirth and Infant Death Survey (SSBID) rather than National Records of Scotland (NRS) deaths data to explore whether potential differences in the way cause of death was coded in these data sources had any impact on the findings. NRS deaths data were available for the whole study period, with cause of death coded in accordance with ICD-10. SSBID data were collected until 2012, and a revised classification system for cause of death was introduced in the last two years of the survey, so only data until 2010 were used for the sensitivity analysis. Up until 2010, the cause of stillbirth or neonatal death was classified using the Scottish Obstetric and Paediatric system last modified in 1987, with classification performed by a single medically qualified individual ensuring consistency in classification[158].

4.4 Results

4.4.1 Study population

In total, 74,043 singleton term births to women with a history of one or more previous caesarean sections were identified as meeting the study eligibility criteria (**Figure 4.1**). Of these, 28,464 (38.4%) were to women classified as having a planned VBAC and 45,579 (61.6%) were to women classified as having an ERCS. The ERCS rate among this group of women increased each year during the study period, from 50.5% in 2002 to 72.4% in 2015 (**Figure 4.2**). **Table 4.3** shows the characteristics of the study population by planned mode of birth. Women who had a planned VBAC were more likely than those who had an ERCS to be younger, born outside the UK, be sole registered mothers (no partner or husband registered on the birth certificate), and be of lower socio-economic status (**Table 4.3**). They were also more likely to have just one prior caesarean, have had one or more prior vaginal births, have a shorter inter-pregnancy interval, be smokers at booking for pregnancy care, have a hypertensive disorder, have pre-labour rupture of membranes, have given birth at late term (39-41 weeks' gestation), and to have given birth to an infant less than the 10th centile for birth weight. They were less likely than women who had an ERCS to be overweight or obese, to have diabetes, and to have given birth to an infant more than the 90th centile for birth weight.

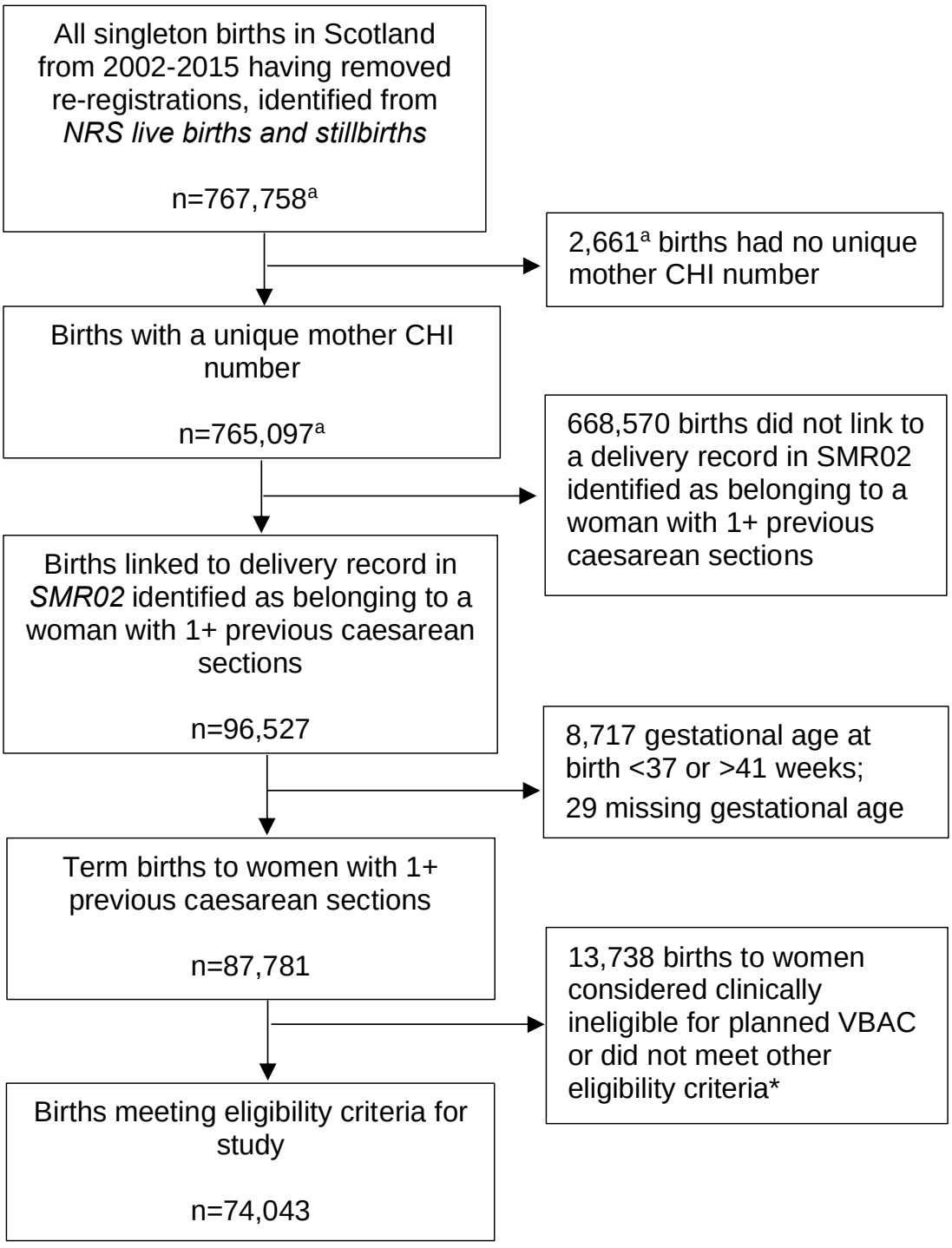


Figure 4.1. Flow diagram of cohort identification for study one

[a] Numbers provided by ISD Scotland, now part of Public Heath Scotland.

* Clinically ineligible for planned VBAC or did not meet other eligibility criteria for study because of one or more of the following: non-cephalic presentation at birth (n=6,100); placenta praevia (n=570); abdominal pregnancy (n=1); known of suspected disproportion of maternal &/or fetal origin (n=113); tumour of corpus uteri (n=268); birth by pre-labour non-elective caesarean section (n=5,954); antepartum stillbirth (n=131); stillbirth missing time of death in relation to birth (n=7); missing information on mode of birth (n=10); births by non-elective caesarean section missing information about duration of labour (n=1,291); & number of previous caesarean sections greater than parity (n=243). Reasons are not mutually exclusive.

Abbreviations: CHI, community health index; ISD, Information Services Division; NRS, National Records of Scotland; SMR02, Scottish Morbidity Record Maternity Inpatient & Day Case dataset; VBAC, vaginal birth after previous caesarean.

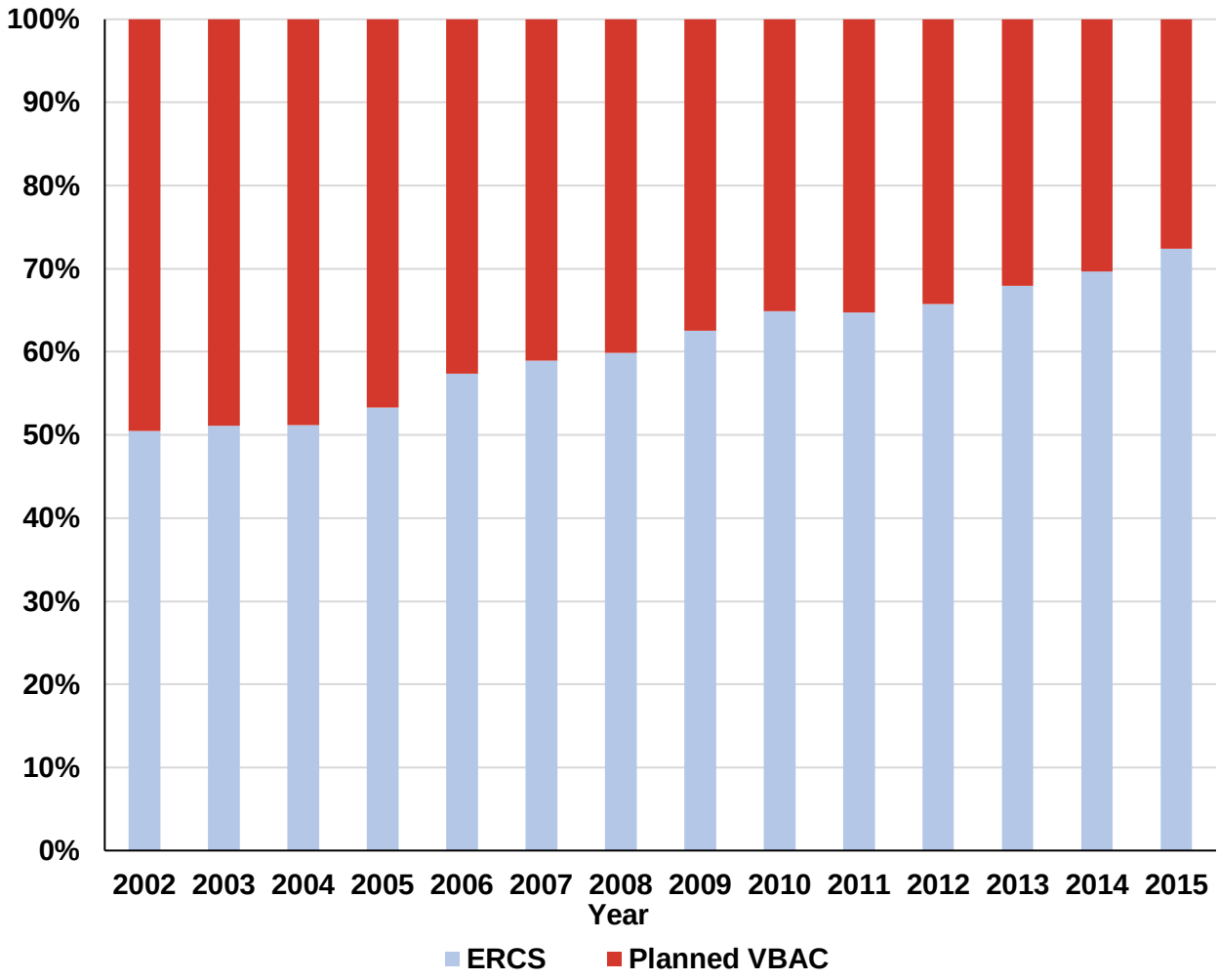


Figure 4.2. ERCS and planned VBAC rate in the study one cohort by year over study period, 2002-2015

Abbreviations: ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean

Table 4.3. Characteristics of the study one cohort by planned mode of birth after previous caesarean section

	ERCS n (%)[a], unless otherwise stated (n=45,579)	Planned VBAC n (%)[a], unless otherwise stated (n=28,464)
Socio-demographic characteristics		
Maternal age (years)		
Less than 25	4,372 (9.6)	3,546 (12.5)
25-29	10,104 (22.2)	6,698 (23.5)
30-34	15,854 (34.8)	9,994 (35.1)
35-39	12,249 (26.9)	6,856 (24.1)
40 or more	3,000 (6.6)	1,370 (4.8)
Median (IQR) maternal age (years)	32 (28-36)	32 (28-35)
Mother's country of birth		
UK	40,420 (88.7)	24,814 (87.2)
Non-UK	5,159 (11.3)	3,650 (12.8)
Marital status/registration type		
Married or joint registration/same address	40,786 (89.5)	25,290 (88.8)
Joint registration/different address	3,321 (7.3)	2,100 (7.4)
Sole registration	1,472 (3.2)	1,074 (3.8)
Socio-economic status[b]		
Managerial/professional	21,951 (48.2)	13,230 (46.5)
Intermediate	10,115 (22.2)	5,988 (21.0)
Routine/manual	11,678 (25.6)	7,819 (27.5)
Other[c]	1,835 (4.0)	1,427 (5.0)
Maternal medical & pregnancy-related characteristics		
Number of previous caesarean sections		
1	33,956 (74.5)	27,509 (96.6)
2 or more	11,623 (25.5)	955 (3.4)
Median (IQR) number of previous caesarean sections	1 (1-2)	1 (1-1)
Any prior vaginal birth[d]		
No	37,523 (82.7)	17,380 (61.2)
Yes	7,874 (17.3)	10,997 (38.8)
Parity[d]		
1	28,262 (62.3)	16,903 (59.7)
2 or more	17,119 (37.7)	11,418 (40.3)
Median (IQR) parity[d]	1 (1-2)	1 (1-2)
Inter-pregnancy interval (months)[d]		
24 or more	25,321 (60.0)	13,720 (56.4)
12-23	10,939 (25.9)	6,700 (27.5)
Less than 12	5,927 (14.0)	3,915 (16.1)
Median (IQR) inter-pregnancy interval (months)[d]	29 (17-50)	27 (16-48)
Mother smoked at booking[d]		
No	34,991 (83.3)	20,677 (78.2)
Yes	7,028 (16.7)	5,773 (21.8)
Maternal BMI at booking (Kg/m^2)[d]		
Less than 25	11,957 (35.9)	8,741 (46.6)
25-29.9	10,181 (30.5)	5,738 (30.6)
30 or more	11,194 (33.6)	4,294 (22.9)
Median (IQR) BMI at booking (Kg/m^2)[d]	27 (24-32)	25 (23-29)
Hypertensive disorder	2,258 (5.0)	1,634 (5.7)
Diabetes	1,960 (4.3)	479 (1.7)
Pre-labour rupture of membranes	451 (1.0)	2,448 (8.6)

Table continued overleaf

Table 4.3 (continued). Characteristics of the study one cohort by planned mode of birth after previous caesarean section

		ERCS n (%)[a], unless otherwise stated (n=45,579)	Planned VBAC n (%)[a], unless otherwise stated (n=28,464)
Infant-related characteristics			
Male infant		23,218 (50.9)	14,651 (51.5)
Gestational age at birth (weeks)			
	39-41	31,880 (69.9)	22,758 (80.0)
	37-38	13,699 (30.1)	5,706 (20.0)
Median (IQR) gestational age at birth (weeks)		39 (38-39)	40 (39-40)
Birth weight centile[d,e]			
	10-90th	35,930 (79.3)	22,928 (80.8)
	Less than 10th	2,640 (5.8)	2,890 (10.2)
	More than 90th	6,749 (14.9)	2,555 (9.0)

[a] Percentage of those with complete data.

[b] Socio-economic status of mother for sole registered birth or highest of mother or father's socio-economic status for births registered inside marriage or jointly registered by both parents outside marriage. Socio-economic status defined by National Statistics Socio-Economic Classification (NS-SEC) based on occupation & employment status.

[c] Other includes never worked/long-term unemployed, student, not stated or not classifiable.

[d] Missing data: any prior vaginal birth 269 (0.36%); parity 341 (0.46%); inter-pregnancy interval 7,521 (10.16%); maternal smoking status 5,574 (7.53%); maternal BMI 21,938 (29.63%); birth weight centile 351 (0.47%).

[e] Derived from gestational age at birth, birth weight & gender of child using sex-specific birth weight for gestational age centiles as reported by Bonellie & colleagues[170].

Abbreviations: BMI, body mass index; ERCS, elective repeat caesarean section; IQR, interquartile range; NS-SEC, National Statistics Socio-Economic Classification; VBAC, vaginal birth after previous caesarean

4.4.2 Planned VBAC compared to ERCS

Maternal and perinatal outcomes according to planned mode of birth are shown in **Table 4.4** and **Figure 4.3A**. Overall, 1.8% of those having a planned VBAC and 0.8% of those having an ERCS experienced serious maternal morbidity (uterine rupture, peripartum hysterectomy, blood transfusion, puerperal sepsis or surgical injury), and 8.0% of the planned VBAC and 6.4% of the ERCS group experienced one or more of the adverse perinatal outcomes considered: intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs and/or intubation or an Apgar score <7 at 5 minutes. Having only adjusted for year of birth (base model) women who had a planned VBAC were significantly more likely than those giving birth by ERCS to have uterine rupture, a blood transfusion, puerperal sepsis, and surgical injury. They were also significantly more likely to have an intrapartum stillbirth or neonatal death, a baby requiring resuscitation with drugs and/or intubation, a baby with an Apgar score of <7 at 5 minutes, and a baby experiencing a composite outcome comprising of any of the adverse perinatal outcomes considered. However, in the base model women who had a planned VBAC were significantly less likely than those giving birth by ERCS to have a postnatal hospital stay greater than 5 days and were significantly less likely to be readmitted overnight to hospital within 42 days of birth. They were also more likely than those giving birth by ERCS to breastfeed at birth or hospital discharge and at 6-8 weeks postpartum.

Table 4.4. Maternal and perinatal outcomes following planned VBAC compared to ERCS

	ERCS n outcome events/total n (%)	Planned VBAC n outcome events/total n (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Maternal outcomes						
Uterine rupture	17/45,579 (0.04)	69/28,464 (0.24)	**6.26 (3.64-10.76) P<0.001**	**6.28 (3.62-10.89) P<0.001**	**7.33 (3.88-13.88) P<0.001**	-
Peripartum hysterectomy	19/45,579 (0.04)	6/28,464 (0.02)	0.47 (0.19-1.16) P=0.102	NC	NC	-
Blood transfusion†	226/45,579 (0.50)	324/28,464 (1.14)	**2.12 (1.78-2.52) P<0.001**	**2.09 (1.76-2.49) P<0.001**	**2.29 (1.88-2.79) P<0.001**	-
Puerperal sepsis‡¥	78/45,579 (0.17)	76/28,464 (0.27)	**1.73 (1.25-2.38) P=0.001**	**1.69 (1.22-2.33) P=0.001**	**1.82 (1.25-2.65) P=0.002**	-
Other puerperal infection‡¥	1,016/45,579 (2.23)	659/28,464 (2.32)	1.00 (0.90-1.11) P=0.986	0.99 (0.89-1.10) P=0.855	**1.22 (1.09-1.36) P<0.001**	-
Surgical injury	40/45,579 (0.09)	# (0.17)	**1.96 (1.29-2.98) P=0.002**	**2.01 (1.33-3.05) P=0.001**	**2.96 (1.83-4.77) P<0.001**	-
Postnatal hospital stay >5 days†‡¥	1,410/45,579 (3.09)	877/28,464 (3.08)	**0.88 (0.81-0.97) P=0.007**	**0.89 (0.82-0.98) P=0.013**	0.97 (0.88-1.08) P=0.574	-
Readmission to hospital within 42 days of birth[a]†‡¥	1,332/45,577 (2.92)	710/28,463 (2.49)	**0.88 (0.80-0.96) P=0.006**	**0.87 (0.79-0.96) P=0.004**	0.94 (0.84-1.04) P=0.234	-
Any breastfeeding at birth or hospital discharge[b]	21,403/39,297 (54.46)	14,906/23,453 (63.56)	**1.18 (1.16-1.20) P<0.001**	**1.19 (1.18-1.21) P<0.001**	**1.18 (1.16-1.20) P<0.001**	**1.15 (1.13-1.18) P<0.001**
Exclusive breastfeeding at 6-8 week review[c]	9,788/39,251 (24.94)	8,085/24,090 (33.56)	**1.34 (1.31-1.38) P<0.001**	**1.37 (1.34-1.41) P<0.001**	**1.38 (1.34-1.41) P<0.001**	**1.31 (1.27-1.35) P<0.001**
Any breastfeeding at 6-8 week review[c]	13,556/39,251 (34.54)	10,496/24,090 (43.57)	**1.27 (1.24-1.30) P<0.001**	**1.29 (1.26-1.31) P<0.001**	**1.29 (1.26-1.32) P<0.001**	**1.24 (1.21-1.27) P<0.001**

Table continued overleaf

Table 4.4 (continued). Maternal and perinatal outcomes following planned VBAC compared to ERCS

	ERCS n outcome events/total n (%)	Planned VBAC n outcome events/total n (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Perinatal outcomes[d]						
Adverse perinatal outcome[e]†‡¥	2,570/40,369 (6.37)	2,049/25,658 (7.99)	**1.22 (1.15-1.30) P<0.001**	**1.22 (1.15-1.30) P<0.001**	**1.35 (1.26-1.44) P<0.001**	**1.57 (1.46-1.68) P<0.001**
Intrapartum stillbirth or neonatal death	5/45,567 (0.01)	20/28,449 (0.07)	**6.59 (2.43-17.87) P<0.001**	NC	NC	NC
Admitted to a neonatal unit†‡¥	2,377/45,062 (5.27)	1,517/27,847 (5.45)	1.00 (0.93-1.07) P=0.967	1.00 (0.94-1.07) P=0.960	**1.11 (1.03-1.20) P=0.006**	**1.31 (1.22-1.41) P<0.001**
Resuscitation requiring drugs &/or intubation†‡¥	133/40,830 (0.33)	429/26,295 (1.63)	**4.67 (3.84-5.68) P<0.001**	**4.68 (3.84-5.70) P<0.001**	**5.19 (4.17-6.45) P<0.001**	**5.22 (4.19-6.50) P<0.001**
Apgar score <7 at 5 minutes†‡¥	192/45,194 (0.42)	405/28,092 (1.44)	**3.45 (2.90-4.09) P<0.001**	**3.46 (2.91-4.11) P<0.001**	**3.66 (3.01-4.46) P<0.001**	**3.84 (3.15-4.68) P<0.001**

[1] Base model adjusted for year of birth.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status/registration type, & socio-economic status).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder where † is shown, diabetes where ‡ is shown & pre-labour rupture of membranes where ¥ is shown).
[4] Model C adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[a] Women who died before discharge or were not discharged within 42 days of birth excluded from analysis of overnight readmission to hospital (n=3).
[b] Intrapartum stillbirths (n=6) & births missing data on feeding at birth & hospital discharge (n=11,287, 15.2%) were excluded from analysis of breastfeeding at birth or hospital discharge.
[c] Intrapartum stillbirths (n=6), neonatal deaths (46) & births missing infant feeding data at 6-8 week review (n=10,650, 14.4%) were excluded from analysis of breastfeeding outcomes at 6-8 weeks.
[d] All perinatal outcomes exclude deaths because of congenital abnormalities (n=27) & any remaining intrapartum stillbirths (n=5) & births missing the outcome in question (n=1,102, 1.5% for admission to a neonatal unit; n=6,886, 9.3% for resuscitation; n=725, 1.0% for Apgar score) additionally excluded from analysis of neonatal unit admission, resuscitation & Apgar score.
[e] Includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation or an Apgar score <7 at 5 minutes.
- numbers have not been shown to protect against potential disclosure risks
Bold text indicates statistically significant findings at the 5% level
OR's calculated for all outcomes shown apart from the breastfeeding outcomes, where RR's were instead calculated
Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; NC, not calculated because of low number of events; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean

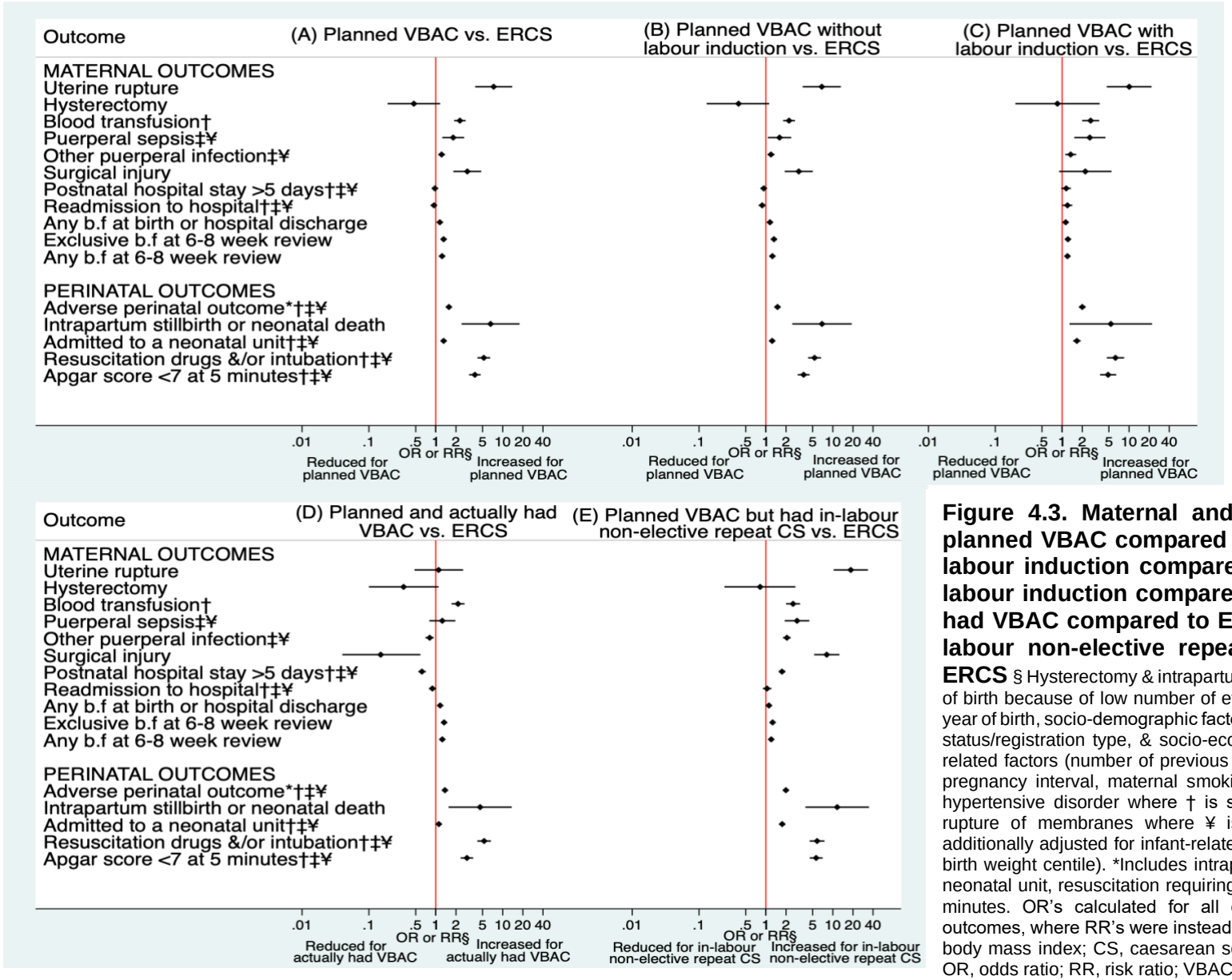


Figure 4.3. Maternal and perinatal outcomes following (A) planned VBAC compared to ERCS (B) planned VBAC without labour induction compared to ERCS (C) planned VBAC with labour induction compared to ERCS (D) planned and actually had VBAC compared to ERCS, (E) planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS § Hysterectomy & intrapartum stillbirth or neonatal death only adjusted for year of birth because of low number of events, whereas other outcomes were adjusted for year of birth, socio-demographic factors (maternal age, mother's country of birth, marital status/registration type, & socio-economic status) & maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder where † is shown, diabetes where ‡ is shown & pre-labour rupture of membranes where ¥ is shown). Breastfeeding & perinatal outcomes additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile). *Includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation or an Apgar score < 7 at 5 minutes. OR's calculated for all outcomes shown apart from the breastfeeding outcomes, where RR's were instead calculated. Abbreviations: b.f, breastfeeding; BMI, body mass index; CS, caesarean section; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean.

Adjustment for socio-demographic factors (model A) essentially did not materially change the findings, whereas further adjustment for maternal medical and pregnancy-related factors (model B) made a difference to some of the effect estimates. In particular, the effect of planned mode of birth on length of postnatal hospital stay and overnight readmission to hospital was attenuated and not statistically significant after adjusting for maternal medical and pregnancy-related factors. However, significant effect modification between planned mode of birth and any prior vaginal birth was found for these outcomes in the fully adjusted models ($p<0.001$ and $p=0.002$ for length of postnatal hospital stay and overnight readmission to hospital respectively). Planned VBAC compared to ERCS was associated with significantly reduced odds of having either a postnatal hospital stay greater than 5 days or an overnight readmission to hospital within 42 days of birth in women with any prior vaginal births (aOR 0.70, 95% CI 0.59-0.84 , $p<0.001$ and aOR 0.74, 95% CI 0.61-0.89, $p=0.001$ respectively) but there was no significant association in women with no prior vaginal births (aOR 1.10, 95% CI 0.98-1.23, $p=0.093$ and aOR 1.03, 95% CI 0.92-1.16, $p=0.618$ respectively). The corresponding absolute risks of having a postnatal hospital stay greater than 5 days for planned VBAC compared to ERCS was 2.74% versus 3.67% respectively in women with any prior vaginal births and 3.30% versus 2.97% respectively in women without any prior vaginal births. The absolute risks of having an overnight readmission to hospital within 42 days of birth for planned VBAC compared to ERCS was 2.19% versus 3.21% respectively in women with any prior vaginal births and 2.67% vs. 2.87% respectively in women without any prior vaginal births. There was also evidence of effect modification ($p=0.003$) between planned mode of birth and number of prior caesarean sections for the outcome postnatal hospital stay greater than 5 days in the fully adjusted model. Planned VBAC compared to ERCS was associated with significantly increased odds of this outcome in women with two or more prior caesarean sections (aOR 1.47, 95% CI 1.10-1.98, $p=0.010$) but there was no significant difference in women with one prior caesarean (aOR 0.92, 95% CI 0.83-1.03, $p=0.143$), with the corresponding absolute risks of this outcome for planned VBAC compared to ERCS 5.76% versus 3.91% in women with

two or more prior caesarean sections and 2.99% versus 2.82% in women with one prior caesarean.

Adjustment for maternal medical and pregnancy-related factors made little difference to the effect estimates for the other outcomes considered with the exception of those for other puerperal infection and admission to a neonatal unit, which were significantly increased in the planned VBAC group following this adjustment. However, for the outcome other puerperal infection, significant effect modification ($p<0.001$) was detected between planned mode of birth and any prior vaginal birth in the fully adjusted model. Planned VBAC compared to ERCS was associated with significantly increased odds of other puerperal infection in those without any prior vaginal births (aOR 1.38, 95% CI 1.22-1.55, $p<0.001$) but significantly reduced odds of other puerperal infection in those with any prior vaginal births (aOR 0.74, 95% CI 0.59-0.93, $p=0.011$), with the corresponding absolute risks of this outcome for planned VBAC compared to ERCS 2.89% versus 2.28% respectively in women without any prior vaginal births and 1.41% versus 1.97% respectively in women with any prior vaginal births. The effect of planned mode of birth on breastfeeding outcomes and perinatal outcomes remained after further adjustment for infant-related factors (Model C). In the fully adjusted model, there was evidence ($p<0.001$) that the effect of planned VBAC on breastfeeding at birth or hospital discharge was slightly stronger in women without prior vaginal births (aRR 1.17, 95% CI 1.15-1.19, $p<0.001$) than in women with any prior vaginal births (aRR 1.09, 95% CI 1.06-1.12, $p<0.001$). No other significant effect modification was found. The absolute risk of third- or fourth-degree perineal tears in the planned VBAC group was 2.9%.

4.4.3 Planned VBAC with and without labour induction compared to ERCS

Of the women who had a planned VBAC, 18.5% (5,245/28,364) had their labour induced. A combination of surgical and medical induction was the main method used to induce labour (42.9% of inductions) with surgical or medical methods alone used less frequently (27.5% and 28.7% of inductions, respectively). Maternal and perinatal outcomes according to whether planned VBAC was attempted with and without labour induction compared to ERCS are shown in **Table 4.5** and **Figure 4.3C and 4.3B** respectively. Essentially the findings largely mirror those reported for planned VBAC compared to ERCS. Women who had a planned VBAC with and those who had a planned VBAC without labour induction were both more likely than women giving birth by ERCS to have uterine rupture, a blood transfusion, puerperal sepsis, or other puerperal infection, and experience all adverse perinatal outcomes considered, at least in the fully adjusted models (**Table 4.5**). The effect estimates for these outcomes were consistently highest in the women who had planned VBAC with labour induction. Women who had a planned VBAC with labour induction were also more likely than those giving birth by ERCS to be readmitted overnight to hospital within 42 days of birth. In contrast, women who had a planned VBAC without labour induction were less likely than those giving birth by ERCS to be readmitted. However, the odds of having surgical injury were only significantly raised in women who had planned VBAC without labour induction noting this subgroup had a greater number of women, increasing the power of this analysis. Both groups of women were more likely to breastfeed at birth or hospital discharge and at 6-8 weeks postpartum than those giving birth by ERCS.

Table 4.5. Maternal and perinatal outcomes following planned VBAC with and without labour induction compared to ERCS

	ERCS	Planned VBAC without labour induction					Planned VBAC with labour induction				
	n outcome events/total N (%)	n outcome events/ total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	n outcome events/ total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Maternal outcomes						-					-
Uterine rupture	17/45,579 (0.04)	53/23,119 (0.23)	**5.92 (3.38-10.37) P<0.001**	**5.89 (3.34-10.41) P<0.001**	**6.85 (3.55-13.19) P<0.001**	-	16/5,245 (0.31)	**7.89 (3.99-15.61) P<0.001**	**8.17 (4.08-16.35) P<0.001**	**10.06 (4.65-21.72) P<0.001**	-
Peripartum hysterectomy	19/45,579 (0.04)	# (0.02)	0.39 (0.13-1.12) P=0.080	NC	NC	-	#	0.85 (0.20-3.64) P=0.828	NC	NC	-
Blood transfusion†	226/45,579 (0.50)	256/23,119 (1.11)	**2.06 (1.72-2.47) P<0.001**	**2.04 (1.70-2.45) P<0.001**	**2.22 (1.81-2.72) P<0.001**	-	68/5,245 (1.30)	**2.42 (1.83-3.19) P<0.001**	**2.38 (1.81-3.14) P<0.001**	**2.67 (1.99-3.58) P<0.001**	-
Puerperal sepsis‡¥	78/45,579 (0.17)	54/23,119 (0.23)	**1.51 (1.06-2.14) P=0.021**	**1.48 (1.04-2.10) P=0.028**	**1.60 (1.07-2.39) P=0.021**	-	21/5,245 (0.40)	**2.55 (1.56-4.16) P<0.001**	**2.49 (1.53-4.06) P<0.001**	**2.59 (1.52-4.44) P<0.001**	-
Other puerperal infection‡¥	1,016/45,579 (2.23)	524/23,119 (2.27)	0.98 (0.88-1.10) P=0.757	0.97 (0.87-1.09) P=0.639	**1.19 (1.06-1.34) P=0.035**	-	135/5,245 (2.57)	1.10 (0.91-1.32) P=0.325	1.08 (0.90-1.30) P=0.415	**1.34 (1.11-1.62) P=0.027**	-
Surgical injury	40/45,579 (0.09)	42/23,119 (0.18)	**2.12 (1.38-3.25) P<0.001**	**2.17 (1.42-3.32) P<0.001**	**3.10 (1.91-5.04) P<0.001**	-	#	1.33 (0.56-3.15) P=0.518	1.37 (0.58-3.26) P=0.470	2.22 (0.90-5.47) P=0.082	-
Postnatal hospital stay >5 days†‡¥	1,410/45,579 (3.09)	672/23,119 (2.91)	**0.83 (0.76-0.92) P<0.001**	**0.84 (0.77-0.93) P=0.001**	0.93 (0.83-1.04) P=0.120	-	202/5,245 (3.85)	1.11 (0.96-1.30) P=0.167	1.11 (0.95-1.29) P=0.189	1.15 (0.97-1.35) P=0.099	-
Readmission to hospital within 42 days of birth[a]†‡¥	1,332/45,577 (2.92)	531/23,118 (2.30)	**0.81 (0.73-0.89) P<0.001**	**0.80 (0.72-0.89) P<0.001**	**0.88 (0.78-0.98) P=0.024**	-	176/5,245 (3.36)	**1.19 (1.01-1.39) P=0.036**	**1.18 (1.00-1.38) P=0.045**	**1.20 (1.01-1.42) P=0.035**	-
Any breastfeeding at birth or hospital discharge[b]	21,403/39,297 (54.46)	12,187/19,083 (63.86)	**1.19 (1.17-1.20) P<0.001**	**1.19 (1.17-1.21) P<0.001**	**1.18 (1.16-1.20) P<0.001**	**1.15 (1.13-1.17) P<0.001**	2,664/4,292 (62.07)	**1.15 (1.12-1.18) P<0.001**	**1.20 (1.17-1.23) P<0.001**	**1.17 (1.14-1.21) P<0.001**	**1.13 (1.09-1.16) P<0.001**
Exclusive breastfeeding at 6-8 week review[c]	9,788/39,251 (24.94)	6,720/19,531 (34.41)	**1.38 (1.34-1.42) P<0.001**	**1.39 (1.36-1.43) P<0.001**	**1.38 (1.34-1.42) P<0.001**	**1.32 (1.28-1.36) P<0.001**	1,339/4,471 (29.9)	**1.20 (1.14-1.26) P<0.001**	**1.29 (1.24-1.35) P<0.001**	**1.33 (1.26-1.41) P<0.001**	**1.22 (1.16-1.30) P<0.001**
Any breastfeeding at 6-8 week review[c]	13,556/39,251 (34.54)	8,663/19,531 (44.36)	**1.29 (1.26-1.32) P<0.001**	**1.29 (1.27-1.32) P<0.001**	**1.29 (1.26-1.32) P<0.001**	**1.25 (1.22-1.28) P<0.001**	1,788/4,471 (40.24)	**1.17 (1.13-1.22) P<0.001**	**1.25 (1.21-1.30) P<0.001**	**1.28 (1.22-1.34) P<0.001**	**1.20 (1.14-1.25) P<0.001**

Table continued overleaf

Table 4.5 (continued). Maternal and perinatal outcomes following planned VBAC with and without labour induction compared to ERCS

	ERCS	Planned VBAC without labour induction					Planned VBAC with labour induction				
	n outcome events/total N (%)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Perinatal outcomes[d]											
Adverse perinatal outcome[e]†‡¥	2,570/40,369 (6.37)	1,583/20,878 (7.58)	**1.15 (1.08-1.23) P<0.001**	**1.16 (1.08-1.24) P<0.001**	**1.30 (1.20-1.39) P<0.001**	**1.49 (1.38-1.60) P<0.001**	458/4,724 (9.70)	**1.51 (1.36-1.68) P<0.001**	**1.49 (1.34-1.66) P<0.001**	**1.56 (1.40-1.75) P<0.001**	**2.00 (1.78-2.25) P<0.001**
Intrapartum stillbirth or neonatal death	5/45,567 (0.01)	# (0.07)	**6.9 (2.48-19.19) P<0.001**	NC	NC	NC	# (0.06)	**5.35 (1.29-22.12) P=0.021**	NC	NC	NC
Admitted to a neonatal unit†‡¥	2,377/45,062 (5.27)	1,171/22,645 (5.17)	0.94 (0.88-1.02) P=0.126	0.95 (0.88-1.02) P=0.182	1.07 (0.99-1.16) P=0.083	**1.24 (1.15-1.35) P<0.001**	340/5,136 (6.62)	**1.23 (1.09-1.39) P<0.001**	**1.21 (1.08-1.37) P=0.002**	**1.27 (1.12-1.45) P<0.001**	**1.66 (1.46-1.89) P<0.001**
Resuscitation requiring drugs &/or intubation†‡¥	133/40,830 (0.33)	335/21,405 (1.57)	**4.69 (3.83-5.75) P<0.001**	**4.72 (3.85-5.78) P<0.001**	**5.30 (4.24-6.62) P<0.001**	**5.34 (4.27-6.68) P<0.001**	91/4,824 (1.89)	**5.66 (4.32-7.40) P<0.001**	**5.59 (4.27-7.33) P<0.001**	**6.17 (4.60-8.27) P<0.001**	**6.27 (4.66-8.45) P<0.001**
Apgar score <7 at 5 minutes†‡¥	192/45,194 (0.42)	309/22,807 (1.35)	**3.24 (2.70-3.88) P<0.001**	**3.26 (2.72-3.91) P<0.001**	**3.50 (2.85-4.29) P<0.001**	**3.66 (2.99-4.50) P<0.001**	95/5,190 (1.83)	**4.39 (3.43-6.62) P<0.001**	**4.31 (3.37-5.53) P<0.001**	**4.47 (3.41-5.86) P<0.001**	**4.87 (3.69-6.43) P<0.001**

[1] Base model adjusted for year of birth.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status/registration type, & socio-economic status).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder where † is shown, diabetes where ‡ is shown & pre-labour rupture of membranes where ¥ is shown).
[4] Model C adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[a] Women who died before discharge or were not discharged within 42 days of birth were excluded from analysis of overnight readmission to hospital (n=3).
[b] Intrapartum stillbirths (n=6) & births missing data on feeding at birth & hospital discharge (n=11,265, 15.2%) were excluded from analysis of breastfeeding at birth or hospital discharge.
[c] Intrapartum stillbirths (n=6), neonatal deaths (46) & births missing infant feeding data at 6-8 week review (n=10,638, 14.4%) excluded from analysis of breastfeeding outcomes at 6-8 weeks.
[d] All perinatal outcomes exclude deaths because of congenital abnormalities (n=27) & any remaining intrapartum stillbirths (n=5) & births missing the outcome in question (n=1,068, 1.4% for admission to a neonatal unit; n=6,852, 9.3% for resuscitation; n=720, 1.0% for Apgar score) additionally excluded from analysis of neonatal unit admission, resuscitation & Apgar score.
[e] Includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation or an Apgar score <7 at 5 minutes.
– numbers or numbers & percentages have not been shown to protect against potential disclosure risks
OR's calculated for all outcomes shown apart from the breastfeeding outcomes, where RR's were instead calculated
Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; NC, not calculated because of low number of events; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean

4.4.4 Actual VBAC and in-labour non-elective repeat caesarean section compared to ERCS

Of the women who had a planned VBAC, 71.6% (20,375/28,464) went on to actually have a VBAC. Maternal and perinatal outcomes following either actual VBAC or in-labour non-elective repeat caesarean section compared with ERCS are shown in **Table 4.6** and **Figure 4.3D and 4.3E**, respectively. Women giving birth by in-labour non-elective repeat caesarean section were significantly more likely than those giving birth by ERCS to experience all adverse outcomes considered, with the exception of peripartum hysterectomy and overnight readmission to hospital within 42 days of birth (**Table 4.6**). Women who actually had a VBAC were more likely than those giving birth by ERCS to have a blood transfusion and experience all adverse perinatal outcomes considered, at least in the fully adjusted models. However, they were less likely than those giving birth by ERCS to have other puerperal infection, surgical injury or a postnatal hospital stay of greater than 5 days. Breastfeeding at birth or hospital discharge and at 6-8 weeks postpartum were both more likely in women giving birth by actual VBAC and those giving birth by in-labour non-elective repeat caesarean section compared to those giving birth by ERCS.

Table 4.6. Maternal and perinatal outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS

	ERCS	Planned and actually had VBAC					Planned VBAC but had in-labour non-elective repeat caesarean section				
	n outcome events/total N (%)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Maternal outcomes											
Uterine rupture	17/45,579 (0.04)	9/20,375 (0.04)	1.14 (0.51-2.56) P=0.744	1.16 (0.51-2.60) P=0.727	1.10 (0.48-2.56) P=0.820	-	60/8,089 (0.74)	**19.28 (11.09-33.53) P<0.001**	**19.28 (10.97-33.88) P<0.001**	**18.58 (10.30-33.53) P<0.001**	-
Peripartum hysterectomy	19/45,579 (0.04)	# (0.01)	0.33 (0.10-1.10) P=0.071	NC	NC	-	#	0.82 (0.24-2.76) P=0.752	NC	NC	-
Blood transfusion†	226/45,579 (0.50)	213/20,375 (1.05)	**1.95 (1.61-2.36) P<0.001**	**1.93 (1.59-2.34) P<0.001**	**2.15 (1.72-2.69) P<0.001**	-	111/8,089 (1.37)	**2.54 (2.02-3.21) P<0.001**	**2.51 (1.99-3.17) P<0.001**	**2.55 (2.00-3.24) P<0.001**	-
Puerperal sepsis‡¥	78/45,579 (0.17)	37/20,375 (0.18)	1.17 (0.79-1.73) P=0.430	1.15 (0.78-1.70) P=0.489	1.25 (0.80-1.96) P=0.319	-	39/8,089 (0.48)	**3.14 (2.12-4.66) P<0.001**	**3.08 (2.08-4.57) P<0.001**	**2.92 (1.91-4.46) P<0.001**	-
Other puerperal infection‡¥	1,016/45,579 (2.23)	312/20,375 (1.53)	**0.66 (0.58-0.75) P<0.001**	**0.65 (0.57-0.74) P<0.001**	**0.81 (0.70-0.93) P=0.004**	-	347/8,089 (4.29)	**1.88 (1.65-2.13) P<0.001**	**1.87 (1.65-2.13) P<0.001**	**2.06 (1.80-2.35) P<0.001**	-
Surgical injury	40/45,579 (0.09)	# (0.01)	**0.11 (0.03-0.47) P=0.003**	**0.12 (0.03-0.48) P=0.003**	**0.15 (0.04-0.59) P=0.007**	-	46/8,089 (0.57)	**6.67 (4.37-10.18) P<0.001**	**6.92 (4.56-10.49) P<0.001**	**8.12 (5.26-12.56) P<0.001**	-
Postnatal hospital stay >5 days†‡¥	1,410/45,579 (3.09)	427/20,375 (2.10)	**0.60 (0.53-0.67) P<0.001**	**0.61 (0.53-0.67) P<0.001**	**0.62 (0.55-0.71) P<0.001**	-	450/8,089 (5.56)	**1.63 (1.46-1.82) P<0.001**	**1.67 (1.50-1.87) P<0.001**	**1.74 (1.55-1.96) P<0.001**	-
Readmission to hospital within 42 days of birth[a]†‡¥	1,332/45,577 (2.92)	478/20,374 (2.35)	**0.82 (0.74-0.92) P<0.001**	**0.82 (0.73-0.91) P<0.001**	0.89 (0.79-1.01) P=0.061	-	232/8,089 (2.87)	1.02 (0.88-1.17) P=0.835	1.01 (0.88-1.16) P=0.899	1.04 (0.90-1.21) P=0.611	-
Any breastfeeding at birth or hospital discharge[b]	21,403/39,297 (54.46)	10,444/16,616 (62.86)	**1.17 (1.15-1.19) P<0.001**	**1.19 (1.17-1.21) P<0.001**	**1.19 (1.17-1.21) P<0.001**	**1.16 (1.14-1.18) P<0.001**	4,462/6,837 (65.26)	**1.21 (1.19-1.24) P<0.001**	**1.20 (1.18-1.22) P<0.001**	**1.14 (1.11-1.17) P<0.001**	**1.11 (1.08-1.14) P<0.001**
Exclusive breastfeeding at 6-8 week review[c]	9,788/39,251 (24.94)	5,723/17,046 (33.57)	**1.34 (1.30-1.38) P<0.001**	**1.40 (1.36-1.44) P<0.001**	**1.40 (1.35-1.44) P<0.001**	**1.33 (1.29-1.37) P<0.001**	2,362/7,044 (33.53)	**1.34 (1.29-1.39) P<0.001**	**1.32 (1.27-1.37) P<0.001**	**1.32 (1.27-1.38) P<0.001**	**1.26 (1.21-1.31) P<0.001**
Any breastfeeding at 6-8 week review[c]	13,556/39,251 (34.54)	7,336/17,046 (43.04)	**1.25 (1.22-1.28) P<0.001**	**1.29 (1.26-1.32) P<0.001**	**1.30 (1.27-1.34) P<0.001**	**1.25 (1.22-1.29) P<0.001**	3,160/7,044 (44.86)	**1.31 (1.27-1.35) P<0.001**	**1.27 (1.24-1.31) P<0.001**	**1.25 (1.21-1.30) P<0.001**	**1.20 (1.16-1.24) P<0.001**

Table continued overleaf

Table 4.6 (continued). Maternal and perinatal outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS

	ERCS	Planned and actually had VBAC					Planned VBAC but had in-labour non-elective repeat caesarean section				
	n outcome events/total N (%)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Perinatal outcomes[d]											
Adverse perinatal outcome[e]†‡¥	2,570/40,369 (6.37)	1,298/18,385 (7.06)	1.07 (1.00-1.15) P=0.065	1.06 (0.99-1.14) P=0.085	**1.17 (1.08-1.27) P<0.001**	**1.37 (1.26-1.48) P<0.001**	751/7,273 (10.33)	**1.61 (1.48-1.76) P<0.001**	**1.65 (1.51-1.80) P<0.001**	**1.72 (1.57-1.89) P<0.001**	**1.99 (1.82-2.19) P<0.001**
Intrapartum stillbirth or neonatal death	5/45,567 (0.01)	10/20,365 (0.05)	**4.60 (1.55-13.64) P=0.006**	NC	NC	NC	10/8,084 (0.12)	**11.63 (3.89-34.75) P<0.001**	NC	NC	NC
Admitted to a neonatal unit†‡¥	2,377/45,062 (5.27)	937/20,014 (4.68)	**0.85 (0.79-0.92) P<0.001**	**0.85 (0.78-0.92) P<0.001**	0.94 (0.86-1.03) P=0.182	**1.11 (1.01-1.21) P=0.023**	580/7,833 (7.40)	**1.38 (1.26-1.52) P<0.001**	**1.42 (1.29-1.56) P<0.001**	**1.49 (1.35-1.65) P<0.001**	**1.75 (1.58-1.93) P<0.001**
Resuscitation requiring drugs &/or intubation†‡¥	133/40,830 (0.33)	290/18,790 (1.54)	**4.62 (3.76-5.68) P<0.001**	**4.61 (3.74-5.67) P<0.001**	**5.24 (4.15-6.61) P<0.001**	**5.28 (4.18-6.67) P<0.001**	139/7,505 (1.85)	**5.58 (4.39-7.09) P<0.001**	**5.70 (4.48-7.26) P<0.001**	**5.85 (4.54-7.53) P<0.001**	**5.83 (4.51-7.52) P<0.001**
Apgar score <7 at 5 minutes†‡¥	192/45,194 (0.42)	232/20,094 (1.15)	**2.76 (2.28-3.33) P<0.001**	**2.74 (2.26-3.32) P<0.001**	**2.78 (2.25-3.45) P<0.001**	**2.92 (2.35-3.62) P<0.001**	173/7,998 (2.16)	**5.22 (4.24-6.42) P<0.001**	**5.36 (4.35-6.60) P<0.001**	**5.39 (4.33-6.72) P<0.001**	**5.64 (4.52-7.04) P<0.001**

[1] Base model adjusted for year of birth.
[2] Model A adjusted for year of birth & sociodemographic factors (maternal age, mother's country of birth, marital status/registration type, & socioeconomic status).
[3] Model B adjusted for variables in model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, interpregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder where † is shown, diabetes where ‡ is shown, & pre-labour rupture of membranes where ¥ is shown).
[4] Model C adjusted for variables in model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth, & birth weight centile).
[a] Women who died before discharge or were not discharged within 42 days of birth were excluded from analysis of overnight readmission to hospital (*n* = 3).
[b] Intrapartum stillbirths (*n* = 6) & births missing data on feeding at birth & hospital discharge (*n* = 11,287, 15.2%) were excluded from analysis of breastfeeding at birth or hospital discharge.
[c] Intrapartum stillbirths (*n* = 6), neonatal deaths (46), & births missing infant feeding data at 6–8 week review (*n* = 10,650, 14.4%) were excluded from analysis of breastfeeding outcomes at 6–8 weeks.
[d] All perinatal outcomes exclude deaths because of congenital abnormalities (*n* = 27) & any remaining intrapartum stillbirths (*n* = 5) & births missing the outcome in question (*n* = 1,102, 1.5% for admission to a neonatal unit; *n* = 6,886, 9.3% for resuscitation; *n* = 725, 1.0% for Apgar score) were additionally excluded from analysis of neonatal unit admission, resuscitation, & Apgar score.
[e] Includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation, or an Apgar score < 7 at 5 minutes.
#Numbers or numbers & percentages have not been shown to protect against potential disclosure risks.
Bold text indicates statistically significant findings at the 5% level.
OR's calculated for all outcomes shown apart from the breastfeeding outcomes, where RR's were instead calculated
Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; NC, not calculated because of low number of events; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean

4.4.5 Sensitivity analyses

Similar effect estimates were obtained from the complete case analyses (**Tables D.1-D.3** in **Appendix D**) compared to those obtained using imputed data for the partially observed covariates, although the effect of planned VBAC on puerperal sepsis and other puerperal infection was not statistically significant in the fully adjusted complete case analyses, noting these analyses would have had more limited power. In addition, the effect of planned VBAC without labour induction on maternal overnight readmission to hospital and the effect of in-labour non-elective repeat caesarean on puerperal sepsis was not statistically significant in the fully adjusted complete case analyses, again noting these analyses would have had more limited power. Restricting the analysis to births at 39 or more weeks' gestation resulted in little change in the effect estimates, although the effect of planned VBAC without labour induction on maternal overnight readmission to hospital and the effect of VBAC on other puerperal infection was not statistically significant in the fully adjusted models. By contrast, the effect of planned VBAC with labour induction on the mother's odds of having a postnatal stay greater than 5 days was only statistically significantly increased when the analysis was confined to births at 39 or more weeks' gestation (**Tables D.4-D.6** in **Appendix D**).

The E-values suggest that relatively strong unmeasured confounding would be needed to explain most of the observed associations between the exposures and outcomes (**Table D.7-D9** in **Appendix D**). For example, to fully explain the observed OR of 2.29 for the association between planned mode of birth after previous caesarean and blood transfusion (**Table 4.4**), an unmeasured confounder would need to be associated with at least a 4.01-fold increased risk of both the primary exposure and outcome through pathways independent of the many covariates included in the fully adjusted model; to move the lower CI to include the null, an unmeasured confounder would need to be associated with at least a 3.17-fold increased risk of both the primary exposure and outcome, above and beyond

the measured covariates. Identifying intrapartum stillbirths and neonatal deaths excluding deaths from congenital abnormalities from SSBID rather than NRS deaths, resulted in very similar effect estimates (**Table D.10** in **Appendix D**).

4.5 Discussion

4.5.1 Main findings

This population-based cohort study of term singleton births in Scotland to women with a history of one or more previous caesarean sections found that around 70% of women who planned a VBAC actually gave birth vaginally. Among women considered clinically eligible to have a planned VBAC, planned VBAC compared to ERCS was associated with an increased risk of the mother having uterine rupture, a blood transfusion, puerperal sepsis, and surgical injury as well as an increased risk of adverse perinatal outcomes. On the other hand, planned VBAC was associated with an increased likelihood of breastfeeding at birth or hospital discharge, and at 6-8 weeks postpartum. The association with the mother's risk of having a postnatal hospital stay greater than 5 days, an overnight readmission to hospital within 42 days of birth, and other puerperal infection differed according to whether she had at least one prior vaginal birth. In particular, the risk of these outcomes was reduced among women having a planned VBAC if they had at least one prior vaginal birth and was either not significantly different or increased in the case of other puerperal infection among those having a planned VBAC without any prior vaginal births. There was also evidence that planned VBAC was associated with an increased risk of the mother having a postnatal hospital stay greater than 5 days among women with two or more previous caesarean sections but not among women with just one previous caesarean.

Although there were significant differences in short-term outcomes between women who had a planned VBAC and those who had an ERCS, the absolute risk of adverse maternal and perinatal outcomes was small for either birth approach. Overall, just 1.8% of those

having a planned VBAC and 0.8% of those having an ERCS experienced serious maternal morbidity (uterine rupture, peripartum hysterectomy, blood transfusion, puerperal sepsis or surgical injury), and 8.0% of the planned VBAC and 6.4% of the ERCS group experienced one or more of the adverse perinatal outcomes considered. Most of the maternal morbidity in the planned VBAC group occurred among those who needed an in-labour non-elective repeat caesarean section.

4.5.2 Comparison with other studies and interpretation

The risk of uterine rupture associated with planned VBAC is well known, although reported risk estimates vary widely between studies, which is likely to reflect differences in study methodology, case definitions used or differences in the study populations such as the proportion of women who underwent induction of labour[67,199]. Although the absolute risk estimates for uterine rupture found in the study reported here are lower than frequently quoted rates[67], they are comparable to several population-based studies[79,101,121], including a UK national study that used validated case criteria[79].

Consistent with the findings of a systematic review conducted by the US Agency for Healthcare Research and Quality (AHRQ) of the literature between 1980 and September 2009[67], and comparable to a number of subsequent predominately small studies[95,98,109,110,117,123], the study presented here found no significant difference in the risk of hysterectomy between women who had a planned VBAC and those who had an ERCS. However, this study did find evidence that planned VBAC is associated with an increased risk of blood transfusion. The AHRQ review[67] also found evidence that planned VBAC is associated with an increased risk of blood transfusion, but only when the meta-analysis was restricted to the four studies of women who gave birth at term rather than at any gestational age (pooled estimates: 0.7% for planned VBAC versus 0.5% for ERCS, uRR 1.30, 95% CI 1.15-1.47). Since the AHRQ review, although a number of studies have found

no significant difference in the risk of blood transfusion between women who had planned VBAC and those that had an ERCS[95,100,121,123], a few of the larger studies have reported an elevated risk of this outcome for planned VBAC[103,109,112].

The AHRQ review reported that the overall risk of any type of maternal infection was not significantly different following planned VBAC compared to ERCS[67]. However, significant heterogeneity was apparent among the mostly small single-centre studies identified and the AHRQ review regarded the strength of evidence about maternal infection overall to be low because of the variability in how infection was defined and because the evidence was considered to be indirect and to have a high risk of bias. Although a more recent population-based study conducted in the UK reported that the risk of severe maternal sepsis did not significantly differ with planned VBAC compared to ERCS[110], a large population-based study conducted in the United States found an elevated risk of puerperal sepsis and major puerperal infection with planned VBAC[112], consistent with the overall findings of the study presented here. However, neither of these prior studies examined whether any associations were modified by previous vaginal birth. The study presented here, which specifically explored the impact of prior vaginal birth, suggests that prior vaginal birth modifies the relationship between planned mode of birth and other puerperal infection. In particular, planned VBAC compared to ERCS was associated with an increased risk of other puerperal infection in women without any prior vaginal birth but with a reduced risk of this outcome in those with one or more prior vaginal births. The study presented here also found evidence that the mother's risk of having either a postnatal hospital stay greater than 5 days or an overnight readmission to hospital within 42 days of birth, was significantly reduced for women who had a planned VBAC compared to ERCS only if they had at least one prior vaginal birth. This apparent protective effect of prior vaginal birth is consistent with several previous studies[109,198,200], and might be explained by women with compared to those without a prior vaginal birth having less complicated labours. It might also be explained by women

with a prior vaginal birth having quicker labours that are more likely to result in a successful VBAC as observed in previous studies[67], as well as the study presented here.

The study presented here also found evidence that the number of prior caesarean sections modifies the relationship between planned mode of birth and the mother's risk of having a postnatal hospital stay greater than 5 days, such that the risk of this outcome was significantly raised in women who had a planned VBAC compared to ERCS only if they had two or more prior caesarean sections. This might be explained by women planning VBAC following two or more prior caesareans experiencing more complications than those with just one prior caesarean, as suggested by a limited number of previous studies[89]. However, the study presented here did not find evidence that the effect of planned mode of birth on the other adverse outcomes considered varied according to the number of prior caesarean sections a woman had noting that few women in this study had more than two prior caesareans. The findings may alternatively reflect the fact that, in this study population, women who had a planned VBAC following two or more prior caesareans were less likely than those with just one prior caesarean to have a successful VBAC.

To the author's knowledge, this is the first study to examine the effects of mode of birth after previous caesarean on breastfeeding at 6-8 weeks postpartum and only two previous studies conducted in the United States have investigated the influence of mode of birth after previous caesarean on breastfeeding initiation[118,201]. Consistent with the findings of the study presented here, both of these previous studies reported that women who had a successful VBAC were more likely to initiate breastfeeding than those giving birth by ERCS. Additionally, comparable to the findings of the study presented here, one of the studies[118] reported that women giving birth by caesarean after an unsuccessful VBAC were also more likely to initiate breastfeeding than women giving birth by ERCS. The findings of the study presented here do not appear to be explained by differences in socio-demographic, maternal medical and obstetric-related factors. Instead, they may reflect a greater intention

to breastfeed, a higher level of breastfeeding self-efficacy, or a greater level of support to breastfeed among women who had a planned VBAC compared to ERCS.

In keeping with the findings of the AHRQ review[67], this study suggests that the risk of intrapartum stillbirth or neonatal death, excluding deaths from congenital abnormalities, is increased with planned VBAC compared to ERCS, although the absolute risk estimates found (0.07% for planned VBAC and 0.01% for ERCS) are on the lower range of those reported by the review. This may reflect the fact that only two of the studies identified by the AHRQ review were population-based and most of the studies did not exclude non-cephalic births, which are associated with a higher risk of adverse outcome including perinatal mortality[202,203]. Furthermore, the recruitment period of the identified studies extends back to the 1990s. Findings from such studies may have limited relevance to current populations owing to advances in obstetric and neonatal care and changes in clinical practice and population characteristics since this time. Having said that, the absolute and relative effect estimates found for intrapartum stillbirth or neonatal death are nevertheless within the range of those reported by a previous Scottish population-based study[164] included in the AHRQ review that was conducted in the 1990s, noting the wide confidence intervals reported in this earlier Scottish study (estimates 0.129%, 95% CI 0.079%-0.199% for planned VBAC versus 0.01%, 95% CI 0-0.061% for ERCS, aOR 11.7, 95% CI 1.4-101.6). The study presented here also adds to the limited evidence[67] about other measures of adverse perinatal outcome. The findings are consistent with two large population-based studies conducted in the United States[104,114], and several small non-population-based studies[96,98,121] that have reported an increased risk of various measures of neonatal morbidity or composite adverse neonatal outcome with planned VBAC compared to ERCS. The increased perinatal risks seen with planned VBAC may be related to complications experienced during labour or birth, most notably uterine rupture[60,61].

4.5.3 Strengths and limitations

A major strength of this study is its large population-based design, which not only minimised the risk of selection bias but also increased statistical power. The study was also able to assess the effect of planned mode of birth after previous caesarean on a comprehensive range of maternal and perinatal outcomes among women considered eligible to have a planned VBAC based on UK guidelines[8,22]. The inclusion of women in the ERCS group who are not eligible to have a planned VBAC has been highlighted as a key limitation with much of the existing literature[67]. Although the study presented here lacked the data to exclude all women with contraindications to planned VBAC, in particular those with any prior classical caesarean scars or previous uterine rupture, given the rarity of such contraindications the study is likely to have excluded the majority of ineligible women. Indeed, a previous study suggests that only 2% of women giving birth after previous caesarean in the UK have any previous non-low transverse incisions[79]. Another strength of the study presented here is that it was able to examine outcomes according to whether planned VBAC was attempted with or without labour induction compared to ERCS, which few previous studies have examined despite the potential of labour induction to influence risk estimates[141]. A further strength of this study is that it was possible to explore the influence of multiple *a priori* covariates on the associations studied, which many studies in this area have not done. However, there is a possibility that residual confounding due to unmeasured or mis-measured confounders could explain some or all the differences found. As discussed in the final chapter, while residual confounding is a potential source of bias in all observational studies, it can be a particular issue in studies using routinely-collected data. The E-values found for this study, however, suggest relatively strong unmeasured confounding would be needed to explain away most of the observed associations between the exposures and outcomes. It is also worth reiterating that although a large randomised controlled trial would be the gold-standard methodology for assessing the effects of planned mode of birth after previous caesarean, a previous study[98] provides strong evidence that such a trial is unlikely

to be feasible in practice, as few women are likely to consent to being randomised to planned mode of birth. Consequently, large population-based observational studies such as this study offer the best opportunity to inform evidence in this area.

The potential for the criteria used to define planned mode of birth to misclassify women who planned ERCS but went into labour before their scheduled caesarean date is recognised. However, restricting the analysis to births at 39 or greater weeks' gestation, the gestation recommended by UK guidelines to carry out ERCS[8,22], resulted in little change in the effect estimates. This suggests that the findings are robust to this potential misclassification. The possibility that some misclassification of the other variables of interest may have occurred is also acknowledged. As discussed in the final chapter, misclassification can represent a particular problem in studies using routinely-collected data. Misclassification could have either biased the findings towards the null or under- or overestimated effect estimates depending upon whether any misclassification was random (e.g. likelihood of outcome being misclassified same regardless of exposure status) or systematic (e.g. likelihood of outcome being misclassified related to exposure status) in nature, respectively. However, the completeness and quality of most routinely-collected Scottish data is considered to be very high, with some of the data sources containing statutorily collected data and many of the data sources undergoing regular quality assurance checks as outlined in Chapter 3. Furthermore, as also outlined in Chapter 3, prior to analysis, extensive data cleaning and checking was undertaken. The proportion of the study population that had missing data on one or more covariates is acknowledged as another limitation, although multiple imputation was used, which is considered a valid approach for handling this issue assuming the unobserved data are missing at random[204]. Lastly, although all the analyses were pre-specified based on clear hypotheses and biological plausibility, the performance of multiple comparisons would have increased the risk of type 1 errors. That is, finding statistically significant associations that are not in fact true associations. However, it is worth noting that

using a more stringent p-value to allow for multiple testing would not have altered the main findings.

4.5.4 Conclusions

This study found that among women considered clinically eligible to have a planned VBAC, planned VBAC compared to ERCS was associated with an increased risk of the mother having serious birth related maternal and perinatal complications. Conversely, the study found planned VBAC was associated with an increased likelihood of breastfeeding, whereas the effect on other maternal outcomes appeared to differ according to whether a woman had any prior vaginal births and the number of prior caesarean sections she had. However, the absolute risk of adverse maternal and perinatal outcomes was small for either birth approach.

5

PLANNED MODE OF BIRTH AFTER PREVIOUS CAESAREAN SECTION AND WOMEN'S USE OF PSYCHOTROPIC MEDICATION IN THE FIRST YEAR POSTPARTUM: A POPULATION-BASED RECORD LINKAGE COHORT STUDY

5.1 Introduction and chapter overview

As mentioned in Chapter 1, concerns have been raised that caesarean section may adversely affect women's mental health by, for example, restricting perceived control over birth, violating expectations about childbirth, disrupting physiological hormonal processes, and leading to a more painful and difficult postnatal recovery[26,27]. However, studies examining the association between mode of birth and women's mental health have reported mixed findings[205-208]. This may partly reflect limitations with the existing studies, with many comprising small non-population-based studies that have focused on the effect of actual mode of birth without differentiating between planned and emergency caesarean despite the very different contexts in which these two types of caesareans are performed. Most previous studies have also not considered potential effects on mental health problems other than postnatal depression. Also, to the author's knowledge, to date only one small study of under 300 women[97] conducted in a single hospital has specifically investigated the effect of planned mode of birth after previous caesarean on women's mental health. As discussed in Chapter 1, studies conducted in the general obstetric population or in women without a

previous caesarean may not be applicable to the situation of birth after previous caesarean as they are more prone to confounding by indication, where adverse outcomes may be a consequence of the underlying causes that led to the need for the caesarean. Furthermore, as certain serious birth-related complications such as uterine rupture, which may adversely affect women's mental health[209], predominately only occur or are more common following a planned VBAC[1,79], planned VBAC compared to ERCS may actually be associated with poorer subsequent maternal mental health.

In addition to providing further information to counsel women, maternal mental health problems have the potential to have a profound impact on the women, her infant and other family members[210], and thus it is important to better understand the aetiology and triggers for such problems to help identify potential targets for intervention. This chapter describes the second population-based cohort study conducted to address more of the evidence gaps identified. The research presented in this chapter has been published in Psychological Medicine[2].

5.2 Objective

The objective of this study was to investigate the association between planned mode of birth after previous caesarean section and women's use of psychotropic medication in the first year postpartum as an indication of their subsequent risk of having mental health problems sufficiently severe as to require medication, among women giving birth to a singleton at term and considered clinically eligible to plan a VBAC (research objective 3).

5.3 Methods

5.3.1 Study population

The data sources, codes and database fields used to identify the population for this study are detailed in **Table 5.1**. The study population included women with a history of one or more previous caesarean sections who gave birth to a singleton baby at term (37-41 completed weeks' gestation) in Scotland, UK, between 1st January 2010 and 31st December 2015. The same exclusions as those used in study one were applied as described in section 4.3.1. In brief, this included excluding the following: births to women not considered clinically eligible to plan VBAC based on UK guidelines[8,22]; births to women who had an antepartum stillbirth; stillbirths missing information about whether they occurred antenatally or intrapartum; births missing information on mode of birth or gestational age at birth; births by non-elective caesarean section missing information about duration of labour; and births to women whose number of previous caesarean sections was greater than their recorded parity. In addition, to identify incident events of psychotropic drug use, all women dispensed any of the primary outcome medications in the year before they gave birth were excluded. Women migrating to Scotland less than one year before they gave birth were also excluded to ensure there was information on their history of psychotropic medication use for at least one year before giving birth. Each woman was followed up from the date they gave birth until the outcome event of interest (section 5.3.3), date of emigration, death, or one year after they gave birth, whichever came first.

Table 5.1. Data sources, codes and database fields used to identify the study two population

	Data source	Database fields/codes
Inclusion criteria		
≥ 1 previous caesarean sections	SMR02	Previous caesarean sections field ≥1 OR at least one previous delivery with a code for caesarean section in mode of delivery field (7 or 8) &/or an OPCS-4 or OPCS-3 code for caesarean section (R17-R18, R251, 764-766, 769), using SMR02 records going back as far as 1981
Singleton birth	NRS live births & stillbirths	Numbirths field=1
Term birth	SMR02	Gestation at birth 37-41 completed weeks according to Estimated gestation field (containing number of completed weeks of gestation as judged by the clinician, usually on the basis of ultrasound) OR according to gestation derived from date of delivery & date of last menstrual period fields if Estimated gestation missing (0.06% of eligible births)
Exclusion criteria		
Non-cephalic presentation	SMR02	Delivery episodes with a code for breech or shoulder in presentation at delivery field (4 or 6) OR a code for breech delivery or breech extraction in mode of delivery field (5 or 6) OR an ICD-10 code for breech delivery or breech extraction (O801, O830-O831) OR an OPCS-4 code for breech delivery or breech extraction (R19-R20) OR an ICD-10 code for maternal care for malpresentation of fetus (0320-0322, 0326-0329)
Placenta praevia	SMR02	Delivery episodes with an ICD-10 code for placenta praevia (O440-O441)
Abdominal pregnancy	SMR02	Delivery episodes with an ICD-10 code for delivery of or maternal care for viable fetus in abdominal pregnancy (O833, O367)
Known or suspected disproportion of maternal &/or fetal origin	SMR02	Delivery episodes with an ICD-10 code for maternal care for known or suspected disproportion (O33)
Tumour of corpus uteri	SMR02	Delivery episodes with an ICD-10 code for maternal care for tumour of corpus uteri (O341)
Pre-labour non-elective caesarean section	SMR02	Code for non-elective caesarean section in mode of delivery field (8) AND duration of labour field=0
Antepartum stillbirth	NRS stillbirths	Code for antepartum stillbirth in period of death field (1)
Migrated to Scotland < 1 year before birth	CHI database & SMR02	Derived from date of immigration & date of delivery fields

Abbreviations: CHI, Community Health Index; ICD-10, International Classification of Diseases 10th revision; NRS, National Records of Scotland; OPCS-3, Office of Population Censuses & Surveys Classification of Surgical Operations & Procedures 3rd revision; OPCS-4, Office of Population Censuses & Surveys Classification of Surgical Operations & Procedures 4th revision; SMR02, Scottish Morbidity Record Maternity Inpatient & Day Case Dataset

5.3.2 Exposure variables

The exposures of interest are detailed in section 3.2.4. In brief, the primary exposure of interest was planned mode of birth after previous caesarean section with planned VBAC (birth vaginally or by non-elective caesarean section with a duration of labour of ≥1 hour) compared to ERCS (birth by elective repeat caesarean). Analyses were also performed according to whether planned VBAC was attempted with or without labour induction compared to ERCS and according to actual mode of birth after previous caesarean section (actual VBAC, in-labour non-elective repeat caesarean section or ERCS).

5.3.3 Outcomes

The data sources, codes and database fields used to identify the outcomes of interest are detailed in **Table 5.2**. The primary outcome was time to first dispensed prescription for any psychotropic medication within the first year postpartum, including medicines in any of the following 'legacy' British National Formulary (BNF) sections[211]: 4.3 'Antidepressant drugs', used to treat a range of affective symptomatology including depressive disorders, anxiety disorders and mixed symptomatology; 4.1.1 'Hypnotics', used to treat insomnia; 4.1.2 'Anxiolytics', used to treat anxiety; and 4.2 'Drugs used in psychoses and related disorders'.

Secondary outcomes included time to first dispensed prescription within the first year postpartum for specific categories of psychotropic medications, analysing antidepressants (BNF 4.3), hypnotics and/or anxiolytics (BNF 4.1.1 and/or 4.1.2), and drugs used in psychoses and related disorders (BNF 4.2) as three separate outcomes. Being dispensed at least two consecutive prescriptions for an antidepressant was also examined as an outcome, where the first antidepressant was dispensed within the first year postpartum followed by at least one additional prescription for an antidepressant within 91 days of the first. Most antidepressants were dispensed over monthly intervals. A 91-day cut-off was used to allow for women decreasing their dosage for a period, using stored medication or the late collection of a repeat prescription.

Although these drugs reflect the main categories used for the treatment of mental health problems, some can be used for other indications. In the absence of data on reason for prescribing, an attempt was made to exclude drugs likely to have been prescribed for other indications by excluding tricyclic antidepressants prescribed at a lower dose than the recommended BNF level for the treatment of depression (see **Table 5.2**), as lower doses may be prescribed for other reasons such as chronic pain.

Table 5.2. Data sources, codes and database fields used to identify the study two outcomes

	Data source	Database fields/codes
Dispensed any psychotropic medication	PIS	First dispensed date within 12 months of delivery date for any medications in the 'legacy' BNF[211] subsection 40101 (Hypnotics) or 40102 (Anxiolytics), or BNF section code 402 (Drugs used in psychoses & related disorders) or BNF subsection codes 40301 (Tricyclic & related antidepressant drugs), 40302 (Monoamine-oxidase inhibitors), 40303 (Selective serotonin re-uptake inhibitor) or 40304 (Other antidepressant drugs), excluding BNF item description "Amitriptlyine Hcl Tab 10mg"
Dispensed an antidepressant	PIS	First dispensed date within 12 months of delivery date for any medications in the BNF subsection 40301 (Tricyclic & related antidepressant drugs), 40302 (Monoamine-oxidase inhibitors), 40303 (Selective serotonin re-uptake inhibitor) or 40304 (Other antidepressant drugs), excluding BNF item description "Amitriptlyine Hcl Tab 10mg"
Dispensed at least two consecutive prescriptions for an antidepressant	PIS	First dispensed date within 12 months of delivery date for any medications in the BNF subsection 40301 (Tricyclic & related antidepressant drugs), 40302 (Monoamine-oxidase inhibitors), 40303 (Selective serotonin re-uptake inhibitor) or 40304 (Other antidepressant drugs), that was followed by at least one consecutive prescription for any medications in the BNF subsection 40301, 40302, 40303 or 40304, not including BNF item description "Amitriptlyine Hcl Tab 10mg". Prescriptions were considered to be consecutive if the second prescription was dispensed within 91 days of the first dispensed prescription
Dispensed a hypnotic &/or anxiolytic	PIS	First dispensed date within 12 months of delivery date for any medications in the BNF subsection 40101 (Hypnotics) or 40102 (Anxiolytics)
Dispensed an antipsychotic &/or related drug	PIS	First dispensed date within 12 months of delivery date for any medications in the BNF section 402 (Drugs used in psychoses & related disorders)

Abbreviations: BNF, British National Formulary; PIS, Prescription Information System

5.3.4 Statistical analysis

The statistical analyses are detailed in section 3.2.7. In brief, associations between the exposures and outcomes were examined using Cox proportional hazards models to estimate HRs and 95% CIs. All models were adjusted for year of birth. Models were then sequentially adjusted for *a priori* covariates as described in section 3.2.7, with a detailed description of the covariates found in section 3.2.6. Categorical covariates were fitted in the models using the categories shown in **Table 3.3**. Linearity of continuous covariates was investigated using fractional polynomials as described in section 3.2.7. Evidence of effect modification between the exposures and breastfeeding at 6-8 weeks postpartum was examined to further explore the potential effect of breastfeeding on the associations considered. The number of previous caesarean sections a woman had and whether the woman had any prior vaginal births were also investigated as potential effect modifiers of the relationship between the primary exposure and outcomes given the plausibility that

some potential mechanisms by which mode of birth may impact on the outcomes may vary according to these factors. For example, mode of birth may affect women's mental health by not meeting expectations about childbirth or influencing the likelihood of birth-related complications, but the effects of mode of birth on these potential mechanisms may plausibly vary according to the number of previous caesarean sections a woman has had and whether the woman has had any prior vaginal births. Effect modification was explored by adding interaction terms to the full models. None of the exposures of interest, but one or more of the covariates in some models appeared to violate the proportional hazards assumption. That is, the assumption that the HR are constant over time, assessed as described in section 3.2.7. The author of this thesis decided not to model these covariates as time-varying covariates (a strategy for dealing with non-proportional hazards), as some of the models took a long time to converge using this approach and did not appear to have any material effect on the exposure estimates. Multiple imputation was used to impute partially observed covariates as described in section 3.2.8.

5.3.5 Sensitivity analyses

In addition to conducting the three sensitivity analyses described in section 3.2.9 (complete case, repeating analyses restricted to births at ≥39 weeks' gestation, and calculating E-values), a further sensitivity analysis was performed in which analyses were repeated restricting the study population to women without a history of being dispensed any of the primary outcome medications in the two (rather than one) years before they gave birth. As the prescription information was only available from 2009, only eligible women who gave birth between 1st January 2011 and 31st December 2015 and did not migrate to Scotland less than 2 years before they gave birth were included in this sensitivity analysis.

5.4 Results

5.4.1 Study population

A total of 31,131 singleton term births to women with a history of one or more previous caesarean sections met the study eligibility criteria (**Figure 5.1**). Overall, 32.8% (10,220) of the women had a planned VBAC and 67.2% (20,911) had an ERCS. The ERCS rate increased over the study period from 64.5% in 2010 to 71.9% in 2015. Women who had a planned VBAC were more likely than those who had an ERCS to be younger, born outside the UK, and be of lower socio-economic status (**Table 5.3**). They were also more likely to have had just one prior caesarean, at least one previous vaginal birth, a shorter inter-pregnancy interval, be smokers at booking for pregnancy care, have a hypertensive disorder, experienced an adverse perinatal outcome or maternal intrapartum or postpartum complication in the current pregnancy, and have breastfed at 6-8 weeks postpartum. They were less likely than those who had an ERCS to have experienced a prior stillbirth or neonatal death, be overweight or obese, or to have diabetes.

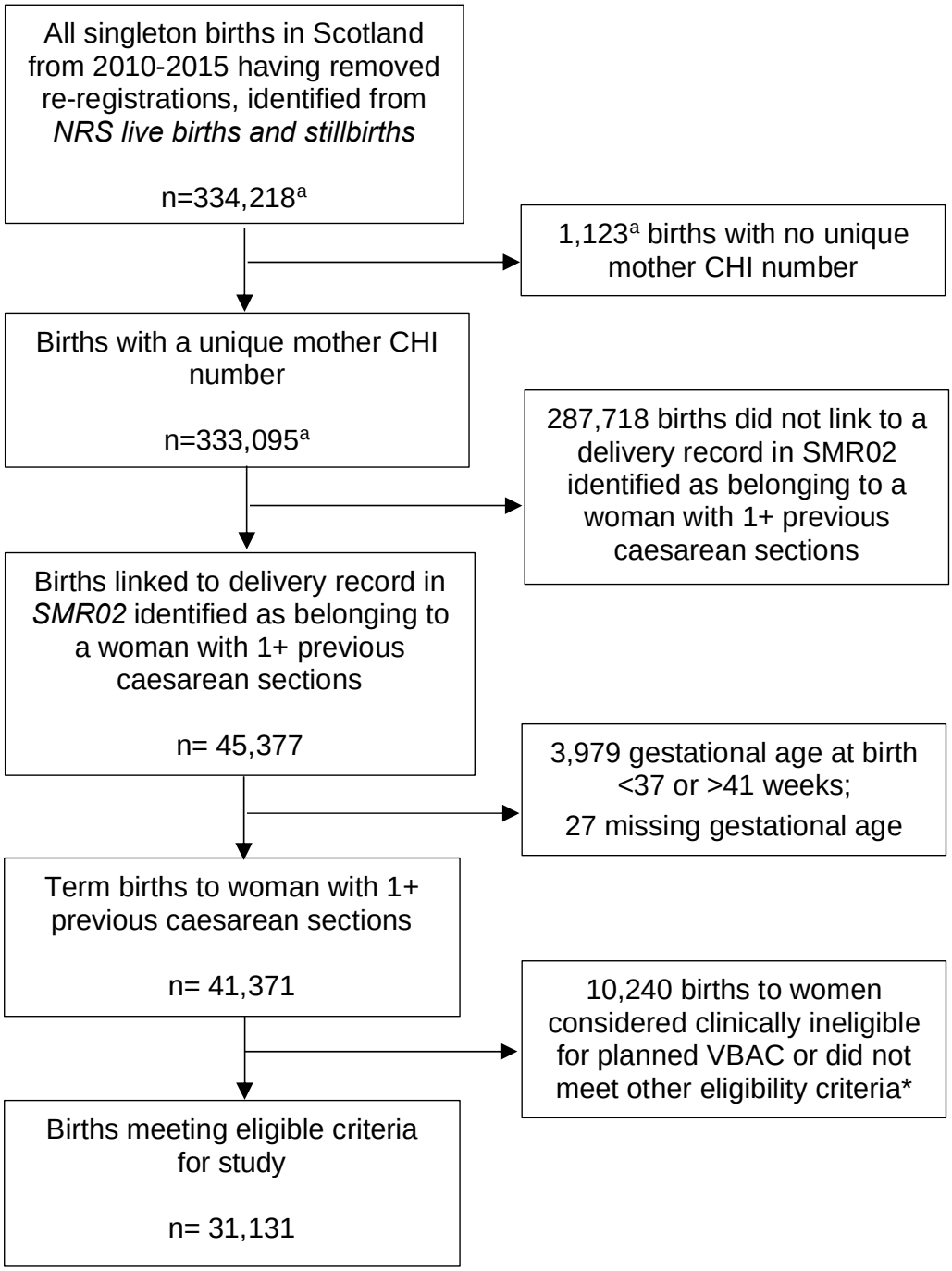


Figure 5.1. Flow diagram of cohort identification for study two

[a] Numbers provided by ISD Scotland, now part of Public Heath Scotland.

* Clinically ineligible for planned VBAC or did not meet other eligibility criteria for study because of one or more of the following: non-cephalic presentation at birth (n=2,214); placenta praevia (n=289); abdominal pregnancy (n=1); known or suspected disproportion of maternal &/or fetal origin (n=23); tumour of corpus uteri (n=150); birth by pre-labour non-elective caesarean section (n=2,279); antepartum stillbirth (n=54); dispensed any of the primary outcome medications in the year before birth (n=5,006); migrated to Scotland less than one year before birth (n=234); stillbirth missing time of death in relation to birth (n=1); missing information on mode of birth (n=3); births by non-elective caesarean section missing information about duration of labour (n=984); & number of previous caesarean sections greater than parity (n=145). Reasons not mutually exclusive.

Abbreviations: CHI, community health index; ISD, Information Services Division; NRS, National Records of Scotland; SMR02, Scottish Morbidity Record Maternity Inpatient & Day Case dataset; VBAC, vaginal birth after previous caesarean

Table 5.3. Characteristics of the study two cohort by planned mode of birth after previous caesarean section

	ERCS n (%)[a], unless otherwise stated (n=20,911)	Planned VBAC n (%)[a], unless otherwise stated (n=10,220)
Sociodemographic characteristics		
Maternal age (years)		
Less than 25	1,871 (8.9)	1,146 (11.2)
25-29	4,756 (22.7)	2,510 (24.6)
30-34	7,269 (34.8)	3,645 (35.7)
35-39	5,553 (26.6)	2,429 (23.8)
40 or more	1,462 (7.0)	490 (4.8)
Median (IQR) maternal age (years)	32 (28-36)	32 (28-35)
Mother's country of birth		
UK	17,900 (85.6)	8,406 (82.3)
Non-UK	3,011 (14.4)	1,814 (17.7)
Marital status/registration type		
Married or joint registration/same address	18,766 (89.7)	9,201 (90.0)
Joint registration/different address	1,594 (7.6)	726 (7.1)
Sole registration	551 (2.6)	293 (2.9)
Socioeconomic status[b]		
Managerial/professional	10,479 (50.1)	5,140 (50.3)
Intermediate	4,429 (21.2)	1,987 (19.4)
Routine/manual	5,261 (25.2)	2,611 (25.5)
Other[c]	742 (3.5)	482 (4.7)
Maternal medical & pregnancy-related characteristics		
Number of previous caesarean sections		
1	15,996 (76.5)	9,821 (96.1)
2 or more	4,915 (23.5)	399 (3.9)
Median (IQR) number of previous caesarean sections	1 (1-1)	1 (1-1)
Any prior vaginal birth[d]		
No	17,330 (83.1)	6,153 (60.4)
Yes	3,517 (16.9)	4,039 (39.6)
Parity[d]		
1	13,458 (64.6)	5,957 (58.5)
2 or more	7,385 (35.4)	4,219 (41.5)
Median (IQR) parity[d]	1 (1-2)	1 (1-2)
Interpregnancy interval (months)[d]		
24 or more	11,634 (60.0)	4,629 (55.3)
12-23	5,192 (26.8)	2,441 (29.1)
Less than 12	2,568 (13.2)	1,307 (15.6)
Median (IQR) interpregnancy interval (months)[d]	29.1 (17.3-48.5)	26.3 (15.8-45.3)
Any prior stillbirth or neonatal death[d]		
No	20,356 (97.6)	10,025 (98.4)
Yes	506 (2.4)	168 (1.7)
Mother smoked at booking[d]		
No	17,295 (86.8)	8,241 (83.3)
Yes	2,637 (13.2)	1,649 (16.7)
Maternal BMI at booking (kg/m^2)[d]		
Less than 25	7,113 (36.7)	4,676 (48.5)
25-29.9	5,919 (30.5)	2,843 (29.5)
30 or more	6,374 (32.8)	2,128 (22.1)

Table continued overleaf

Table 5.3 (continued). Characteristics of the study two cohort by planned mode of birth after previous caesarean section

		ERCS n (%)[a], unless otherwise stated (n=20,911)	Planned VBAC n (%)[a], unless otherwise stated (n=10,220)
Median (IQR) BMI at booking (kg/m^2)[d]		26.9 (23.5-31.9)	25.2 (22.4-29.3)
Any hypertensive disorder		694 (3.3)	430 (4.2)
Pre-existing or gestational diabetes		1,081 (5.2)	253 (2.5)
Intrapartum & postpartum characteristics			
Adverse perinatal outcome[d,e]			
	No	18,065 (94.7)	8,956 (93.9)
	Yes	1,020 (5.3)	580 (6.1)
Maternal intrapartum or postpartum complication[f]			
	No	19,901 (95.2)	9,270 (90.7)
	Yes	1,010 (4.8)	950 (9.3)
Any breastfeeding at 6-8 week review[d]			
	No	12,208 (63.6)	5,007 (52.5)
	Yes	6,990 (36.4)	4,525 (47.5)

[a] Percentage of those with complete data.

[b] Socioeconomic status of mother for sole registered birth or highest of mother's or father's socioeconomic status for births registered inside marriage or jointly registered by both parents outside marriage. Socioeconomic status defined by NS-SEC based on occupation & employment status.

[c] Other includes never worked/long-term unemployed, student, not stated, or not classifiable.

[d] Missing data: any prior vaginal birth 92 (0.30%); parity 112 (0.36%); interpregnancy interval 3,360 (10.8%); any prior stillbirth or neonatal death 76 (0.24%); maternal smoking status 1,309 (4.20%); maternal BMI 2,078 (6.68%); adverse perinatal outcome 2,510 (8.77%); any breastfeeding at 6-8 week review 2,401 (7.71%).

[e] Adverse perinatal outcome includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation with drugs &/or intubation or an Apgar score <7 at 5 minutes.

[f] Intrapartum or postpartum complication includes uterine rupture, peripartum hysterectomy, blood transfusion, puerperal sepsis, other puerperal infection, surgical injury (damage to bowel, bladder or ureter requiring surgical repair), third- or fourth-degree perineal tear or overnight readmission to hospital within 42 days of birth.

Abbreviations: BMI, body mass index; ERCS, elective repeat caesarean section; IQR, interquartile range; NS-SEC, National Statistics Socio-Economic Classification; VBAC, vaginal birth after previous caesarean

5.4.2 Outcome event rates

Less than 1% of the study population were lost to follow-up because of emigration or death, with these women contributing person-years up to the date of loss. During 29,097 person-years of follow-up, 3,585 (11.5%) of the study population were dispensed at least one prescription for any psychotropic medication. Antidepressants were the most common type of psychotropic medication dispensed, with 9.9% of women dispensed an antidepressant, 2.9% dispensed a hypnotic and/or anxiolytic, and 0.20% dispensed an antipsychotic and/or related drug. Crude rates of first dispensed prescription for any psychotropic medication, an antidepressant, and at least two consecutive antidepressants peaked around month two to three following childbirth, whereas crude rates of first dispensed prescription for a hypnotic and/or anxiolytic or an antipsychotic and/or related drug remained fairly constant over the follow-up period (**Figure 5.2**). At each month in the first year postpartum, rates of any psychotropic medication or antidepressants tended to be higher in women who had an ERCS than in those who planned a VBAC.

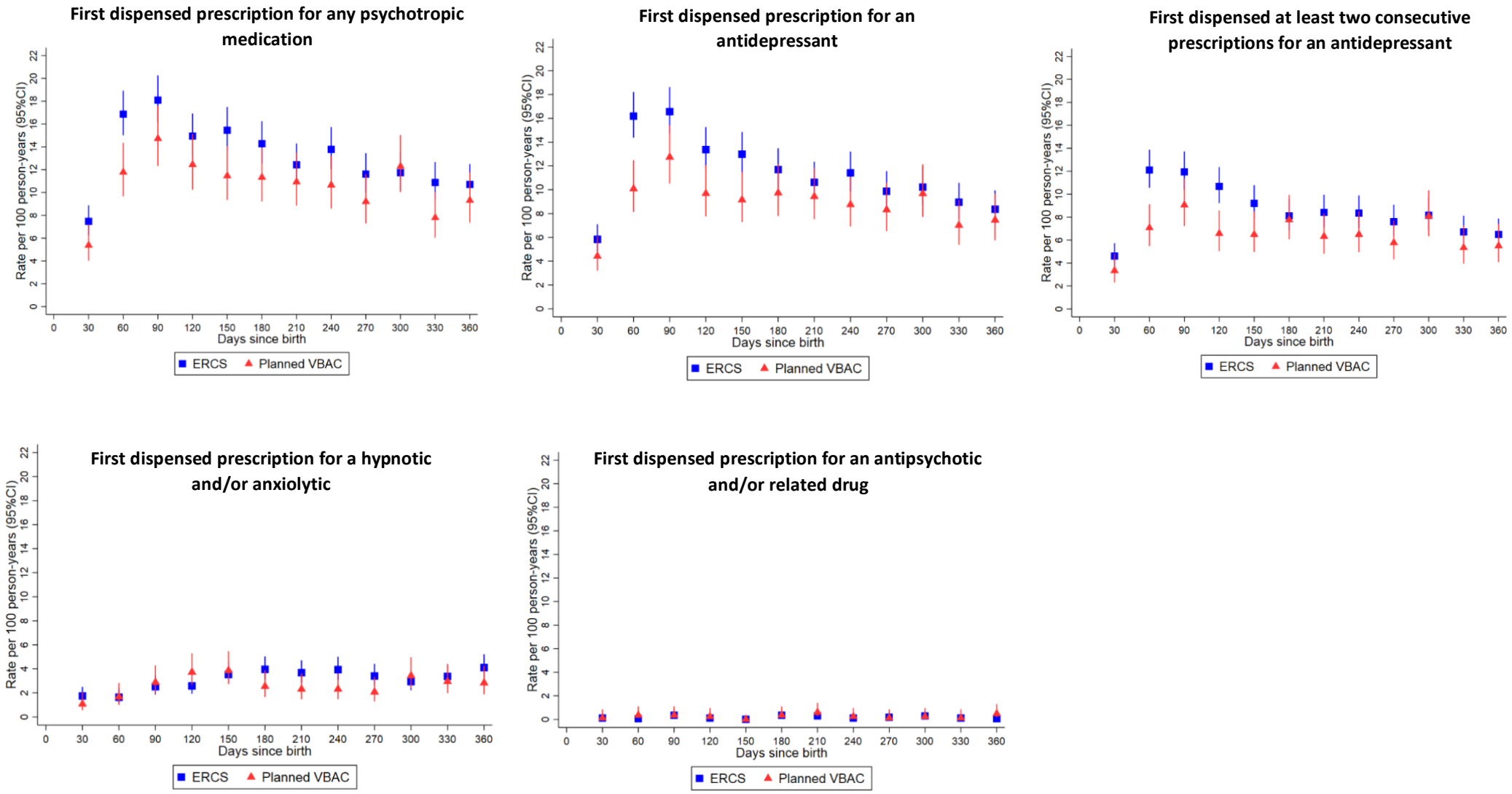


Figure 5.2. Crude rates of each outcome over the first year postpartum

Abbreviations: CI, confidence interval; ERCS, elective repeat caesarean section; VBAC, vaginal birth after previous caesarean

5.4.3 Planned VBAC compared to ERCS

Outcomes according to planned mode of birth are shown in **Table 5.4 and Figure 5.3A**. Having only adjusted for year of birth, women who planned a VBAC had a significantly lower risk than those giving birth by ERCS of being dispensed any psychotropic medication (HR 0.80, 95% CI 0.75 to 0.87) and all categories of psychotropic medication (antidepressant: HR 0.78, 95% CI 0.72 to 0.85; at least two consecutive antidepressants: HR 0.76, 95% CI 0.69 to 0.83; and hypnotic and/or anxiolytic 0.85: 95% CI 0.74 to 0.99) except antipsychotic and/or related drugs (HR 1.54, 95% CI 0.94 to 2.52). Adjustment for socio-economic factors and maternal medical and pregnancy-related factors had little material impact on the effect estimates. Adjusting for any breastfeeding at 6-8 weeks postpartum slightly attenuated all the effect estimates, but the risk of being dispensed any psychotropic medication (aHR 0.85, 95% CI 0.78 to 0.92), an antidepressant (aHR 0.83, 95% CI 0.76 to 0.90), and at least two consecutive antidepressants (aHR 0.83, 95% CI 0.75 to 0.91) remained significantly lower in women who planned a VBAC compared to giving birth by ERCS. There was no evidence of effect modification between planned mode of birth and the number of prior caesareans a woman had, or whether the woman had any prior vaginal births (P-values for interaction all >0.05).

Table 5.4. Outcomes following planned VBAC compared to ERCS

Outcomes	ERCS Number of events/person-years (Rate per 100 person-years)	Planned VBAC Number of events/person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	2,565/19,459 (13.18)	1,020/9,638 (10.58)	**0.80 (0.75-0.87) P<0.001**	**0.80 (0.75-0.86) P<0.001**	**0.80 (0.74-0.87) P<0.001**	**0.85 (0.78-0.92) P<0.001**
Dispensed an antidepressant	2,228/19,620 (11.36)	859/9,722 (8.84)	**0.78 (0.72-0.85) P<0.001**	**0.78 (0.72-0.84) P<0.001**	**0.78 (0.72-0.85) P<0.001**	**0.83 (0.76-0.90) P<0.001**
Dispensed at least two consecutive prescriptions for an antidepressant	1,702/19,913 (8.55)	633/9,843 (6.43)	**0.76 (0.69-0.83) P<0.001**	**0.76 (0.69-0.83) P<0.001**	**0.77 (0.70-0.85) P<0.001**	**0.83 (0.75-0.91) P<0.001**
Dispensed a hypnotic &/or anxiolytic	637/20,535 (3.10)	267/10,040 (2.66)	**0.85 (0.74-0.99) P=0.032**	0.87 (0.75-1.00) P=0.054	**0.83 (0.71-0.97) P=0.021**	0.88 (0.76-1.03) P=0.119
Dispensed an antipsychotic &/or related drug	36/20,800 (0.17)	27/10,152 (0.27)	1.54 (0.94-2.52) P=0.088	1.50 (0.90-2.49) P=0.116	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

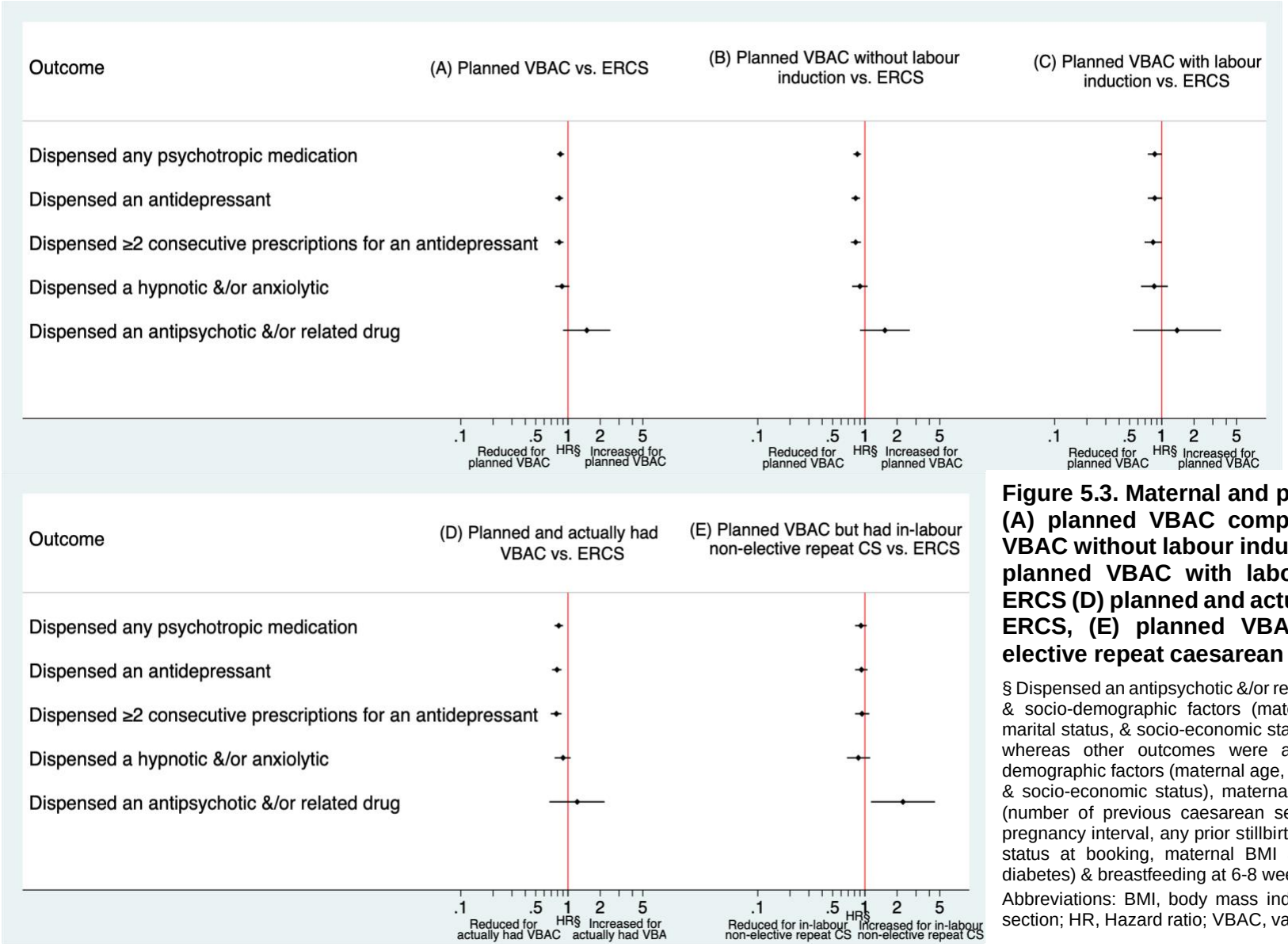


Figure 5.3. Maternal and perinatal outcomes following (A) planned VBAC compared to ERCS (B) planned VBAC without labour induction compared to ERCS (C) planned VBAC with labour induction compared to ERCS (D) planned and actually had VBAC compared to ERCS, (E) planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS

§ Dispensed an antipsychotic &/or related drug only adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status) because of low number of events, whereas other outcomes were adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status & socio-economic status), maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes) & breastfeeding at 6-8 weeks postpartum.

Abbreviations: BMI, body mass index; ERCS, elective repeat caesarean section; HR, Hazard ratio; VBAC, vaginal birth after previous caesarean

5.4.4 Planned VBAC with and without labour induction compared to ERCS

Of the women who planned a VBAC, 19.3% (1,960/10,180) had their labour induced (30.3% using surgical induction alone, 33.5% using medical induction alone and 34.7% using surgical and medication induction). Outcomes by whether planned VBAC was attempted with or without labour induction compared to ERCS (**Table 5.5** and **Figure 5.3B and 5.3C**) were very similar to those reported for planned VBAC compared to ERCS. Compared to the women who gave birth by ERCS, women who planned a VBAC with or without labour induction had a significantly reduced risk of being dispensed any psychotropic medication even having adjusted for breastfeeding (aHR 0.86, 95% CI 0.74 to 1.00 and aHR 0.85, 95% CI 0.78 to 0.92 respectively). There was also evidence that women who planned a VBAC with or without labour induction had a reduced risk of being dispensed an antidepressant and at least two consecutive antidepressants. However, for women who planned a VBAC with labour induction these effects were not statistically significant having adjusted for breastfeeding noting the smaller number of women in this subgroup.

Table 5.5. Outcomes following planned VBAC with and without labour induction compared to ERCS

Outcomes	ERCS	Planned VBAC without labour induction					Planned VBAC with labour induction				
	Number of events/ person-years (Rate per 100 person-years)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	2,565/19,459 (13.18)	805/7,758 (10.38)	**0.79 (0.73-0.85) P<0.001**	**0.80 (0.73-0.86) P<0.001**	**0.80 (0.74-0.87) P<0.001**	**0.85 (0.78-0.92) P<0.001**	212/1,841 (11.51)	0.87 (0.76-1.01) P=0.060	**0.83 (0.72-0.96) P=0.012**	**0.81 (0.70-0.94) P=0.005**	**0.86 (0.74-1.00) P=0.046**
Dispensed an antidepressant	2,228/19620 (11.36)	673/7,825 (8.60)	**0.76 (0.70-0.83) P<0.001**	**0.76 (0.70-0.83) P<0.001**	**0.77 (0.70-0.85) P<0.001**	**0.82 (0.75-0.90) P<0.001**	183/1,858 (9.85)	0.87 (0.74-1.01) P=0.065	**0.82 (0.71-0.96) P=0.011**	**0.81 (0.69-0.95) P=0.009**	0.86 (0.74-1.01) P=0.065
Dispensed at least two consecutive prescriptions for an antidepressant	1,702/19,913 (8.55)	499/7,915 (6.30)	**0.74 (0.67-0.82) P<0.001**	**0.75 (0.68-0.83) P<0.001**	**0.77 (0.69-0.86) P<0.001**	**0.82 (0.74-0.92) P<0.001**	132/1,889 (6.99)	**0.82 (0.68-0.98) P=0.026**	**0.78 (0.66-0.94) P=0.008**	**0.78 (0.65-0.94) P=0.008**	0.83 (0.69-1.00) P=0.055
Dispensed a hypnotic &/or anxiolytic	637/20,535 (3.10)	214/8,074 (2.65)	**0.85 (0.73-0.99) P=0.042**	0.87 (0.75-1.02) P=0.088	**0.85 (0.72-1.00) P=0.048**	0.90 (0.76-1.06) P=0.200	53/1,926 (2.75)	0.89 (0.67-1.17) P=0.405	0.87 (0.66-1.15) P=0.332	0.80 (0.60-1.07) P=0.137	0.85 (0.64-1.14) P=0.289
Dispensed an antipsychotic &/or related drug	36/20,800 (0.17)	22/8,161 (0.27)	1.56 (0.92-2.64) P=0.098	1.54 (0.90-2.63) P=0.117	NC	NC	5/1,951 (0.26)	1.48 (0.58-3.78) P=0.412	1.39 (0.54-3.58) P=0.493	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status)

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

5.4.5 Actual VBAC and in-labour non-elective repeat caesarean section compared to ERCS

Of the women who planned a VBAC, 71.6% (7,314/10,220) went on to actually have a VBAC and 28.4% (2,906/10,220) went on to have an in-labour non-elective repeat caesarean. Compared to the women who gave birth by ERCS, both the women who actually had a VBAC and the women planning a VBAC who actually gave birth by in-labour non-elective repeat caesarean had a reduced risk of being dispensed any psychotropic medication, an antidepressant, and at least two consecutive antidepressants. However, for women who had an in-labour non-elective repeat caesarean the effect sizes were smaller and not statistically significant in the fully adjusted models (**Table 5.6** and **Figure 5.3D and 5.3E**). Women giving birth by in-labour non-elective repeat caesarean had a significantly increased risk compared to those giving birth by ERCS of being dispensed an antipsychotic and/or related drug having adjusted for year of birth alone or year of birth in addition to socio-demographic factors. However, due to the small number of outcome events it was not possible to adjust for additional factors that may influence this association.

Table 5.6. Outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS

Outcomes	ERCS	Planned and actually had VBAC					Planned VBAC but had in-labour non-elective repeat caesarean section				
	Number of events/ person-years (Rate per 100 person-years)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	2,565/19,459 (13.18)	725/6,900 (10.51)	**0.80 (0.73-0.87) P<0.001**	**0.79 (0.72-0.85) P<0.001**	**0.78 (0.71-0.85) P<0.001**	**0.82 (0.75-0.90) P<0.001**	295/2,738 (10.77)	**0.82 (0.73-0.92) P=0.001**	**0.85 (0.75-0.96) P=0.007**	**0.86 (0.76-0.97) P=0.013**	0.92 (0.81-1.04) P=0.163
Dispensed an antidepressant	2,228/19,620 (11.36)	600/6,961 (8.62)	**0.76 (0.70-0.84) P<0.001**	**0.75 (0.68-0.82) P<0.001**	**0.74 (0.67-0.82) P<0.001**	**0.79 (0.71-0.87) P<0.001**	259/2,760 (9.38)	**0.83 (0.73-0.94) P=0.004**	**0.85 (0.75-0.97) P=0.017**	**0.87 (0.76-0.99) P=0.031**	0.93 (0.81-1.06) P=0.268
Dispensed at least two consecutive prescriptions for an antidepressant	1,702/19,913 (8.55)	436/7,053 (6.18)	**0.73 (0.66-0.81) P<0.001**	**0.72 (0.65-0.80) P<0.001**	**0.73 (0.65-0.82) P<0.001**	**0.78 (0.69-0.87) P<0.001**	197/2,790 (7.06)	**0.83 (0.71-0.96) P=0.013**	0.86 (0.74-1.00) P=0.052	0.87 (0.75-1.01) P=0.077	0.94 (0.81-1.10) P=0.437
Dispensed a hypnotic &/or anxiolytic	637/20,535 (3.10)	198/7,181 (2.76)	0.89 (0.75-1.04) P=0.137	0.88 (0.75-1.04) P=0.135	0.84 (0.71-1.00) P=0.053	0.90 (0.75-1.06) P=0.189	69/2,859 (2.41)	**0.78 (0.61-1.00) P=0.046**	0.83 (0.64-1.06) P=0.130	0.81 (0.63-1.05) P=0.109	0.87 (0.68-1.12) P=0.283
Dispensed an antipsychotic &/or related drug	36/20,800 (0.17)	16/7,264 (0.22)	1.27 (0.71-2.28) P=0.417	1.22 (0.67-2.20) P=0.512	NC	NC	11/2,888 (0.38)	**2.20 (1.12-4.32) P=0.022**	**2.27 (1.14-4.52) P=0.020**	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

5.4.6 Analysis by breastfeeding status and sensitivity analyses

Examining the associations by breastfeeding status at 6-8 weeks postpartum, the effects of planned VBAC, planned VBAC without labour induction and actual VBAC were still evident in women who did and did not breastfeed with no evidence of effect modification between the exposures and breastfeeding status (**Figure 5.4**). The sensitivity analyses presented in **Tables E.1-E.6** and **E.10-E.12** in **Appendix E** resulted in similar effect estimates, although the significance of some of the associations varied noting these analyses included a smaller number of women and would have had more limited power.

The E-values suggest that relatively modest unmeasured confounding could fully explain the observed associations between the exposures and outcomes (**Tables E.7-E.9** in **Appendix E**). For example, to fully explain the observed HR of 0.85 for the association between planned mode of birth after previous caesarean and any psychotropic medication (**Table 5.4**), an unmeasured confounder would need to be associated with at least a 1.63-fold increased risk of both the primary exposure and outcome through pathways independent of the covariates included in the fully adjusted model; to move the upper CI to include the null, an unmeasured confounder would need to be associated with at least a 1.39-fold increased risk of both the primary exposure and outcome, above and beyond the measured covariates.

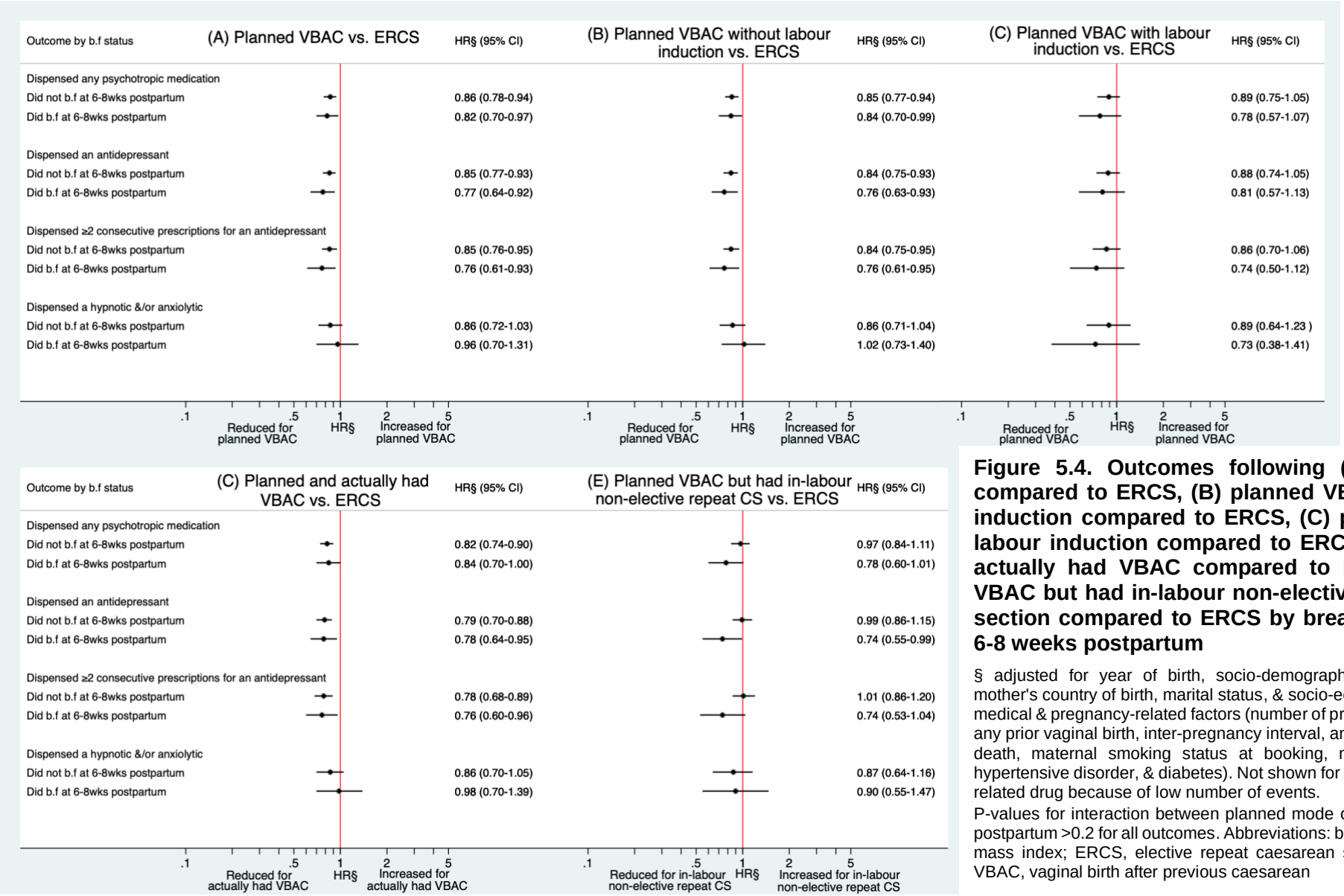


Figure 5.4. Outcomes following (A) planned VBAC compared to ERCS, (B) planned VBAC without labour induction compared to ERCS, (C) planned VBAC with labour induction compared to ERCS, (D) planned and actually had VBAC compared to ERCS, (E) planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS by breastfeeding status at 6-8 weeks postpartum

§ adjusted for year of birth, socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status) & maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes). Not shown for outcome antipsychotic &/or related drug because of low number of events.

P-values for interaction between planned mode of birth & b.f. at 6-8 weeks postpartum >0.2 for all outcomes. Abbreviations: b.f, breastfeeding; BMI, body mass index; ERCS, elective repeat caesarean section; HR, Hazard ratio; VBAC, vaginal birth after previous caesarean

5.5 Discussion

5.5.1 Main findings

To the author's knowledge, this is the first large population-based study to consider the possible mental health effects of planned mode of birth after previous caesarean section. Among women considered clinically eligible to plan VBAC without a history of psychotropic drug use in the year before giving birth, planned VBAC compared to ERCS was associated with a 15% reduced risk of being dispensed any psychotropic medication, and a 17% reduced risk of being dispensed an antidepressant and at least two consecutive antidepressants in the first year postpartum. These findings were adjusted for many potential confounders as well as breastfeeding at 6-8 weeks postpartum, a potential mediating factor.

5.5.2 Strengths and limitations

The strengths of this study are similar to those described in Chapter 4 for the short-term outcomes study. These include the study's large population-based design with very little loss to follow-up, which reduces the risk of selection bias and increases statistical power. Other strengths include making a concerted effort to restrict the study to women considered clinically eligible to plan a VBAC based on UK guidelines[8,22], and the use of prospectively collected routine data which avoids recall bias. It was also possible to explore the influence of many *a priori* potential confounders as well as the influence of breastfeeding, a potential mediating factor. However, the possibility of residual confounding due to mis-measured or unmeasured confounding factors that we have not been able to consider, such as indication for the previous caesarean, again cannot be ruled out. The reported E-values suggest that relatively modest unmeasured confounding could fully explain the observed associations. However, as mentioned in previous chapters, in the absence of conducting a large randomised trial, which a previous study[98] indicates is unlikely to be feasible, large

population-based observational studies with the ability to consider multiple covariates, such as this study, offer the best opportunity to inform evidence in this area.

The points made in the limitations section of Chapter 4 (section 4.5.3) for the short-term outcomes study around misclassification, missing data, and the performance of multiple comparisons also apply to this study, although it is worth noting that using a more stringent p-value to allow for multiple testing would again not have altered the main findings. In addition, by using available routinely-collected data, this study was limited by only being able to infer mental health problems from dispensed prescriptions of psychotropic medication. This is likely to have led to an underestimate of the proportion of women with mental health problems, as not all women with mental health problems will present for treatment[212]. Furthermore, while psychotropic medication tends to be the most commonly used type of mental health treatment[196,212], other treatments, most notably psychological interventions, may be offered. There may also be a higher threshold in the postnatal period for using psychotropic medication amid concerns about the safety of these drugs for the breastfed baby[182], noting, however, that the effects found were still evident in women who did and did not breastfeed suggesting breastfeeding does not modify the effects of the exposures. The study also lacked information about the indication for the medication or whether women actually took the dispensed medication. It is also acknowledged that excluding women dispensed psychotropic drugs in the year, or two years in the case of the sensitivity analysis (**Tables E10-E12** in **Appendix E**), before they gave birth would have been unlikely to have excluded all women with previous mental health problems linked to the points raised above. While the time when psychotropic drugs are most likely to be stopped is around the time of pregnancy recognition and restarting treatment in pregnancy is not uncommon[213], the study may also have not excluded all women with previous mental health problems as some women may have discontinued psychotropic drugs when trying to conceive. Furthermore, some women develop mental health problems *de novo* during pregnancy and remain untreated or are not treated with medication. However, this would

only have biased the results if the proportion of women with either untreated or non-pharmacologically treated mental health problems before birth differed between those who planned a VBAC and those that had an ERCS.

5.5.3 Comparison with other studies and interpretation

To the author's knowledge, to date only one study[97] conducted in a single hospital in Hong Kong has investigated the effect of planned VBAC compared to ERCS on women's mental health. This earlier study had the advantage of using psychometric tests during pregnancy and up to six months postpartum to assess anxiety, depression, and general psychological wellbeing, but was small including fewer than 300 women, and was not population-based. The authors reported no significant differences between women who planned a VBAC compared to an ERCS. Consistent with the findings of the study presented here, another small study of 169 Australian women who had one previous caesarean found that women who had a spontaneous vaginal birth were less likely than those giving birth by planned or emergency repeat caesarean or instrumental vaginal birth to have symptoms suggestive of postnatal depression[214]. More recently, and again consistent with the findings of the present study, a study of nearly 900 women conducted in 15 maternity units in Europe reported that compared to women who had an emergency or planned repeat caesarean, women who had a spontaneous vaginal birth after one previous caesarean had higher postnatal health-related quality of life scores encompassing physical, psychological, and social dimensions of health[215]. A further analysis of the same study population found that women with an antenatal preference for vaginal birth who gave birth by ERCS had lower postnatal health-related quality of life scores compared to women with an antenatal preference for vaginal birth who actually gave birth vaginally[216]. The effect sizes found in the study presented here were stronger in women who planned and actually had a VBAC than in women who planned but had an in-labour non-elective repeat caesarean, supporting the potential importance of a match between preferred and actual mode of birth on women's wellbeing.

Although more studies have been conducted in the general obstetric population, as mentioned previously, these studies may not be applicable to women with previous caesarean and most have focused on the effect of actual mode of birth on postnatal depression. Caesarean section has been reported to be both protective of and a risk factor for postnatal depression[205]. A limited number of studies have also reported caesarean section to be a risk factor for postpartum psychosis[206] and anxiety disorders such as post-traumatic stress disorder[207]. However, other studies have not found a significant association between mode of birth and these outcomes, or have only found an association in women with a previous history of mental health problems[205,208]. These inconsistencies in findings may partly reflect limitations with the existing studies, with many comprising small non-population-based studies that have not differentiated between elective and emergency caesarean despite the very different contexts in which these two types of caesareans are performed. As described in Chapter 1, emergency in contrast to elective caesareans are often carried out with little time for women to prepare themselves and are frequently accompanied by concerns around the safety of the mother and/or her baby. A recent meta-analysis of a small number of studies that did distinguish between type of caesarean, reported that emergency but not elective caesareans were associated with an increased risk of postnatal depression[217].

Mode of birth may affect the mother's postnatal wellbeing by influencing the likelihood of the mother or baby experiencing birth-related complications. However, the study presented here found that despite being more likely to experience a range of adverse perinatal and maternal intrapartum or postpartum outcomes[1], women who planned a VBAC were less likely than those giving birth by ERCS to be dispensed psychotropic medication including antidepressants in the first year postpartum. This may be because women who planned a VBAC were less likely than those having an ERCS to seek treatment for mental health problems or were less likely to be offered and/or accept pharmacological treatment in the first year postpartum. The study findings may alternatively imply that women giving birth by

ERCS are more likely than those having a planned VBAC to experience mental health problems severe enough to warrant pharmacological treatment, at least in the year after birth. This may arise through several potential mechanisms. Women giving birth by caesarean are more likely to express not feeling in control over their birth, may be more likely to have their expectations about childbirth violated, even in the case of planned caesarean, and may experience a more painful and difficult postnatal recovery, all of which may adversely affect their subsequent mental health[26]. Caesarean birth may also adversely impact maternal mental health by disrupting physiological hormonal processes such as the release of oxytocin, a hormone which helps to reduce stress, increase sociability, and maternal-infant attachment[27]. While women with a history of psychotropic drug use in the 1-2 years before birth were excluded from the present study, it also cannot be ruled out that the possible increased likelihood of mental health problems in women giving birth by ERCS may be due to more prior psychiatric vulnerability in this group of women. Indeed, there is some evidence that some women with a preference for elective caesarean are more likely to have a fear of childbirth, which in itself is thought to be associated with mental health problems[218]. It is also possible that women who plan VBAC may have personality traits associated with better mental health.

5.5.4 Conclusions

Among women considered clinically eligible to plan VBAC without a history of psychotropic drug use in the year before birth, planned VBAC compared to ERCS was associated with a reduced risk of the mother being dispensed psychotropic medication including antidepressants in the first year postpartum. While residual confounding cannot be ruled out, as has been discussed, there are several possible alternative explanations for these findings.

6

PLANNED MODE OF BIRTH AFTER PREVIOUS CAESAREAN SECTION AND SPECIAL EDUCATIONAL NEEDS IN CHILDHOOD: A POPULATION-BASED RECORD LINKAGE COHORT STUDY

6.1 Introduction and chapter overview

As discussed in Chapter 1, concerns have been raised that caesarean section may adversely affect the child's subsequent neurodevelopment through several possible mechanisms, including altering the composition of the infant's gut microbiota[34,219,220], affecting the stress response[13,38], birth at an earlier gestation[178], or reducing the likelihood of breastfeeding[23,31,184,185]. However, while a recent meta-analysis[221] reported that both planned and emergency caesarean were associated with an increased risk of autism spectrum disorder (ASD) and attention deficit/hyperactivity disorder, no significant association was evident for other neurodevelopmental and psychiatric outcomes examined, possibly reflecting the limited number of studies. Heterogeneity among studies was also high in the meta-analysis of some of the outcomes assessed. Also, to the author's knowledge, to date only one study has examined the effect of planned mode of birth after previous caesarean on such outcomes[111]. However, this study did not exclude children born to women with contraindications to planned VBAC and only investigated the effect on learning disability and cerebral palsy in around 8,000 children in two Scottish health boards.

As discussed in Chapter 1, research conducted in the general obstetric population, women without a previous caesarean or populations with specific complications such as breech presentation may not be generalisable to the situation of birth after previous caesarean. Furthermore, several studies have demonstrated that planned VBAC is associated with an increased risk of serious birth-related maternal and perinatal complications[1,67,79,98], which may adversely affect a child's longer-term neurodevelopment. Therefore, planned VBAC compared to ERCS may actually be associated with poorer neurodevelopmental outcomes in childhood. This chapter describes the third population-based cohort study conducted to meet the final research objective of this thesis. The research presented in this chapter has been published in BJOG**:** An International Journal of Obstetrics and Gynaecology[3].

6.2 Objective

The objective of this study was to investigate the association between planned mode of birth after previous caesarean section and the child's risk of having a record of special educational needs (SENs) as a marker of adverse neurodevelopmental outcome(s), among singleton children born at term to women considered clinically eligible to plan VBAC (research objective 4).

6.3 Methods

6.3.1 Study population

The data sources, codes and database fields used to identify the population for this study are detailed in **Table 6.1**. The study population included live singleton births at term (37-41 completed weeks' gestation) in Scotland, UK, between 1st January 2002 and 31st December 2011 to women with a history of one or more previous caesarean sections. Many of the same exclusions as those used in study one (see section 4.3.1) were applied. Specifically, births to women not considered clinically eligible to plan VBAC based on UK guidelines[8,22],

births missing information about mode of birth or gestational age at birth, births by non-elective caesarean section missing information about duration of labour, and births to women whose number of previous caesarean sections was greater than their recorded parity were excluded. In addition, children who died before they were 4 years old were excluded since outcome data would not have been collected for these children.

Table 6.1. Data sources, codes and database fields used to identify the study three population

	Data source	Database fields/codes
Inclusion criteria		
≥ 1 previous caesarean sections	SMR02	Previous caesarean sections field ≥1 OR at least one previous birth with a code for caesarean section in mode of delivery field (7 or 8) &/or an OPCS-4 or OPCS-3 code for caesarean section (R17-R18, R251, 764-766, 769), using SMR02 records going back to 1981
Baby live born	NRS live births, stillbirths & deaths	Data source=NRS Births, checked against period of death field
Singleton birth	NRS live births & stillbirths	Numbirths field=1
Term birth	SMR02	Gestation at birth 37-41 completed weeks according to Estimated gestation field (containing number of completed weeks of gestation as judged by the clinician, usually on the basis of ultrasound) OR according to gestation derived from date of delivery & date of last menstrual period fields if Estimated gestation missing (0.04% of eligible births)
Exclusion criteria		
Non-cephalic presentation	SMR02	Delivery episodes with a code for breech or shoulder in presentation at delivery field (4 or 6) OR a code for breech delivery or breech extraction in mode of delivery field (5 or 6) OR an ICD-10 code for breech delivery or breech extraction (O801, O830-O831) OR an OPCS-4 code for breech delivery or breech extraction (R19-R20) OR an ICD-10 code for maternal care for malpresentation of fetus (0320-0322, 0326-0329)
Placenta praevia	SMR02	Delivery episodes with an ICD-10 code for placenta praevia (O440-O441)
Abdominal pregnancy	SMR02	Delivery episodes with an ICD-10 code for delivery of or maternal care for viable fetus in abdominal pregnancy (O833, O367)
Known or suspected disproportion of maternal &/or fetal origin	SMR02	Delivery episodes with an ICD-10 code for maternal care for known or suspected disproportion (O33)
Tumour of corpus uteri	SMR02	Delivery episodes with an ICD-10 code for maternal care for tumour of corpus uteri (O341)
Pre-labour non-elective caesarean section	SMR02	Code for non-elective caesarean section in mode of delivery field (8) AND duration of labour field=0
Child died before the age of 4 years old	NRS deaths	Age at death <4 years

Abbreviations: ICD-10, International Classification of Diseases 10th revision; NRS, National Records of Scotland; OPCS-3, Office of Population Censuses & Surveys Classification of Surgical Operations & Procedures 3rd revision; OPCS-4, Office of Population Censuses & Surveys Classification of Surgical Operations & Procedures 4th revision; SMR02, Scottish Morbidity Record Maternity Inpatient & Day Case Dataset

6.3.2 Exposure variables

The exposures of interest are detailed in section 3.2.4. In brief, the primary exposure of interest was planned mode of birth after previous caesarean section with planned VBAC (birth vaginally or by non-elective caesarean section with a duration of labour of ≥1 hour) compared to ERCS (birth by elective repeat caesarean). Analyses were also performed according to whether planned VBAC was attempted with or without labour induction compared to ERCS and according to actual mode of birth after previous caesarean section (actual VBAC, in-labour non-elective repeat caesarean section or ERCS).

6.3.3 Outcomes

The data sources, codes and database fields used to identify the outcomes of interest are shown in **Table 6.2**. The primary outcome was any record of SENs, with children classified as having a record of SENs if this was recorded in any pupil census year when they were aged 4-11 years and attending a Scottish primary or special school (school providing education to children with complex or specific needs which cannot be met in mainstream schools). Secondary outcomes were specific types of SEN. Records relating to when a child was over the age of 11 years and attending a secondary or special school were not considered as few children in the study population had data at this age/stage of their education and provision of SENs is likely to differ between primary and secondary school. The Education (Additional Support for Learning) Scotland Act 2004 (as amended) defines SENs as being unable to benefit from the school education provided without the provision of additional support beyond that normally given to school children of the same age[222]. Educational authorities have a statutory duty to identify and provide support for children with SENs. Support may include an individualised educational programme (a written plan detailing targets that a child with additional needs is expected to achieve), a co-ordinated support plan (a statutory educational plan to ensure provision for those with complex or multiple additional support needs) or since 2011 a child's plan (single or multi agency plans

based on an assessment guided by the "Getting it Right for Every Child National Practice") or some other type of support[223]. For this study, SENs attributed to the following were included: learning disability, dyslexia, other specific or moderate learning difficulty, sensory impairment, physical or motor impairment, language or speech disorder, ASD, social, emotional and behavioural difficulty or mental health problem, and physical health problem. A child can be recorded as having more than one type of SEN.

Table 6.2. Data sources, codes and database fields used to identify the study three outcomes

	Data source	Database fields/codes
Outcomes		
Any record of special educational needs (SENs)	Pupil census	Main analysis – any of the following codes in student need category/reason for support fields in any pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP): 10 (learning disability), 11 (dyslexia), 12 (other specific learning difficulty), 13 (other moderate learning difficulty), 20 (visual impairment), 21 (hearing impairment), 22 (deafblind), 23 (physical or motor impairment), 24 (language or speech disorder), 25 (autistic spectrum disorder), 26 (social, emotional & behavioural difficulty), 27 (physical health problem), 28 (mental health problem). Detailed descriptions of each student need category/reason for support can be found in the School/pupil Census Data Specification[224] Sensitivity analysis – any of the above codes in student need category/reason for support fields at a particular pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP), analysed as a repeated measures yearly outcome. *(Main analysis categorised as: No, Yes. Sensitivity analysis categorised as: No, Yes for each pupil census year)*
Learning disability	Pupil census	Main analysis – code for learning disability in student need category/reason for support fields (10) in any pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP). Sensitivity analysis – code for learning disability in student need category/reason for support fields (10) at a particular pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP), analysed as a repeated measures yearly outcome. *(Main analysis categorised as: No, Yes. Sensitivity analysis categorised as: No, Yes for each pupil census year)*
Dyslexia	Pupil census	Main analysis – code for dyslexia in student need category/reason for support fields (11) in any pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP). Sensitivity analysis – code for dyslexia in student need category/reason for support fields (11) at a particular pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP), analysed as a repeated measures yearly outcome. *(Main analysis categorised as: No, Yes. Sensitivity analysis categorised as: No, Yes for each pupil census year)*

Table continued overleaf

Table 6.2. (continued). Data sources, codes and database fields used to identify the study three outcomes

	Data source	Database fields/codes
Other learning difficulty	Pupil census	Main analysis – code for other specific or other moderate learning difficulty in student need category/reason for support fields (12 or 13) in any pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP). Sensitivity analysis – code for other specific or other moderate learning difficulty in student need category/reason for support fields (12 or 13) at a particular pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP), analysed as a repeated measures yearly outcome. *(Main analysis categorised as: No, Yes. Sensitivity analysis categorised as: No, Yes for each pupil census year)*
Sensory impairment	Pupil census	Main analysis – code for visual impairment, hearing impairment or deafblind in student need category/reason for support fields (20-22) in any pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP). Sensitivity analysis – code for visual impairment, hearing impairment or deafblind in student need category/reason for support fields (20-22) at a particular pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP), analysed as a repeated measures yearly outcome. *(Main analysis categorised as: No, Yes. Sensitivity analysis categorised as: No, Yes for each pupil census year)*
Physical or motor impairment	Pupil census	Main analysis – code for physical or motor impairment in student need category/reason for support fields (23) in any pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP). Sensitivity analysis – code for physical or motor impairment in student need category/reason for support fields (23) at a particular pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP), analysed as a repeated measures yearly outcome. *(Main analysis categorised as: No, Yes. Sensitivity analysis categorised as: No, Yes for each pupil census year)*
Language or speech disorder	Pupil census	Main analysis – code for language or speech disorder in student need category/reason for support fields (24) in any pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP). Sensitivity analysis – code for language or speech disorder in student need category/reason for support fields (24) at a particular pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP), analysed as a repeated measures yearly outcome. *(Main analysis categorised as: No, Yes. Sensitivity analysis categorised as: No, Yes for each pupil census year)*
Autistic spectrum disorder (ASD)	Pupil census	Main analysis – code for autistic spectrum disorder in student need category/reason for support fields (25) in any pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP). Sensitivity analysis – code for autistic spectrum disorder in student need category/reason for support fields (25) at a particular pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP), analysed as a repeated measures yearly outcome. *(Main analysis categorised as: No, Yes. Sensitivity analysis categorised as: No, Yes for each pupil census year)*

Table continued overleaf

Table 6.2. (continued). Data sources, codes and database fields used to identify the study three outcomes

	Data source	Database fields/codes
Social, emotional & behavioural difficulty or mental health problem	Pupil census	Main analysis – code for social, emotional & behavioural difficulty or mental health problem in student need category/reason for support fields (26 or 28) in any pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP). Sensitivity analysis – code for social, emotional & behavioural difficulty or mental health problem in student need category/reason for support fields (26 or 28) at a particular pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP), analysed as a repeated measures yearly outcome. *(Main analysis categorised as: No, Yes. Sensitivity analysis categorised as: No, Yes for each pupil census year)*
Physical health problem	Pupil census	Main analysis – code for physical health problem in student need category/reason for support fields (27) in any pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP). Sensitivity analysis – code for physical health problem in student need category/reason for support fields (27) at a particular pupil census year when child was aged 4-11 years & attending a primary or special school (student stage field P1-P7 or SP), analysed as a repeated measures yearly outcome. *(Main analysis categorised as: No, Yes. Sensitivity analysis categorised as: No, Yes for each pupil census year)*

6.3.4 Statistical analysis

The statistical approach is detailed in section 3.2.7. In brief, associations between the exposures and outcomes were examined using logistic regression to estimate ORs and 95% CIs where the outcome was rare (affecting <10% of population), and modified Poisson regression[171] to estimate RRs and 95% CIs where the outcome was common[172]. All models were adjusted for year of birth. Models were then sequentially adjusted for *a priori* covariates as described in section 3.2.7, with a detailed description of the covariates found in section 3.2.6. Categorical covariates were fitted in the models using the categories shown in **Table 3.3**. Linearity of continuous covariates was investigated using fractional polynomials (see section 3.2.7). Evidence of effect modification between the exposures and whether the mother breastfed the infant around 6-8 weeks postpartum was examined to further explore the potential effect of breastfeeding on the associations considered. The number of previous caesarean sections a woman had, whether the woman had at least one prior vaginal birth, and the gestational age at birth were also investigated as potential effect modifiers of the relationship between the primary exposure and outcomes. Effect modification was explored

by adding interaction terms to the full models. Multiple imputation was used to impute partially observed covariates as described in section 3.2.8.

6.3.5 Sensitivity analyses

In addition to conducting the three sensitivity analyses described in section 3.2.9 (complete case, repeating analyses restricted to births at ≥39 weeks' gestation, and calculating E-values), a further sensitivity analysis was carried out taking a different approach to the analysis to see if this made any difference to the findings. In particular, instead of classifying children as having SENs if this was recorded in any pupil census year when the child was aged 4-11 years and attending a Scottish primary or special school (as was done for the main analysis), SENs was analysed as a repeated measures yearly outcome allowing all yearly measurements to contribute to the analysis. Here, models were fitted using robust standard errors clustered on child ID to account for correlations between observations relating to the same child across different school years. As this approach can only account for one source of non-independence, a woman's first (oldest) child that met the study eligibility criteria (see section 6.2.1) was selected where there was more than one eligible child born to the same mother. Multilevel logistic regression models, which can account for more than one source of non-independence, were not used for these repeated measures analyses due to difficulties with model convergence when attempting to use this approach. For this sensitivity analysis the age of the child at the time of the pupil census was included as a covariate in all models as this factor may influence the likelihood of a child being identified with SENs. Evidence of effect modification between the primary exposure and the age of the child was also examined by the addition of interaction terms to the models. As the proportion of missing data for the covariate maternal BMI at booking was high in this study, an additional sensitivity analysis was performed repeating analyses omitting this covariate.

6.4 Results

6.4.1 Study population

In total, 50,025 live singleton term births to women with one or more previous caesarean sections met the study eligibility criteria. Of these, 5,133 (10.3%) were excluded because they did not link to any subsequent pupil census records between 2007 and 2016, when the child was aged 4-11 years and attending a primary or special school (**Figure 6.1**). The characteristics of the 44,892 children included in the analysis, compared with the 5,133 excluded, are shown in **Table F.1** in **Appendix F**. The mothers of the children not included were more likely to be older than the mothers of the children included, born outside of the UK, be married or cohabitating, be of higher socio-economic status, have a shorter inter-pregnancy interval, and have breastfed at 6-8 weeks postpartum. They were less likely than the mothers of the children included to be smokers at booking for pregnancy care, obese, or have a hypertensive disorder, while the other characteristics including planned mode of birth were comparable.

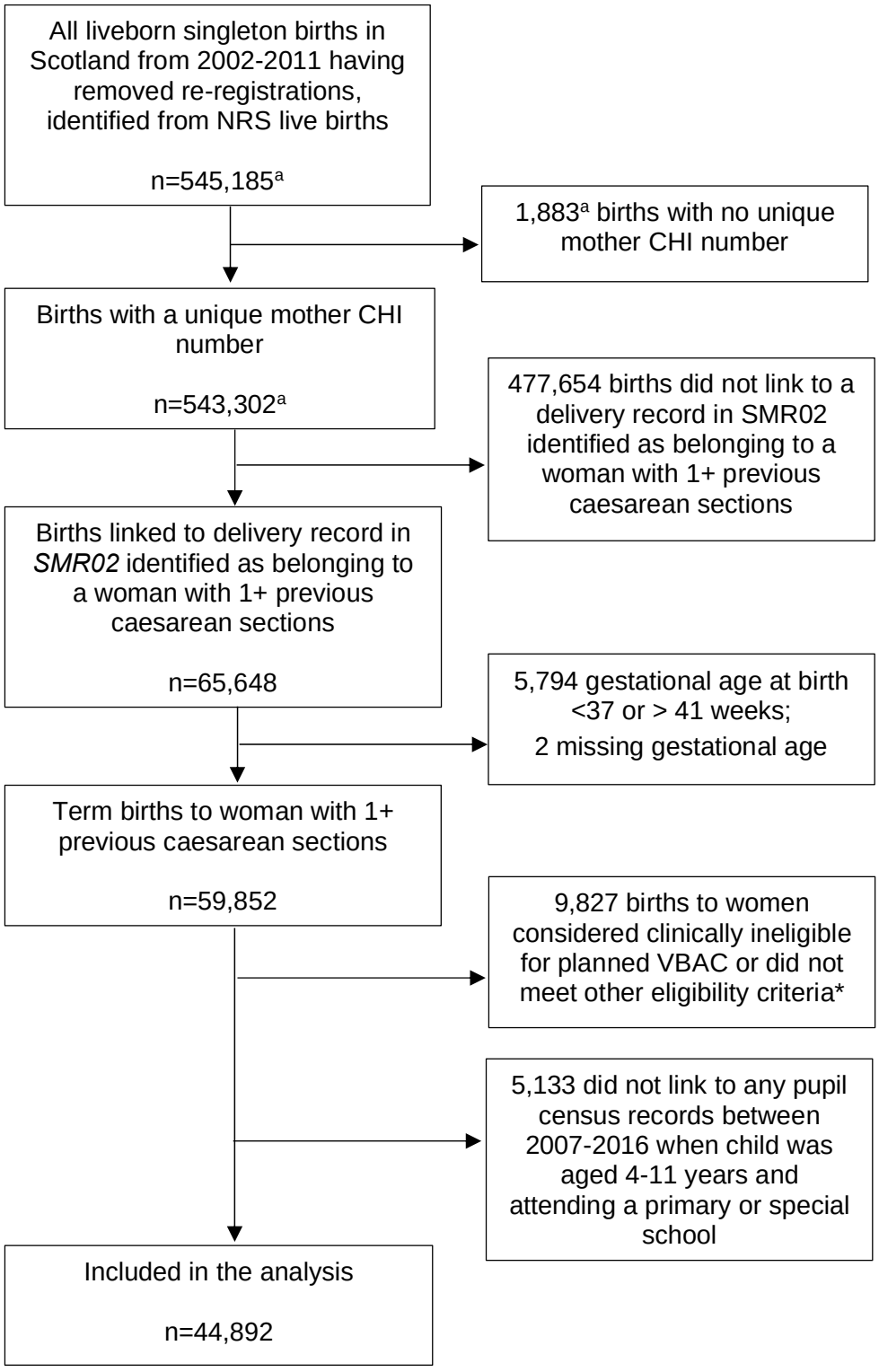


Figure 6.1. Flow diagram of cohort identification for study three

[a] Numbers provided by ISD Scotland, now part of Public Heath Scotland.

* Clinically ineligible for planned VBAC or did not meet other eligibility criteria for study due to one or more of the following: non-cephalic presentation at birth (n=4,574); placenta praevia (n=378); abdominal pregnancy (n=0); known or suspected disproportion of maternal &/or fetal origin (n=99); tumour of corpus uteri (n=166); birth by pre-labour non-elective caesarean section (n=4,476); missing information on mode of birth (n=9); birth by non-elective caesarean section missing information about duration of labour (n=507); number of previous caesarean sections greater than parity (n=151); child died before the age of 4 years old (n=172). Reasons not mutually exclusive.

Abbreviations: CHI, community health index; NRS, National Records of Scotland; SMR02, Scottish Morbidity Record Maternity Inpatient & Day Case dataset; VBAC, vaginal birth after previous caesarean

Of the children included, 18,851 (42.0%) were born following planned VBAC and 26,041 (58.0%) were born by ERCS. The ERCS rate increased from 50.2% in 2002 to 64.7% in 2011. As found in studies 1 and 2, the mothers of children born following planned VBAC were more likely than those born by ERCS to be younger, born outside the UK, and have a lower socioeconomic status (**Table 6.3**). They were also more likely to have just one prior caesarean, have had one or more prior vaginal births, a shorter interpregnancy interval, be smokers at booking for pregnancy care, have prelabour rupture of membranes, experienced an adverse perinatal outcome or maternal intrapartum or postpartum complication in the current pregnancy, and have breastfed at 6-8 weeks postpartum. They were less likely to be married or cohabitating, be obese or to have diabetes. Children born following planned VBAC were less likely than those born by ERCS to be of white ethnicity, female, born at early term (37-38 weeks' gestation), and have a larger birth weight for gestational age at birth.

Table 6.3. Characteristics of the study three cohort by planned mode of birth after previous caesarean section

	ERCS n (%)[a], unless otherwise stated (n=26,041)	Planned VBAC n (%)[a], unless otherwise stated (n=18,851)
Sociodemographic characteristics		
Maternal age (years)		
Less than 25	2,706 (10.4)	2,501 (13.3)
25-29	5,673 (21.8)	4,336 (23)
30-34	8,962 (34.4)	6,573 (34.9)
35-39	7,073 (27.2)	4,555 (24.2)
40 or more	1,627 (6.2)	886 (4.7)
Median (IQR) maternal age (years)	32 (28-36)	32 (27-35)
Mother's country of birth		
UK	24,050 (92.4)	17,144 (90.9)
Non-UK	1,991 (7.6)	1,707 (9.1)
Marital status/registration type		
Married or joint registration/same address	23,478 (90.2)	16,696 (88.6)
Joint registration/different address	1,688 (6.5)	1,415 (7.5)
Sole registration	875 (3.4)	740 (3.9)
Socioeconomic status[b]		
Managerial/professional	12,184 (46.8)	8,388 (44.5)
Intermediate	6,072 (23.3)	4,158 (22.1)
Routine/manual	6,844 (26.3)	5,424 (28.8)
Other[c]	941 (3.6)	881 (4.7)
Child's ethnicity[d]		
White	24,205 (94.9)	17,176 (92.7)
Asian	777 (3.0)	882 (4.8)
African/Caribbean/Back/Mixed/Other	528 (2.1)	476 (2.6)
Maternal medical & pregnancy-related characteristics		
Number of previous caesarean sections		
1	19,284 (74.1)	18,261 (96.9)
2 or more	6,757 (25.9)	590 (3.1)
Median (IQR) number of previous caesarean sections	1 (1-2)	1 (1-1)
Any prior vaginal birth[d]		
No	21,541 (83.2)	11,622 (61.9)
Yes	4,365 (16.8)	7,160 (38.1)
Parity[d]		
1	16,125 (62.3)	11,338 (60.5)
2 or more	9,767 (37.7)	7,397 (39.5)
Median (IQR) parity[d]	1 (1-2)	1 (1-2)
Interpregnancy interval (months)[d]		
24 or more	14,796 (60.4)	9,468 (56.8)
12-23	6,273 (25.6)	4,495 (27)
Less than 12	3,444 (14.0)	2,708 (16.2)
Median (IQR) interpregnancy interval (months)[d]	29.5 (17.0-49.9)	27.7 (15.8-48.8)
Mother smoked at booking[d]		
No	19,168 (81.7)	13,114 (76.1)
Yes	4,303 (18.3)	4,124 (23.9)

Table continued overleaf

Table 6.3 (continued). Characteristics of the study three cohort by planned mode of birth after previous caesarean section

	ERCS n (%)[a], unless otherwise stated (n=26,041)	Planned VBAC n (%)[a], unless otherwise stated (n=18,851)
Maternal BMI at booking (kg/m^2)[d]		
Less than 25	5,623 (35.3)	4,766 (45.4)
25-29.9	4,925 (30.9)	3,294 (31.4)
30 or more	5,375 (33.8)	2,433 (23.2)
Median (IQR) BMI at booking (kg/m^2)[d]	27.1 (23.7-32.1)	25.5 (22.7-29.4)
Any hypertensive disorder	1,600 (6.1)	1,219 (6.5)
Pre-existing or gestational diabetes	865 (3.3)	231 (1.2)
Prelabour rupture of membranes	263 (1.0)	1,488 (7.9)
Infant-related characteristics		
Male infant	13,169 (50.6)	9,720 (51.6)
Gestational age at birth (weeks)		
39-41	17,110 (65.7)	15,179 (80.5)
37-38	8,931 (34.3)	3,672 (19.5)
Median (IQR) gestational age at birth (weeks)	39 (38-39)	40 (39-40)
Birth weight centile[d]		
10-90th	20,298 (78.4)	15,117 (80.4)
Less than 10th	1,555 (6.0)	1,992 (10.6)
More than 90th	4,021 (15.5)	1,688 (9.0)
Other characteristics		
Adverse perinatal outcome[d,e]		
No	20,783 (93.4)	15,262 (91.7)
Yes	1,470 (6.6)	1,384 (8.3)
Maternal intrapartum or postpartum complication[f]		
No	25,250 (97)	17,606 (93.4)
Yes	791 (3.0)	1,245 (6.6)
Any breastfeeding at 6-8 week review[d]		
No	14,586 (67.3)	9,201 (59.4)
Yes	7,102 (32.7)	6,279 (40.6)

[a] Percentage of those with complete data.

[b] Socioeconomic status of mother for sole registered birth or highest of mother's or father's socioeconomic status for births registered inside marriage or jointly registered by both parents outside marriage. Socioeconomic status defined by NS-SEC based on occupation & employment status.

[c] Other includes never worked/long-term unemployed, student, not stated, or not classifiable.

[d] Missing data: child's ethnicity 848 (1.89%), any prior vaginal birth 204 (0.45%); parity 265 (0.59%); interpregnancy interval 3,708 (8.26%); maternal smoking status 4,183 (9.32%); maternal BMI 18,476 (41.16%); birth weight centile 221 (0.49%); adverse perinatal outcome 5,993 (13.35%); any breastfeeding at 6-8 weeks 7,724 (17.21%).

[e] Adverse perinatal outcome includes admission to a neonatal unit, resuscitation with drugs &/or intubation or an Apgar score <7 at 5 minutes.

[f] Intrapartum or postpartum complication includes uterine rupture, peripartum hysterectomy, blood transfusion, puerperal sepsis, other puerperal infection, surgical injury (damage to bowel, bladder or ureter requiring surgical repair), or third- or fourth-degree perineal tear

Abbreviations: BMI, body mass index; ERCS, elective repeat caesarean section; IQR, interquartile range; NS-SEC, National Statistics Socio-Economic Classification; VBAC, vaginal birth after previous caesarean

6.4.2 Planned VBAC compared to ERCS

Overall, 18.3% of the children included in the analysis had any record of SENs when they were aged 4-11 years and attending a primary or special school:

- 2.9% had a learning disability
- 2.1% had dyslexia
- 8.3% had other specific or moderate learning difficulties
- 0.8% had sensory impairment
- 1.0% had physical or motor impairment
- 3.8% had a language or speech disorder
- 1.6% had ASD
- 4.8% had a social, emotional and behavioural difficulty or mental health problem
- 1.5% had a physical health problem
- 5.7% of the children had more than one type of SEN

Outcomes by planned mode of birth are reported in **Table 6.4** and **Figure 6.2A**. Having only adjusted for year of birth, children born following planned VBAC had a similar risk to those born by ERCS of having any SENs or specific types of SEN with the exception of a social, emotional and behavioural difficulty or mental health problem, which was slightly increased in children born following planned VBAC (OR 1.12, 95% CI 1.02-1.22). However, this risk was attenuated following adjustment for socio-demographic factors. The risk of any SENs and specific types of SEN remained comparable between children born following planned VBAC and those born by ERCS after further adjustment for maternal medical and pregnancy-related factors, infant-related factors, and breastfeeding at 6-8 weeks postpartum, with these adjustments having little material impact on effect estimates. There was no evidence of effect modification between planed mode of birth and the number of prior caesarean sections a woman had, whether the woman had any prior vaginal births, or the gestational age at birth (P-values for interaction all >0.05).

Table 6.4. Outcomes following planned VBAC compared to ERCS

Outcomes	ERCS n outcome events (%) (n=26,041)	Planned VBAC n outcome events (%) (n=18,851)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	4,592 (17.63)	3,627 (19.24)	1.03 (0.99-1.07) P=0.194	1.00 (0.96-1.04) P=0.894	1.02 (0.98-1.07) P=0.363	1.04 (0.99-1.08) P=0.134	1.04 (0.99-1.09) P=0.099
Learning disability	712 (2.73)	581 (3.08)	1.02 (0.91-1.14) P=0.754	0.98 (0.87-1.10) P=0.718	1.02 (0.90-1.16) P=0.759	1.06 (0.93-1.22) P=0.392	1.08 (0.94-1.24) P=0.292
Dyslexia	491 (1.89)	440 (2.33)	1.02 (0.89-1.17) P=0.765	1.04 (0.91-1.19) P=0.560	1.11 (0.95-1.29) P=0.184	1.11 (0.95-1.30) P=0.191	1.09 (0.94-1.28) P=0.260
Other specific or moderate learning difficulty	2,064 (7.93)	1,644 (8.72)	1.02 (0.95-1.09) P=0.658	0.98 (0.91-1.05) P=0.534	1.02 (0.94-1.10) P=0.640	1.04 (0.96-1.13) P=0.311	1.05 (0.97-1.14) P=0.251
Sensory impairment	204 (0.78)	165 (0.88)	1.05 (0.85-1.30) P=0.633	1.04 (0.84-1.28) P=0.735	1.10 (0.87-1.40) P=0.430	1.18 (0.92-1.52) P=0.190	1.17 (0.91-1.50) P=0.220
Physical or motor impairment	259 (0.99)	204 (1.08)	1.03 (0.86-1.24) P=0.731	1.03 (0.85-1.24) P=0.758	1.08 (0.87-1.34) P=0.485	1.14 (0.91-1.43) P=0.240	1.15 (0.92-1.44) P=0.226
Language or speech disorder	983 (3.77)	719 (3.81)	1.02 (0.92-1.12) P=0.762	1.00 (0.90-1.10) P=0.964	1.03 (0.92-1.15) P=0.646	1.01 (0.90-1.13) P=0.891	1.02 (0.91-1.15) P=0.757
Autistic spectrum disorder	419 (1.61)	302 (1.60)	0.97 (0.84-1.13) P=0.732	0.97 (0.83-1.13) P=0.659	1.00 (0.84-1.18) P=0.963	1.03 (0.86-1.22) P=0.780	1.02 (0.86-1.22) P=0.803
Social, emotional & behavioural difficulty or mental health problem	1,162 (4.46)	997 (5.29)	**1.12 (1.02-1.22) P=0.017**	1.05 (0.96-1.15) P=0.271	1.03 (0.93-1.14) P=0.598	1.05 (0.94-1.17) P=0.359	1.06 (0.95-1.18) P=0.289
Physical health problem	381 (1.46)	285 (1.51)	0.98 (0.84-1.15) P=0.822	0.97 (0.83-1.14) P=0.739	1.05 (0.88-1.25) P=0.617	1.07 (0.89-1.29) P=0.449	1.08 (0.90-1.30) P=0.414

[1] Base model adjusted for year of birth only.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level. OR's calculated for all outcomes shown apart from any SEN, where RR's were calculated. Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

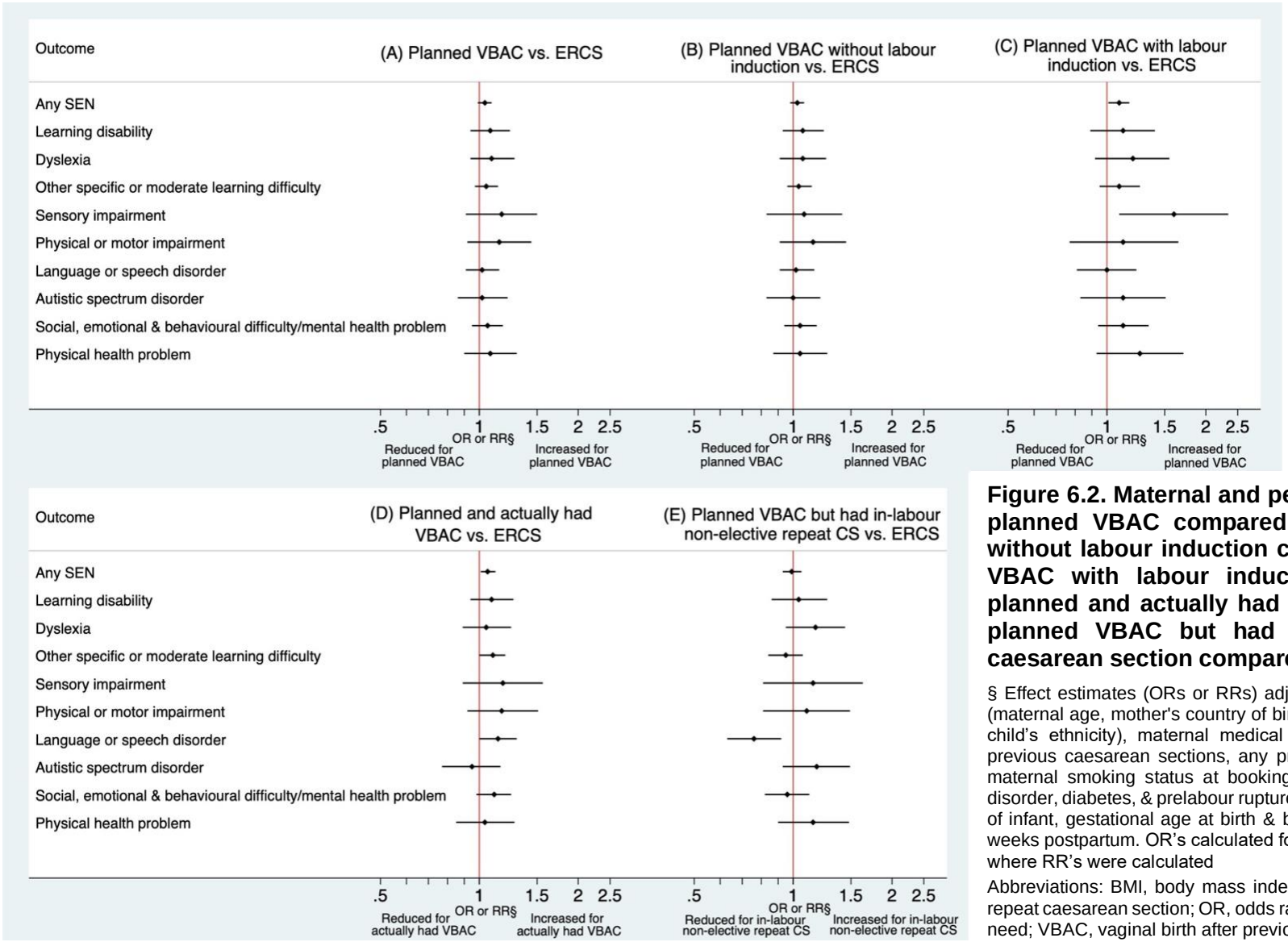


Figure 6.2. Maternal and perinatal outcomes following (A) planned VBAC compared to ERCS (B) planned VBAC without labour induction compared to ERCS (C) planned VBAC with labour induction compared to ERCS (D) planned and actually had VBAC compared to ERCS, (E) planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS

§ Effect estimates (ORs or RRs) adjusted for year of birth, socio-demographic (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity), maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes, & prelabour rupture of membranes), infant-related factors (sex of infant, gestational age at birth & birth weight centile) & breastfeeding at 6-8 weeks postpartum. OR's calculated for all outcomes shown apart from any SEN, where RR's were calculated

Abbreviations: BMI, body mass index; CS, caesarean section; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

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6.4.3 Planned VBAC with and without labour induction compared to ERCS

Of the children born following planned VBAC, 17.6% (3,305/18,793) were born to mothers who had their labour induced (25.8% using only surgical methods, 26.9% using only medical methods, 46.6% using surgical and medical methods). Outcomes following planned VBAC with or without labour induction compared to ERCS are shown in **Table 6.5** and **Figure 6.2C and 6.2B**, respectively. In the fully adjusted models, planned VBAC with labour induction compared to ERCS was associated with only a slight increase in the risk of any SENs (RR 1.09, 95% CI 1.01-1.17), but a larger increase in risk was evident for sensory impairment (OR 1.60, 95% CI 1.09-2.34), although the absolute risk difference for sensory impairment was small (1.18%-0.78%=0.4%). No other statistically significant differences in outcomes were evident following VBAC with or without labour induction compared to ERCS in the fully adjusted models.

Table 6.5. Outcomes following planned VBAC with and without labour induction compared to ERCS

Outcomes	ERCS	Planned VBAC without labour induction						Planned VBAC with labour induction					
	n outcome events (%) (n=26,041)	n outcome events (%) (n=15,488)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)	n outcome events (%) (n=3,305)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	4,592 (17.63)	2,909 (18.78)	1.01 (0.96–1.05) P=0.767	0.99 (0.95–1.03) P=0.517	1.01 (0.97–1.06) P=0.535	1.03 (0.98–1.08) P=0.274	1.03 (0.98–1.08) P=0.212	708 (21.42)	**1.13 (1.05-1.21) P=0.001**	1.05 (0.98-1.13) P=0.180	1.05 (0.98–1.13) P=0.201	**1.08 (1.01-1.17) P=0.033**	**1.09 (1.01–1.17) P=0.027**
Learning disability	712 (2.73)	467 (3.02)	1.01 (0.89-1.14) P=0.910	0.98 (0.86-1.10) P=0.685	1.02 (0.89-1.17) P=0.728	1.06 (0.92-1.22) P=0.439	1.07 (0.93-1.24) P=0.331	114 (3.45)	1.09 (0.89-1.33) P=0.432	1.01 (0.82-1.24) P=0.907	1.02 (0.82-1.26) P=0.854	1.11 (0.88-1.39) P=0.389	1.12 (0.89-1.40) P=0.338
Dyslexia	491 (1.89)	346 (2.23)	1.00 (0.86-1.15) P=0.955	1.01 (0.88-1.17) P=0.837	1.08 (0.92-1.27) P=0.327	1.09 (0.93-1.28) P=0.300	1.07 (0.91-1.26) P=0.395	92 (2.78)	1.11 (0.88-1.40) P=0.361	1.14 (0.90-1.44) P=0.271	1.20 (0.94-1.54) P=0.144	1.21 (0.93-1.57) P=0.148	1.20 (0.92-1.55) P=0.174
Other specific or moderate learning difficulty	2,064 (7.93)	1,321 (8.53)	1.00 (0.92-1.07) P=0.928	0.97 (0.90-1.05) P=0.441	1.02 (0.94-1.10) P=0.710	1.04 (0.95-1.13) P=0.402	1.04 (0.96-1.14) P=0.329	319 (9.65)	1.11 (0.98-1.27) P=0.097	1.01 (0.89-1.15) P=0.849	1.04 (0.91-1.19) P=0.575	1.09 (0.95-1.25) P=0.227	1.09 (0.95-1.26) P=0.203
Sensory impairment	204 (0.78)	124 (0.80)	0.97 (0.77-1.22) P=0.794	0.96 (0.76-1.20) P=0.696	1.02 (0.79-1.33) P=0.869	1.09 (0.84-1.42) P=0.527	1.08 (0.83-1.41) P=0.583	39 (1.18)	1.38 (0.97-1.97) P=0.072	1.36 (0.95-1.93) P=0.090	1.43 (0.99-2.07) P=0.060	**1.61 (1.10-2.36) P=0.015**	**1.60 (1.09-2.34) P=0.017**
Physical or motor impairment	259 (0.99)	167 (1.08)	1.03 (0.85-1.26) P=0.734	1.03 (0.85-1.26) P=0.752	1.09 (0.87-1.36) P=0.462	1.14 (0.91-1.44) P=0.257	1.15 (0.91-1.45) P=0.242	36 (1.09)	1.01 (0.71-1.44) P=0.947	1.00 (0.70-1.43) P=0.984	1.02 (0.71-1.46) P=0.936	1.12 (0.76-1.64) P=0.561	1.12 (0.77-1.65) P=0.549
Language or speech disorder	983 (3.77)	588 (3.80)	1.01 (0.90-1.12) P=0.895	1.00 (0.89-1.11) P=0.925	1.03 (0.92-1.16) P=0.597	1.01 (0.90-1.14) P=0.836	1.02 (0.91-1.16) P=0.703	129 (3.90)	1.06 (0.88-1.28) P=0.528	1.02 (0.84-1.23) P=0.859	1.01 (0.83-1.22) P=0.956	1.00 (0.81-1.22) P=0.942	1.00 (0.81-1.23) P=0.994
Autistic spectrum disorder	419 (1.61)	241 (1.56)	0.95 (0.81-1.11) P=0.519	0.94 (0.80-1.11) P=0.487	0.98 (0.82-1.18) P=0.858	1.01 (0.84-1.21) P=0.953	1.00 (0.83-1.21) P=0.978	60 (1.82)	1.09 (0.83-1.45) P=0.522	1.07 (0.81-1.41) P=0.629	1.05 (0.78-1.41) P=0.744	1.12 (0.83-1.52) P=0.455	1.12 (0.83-1.51) P=0.465
Social, emotional & behavioural difficulty or mental health problem	1,162 (4.46)	796 (5.14)	1.09 (0.99-1.20) P=0.078	1.04 (0.95-1.15) P=0.403	1.03 (0.92-1.14) P=0.629	1.04 (0.93-1.17) P=0.448	1.05 (0.94-1.18) P=0.369	201 (6.08)	**1.26 (1.08-1.48) P=0.004**	1.12 (0.95-1.31) P=0.174	1.05 (0.89-1.24) P=0.547	1.11 (0.93-1.33) P=0.229	1.12 (0.94-1.34) P=0.199
Physical health problem	381 (1.46)	225 (1.45)	0.95 (0.80-1.12) P=0.526	0.94 (0.80-1.11) P=0.485	1.02 (0.85-1.23) P=0.832	1.04 (0.86-1.26) P=0.656	1.05 (0.87-1.27) P=0.614	60 (1.82)	1.16 (0.88-1.53) P=0.290	1.14 (0.86-1.50) P=0.368	1.19 (0.89-1.58) P=0.250	1.26 (0.93-1.70) P=0.137	1.26 (0.93-1.71) P=0.130

[1] Base model adjusted for year of birth only.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level.
OR's calculated for all outcomes shown apart from any SEN, where RR's were calculated. Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

6.4.4 Actual VBAC and in-labour non-elective repeat caesarean section compared to ERCS

Of the children born following planned VBAC, 72.0% (13,564/18,851) were actually born by VBAC and 28.0% (5,287/18,851) were born by in-labour non-elective repeat caesarean section. There was no strong evidence that actual mode of birth after previous caesarean was associated with the child's risk of having a record of any SENs or most types of SEN (**Table 6.6** and **Figure 6.2D and 6.2E**). In the fully adjusted models, only a slight increase in the risk of any SENs (RR 1.06, 95% CI 1.01-1.12), other specific or moderate learning difficulties (OR 1.10, 95% CI 1.00-1.20), and a language or speech disorder (OR 1.14, 95% CI 1.00-1.30) was evident with actual VBAC compared to ERCS. By contrast, a reduced risk of language or speech disorder was seen with in-labour non-elective repeat caesarean compared to ERCS (fully adjusted OR 0.76, 95% CI 0.63-0.92), although the absolute risk difference was small (0.99%).

Table 6.6. Outcomes according to actual mode of birth – planned and actually had VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS

	ERCS	Planned and actually had VBAC						Planned VBAC but had in-labour non-elective repeat caesarean section					
	n outcome events (%) (n=26,041)	n outcome events (%) (n=13,564)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)	n outcome events (%) (n=5,287)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	4,592 (17.63)	2,661 (19.62)	**1.05 (1.01–1.10) P=0.026**	1.01 (0.97–1.06) P=0.505	1.04 (0.99–1.09) P=0.140	**1.06 (1.01–1.11) P=0.031**	**1.06 (1.01–1.12) P=0.021**	966 (18.27)	0.96 (0.91–1.03) P=0.249	0.95 (0.89-1.01) P=0.113	0.99 (0.92–1.05) P=0.623	0.99 (0.93–1.06) P=0.750	0.99 (0.93–1.06) P=0.820
Learning disability	712 (2.73)	426 (3.14)	1.05 (0.93-1.19) P=0.462	1.00 (0.88-1.13) P=0.931	1.04 (0.90-1.20) P=0.634	1.08 (0.93-1.25) P=0.332	1.09 (0.94-1.27) P=0.242	155 (2.93)	0.94 (0.79-1.13) P=0.535	0.94 (0.78-1.13) P=0.498	0.99 (0.82-1.19) P=0.906	1.03 (0.85-1.25) P=0.766	1.04 (0.86-1.27) P=0.683
Dyslexia	491 (1.89)	298 (2.20)	0.98 (0.84-1.14) P=0.769	0.99 (0.85-1.15) P=0.883	1.06 (0.90-1.25) P=0.502	1.07 (0.90-1.27) P=0.435	1.05 (0.89-1.25) P=0.547	142 (2.69)	1.12 (0.93-1.36) P=0.234	1.17 (0.96-1.42) P=0.114	1.20 (0.98-1.47) P=0.071	1.19 (0.96-1.46) P=0.107	1.17 (0.95-1.44) P=0.134
Other specific or moderate learning difficulty	2,064 (7.93)	1,229 (9.06)	1.07 (0.99-1.15) P=0.101	1.02 (0.94-1.10) P=0.680	1.06 (0.97-1.16) P=0.184	1.09 (1.00-1.19) P=0.062	**1.10 (1.00-1.20) P=0.046**	415 (7.85)	**0.89 (0.80-0.99) P=0.038**	**0.88 (0.78-0.98) P=0.022**	0.93 (0.83-1.04) P=0.219	0.95 (0.84-1.07) P=0.364	0.95 (0.84-1.07) P=0.411
Sensory impairment	204 (0.78)	121 (0.89)	1.08 (0.85-1.36) P=0.521	1.05 (0.83-1.33) P=0.676	1.12 (0.85-1.46) P=0.428	1.19 (0.90-1.58) P=0.210	1.18 (0.89-1.56) P=0.242	44 (0.83)	0.99 (0.70-1.39) P=0.943	1.00 (0.71-1.40) P=0.998	1.07 (0.76-1.52) P=0.689	1.16 (0.81-1.65) P=0.422	1.15 (0.81-1.63) P=0.448
Physical or motor impairment	259 (0.99)	147 (1.08)	1.04 (0.85-1.27) P=0.711	1.03 (0.84-1.27) P=0.764	1.10 (0.86-1.40) P=0.452	1.17 (0.91-1.50) P=0.220	1.17 (0.92-1.51) P=0.206	57 (1.08)	1.02 (0.76-1.36) P=0.909	1.02 (0.77-1.37) P=0.873	1.04 (0.78-1.40) P=0.786	1.09 (0.80-1.48) P=0.574	1.10 (0.81-1.49) P=0.560
Language or speech disorder	983 (3.77)	572 (4.22)	**1.12 (1.01-1.25) P=0.034**	1.09 (0.98-1.22) P=0.105	**1.14 (1.01-1.29) P=0.039**	1.13 (0.99-1.28) P=0.069	**1.14 (1.00-1.30) P=0.047**	147 (2.78)	**0.74 (0.62-0.88) P=0.001**	**0.74 (0.62-0.88) P=0.001**	**0.78 (0.65-0.94) P=0.007**	**0.75 (0.63-0.91) P=0.003**	**0.76 (0.63-0.92) P=0.004**
Autistic spectrum disorder	419 (1.61)	198 (1.46)	0.89 (0.75-1.06) P=0.178	0.88 (0.74-1.04) P=0.144	0.91 (0.75-1.11) P=0.349	0.95 (0.78-1.16) P=0.611	0.95 (0.77-1.16) P=0.590	104 (1.97)	1.19 (0.96-1.49) P=0.111	1.20 (0.96-1.49) P=0.112	1.18 (0.94-1.48) P=0.163	1.18 (0.93-1.49) P=0.167	1.18 (0.93-1.49) P=0.173
Social, emotional & behavioural difficulty or mental health problem	1,162 (4.46)	746 (5.50)	**1.17 (1.06-1.29) P=0.002**	1.09 (0.99-1.21) P=0.085	1.06 (0.95-1.19) P=0.307	1.10 (0.98-1.24) P=0.118	1.11 (0.98-1.25) P=0.089	251 (4.75)	0.98 (0.85-1.13) P=0.778	0.95 (0.82-1.10) P=0.482	0.96 (0.82-1.11) P=0.556	0.95 (0.82-1.11) P=0.532	0.96 (0.82-1.12) P=0.591
Physical health problem	381 (1.46)	197 (1.45)	0.95 (0.79-1.13) P=0.545	0.93 (0.78-1.11) P=0.438	1.02 (0.83-1.24) P=0.860	1.04 (0.85-1.27) P=0.726	1.04 (0.85-1.28) P=0.682	88 (1.66)	1.07 (0.85-1.35) P=0.567	1.08 (0.85-1.37) P=0.519	1.10 (0.87-1.41) P=0.426	1.15 (0.90-1.47) P=0.276	1.15 (0.90-1.48) P=0.261

[1] Base model adjusted for year of birth only.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level.
OR's calculated for all outcomes shown apart from any SEN, where RR's were calculated. Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

6.4.5 Analysis by breastfeeding status and sensitivity analyses

There was no evidence of effect modification by breastfeeding status at 6-8 weeks postpartum (P-values for interaction all >0.05). In the repeated measures sensitivity analyses, there was also no evidence of effect modification between the primary exposure and the age of the child (P-values for interaction all >0.05). The sensitivity analyses presented in **Tables F.2-F.7 and F.10-F.15** in **Appendix F** largely yielded similar effect estimates. They were at least in the range of those reported for the main analyses, although the statistical significance of some associations varied, noting the sensitivity analyses presented in **Tables F.2-F.7** included a smaller number of children and would have had more limited power.

The E-values suggest that relatively small or modest levels of unmeasured confounding could fully explain the observed associations between the exposures and outcomes (**Tables F.8 and F.9 in Appendix F**). For example, to fully explain the observed OR of 1.60 for sensory impairment with planned VBAC with labour induction compared to ERCS (**Table 6.5**), an unmeasured confounder would need to be associated with at least a 2.58-fold increased risk of both the exposure and outcome through pathways independent of the covariates included in the fully adjusted model; to move the lower CI to include the null, an unmeasured confounder would need to be associated with at least a 1.40-fold increased risk of both the exposure and outcome, above and beyond the measured covariates.

6.5 Discussion

6.5.1 Main findings

In this study of 44,892 children born to women considered clinically eligible to plan VBAC, planned VBAC compared with ERCS was associated with a similar risk of the child having a record of any SENs or specific types of SEN when they were aged 4-11 years and

attending a primary or special school. However, planned VBAC with labour induction compared to ERCS was associated with a 60% increased risk of sensory impairment, although the absolute risk difference was small (0.4%). There was also evidence of a 24% reduced risk of language or speech disorder with in-labour non-elective repeat caesarean compared to ERCS, although the absolute risk difference was again small (0.99%). These small differences are likely to be the result of residual confounding or performing multiple comparisons.

6.5.2 Strengths and limitations

Strengths of this study are similar to those described in Chapters 4 and 5 for the short-term outcomes and psychotropic medication studies. These include its large population-based design, the use of national prospectively collected data subject to regular quality checks, a concerted effort to restrict the study to the child of women considered clinically eligible to plan a VBAC based on UK guidelines[8,22], and the ability to explore the influence of many *a priori* covariates. However, the possibility of residual confounding again remains, with the reported E-values suggesting that relatively small or modest levels of unmeasured confounding could fully explain the observed associations. While a large randomised controlled trial could overcome this limitation, as previously discussed, such a trial is unlikely to be feasible[98]. Therefore, large population-based observational studies, like this study, provide the best opportunity to inform evidence in this area.

This study only included children who could be linked to pupil census records. The most likely explanations for not linking are the child either emigrated from Scotland or attended a private school (an average of around 4% of the Scottish population under the age of 4 years are estimated to have migrated out of Scotland in the period 2018-2020[225] and around 4% of children in Scotland attend private schools[161], which are not included in pupil census). However, this is unlikely to have significantly biased the findings given that only 10.3% of children could not be linked[226], and the planned mode of birth in those who could and could

not be linked was similar. While it is acknowledged that the criteria used to identify planned mode of birth may have misclassified women who planned ERCS but went into labour before their scheduled caesarean date, limiting the analysis to births at the gestation recommended by UK guidelines to perform an ERCS did not fundamentally change the findings. It is also recognised that the proportion of children recorded with SENs in Scotland has increased over the study period, probably due to changes and improvements in the recording of SENs[227]. However, all the analyses were adjusted for year of birth so this should not have affected the reported relative effect estimates. It is also recognised that whether a child is identified with SEN's may be socially patterned[228], which may not have been fully accounted for by adjusting for socioeconomic status around the time of birth registration. We also didn't have data on unmet SEN or the appropriateness of the SEN provision. It was also not possible in this cohort of children to assess the effect of planned mode of birth after previous caesarean section on educational attainment, another indication of adverse neurodevelopment, as this data was only available at the age of leaving school (~16-17 years old) which this cohort of children hadn't reached at the time the data was requested. Missing covariate data, particularly for maternal BMI, is acknowledged as another limitation. However, multiple imputation was used, which is considered an appropriate method for overcoming this providing the unobserved data are missing at random[204]. Furthermore, the sensitivity analysis omitting maternal BMI from the models had little material impact on the effect estimates. While all analyses were prespecified, it is also acknowledged that the performance of multiple comparisons would have increased the risk of type 1 error. That is, finding statistically significant associations that are not in fact true associations. Finally, the analyses didn't account for the potential lack of independence in the data resulting from children clustering in schools/local authorities due to the difficulties of children moving schools/areas during the long follow-up period.

6.5.3 Comparison with other studies and interpretation

To the author's knowledge, to date only one study[111] has investigated the effect of planned VBAC compared to ERCS on child neurodevelopmental outcomes. This prior study, consistent with the study presented here, reported no significant differences in the risk of learning disability or cerebral palsy among around 8,000 singleton school-aged children in two Scottish health boards born at term following planned VBAC compared to ERCS. However, this prior study did find an increased risk of learning disability with non-elective repeat caesarean compared to actual VBAC, which the findings from this current study do not suggest. This might reflect that the prior study, unlike the study presented here, included pre-labour non-elective repeat caesareans, which are potentially more prone to confounding by indication. No other types of SENs were investigated in the prior Scottish study. Another study of around 1,200-3,500 Australian children, depending on the outcome considered, reported no differences in child development at the age of 5 years and in school achievement at the age of 8 years between children born by actual VBAC compared to ERCS[229]. The study presented here only found a slight increase in the risk of any SENs and certain types of SEN with actual VBAC compared to ERCS that might well be attributable to residual confounding (see E-values in **Table F.9 in Appendix F**) or type 1 error. In the absence of any clinical reason to explain the small reduction in the risk of language or speech disorder seen only with in-labour non-elective repeat caesarean compared to ERCS and considering the reported E-values (**Table F.9 in Appendix F**), this finding might also be attributable to residual confounding or type 1 error.

It is possible that the slight increase in risk of any SENs and the increased risk of sensory impairment seen with planned VBAC with labour induction may be related to the increased risk of complications, most notably uterine rupture, that has been observed particularly with inducing labour in women with previous caesarean[79,141]. The increased risks seen may alternatively be related to the underlying indications for induction or the induction agents themselves, with concerns raised, for example, that excess circulating oxytocin might reach

the neonate's brain and desensitize oxytocin receptors, potentially leading to adverse developmental effects[146]. However, with any of these potential explanations, one might expect to see an increased risk for other types of SEN with planned VBAC with labour induction, which was not the case. The increased risks that were seen with planned VBAC with labour induction are also therefore likely be the result of residual confounding (see E-values in **Table F.8 in Appendix F**) or performing multiple comparisons. To the author's knowledge, the study presented here is the first to have examined the effect of labour induction after previous caesarean on child neurodevelopmental outcomes. The small number of previous studies that have investigated the effect of labour induction on such outcomes in the general obstetric population have reported mixed findings[230].

6.5.4 Conclusions

This study provides little evidence of an association between planned mode of birth after previous caesarean and SENs beyond a small absolute increased risk of sensory impairment seen with planned VBAC with labour induction. This finding is likely to be the result of residual confounding or performing multiple comparisons.

7

OVERALL DISCUSSION AND CONCLUSION

7.1 Introduction and chapter overview

The overall aim of the research presented in this thesis was to provide evidence-based information to help women make informed decisions with respect to planned mode of birth after previous caesarean section, by investigating the associated short and longer-term outcomes for women and their children. To address this aim, a structured review of the evidence on the short and longer-term outcomes for women and their children born following planned VBAC compared to ERCS was carried out. In conjunction with describing the findings of a systematic review conducted in 2010 by the US Agency for Healthcare Research and Quality (AHRQ)[67], the objective of the structured review was to provide a comprehensive up-to-date understanding of the evidence in high-income settings. The initial findings were used to inform three population-based cohort studies conducted by linking a number of routinely-collected Scottish national datasets. The objective of the first study was to investigate the short-term maternal and perinatal outcomes associated with planned mode of birth after previous caesarean section among women giving birth to a singleton at term and considered clinically eligible to plan a VBAC. The objective of the second study was to investigate the association between planned mode of birth after previous caesarean section and women's use of psychotropic medication in the first year postpartum as an indication of their subsequent risk of having mental health problems sufficiently severe as to require medication, among women giving birth to a singleton at term and considered clinically eligible to plan a VBAC. The objective of the final study was to investigate the

association between planned mode of birth after previous caesarean section and the child's risk of having a record of special educational needs (SENs) as a marker of adverse neurodevelopmental outcome(s), again among women giving birth to a singleton at term and considered clinically eligible to plan a VBAC. This final chapter summarises the main findings from each of these studies, the key strengths and limitations of the approach used, and includes a discussion of the implications for practice, policy, and future research in addition to providing recommendations around routinely-collected data.

7.2 Summary of main findings

The first study of just over 74,000 women giving birth to a singleton at term in Scotland between 2002 and 2015 (Chapter 4), suggests that among women considered clinically eligible to have a planned VBAC, planned VBAC compared to ERCS is associated with around a seven-fold increased risk of the mother having uterine rupture, around a two-fold increased risk of the mother needing a blood transfusion, nearly a two-fold increased risk of the mother having puerperal infection, around a three-fold increased risk of the mother having surgical injury, as well as nearly a 60% increased risk of one or more adverse perinatal outcomes including perinatal death, admission to a neonatal unit, resuscitation requiring drugs and/or intubation, and an Apgar score <7 at 5 minutes after birth. Conversely, the findings suggest planned VBAC is associated with around a 20% increased likelihood of any breastfeeding at birth or hospital discharge, and at 6-8 weeks postpartum. The effect on the mother's risk of having a postnatal hospital stay greater than 5 days, an overnight readmission to hospital within 42 days of birth, and other puerperal infection varied according to whether she had at least one previous vaginal birth and, in the case of length of postnatal stay, also varied according to the number of prior caesarean sections. However, the absolute risk of adverse maternal and perinatal outcomes was small for either birth approach. Overall, only 1.8% of those having a planned VBAC and 0.8% of those having an ERCS experienced serious maternal morbidity (uterine rupture, peripartum

hysterectomy, blood transfusion, puerperal sepsis, or surgical injury), and 8.0% of the planned VBAC and 6.4% of the ERCS group experienced one or more of the adverse perinatal outcomes considered. The study also suggests that around 70% of women planning a VBAC will actually give birth vaginally, with most of the maternal morbidity in the planned VBAC group occurring among those women who need an in-labour non-elective repeat caesarean section.

The second study of just over 31,000 women giving birth to a singleton at term in Scotland between 2010 and 2015 (Chapter 5) suggests that among women considered clinically eligible to plan VBAC without a history of psychotropic drug use in the year before birth, planned VBAC compared to ERCS is associated with a 15% reduced risk of the mother being dispensed any psychotropic medication, and a 17% reduced risk of the mother being dispensed an antidepressant and at least two consecutive antidepressants in the first year postpartum. While residual confounding cannot be ruled out, there are several possible alternative explanations for these findings. Women who planned a VBAC may have been less likely than those giving birth by ERCS to seek treatment or be offered and/or accept pharmacological treatment for mental health problems. The findings might alternatively reflect an increased likelihood of subsequent mental health problems severe enough to warrant pharmacological treatment in women giving birth by ERCS, which could arise through various potential mechanisms such as the caesarean disrupting physiological hormonal processes or leading to a more painful and difficult postnatal recovery.

The third study of nearly 45,000 term singleton births in Scotland between 2002 and 2011 (Chapter 6) suggests that among children born to women considered clinically eligible to plan VBAC, planned VBAC compared to ERCS is associated with a similar risk of the child being identified with any SENs or specific types of SEN when they are aged 4-11 years and attending a primary or special school. However, the study found that planned VBAC with labour induction compared to ERCS was associated with a 60% increased risk of sensory

impairment, although the absolute risk difference appeared to be small (0.4%) and is likely to be the result of residual confounding or performing multiple comparisons.

7.3 Strengths and limitations

Compared to birth cohort studies involving *de novo* data collection, linkage of existing routinely-collected data sources offers a cost-effective and timely way to study short and longer-term outcomes for large numbers of women and their children. The use of linked routinely-collected Scottish data, in particular, offered a number of advantages and allowed many of the limitations and gaps that were apparent with the existing evidence to be addressed. Scotland, in contrast to many countries, has a long history of linking a wealth of high-quality health-related routine data, providing the ability to study a comprehensive range of both short and longer-term outcomes for women and their children. This includes outcomes highlighted as particularly lacking in evidence, such as women's mental health and the child's longer-term neurological development. The ability to study the latter of these outcomes follows recent enhancements allowing linkage of Scottish education and health data. As highlighted in previous chapters, another limitation with much of the existing evidence was questionable comparability between the exposure groups, including women in the ERCS group who would not have been advised to plan VBAC due to obstetric/medical reasons. The extent of information available from the routinely-collected Scottish data facilitated the ability to make a concerted effort to restrict the studies conducted to women considered clinically eligible to plan VBAC based on UK guidelines[8,22], acknowledging the data did not allow all women with contraindications to be excluded. The Scottish datasets also allowed outcomes to be investigated according to whether planned VBAC was attempted with or without labour induction compared to ERCS, representing a further strength over much of the existing literature, acknowledging that it was not feasible to study outcomes according to the type of induction used. This was due to the limited number of women identified as having a planned VBAC with labour induction. The Scottish datasets

also allowed the influence of a comprehensive range of covariates to be studied, which have not been available or considered by many previous studies. A further advantage of using routinely-collected Scottish data includes its national coverage, which not only minimised selection bias but also maximised statistical power. This is particularly important given the rarity of many of the outcomes considered.

Using routinely-collected data is not, however, without its limitations. While residual confounding due to unmeasured or mis-measured confounders is a potential source of bias in all observational studies, it can be a particular issue in studies using routinely-collected data. This is because these studies can only use the data available, with researchers having no control over the data collected such that potential confounding variables may not be available and/or may not have been accurately measured. In the studies conducted as part of this thesis it was possible to adjust for many potential confounders. Nevertheless, the calculated E-values suggest that while relatively strong unmeasured confounding would be needed to explain most of the associations observed in the first study, relatively small or modest levels of unmeasured confounding could potentially explain the associations found in the second and third studies. There are several possible unmeasured confounders of the associations studied such as indication for the previous caesarean, maternal ethnicity, education, alcohol, and drug use. Furthermore, some of the potential measured confounders, such as hypertensive disorder or pre-existing or gestational diabetes, may not have been accurately measured potentially contributing to residual confounding. Although women with a history of psychotropic drug use in the 1-2 years before birth were excluded in study 2, as discussed in Chapter 5, this is unlikely to have excluded all women with previous mental health problems which may also have led to residual confounding.

In addition to the issue of unmeasured or mis-measured confounders, missing data and misclassification of the variables used to identify the study populations, exposures, outcomes, and other covariates of interest can represent particular problems when using

routinely-collected data. A related issue is only having proxy measures of the variables of interest. This is most clearly demonstrated by having to infer mental health problems from dispensed prescriptions of psychotropic medication in study two. These issues are again due to the fact that when using routinely-collected data, researchers can only use the data that is available to them with no control over the data collection. Misclassification is intuitively more likely where there is potential for confusion or subjectivity around the definition of a data item, and the completeness and accuracy of diagnostic and procedure codes is often a particular concern with routine data. Although standardised coding rules exist, coding may vary according, for example, to the quality and detail of discharge summaries[231] or whether there are financial incentives to use certain codes[232]. Misclassification can bias study findings towards the null or under- or overestimate effect estimates depending upon whether any misclassification is random (e.g. likelihood of outcome being misclassified same regardless of exposure status) or systematic (e.g. likelihood of outcome being misclassified related to exposure status) in nature, respectively. However, the completeness and quality of most routinely-collected Scottish data is considered to be very high and, prior to analysis, extensive cleaning and checking of the data received was undertaken. Furthermore, missing data was handled using multiple imputation, which is considered a valid approach assuming the data are missing at random[204]. Various sensitivity analyses were also conducted for each of the studies. Collectively, this helps provide confidence in the study findings. However, it should be acknowledged that due to time constraints it was not possible to perform all possible data validation checks, such as checking the delivery records which were identified as having contraindications to planned VBAC like placenta praevia against the recorded mode of birth in the record. If time had allowed, it is also worth noting that study two would have been strengthened by looking at other available indicators of maternal mental health including psychiatric hospital admissions and admissions relating to self-harm, acknowledging that these events are rare[233] and only capture more severe cases.

A further strength of the research presented in this thesis was the use of PPI. PPI representatives advised on the research plan, influenced the choice of outcomes considered, and advised on the interpretation and communication of the findings. This included producing, with the help of the PPI representatives, a plain English one page summary and a plain English longer leaflet of the research findings, copies of which can be found in **Appendix G** and on a webpage about the research that was created on the National Perinatal Epidemiology Unit's website (see section 3.2.11). Given there is frequently a mismatch between research priorities identified by patients, clinicians, and researchers[234], using PPI in this way helped to ensure the research addressed relevant information needs of women and their partners. It also helped present the research findings in a way that can be understood by women and their partners and highlighted what the PPI representatives considered as the key messages for women and their families. This resulted in highlighting what proportion of women planning a VBAC actually had a VBAC – information the author of this thesis would not have thought to highlight as a key message. While this research has been strengthened by PPI, it should be acknowledged that the advice and views provided by the PPI representatives involved may not have been representative of all women and their partners faced with deciding about how to plan birth after previous caesarean. It is also important to highlight that it was not possible with the data or time available to study all outcomes the PPI representatives considered to be important, including women's longer-term risk of experiencing pelvic floor disorders.

7.4 Contribution to knowledge

The research presented in this thesis provides a more comprehensive understanding of the short and longer-term outcomes for women and their children born following planned VBAC compared to ERCS, including various outcomes that have been identified as particularly lacking in robust evidence. Studies two and three, to the author's knowledge, are the first large population-based studies to have considered the possible effects of planned mode of

birth after previous caesarean on the mother's mental health-related outcomes and the child's longer-term neurodevelopment, respectively. The first study also represents one of the largest studies to have investigated the effect of planned mode of birth after previous caesarean on a comprehensive range of short-term maternal and perinatal outcomes. This is against a background of literature comprising predominately of small studies that are likely to have lacked statistical power and have focused almost exclusively on a rather limited range of short-term outcomes or maternal complications in future pregnancies. This is despite evidence suggesting that many women who have had a caesarean before would find it helpful to have access to accurate, comprehensive, and well-balanced information on the risks and benefits of their subsequent birth choices when making what is often viewed as a very difficult decision[73-76]. This is also despite recent legal developments in the UK that require women to be informed of all risks they may consider to be important as well as their options when giving informed consent[77].

7.5 Generalisability

The studies conducted as part of this thesis all used Scottish national data and included term singleton births in Scotland between 2002-2015, 2010-2015 or 2002-2011, depending upon the study, to women with one or more previous caesarean sections who were considered clinically eligible to plan VBAC based on UK guidelines[8,22]. While the studies were conducted in one area of the UK, the findings are likely to be generalisable to women with previous caesarean giving birth to a term singleton in other parts of the UK for several reasons. Firstly, the available national data suggests Scotland's obstetric population is comparable in characteristics such as maternal age and caesarean section rate to the obstetric population in other parts of the UK[43-45]. Secondly, the characteristics of the derived study populations were largely comparable to available data identified on the characteristics of women who gave birth after previous caesarean reported in previous UK studies[79,195] (see section C.1.3 in **Appendix C**). Thirdly, clinical practice in Scotland should be similar to

other areas of the UK, as it has a comparable healthcare system and follows the same or at least comparable clinical guidelines, with no reason to believe that the extent to which guidelines are followed in practice varies systematically between different parts of the UK. In addition, with reference to study three, school support in Scotland is likely to be similar to other parts of the UK such as England, where the overall prevalence of SEN over the study period ranged from around 14-21% and the most common primary type of SEN was moderate learning difficulty[235], comparable to what was found in study three. As most women in the studies conducted had one or two previous births, it should, however, be highlighted that the findings may not apply to women who have had a larger number of previous births, particularly if they have had a large number of previous caesarean sections.

The study findings may also be generalisable to other high-income countries with similar population characteristics, clinical practice, and in the case of the study three findings, school support. However, it should be noted that while the available clinical guidelines around birth after previous caesarean from high-income settings[21,63-65,236] are broadly similar to each other and all support offering choice between planned VBAC and ERCS provided women do not have contraindications, there are some differences that may affect the generalisability of the study findings to other high-income countries. For example, French guidelines[236] state that ERCS must be planned from the outset for women with a BMI of >50 or an estimated fetal weight of >4500g. By contrast, UK guidelines[8,22] state that a BMI of >50 alone should not be used as an indication for planned caesarean and simply state that unsuccessful VBAC is more likely with a BMI of >30. UK guidelines also do not preclude planned VBAC in the case of fetal macrosomia, although they do advise a cautious approach in this situation amid uncertainty about the safety of planned VBAC[22]. Such variations and any deviations in the extent to which guidelines are followed, may lead to differences between countries in both the population of women considered clinically eligible to plan VBAC and the population actually offered a choice about how to plan to give birth after previous caesarean. There may also have been changes in these populations over

time due to temporal changes in maternal characteristics[9,147,148], clinical guidelines, and practice. Indeed, the policy of even giving women an informed choice in many areas of their maternity care is, at least in the UK, relatively recent. Country and temporal variations in clinical guidelines and practice, such as changing the recommended timing of prophylactic antibiotic administration in women undergoing caesarean in a bid to reduce maternal postpartum infection[8], may also lead to country and temporal differences in the likelihood of particular outcomes occurring. While such country and temporal differences may limit the generalisability of the absolute effect estimates found in the Scottish studies to other high-income countries or far outside of the study periods, there has been much debate on how study representativeness (i.e. how representative a study sample is of a target population) affects the magnitude, direction, and generalisability of relative measures of association[237-239]. Using the UK Biobank cohort as an example, some researchers have argued that even though this cohort is not representative of the UK population, its large sample size and heterogeneity of exposures and backgrounds allows valid measures of association between exposures and outcomes that are generalisable to other populations[240]. However, others suggest that the lack of representativeness in studies like UK Biobank may in some situations affect relative measures of association and their generalisability[241-243], such as where there are effect modifiers of the exposure-outcome association that are distributed differently in the study sample compared to the target population.

7.6 Implications for practice and policy

The findings, at least from studies one and three, can inform women and their partners, clinicians, and clinical guidelines around birth after previous caesarean. They provide valuable information to manage and counsel women with previous caesarean about the risks and benefits of their birth choices, as recommended by clinical guidelines[8,22,64-66] and supported by recent legal developments in the UK[77]. Of particular importance to highlight, the absolute risk estimates for uterine rupture are lower than frequently quoted rates[67], but

are comparable and add support to several previous population-based studies[79,101,121], including a UK national study that used validated case criteria[79]. The absolute risk estimates for intrapartum stillbirth or neonatal death are also at the lower range of those reported by the detailed systematic review by the US AHRQ[67]. This may reflect the more contemporary, population-based nature of the study conducted as part of this thesis and the fact that this study specifically excluded non-cephalic births in contrast to most of the studies identified by the systematic review[67]. These findings, along with the overall small absolute risk of birth-related maternal and perinatal complications for either birth approach and the finding of little evidence of an association between planned mode of birth after previous caesarean and SENs in childhood, have significant potential to influence counselling practice and thus impact on caesarean section rates. However, it is important to highlight that this thesis did not study all possible outcomes. As noted in the latest RCOG guidelines[22], there is a large body of evidence to show that repeat ERCS is associated with an increased risk of serious maternal morbidity in subsequent pregnancies such as morbidly adherent placenta. Such information should be considered alongside the findings presented in this thesis. Collectively, the evidence supports existing consensus that there are risks and benefits associated with both planned VBAC and ERCS, and therefore women without contraindications to VBAC should be given an informed choice about planned mode of birth after previous caesarean section.

The finding that most maternal morbidity in the planned VBAC group occurred among those who needed an in-labour non-elective repeat caesarean highlights the importance of considering a woman's likelihood of successful VBAC. As mentioned in clinical guidelines[22,64,65], several factors are thought to influence a woman's likelihood of success such as whether she has had a previous vaginal birth, her BMI, age, ethnicity, whether her labour started spontaneously, and the indication for the previous caesarean. Various attempts have been made to use such information to develop models to help predict a woman's likelihood of successful VBAC. Recent US guidelines[64] highlight that one such

model in particular may be useful for counselling women, having been shown to accurately estimate VBAC success in various populations including a sample of the UK population[244].

Whilst planned VBAC was associated with an increased risk of maternal postpartum infection compared to ERCS, analysis by actual mode of birth revealed that this increased risk seems to be confined to women who needed an in-labour non-elective repeat caesarean. This emphasises the importance of infection control measures, particularly in emergency caesarean sections. In 2011, UK guidelines[8] were revised from advising that prophylactic antibiotics should be given after cord clamping to recommending that antibiotics should be given before skin incision in women undergoing caesarean. This followed evidence suggesting that earlier administration helps prevent maternal postpartum infection. While preoperative prophylactic antibiotics have not be shown to affect the baby in the short-term[8], research into the possible long-term effects on the child is currently ongoing[245].

While it was not possible to explore the reasons behind the finding that women who planned VBAC were more likely than women who had an ERCS to breastfeed, this might indicate that women planning an ERCS may need additional support to breastfeed. Previous research suggests that various interventions may help promote breastfeeding such as early skin-to-skin contact[246], healthcare professional-led breastfeeding education and support, and non-healthcare professional-led counselling and peer support[247].

Lastly, the findings from this thesis should be considered by women and clinicians when decisions are being made about performing a primary caesarean, particularly in the case of caesarean's requested by the mother in the absence of any obstetric or medical reason.

7.7 Implications for research

Given the unlikely possibility of being able to perform a large randomised controlled trial, further large population-based observational studies, with the ability to explore the influence of multiple important covariates and confined to those considered clinically eligible to plan VBAC, are needed to replicate the findings found in this thesis. Given the paucity of research, there is a particular need for further studies into the longer-term effects on women and their children of planned mode of birth after previous caesarean beyond the risk of maternal complications in future pregnancies associated with repeat caesarean. This should include further research to establish the reasons behind the observed association between planned mode of birth after previous caesarean and women's subsequent use of psychotropic medication. This could include examining the mental health of women with a previous caesarean before and during a subsequent pregnancy and determining whether pre-existing mental health problems are more common in women planning birth by ERCS. Having accounted for any potential differences in prior psychiatric vulnerability, future research should also assess whether there is evidence that women giving birth by ERCS are more likely than those having a planned VBAC to experience mental health problems in the postnatal period using measures of mental health problems beyond just psychotropic drug use. The evidence base around planned mode of birth and maternal mental health would be further enhanced by conducting qualitative studies to understand the lived experience of affected women.

More research is also needed to examine the effect of mode of birth, both in general and in the specific situation of prior caesarean, on other longer-term maternal outcomes. A recent systematic review[14] on the long-term risks and benefits of caesarean revealed that particularly few or no studies have considered the effects on various maternal outcomes including pelvic organ prolapse, pelvic pain, dysmenorrhea, menorrhagia, sexual dysfunction, and healthcare usage. The PPI representatives who supported the research

presented in this thesis are particularly keen to see further research into the longer-term effects of mode of birth, both in general and in the specific situation of prior caesarean, on women's risk of experiencing pelvic floor disorders.

Although study three provides some reassurance regarding the effect of planned mode of birth after previous caesarean on the child's longer-term neurodevelopment, further research is needed not only to establish if the findings can be replicated in other populations but also to explore the effects of planned mode of birth after previous caesarean on other measures of adverse neurodevelopmental outcomes in the child. This could include examining the effects on the child's educational attainment. More studies are also needed to investigate the longer-term health consequences to the child of planned mode of birth after previous caesarean and whether any effects change over childhood. Any future studies would benefit from distinguishing between whether planned VBAC was attempted with or without labour induction, as in this thesis, and ideally should examine outcomes according to type of induction and whether labour augmentation was used. This could include examining outcomes in women with previous caesarean according to whether labour is induced, or birth is by ERCS compared to expectant management at particular gestational ages. Such an analysis has currently, to the author's knowledge, only been conducted in a limited number of studies and only for some short-term maternal and perinatal outcomes[165,248,249].

While the findings from this thesis provide valuable information, the question of how best to convey such information and facilitate the informed decision-making process on mode of birth after previous caesarean remains. On the advice and with the help of the PPI representatives who supported this research, a plain English one page summary and a plain English longer leaflet describing the specific findings of the studies conducted as part of this thesis were produced (see **Appendix G**). UK guidelines[22] recommend the use of a VBAC versus ERCS checklist or clinical care pathway and providing a patient information leaflet

during antenatal counselling. Decision aids based on the type of information arising from this thesis have also been shown in a limited number of previous studies to help facilitate the decision-making process around mode of birth after previous caesarean by reducing decisional conflict, improving knowledge, satisfaction, and the perception of involvement in decision-making[250-253]. However, this is an area that could benefit from further research[254].

Lastly, the findings from the studies carried out as part of this thesis can inform any future reviews, meta-analyses, and economic evaluations of planned mode of birth after previous caesarean.

7.8 Recommendations around routinely-collected data

The large delays experienced getting access to the datasets required to conduct the research presented in this thesis highlights the need for data providers to do more to ensure timely access to routinely-collected data. Researchers and funding organisations should also be aware of the considerable time it can take to obtain, clean, check, and prepare routinely-collected data and should allow adequate time and resources. The author of this thesis would ideally recommend researchers should start the process of applying to access routine data as soon as possible after receiving confirmation of funding. Researchers using routinely-collected data should also report how they assessed data quality and dealt with any incomplete and inconsistent data.

While many of the Scottish routinely-collected data sources undergo regular quality assurance checks, confidence in the data could be enhanced by evaluating the validity of specific diagnostic and procedural codes in the records as has been done for some of the Scandinavian routinely-collected datasets[255-257]. Efforts should also be made to improve the accuracy of data items such as ethnic group in SMR02, which have been highlighted in the quality assurance assessments as not meeting the ISD recommended minimum standard

of 90%[156]. Further efforts are also needed to minimise missing data, with my research demonstrating this is particularly needed for data items such as maternal BMI at booking. The ability of routinely-collected data to robustly answer the types of research questions covered in this thesis could be further enhanced by the collection of additional hard-coded data items including a variable such as 'planned mode of birth at the onset of birth care' and variables to capture unmeasured confounders such as maternal education. Recent initiatives, such as the development of the Scottish Primary Care Information Resource, a service allowing information to be requested from Scottish GP practice records[258], is also likely to further enhance the ability to investigate the type of research questions covered in this thesis including those around maternal mental health. The increasing ability to link routinely-collected health to education data, both in Scotland and other parts of the UK[259], should also facilitate the ability to conduct further research around mode of birth and indicators of the child's longer-term neurodevelopment including attainment in assessments in addition to SEN.

7.9 Conclusion

The research presented in this thesis provides a more comprehensive understanding of the short and longer-term outcomes for women and their children born following planned VBAC compared to ERCS. The research suggests that while planned VBAC compared to ERCS is associated with an increased risk of various serious birth-related complications for both the mother and her baby, the absolute risk of these complications is small for either birth approach. Furthermore, little evidence was found to support an association between planned mode of birth after previous caesarean section and SENs in childhood. Further studies into the longer-term effects on women and their children of planned mode of birth after previous caesarean are particularly needed, including further research to establish the reasons behind the observed association between planned mode of birth after previous caesarean and women's subsequent use of psychotropic medication. The findings from this

thesis should be considered alongside the existing evidence of the increased risk of complications in subsequent pregnancies associated with repeat caesarean. Overall, this thesis provides valuable information to help manage and counsel the increasing number of women with a history of previous caesarean section.

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Appendix A: Literature review - databases and search terms

- MEDLINE:

1. exp Vaginal Birth after Cesarean/
2. vbac.mp.
3. (vagina$ adj3 (birth$ or born or deliver$) adj7 ((after$ or follow$ or previous$ or prior or history) adj3 (cesarean$ or caesarean$))).mp.
4. 1 or 2 or 3
5. exp "Trial of Labor"/
6. (trial of labor or trial of labour).mp.
7. tol.mp.
8. 6 or 7
9. exp pregnancy/ or exp pregnancy complications/
10. exp Infant, Newborn/
11. exp child/
12. exp Obstetrics/
13. exp Obstetric Surgical Procedures/
14. 9 or 10 or 11 or 12 or 13
15. 8 and 14
16. 15 or 5
17. exp Cesarean Section, Repeat/
18. ((repeat$ or multip$ or another or prior or previous$) adj3 (cesarean$ or caesarean$)).mp.
19. ((second or third) adj cesarean).mp.
20. 17 or 18 or 19
21. 4 or 16 or 20
22. limit 21 to (english language and yr="2009-Current")
23. exp animals/ not humans.sh.
24. 22 not 23

1. exp Vaginal Birth after Cesarean/
2. vbac.mp.
3. (vagina$ adj3 (birth$ or born or deliver$) adj7 ((after$ or follow$ or previous$ or prior or history) adj3 (cesarean$ or caesarean$))).mp.
4. 1 or 2 or 3
5. exp "Trial of Labor"/
6. (trial of labor or trial of labour).mp.
7. tol.mp.
8. 5 or 6 or 7
9. exp Cesarean Section, Repeat/
10. ((repeat$ or multip$ or another or prior or previous$) adj3 (cesarean$ or caesarean$)).mp.
11. ((second or third) adj cesarean).mp.
12. 9 or 10 or 11
13. 4 or 8 or 12
14. Mental disorders/ or Mood Disorders/ or Depressive disorder/ or Depression, Postpartum/ or Depressive disorder, major/ or Depressive disorder, treatment-resistant/ or Dysthymic Disorder/ or exp Anxiety Disorders/ or anxiety/ or Stress Disorders, Post-Traumatic/ or exp "bipolar and related disorders"/ or exp "schizophrenia spectrum and other psychotic disorders"/ or exp Psychotropic Drugs/
15. (mental health or mental illness or psychological health or depression or anxiety or post traumatic stress or Post-traumatic stress or bipolar or Schizophrenia or psychoses or Psychosis or psychotic or antidepressant or antipsychotic or anxiolytics or antimanic or psychotropic).mp.
16. 14 or 15
17. 13 and 16
18. limit 17 to (English language and yr="1980 – 2008")
19. exp animals/ not humans.sh.
20. 18 not 19

1. exp Vaginal Birth after Cesarean/
2. vbac.mp. [mp=title, original title, abstract, name of substance word, subject heading word]
3. (vagina$ adj3 (birth$ or born or deliver$) adj7 ((after$ or follow$ or previous$ or prior or history) adj3 (cesarean$ or caesarean$))).mp.
4. 1 or 3 or 2
5. exp "Trial of Labor"/
6. (trial of labor or trial of labour).mp.
7. tol.mp.
8. 6 or 7
9. exp pregnancy/ or exp pregnancy complications/
10. exp Infant, Newborn/
11. exp child/
12. exp Obstetrics/
13. exp Obstetric Surgical Procedures/
14. 9 or 10 or 11 or 12 or 13
15. 8 and 14
16. 15 or 5
17. exp Cesarean Section, Repeat/
18. ((repeat$ or multip$ or another or prior or previous$) adj3 (cesarean$ or caesarean$)).mp.
19. ((second or third) adj cesarean).mp.
20. 17 or 18 or 19
21. 4 or 16 or 20
22. Pediatric Obesity/
23. ((child* or pediatric or paediatric) adj3 obes*).mp.
24. exp Neoplasms/
25. (leukaemia or leukemia or lymphoma or sarcoma or Osteosarcoma or Neuroblastoma or Retinoblastoma or Rhabdomyosarcoma or cancer* or tumor* or tumour*).mp.
26. exp Infection/ or exp respiratory tract infection/ or exp Pneumonia/ or exp Influenza, Human/ or exp Bronchitis/ or exp Diarrhea/ or exp Gastroenteritis/ or exp Meningitis/ or Bacterial Infections/
27. (infection or infectious or respiratory or pneumonia or influenza or bronchitis or bronchiolitis or gastroenteritis or diarrhea or diarrhoea or meningitis or viral or bacterial).mp.
28. exp Diabetes Mellitus, Type 1/
29. (type 1 diabetes or type i diabetes).mp.
30. Asthma/
31. asthma*.mp.
32. exp Inflammatory Bowel Diseases/
33. (inflammatory bowel disease or crohn* disease or colitis).mp.
34. 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33
35. 21 and 34
36. limit 35 to "all child (0 to 18 years)"
37. 21 and (22 or 23)
38. 36 or 37
39. limit 38 to (english language and yr="1980 – 2008")

- EMBASE:

1. exp Vaginal Birth after Cesarean/
2. vbac.mp.
3. (vagina$ adj3 (birth$ or born or deliver$) adj7 ((after$ or follow$ or previous$ or prior or history) adj3 (cesarean$ or caesarean$))).mp.
4. 1 or 2 or 3
5. exp "Trial of Labor"/
6. (trial of labor or trial of labour).mp.
7. tol.mp.
8. 6 or 7
9. exp pregnancy/ or exp pregnancy complications/
10. exp Infant, Newborn/
11. exp child/
12. exp Obstetrics/
13. exp Obstetric Operation/
14. 9 or 10 or 11 or 12 or 13
15. 8 and 14
16. 15 or 5
17. exp Cesarean Section, Repeat/
18. ((repeat$ or multip$ or another or prior or previous$) adj3 (cesarean$ or caesarean$)).mp.
19. ((second or third) adj cesarean).mp.
20. 17 or 18 or 19
21. 4 or 16 or 20
22. limit 21 to (english language and yr="2009-Current")
23. (exp animals/ or nonhuman/) not human/
24. 22 not 23
25. conference*.pt
26. 24 not 25

1. exp Vaginal Birth after Cesarean/
2. vbac.mp.
3. (vagina$ adj3 (birth$ or born or deliver$) adj7 ((after$ or follow$ or previous$ or prior or history) adj3 (cesarean$ or caesarean$))).mp.
4. 1 or 2 or 3
5. exp "Trial of Labor"/
6. (trial of labor or trial of labour).mp.
7. tol.mp.
8. 5 or 6 or 7
9. exp Cesarean Section, Repeat/
10. ((repeat$ or multip$ or another or prior or previous$) adj3 (cesarean$ or caesarean$)).mp.
11. ((second or third) adj cesarean).mp.
12. 9 or 10 or 11
13. 4 or 8 or 12
14. mental disease/ or exp mood disorder/ or exp anxiety disorder/ or anxiety/ or exp psychosis/ or exp psychotropic agent/
15. (mental health or mental illness or psychological health or depression or anxiety or post traumatic stress or Post-traumatic stress or bipolar or Schizophrenia or psychoses or Psychosis or psychotic or antidepressant or antipsychotic or anxiolytics or antimanic or psychotropic).mp.
16. 14 or 15
17. 13 and 16
18. limit 17 to (English language and yr="1980 – 2008")
19. (exp animals/ or nonhuman/) not human/
20. 18 not 19
21. conference*.pt
22. 20 not 21

1. exp Vaginal Birth after Cesarean/
2. vbac.mp. [mp=title, original title, abstract, name of substance word, subject heading word]
3. (vagina$ adj3 (birth$ or born or deliver$) adj7 ((after$ or follow$ or previous$ or prior or history) adj3 (cesarean$ or caesarean$))).mp.
4. 1 or 3 or 2
5. exp "Trial of Labor"/
6. (trial of labor or trial of labour).mp.
7. tol.mp.
8. 6 or 7
9. exp pregnancy/ or exp pregnancy complications/
10. exp Infant, Newborn/
11. exp child/
12. exp Obstetrics/
13. exp Obstetric Operation/
14. 9 or 10 or 11 or 12 or 13
15. 8 and 14
16. 15 or 5
17. exp Cesarean Section, Repeat/
18. ((repeat$ or multip$ or another or prior or previous$) adj3 (cesarean$ or caesarean$)).mp.
19. ((second or third) adj cesarean).mp.
20. 17 or 18 or 19
21. 4 or 16 or 20
22. childhood obesity/
23. ((child* or pediatric or paediatric) adj3 obes*).mp.
24. exp neoplasm/
25. (leukaemia or leukemia or lymphoma or sarcoma or Osteosarcoma or Neuroblastoma or Retinoblastoma or Rhabdomyosarcoma or cancer* or tumor* or tumour*).mp.
26. exp Infection/ or exp respiratory tract infection/ or exp pneumonia/ or exp Influenza/ or exp Bronchitis/ or exp diarrhea/ or exp gastroenteritis/ or exp meningitis/ or exp bacterial infection/
27. (infection or infectious or respiratory or pneumonia or influenza or bronchitis or bronchiolitis or gastroenteritis or diarrhea or diarrhoea or meningitis or viral or bacterial).mp.
28. exp insulin dependent diabetes mellitus/
29. (type 1 diabetes or type i diabetes).mp.
30. asthma/
31. asthma*.mp.
32. exp inflammatory bowel disease/
33. (inflammatory bowel disease or crohn*disease or colitis).mp.
34. 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33
35. 21 and 34
36. limit 35 to (infant <to one year> or child <unspecified age> or preschool child <1 to 6 years> or school child <7 to 12 years> or adolescent <13 to 17 years>)
37. 21 and (22 or 23)
38. 36 or 37
39. limit 38 to (english language and yr="1980 – 2008")
40. conference*.pt.
41. 39 not 40

- PsycINFO:

1. vbac.mp.
2. (vagina$ adj3 (birth$ or born or deliver$) adj7 ((after$ or follow$ or previous$ or prior or history) adj3 (cesarean$ or caesarean$))).mp.
3. 1 or 2
4. (trial of labor or trial of labour).mp.
5. tol.mp.
6. 4 or 5
7. ((repeat$ or multip$ or another or prior or previous$) adj3 (cesarean$ or caesarean$)).mp.
8. ((second or third) adj cesarean).mp.
9. 7 or 8
10. 3 or 6 or 9
11. mental disorders/ or Affective Disorders/ or exp Major Depression/ or exp "depression (emotion)"/ or exp Anxiety Disorders/ or anxiety/ or exp Bipolar Disorder/ or exp psychosis/ or exp Antidepressant Drugs/
12. (mental health or mental illness or psychological health or depression or anxiety or post traumatic stress or Post-traumatic stress or bipolar or Schizophrenia or psychoses or Psychosis or psychotic or antidepressant or antipsychotic or anxiolytics or antimanic or psychotropic).mp.
13. 11 or 12
14. 10 and 13
15. limit 14 to (english language and yr="1980 -Current")
16. exp animals/ or animal models/
17. 15 not 16

Appendix B: Studies included in the literature review of short and longer-term outcomes for women and their children of planned VBAC compared to ERCS (Chapter 2)

Table B.1. Studies investigating risk of maternal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **USA (9 studies), Canada (1 study), Netherlands (1 study), Japan (1 study)** **Ranged from 1980-2002**	**Systematic review & meta-analysis of 12 identified cohort studies - 7 single, 3 multicentre & 2 population-based (4 confined to women who gave birth at ≥37 weeks' gestation)** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant in a developed country**	**167,220 (156,690 who gave birth at ≥37 weeks' gestation)**	**229,635 (225,239 who gave birth at ≥37 weeks' gestation)**	**Death (time period not defined but likely up to time of primary hospital discharge after birth)**	**Planned VBAC vs. ERCS in women who gave birth at any gestational age**	**4 per 100,000 (95% CI 1–16 per 100,000) vs. 13 per 100,000 (95% CI 4–42 per 100,000)**	**uRR 0.33 (0.13-0.88)**	**--**
					Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation	**2 per 100,000 (95% CI 0.4-10 per 100,000) vs. 10 per 100,000 (95% CI 2-43 per 100,000)**	**uRR 0.27 (0.09-0.85)**	
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Death up to time of primary hospital discharge after birth, identified from medical records	Planned VBAC vs. ERCS	No deaths	--	--

Table continued overleaf

Table B.1 (continued). Studies investigating risk of maternal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Gilbert, 2012[96] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 prior CS eligible to plan VBAC, who gave birth to a live, vertex presenting singleton infant without aneuploidy or congenital malformations at ≥ 37 weeks' gestation by ERCS (without indication other than prior CS) or planned VBAC where labour began spontaneously, identified from 19 centres of the Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	3,981 (all spontaneous labour onset)	3,981	Death during birth, identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	0 per 100,000 vs. 25 per 100,000	*aOR 0.33 (0.01-8.18)§*	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, marital status, antenatal care, private medical payment, BMI, maternal age, prior CS indication, interval since last CS, whether had prior VB or prior VBAC, EDD confirmed by 1st trimester ultrasound, diabetes, asthma, thyroid disease, seizure disorder, chronic hypertension, heart disease, cigarette use, alcohol use, street drug use, preterm labour requiring tocolysis, infection, antepartum antibiotic administration, gestational hypertension/ preeclampsia, other maternal comorbidity & recruitment centre)
Schmitz, 2013[107] France 1988-2010	Single centre cohort Women with 1 prior CS not including those with a prior classical uterine incision, who gave birth to a cephalic presenting singleton infant at ≥ 37 weeks' gestation, identified at a single University hospital	3,544 (1,828 spontaneous labour; 1,716 induction or augmentation of labour; 1,201 oxytocin only; 274 prostaglandins only; 241 prostaglandins & oxytocin; 251 labour induced with oxytocin; 950 labour augmented with oxytocin)	593	Death (time period not defined but likely up to time of primary hospital discharge after birth) identified from hospital database	Planned VBAC vs. ERCS	No deaths	--	--

Table continued overleaf

Table B.1 (continued). Studies investigating risk of maternal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Death (time period not defined but likely up to time of primary hospital discharge after birth) identified from hospital database	Planned VBAC vs. ERCS	No deaths	--	--
					Planned VBAC with spontaneous labour onset vs. ERCS	No deaths	--	
					Planned VBAC with induced labour onset vs. ERCS	No deaths	--	
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province	11,340 (7,614 after 1-2 prior CSs only; 3,726 after 1-2 prior CSs & ≥ 1 prior VB; 7,504 after 1 prior CS only; 3,623 after 1 prior CS & ≥ 1 prior VB)	22,472 (20,792 after 1-2 prior CSs only; 1,680 after 1-2 prior CSs & ≥ 1 prior VB; 16,913 after 1 prior CS only; 1,406 after 1 prior CS & ≥ 1 prior VB)	Death (time period not defined but likely up to time of primary hospital discharge after birth) identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	No deaths	--	--
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	No deaths	--	
					Planned VBAC vs. ERCS in women with 1 prior CS only	No deaths	--	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	No deaths	--	

Table continued overleaf

Table B.1 (continued). Studies investigating risk of maternal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Stattmiller, 2016[112] USA 2003-2011	Population-based cohort Women with prior CS (number not stated), excluding those with indication for ERCS (including diabetes, hypertension, preterm, soft-tissue disorders, malpresentation, mental health disorders, asthma, thyroid abnormalities, isoimmunisation, antenatal bleed, oligohydramnios, herpes, multiple pregnancy, intra-uterine growth restriction, polyhydramnios, cardiovascular diseases, stillbirth, unengaged fetal head, substance use, uterine scar not from previous CS, renal abnormalities, congenital fetal anomalies, systemic lupus erythematosus, liver abnormalities, cerebral haemorrhage), identified using database of nationwide sample of hospital inpatient stays	144,066	541,071	In hospital death, identified using NIS code	Planned VBAC vs. ERCS	No deaths	--	--
Huisman, 2019[127] Netherlands 2011-2012	Multicentre cohort Women with 1 prior CS, who gave birth to a live singleton infant in cephalic presentation at 37-41 weeks' gestation & had an unfavourable cervix & an indication for delivery, excluding contraindications for VB such as placenta previa, previous classical uterine incision or obstructing cervical fibroids, identified from 51 hospitals	993 (all had labour induced with a balloon catheter)	321	Death (time period not defined but likely up to time of primary hospital discharge after birth) identified from medical records	Planned VBAC where labour induced with a balloon catheter vs. ERCS	No deaths	--	--

Table continued overleaf

Table B.1 (continued). Studies investigating risk of maternal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Modzelewski, 2019[129] Poland 2010-2017	Single centre cohort Women with 2 prior CS, who gave birth to a singleton infant at term, excluding those with placenta previa, identified from a single tertiary hospital	35	377	Death (time period not defined but likely up to time of primary hospital discharge after birth) identified from hospital database	Planned VBAC vs. ERCS	No deaths	--	--
Takeya, 2020[134] Japan 2013-2015	Population-based cohort Women with 1 prior CS, who gave birth to a singleton at 37-41 weeks' gestation, excluding those with placenta previa, intrauterine fetal death or non-cephalic presentation, identified from a nationwide institution-based registry	1,730	32,739	Death (time period not defined but likely up to time of primary hospital discharge after birth) identified from a nationwide institution-based registry	Planned VBAC vs. ERCS	0.00% vs. 0.01%	*uOR 2.70 (0.14-52.33)§*	--

Abbreviations: aOR, adjusted odds ratio; BMI, body mass index; CS, caesarean section; EDD, estimated date of delivery; ERCS, elective repeat caesarean section; RCT, randomised control trial; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.2. Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **USA (3 studies) & Canada (1 study)** **Ranged from 1986-2002**	**Systematic review & meta-analysis of 4 identified cohort studies - 1 single, 2 multicentre & 1 population-based (2 confined to women who gave birth at ≥37 weeks' gestation)** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant in a developed country**	**24,540**	**22,662**	**Separation through entire thickness of wall including visceral serosa, with or without extrusion of part of all of fetal-placental unit**	**Planned VBAC vs. ERCS in women who gave birth at any gestational age**	**0.47% (95% CI 0.28–0.77%) vs. 0.026% (95% CI 0.009–0.082%)**	**uRR 20.74 (9.77-44.02)**	**--**
Al-Zirqi, 2010[99] Norway 1999-2005	Population-based cohort Women with previous CS (number unknown but national guidelines state VBAC should only be attempted if 1 prior CS), who gave birth at ≥28 weeks' gestation, excluding antepartum stillbirths, identified using a national birth registry	11,954 (9,239 spontaneous & 2,715 induced labour onset)	5,442	Uterine rupture, identified using ICD-10 diagnostic codes (O71.0 & O71.1)	Planned VBAC vs. ERCS	0.67% vs. 0.07%	aOR 7.96 (2.9-22.0)	Adjusted for maternal age, ethnic origin, parity & gestational age
					Planned VBAC with spontaneous labour onset vs. ERCS	0.55% vs. 0.07%	aOR 6.65 (2.4-18.6)	
					Planned VBAC with induced labour onset vs. ERCS	1.07% vs. 0.07%	aOR 12.60 (4.4-36.4)	
Cahill, 2010[100] USA 1996-2000	Multicentre cohort Women with ≥ 1 prior CS, identified from 17 tertiary & community birth centres	13,706 (12,535 after 1 prior CS; 1,082 after 2 prior CSs; 89 after ≥3 prior CSs)	771 (all after ≥3 prior CSs)	Full-thickness disruption of uterine scar, identified at laparotomy, accompanied by 1 of following: acute maternal haemorrhage, maternal hypotension, maternal heart rate >120 beats/min, blood in peritoneal cavity at time of laparotomy or non-reassuring fetal heart rate tracing immediately preceding surgery, identified from medical records	Planned VBAC vs. ERCS in women with ≥3 prior CSs	No cases	--	--

Table continued overleaf

Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Dekker, 2010[101] Australia 1998-2000	Population-based cohort Women with 1 prior CS only, who gave birth to a singleton infant, where the first birth was a live singleton, identified from the perinatal data collections of 4 states	10,958 (8,221 spontaneous onset of labour, no augmentation; 628 spontaneous onset of labour, augmentation with oxytocin; 735 labour induced, oxytocin only; 586 labour induced, prostaglandins only; 226 labour induced, oxytocin & prostaglandins; 320 labour induced, no oxytocin or prostaglandins; 242 labour induced, unspecified method)	18,050	Rupture through full thickness of uterus with fetal parts &/or amniotic fluid in abdominal cavity, identified using ICD codes then validated using medical records	Planned VBAC vs. ERCS	0.33% vs. 0.01%	uRR 59.30 (8.13-432.46)	Where indicated adjusted for placental abruption, the only covariable found to be associated with complete uterine rupture (other covariates considered included maternal age, indigenous status, area of residence, patient type, diabetes, pre-existing hypertension, prelabour rupture of membranes, gestational diabetes, genital herpes, pregnancy hypertension, breech presentation, antepartum haemorrhage from placenta praevia, failure to progress, cord prolapse gestational age, birth weight)
					Planned VBAC with spontaneous labour onset, no augmentation vs. ERCS	0.15% vs. 0.01%	aOR 25.00 (3.33-100.00)	
					Planned VBAC with spontaneous onset of labour, augmentation with oxytocin vs. ERCS	1.91% vs. 0.01%	*uOR 243.98 (44.77-1329.53)§*	
					Planned VBAC with induced labour onset, oxytocin only vs. ERCS	0.54% vs. 0.01%	*uOR 74.02 (11.65-470.47)§*	
					Planned VBAC with induced labour onset, prostaglandins only vs. ERCS	0.68% vs. 0.01%	*uOR 92.96 (14.62-591.03)§*	
					Planned VBAC with induced labour onset, oxytocin & prostaglandins vs. ERCS	0.88% vs. 0.01%	*uOR 124.05 (16.32-942.84)§*	
					Planned VBAC with induced labour onset, no oxytocin or prostaglandins vs. ERCS	0.63% vs. 0.01%	*uOR 94.45 (12.44-717.20)§*	
					Planned VBAC with induced labour onset, unspecified method vs. ERCS	0.00% vs. 0.01%	*uOR 24.81 (1.01-610.56)§*	

Table continued overleaf

Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	Total number ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Dekker, 2010[101] continued				Rupture through full thickness of uterus with fetal parts &/or amniotic fluid in abdominal cavity **or** ballooning of thin membrane but no fetal parts or amniotic fluid in abdominal cavity, identified using ICD codes then validated using medical records	Planned VBAC vs. ERCS	0.40% vs. 0.02%	uRR 18.12 (6.51-50.41)	Did not adjust as no covariables found to be associated with complete & partial uterine rupture (covariates considered included maternal age, indigenous status, area of residence, patient type, diabetes, pre-existing hypertension, prelabour rupture of membranes, gestational diabetes, genital herpes, pregnancy hypertension, breech presentation, antepartum haemorrhage from placenta praevia, placental abruption, failure to progress, cord prolapse gestational age, birth weight)
					Planned VBAC with spontaneous labour onset, no augmentation vs. ERCS	0.19% vs. 0.02%	uOR 9.09 (2.94-25.00)	
					Planned VBAC with spontaneous onset of labour, augmentation with oxytocin vs. ERCS	1.91% vs 0.02%	*uOR 81.31 (27.60-239.55)§*	
					Planned VBAC with induced labour onset, oxytocin only vs. ERCS	0.82% vs. 0.02%	*uOR 35.73 (10.72-119.14)§*	
					Planned VBAC with induced labour onset, prostaglandins only vs. ERCS	0.68% vs. 0.02%	*uOR 30.98 (8.37-114.73)§*	
					Planned VBAC with induced labour onset, oxytocin & prostaglandins vs. ERCS	1.77% vs. 0.02%	*uOR 81.11 (21.81-301.60)§*	
					Planned VBAC with induced labour onset, no oxytocin or prostaglandins vs. ERCS	0.63% vs. 0.02%	*uOR 31.48 (6.68-148.31)§*	
					Planned VBAC with induced labour onset, unspecified method vs. ERCS	0.00% vs. 0.02%	*uOR 8.27 (0.44-154.00)§*	

Table continued overleaf

Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Cieminski, 2011[102] Poland 1992-2002	Single centre cohort Women with prior CS (number not stated) via low transverse incision, who gave birth at a single hospital	492 (all spontaneous labour onset)	228	Puncture of uterine wall affecting endometrium, myometrium & parietal wall that is characterised by a vehement course & threat to mother & child, requiring urgent laparotomy, identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	0.41% vs. 0.00%	*uOR 2.33 (0.11-48.71)§*	--
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Clinically significant rupture involving full thickness of uterine wall & requiring surgical repair, identified from medical records	Planned VBAC vs. ERCS	0.24% vs. 0.09%	aRR 2.70 (0.28-25)	Adjusted for key prognostic variables where there was an imbalance between the comparison groups: maternal socioeconomic status, BMI & indication for previous CS

Table continued overleaf

Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Fitzpatrick, 2012[79] UK 2009-2010	Population-based case-control All women identified as having a uterine rupture using a prospective national surveillance system covering all obstetrician-led maternity units in country, & a control group of women who gave birth to a fetus or infant who had not had a uterine rupture & who had given birth by CS in any previous pregnancy, identified from random sample of obstetrician-led maternity units in country in month 4 & 12 of study, weighted by total number of births.	Estimated number: 56,246 (41,622 laboured without prostaglandin induction or oxytocin in labour; 2,812 labour induced with prostaglandin & oxytocin not used in labour; 10,124 laboured without prostaglandin induction but oxytocin used in labour; 1,687 labour induced with prostaglandin & oxytocin used in labour)	Estimated number: 71,585	Complete separation of wall of pregnant uterus, with or without expulsion of fetus, involving rupture of membranes at site of uterine rupture or extension of the complete separation of wall of the uterus into uterine muscle separate from any previous scar, & endangering life of mother or fetus, identified from medical records	Planned VBAC vs. ERCS	0.21% vs. 0.03%	aOR 19.37 (8.53-43.98)	Adjusted for maternal age, ethnicity, BMI, parity, number of previous CSs, other previous uterine surgery, time since last CS & last menstrual period, placenta praevia & macrosomia
					Planned VBAC where laboured without prostaglandin induction or oxytocin in labour vs. ERCS	0.13% vs. 0.03%	aOR 12.74 (5.44-29.87)	
					Planned VBAC where labour induced with prostaglandin & oxytocin not used in labour vs. ERCS	0.36% vs. 0.03%	aOR 35.91 (10.38-124.28)	
					Planned VBAC where laboured without prostaglandin induction but oxytocin used in labour vs. ERCS	0.28% vs. 0.03%	aOR 35.36 (13.38-93.41)	
					Planned VBAC where labour induced with prostaglandin & oxytocin used in labour vs. ERCS	0.36% vs. 0.03%	aOR 52.05 (11.30-239.84)	

Table continued overleaf

Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Gilbert, 2012[96] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 prior CS eligible to plan VBAC, who gave birth to a live, vertex presenting singleton infant without aneuploidy or congenital malformations at ≥ 37 weeks' gestation by ERCS (without indication other than prior CS) or planned VBAC where labour began spontaneously, identified from 19 centres of the Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	3,981 (all spontaneous labour onset)	3,981	Disruption or tear of uterine muscle & visceral peritoneum or a uterine muscle separation with extension to adjacent structures, identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	0.78% vs. 0.00%	*aOR 63.49 (3.88-1037.96)§*	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, marital status, antenatal care, private medical payment, BMI, maternal age, prior CS indication, interval since last CS, whether had prior VB or prior VBAC, EDD confirmed by 1st trimester ultrasound, diabetes, asthma, thyroid disease, seizure disorder, chronic hypertension, heart disease, cigarette use, alcohol use, street drug use, preterm labour requiring tocolysis, infection, antepartum antibiotic administration, gestational hypertension/ preeclampsia, other maternal comorbidity & recruitment centre)
Fruscalzo, 2012[119] Italy 2007-2008	Single centre cohort Women with 1 prior CS not including those with a prior T incision or previous full thickness uterotomy, metroplasty or myomectomy, presenting with a singleton pregnancy with the foetus in cephalic presentation or twin pregnancy with the foetuses in cephalic-cephalic presentation, identified at a single hospital	170	24	Uterine rupture (not defined), identified from hospital database	Planned VBAC vs. ERCS	0.59% vs. 0.00%	*uOR 0.43 (0.02-10.95)§*	--

Table continued overleaf

Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Studsgaard, 2013[120] Denmark 2003-2010	Single centre cohort Women with 1 prior CS & no diabetes, who gave birth to a singleton infant at ≥37 weeks' gestation by planned VBAC or ERCS without contraindications for VBAC, not including antepartum stillbirths, identified at a single University hospital	1,161	622	Rupture that included myometrium, peritoneum & fetal membranes, identified from hospital database	Planned VBAC vs. ERCS	1.29% vs. 0.00%	*uOR 16.83 (1.01-281.78)§*	Where indicated adjusted for prior vaginal deliveries, age of mother, pre-pregnancy BMI, birth weight
				Rupture that included myometrium, peritoneum & fetal membranes or rupture of myometrium but with intact peritoneum &/or fetal membranes, identified from hospital database	Planned VBAC vs. ERCS	3.10% vs. 0.80%	aOR 2.9 (1.1-7.6)	
Schmitz, 2013[107] France 1988-2010	Single centre cohort Women with 1 prior CS not including those with a prior classical uterine incision, who gave birth to a cephalic presenting singleton infant at ≥37 weeks' gestation, identified at a single University hospital	3,544 (1,828 spontaneous labour; 1,716 induction or augmentation of labour; 1,201 oxytocin only; 274 prostaglandins only; 241 prostaglandins & oxytocin; 251 labour induced with oxytocin; 950 labour augmented with oxytocin)	593	Complete disruption of the uterine muscle & visceral peritoneum, identified from hospital database	Planned VBAC vs. ERCS	0.87% vs. 0.51%	*uOR 1.51 (0.50-4.58)§*	--
					Planned VBAC with spontaneous labour onset vs. ERCS	0.71% vs. 0.51%	*uOR 1.25 (0.39-4.08)§*	
					Planned VBAC with induction or augmentation of labour vs. ERCS	1.05% vs. 0.51%	*uOR 1.84 (0.58-5.78)§*	
					Planned VBAC with oxytocin only vs. ERCS	1.17% vs. 0.51%	*uOR 2.06 (0.64-6.65)§*	
					Planned VBAC with prostaglandins only vs. ERCS	0.73% vs. 0.51%	*uOR 1.55 (0.30-7.89)§*	
					Planned VBAC with prostaglandins & oxytocin vs. ERCS	0.83% vs. 0.51%	*uOR 1.76 (0.35-8.99)§*	
					Planned VBAC where labour induced with oxytocin vs. ERCS	1.20% vs. 0.51%	*uOR 2.38 (0.54-10.53)§*	
					Planned VBAC where labour augmented with oxytocin vs. ERCS	1.16% vs. 0.51%	*uOR 2.07 (0.62-6.86)§*	

Table continued overleaf

Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Melamed, 2013[106] Israel 1996-2011	Single centre cohort Women with 1 prior CS at ≥37 weeks' gestation following a failed trial of operative VB, who gave birth to a subsequent singleton infant at ≥37 weeks' gestation, excluding those with a prior vertical uterine incision & those who needed an urgent CS prior to labour onset in the subsequent pregnancy because of maternal &/or neonatal complications or major fetal anomalies, identified at a single university-affiliated tertiary medical centre	93	111	Uterine rupture (not defined), identified from patient files & hospital electronic records	Planned VBAC vs. ERCS	No cases	--	--
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Uterine rupture defined as complete tear of uterine wall, including visceral peritoneum, with a direct communication between uterine & abdominal cavities, identified from hospital database	Planned VBAC vs. ERCS	0.26% vs. 0.31%	*uRR 0.82 (0.32-2.11)§*	--
					Planned VBAC with spontaneous labour onset vs. ERCS	0.21% vs. 0.31%	*uRR 0.67 (0.24-1.89)§*	
					Planned VBAC with induced labour onset vs. ERCS	0.38% vs. 0.31%	*uRR 0.37 (0.12-1.15)§*	

Table continued overleaf

Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Sananès, 2014[108] France 2007-2012	Multicentre cohort Women with 1 prior CS, who gave birth to a singleton infant at a level 2 & a level 3 maternity hospital	1,269 (1,045 spontaneous onset of labour; 89 labour induced with oxytocin & amniotomy; 135 labour induced with Foley catheter)	806	Uterine rupture (not defined), identified from computerised medical dossier	Planned VBAC vs. ERCS	0.47% vs. 0.25%	*uOR 1.66 (0.38-7.14)§*	--
					Planned VBAC with spontaneous onset of labour vs. ERCS	0.57% vs. 0.25%	*uOR 2.01 (0.47-8.68)§*	
					Planned VBAC where labour induced with oxytocin & amniotomy vs. ERCS	0.00% vs. 0.25%	*uOR 1.80 (0.09-37.74)§*	
					Planned VBAC where labour induced with Foley catheter vs. ERCS	0.00% vs. 0.25%	*uOR 1.19 (0.06-24.87)§*	
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province	11,340 (7,614 after 1-2 prior CSs only; 3,726 after 1-2 prior CSs & ≥ 1 prior VB; 7,504 after 1 prior CS only; 3,623 after 1 prior CS & ≥ 1 prior VB)	22,472 (20,792 after 1-2 prior CSs only; 1,680 after 1-2 prior CSs & ≥ 1 prior VB; 16,913 after 1 prior CS only; 1,406 after 1 prior CS & ≥ 1 prior VB)	Uterine rupture (not defined), identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.43% vs. 0.06%	uRR 6.93 (3.65–13.16)	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.19% vs. 0.06%	uRR 3.16 (0.39–25.63)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.43% vs 0.07%	uRR 6.56 (3.31–13.00)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.17% vs. 0.07%	uRR 2.33 (0.28–19.32)	

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Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Kok, 2015[121] Netherlands 2000-2007	Population-based cohort Women with 1 prior CS at ≥37 weeks' gestation, having a second birth of a live singleton cephalic presenting infant without congenital abnormalities by ERCS at ≥39 weeks' gestation or spontaneous planned VBAC at ≥37 weeks' gestation, identified using a national perinatal registry	4,109 (all with spontaneous onset of labour)	4,109	Uterine muscle separation or tear of uterine muscle with involvement of adjacent structures or placental abruption, identified from national database of data entered by clinicians	Planned VBAC with spontaneous labour onset vs. ERCS	0.22% vs. 0.02%	aOR 10.00 (1.25–333.33)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, socio-economic status; 1st pregnancy history: IVF, maternal age, non-gestational diabetes, pre-existing hypertension, pregnancy induced hypertensive disorder, spontaneous labour, malpresentation, ECS, gestational age, birth weight, Apgar score at 5 min, male gender, haemorrhage, transfusion; 2nd pregnancy: pregnancy interval <15 months, IVF, maternal age, gestational age)
Miller, 2015[95] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1-2 prior CSs via low transverse or unknown incision & no contraindication to VB, who gave birth to a singleton infant with no anomaly, excluding antenatal stillbirths, identified from 19 centres of Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	4,252 (all induction of labour; 4,100 had 1 prior CS; 152 had 2 prior CSs)	6,010 (all after 2 prior CSs)	Either a disruption of myometrium & serosa or a disruption of only the myometrium but with extension into bladder or broad ligament, identified from medical records, identified from medical records	Planned VBAC with induction of labour vs. ERCS in women with 2 prior CSs	0.66% vs. 0.12%	uOR 5.68 (0.69-46.45)	No

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Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/ adjusted for potential confounders
		Planned VBAC	ERCS					
Stattmiller, 2016[112] USA 2003-2011	Population-based cohort Women with prior CS (number not stated), excluding those with indication for ERCS (including diabetes, hypertension, preterm, soft-tissue disorders, malpresentation, mental health disorders, asthma, thyroid abnormalities, isoimmunisation, antenatal bleed, oligohydramnios, herpes, multiple pregnancy, intra-uterine growth restriction, polyhydramnios, cardiovascular diseases, stillbirth, unengaged fetal head, substance use, uterine scar not from previous CS, renal abnormalities, congenital fetal anomalies, systemic lupus erythematosus, liver abnormalities, cerebral haemorrhage), identified using database of nationwide sample of hospital inpatient stays	144, 066	541, 071	Uterine rupture, identified using ICD-9 diagnostic codes (665.0 & 665.1)	Planned VBAC vs. ERCS	0.81% vs. 0.04%	aOR 22.52 (19.35-26.20)	Adjusted for maternal age, race, median household income, hospital, region, primary payer & year
Vandenberghe, 2016[122] Belgium 2012-2013	Population-based cohort All women identified as having a uterine rupture using a prospective national surveillance system covering 97% of maternity units in the country. Data on denominators available from the national perinatal registry covering nearly all births in maternity units & at home in the country	12,754	14,253	Complete separation of wall of pregnant uterus, with or without expulsion of fetus, involving rupture of membranes at site of the uterine rupture or extension into uterine muscle separate from any previous scar, & endangering life of the mother or the fetus or occurrence of clinical symptoms leading to emergency CS, at which the presumed diagnosis of uterine rupture was confirmed; or a peripartum hysterectomy or laparotomy is required for uterine rupture after a VB, identified using medical records	Planned VBAC vs. ERCS	0.45% vs. 0.09%	uRR 1.39 (1.15 to 1.69)	No

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Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Vigorito, 2016[113] Italy 2011-2015	Single centre cohort Women with 3 prior CSs & ≥ 1 prior VB, who gave birth to a singleton vertex presenting infant at term not including those who had a CS for medical reasons (e.g. placenta praevia, non-reassuring patterns in the intrapartum or antepartum fetal heart monitoring, medical condition precluding a planned VBAC), referred to a single centre	10 (all without induction of labour or oxytocin)	40	Disruption of uterine muscle & visceral peritoneum or a uterine muscle separation with extension to the bladder or broad ligament during the CS or laparotomy following planned VBAC, identified using medical records	Planned VBAC without induction of labour or oxytocin vs. ERCS	No cases	--	--
Colmorn, 2017[123] Denmark, Finland, Norway & Sweden 2009-2012	Multicountry population-based cohort Women having their second birth who had complete uterine rupture, abnormally invasive placenta, peripartum hysterectomy, or severe blood loss, identified from prospective surveillance system covering 91% of all Nordic births cross-checked with national medical birth registers, hospital discharge registers & transfusion databases. Data on denominators collected from national medical birth registers	24,366	11,084	Complete rupture of the myometrium, peritoneum, & fetal membranes, identified from medical records cross-checked with registers	Planned VBAC vs. ERCS	0.99% vs. 0.02%	aOR 52.0 (13.0-209.1)	Adjusted for maternal age, BMI & multiple pregnancy at the second pregnancy
Tsai, 2017[116] Taiwan 2006-2015	Single centre cohort Women with 1 prior CS not including those with a classical or inverted-T incision, history of myomectomy, major brain lesions, major cardiac diseases, & severe pelvic trauma history, who gave birth at ≥37 weeks' gestation by planned VBAC or ERCS, identified at a single hospital	73	204	Uterine rupture (not defined), identified from medical records	Planned VBAC vs. ERCS	No cases	--	--

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Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Gobillot, 2018[124] France 2013-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton infant after 37 weeks' gestation, who did not go spontaneously into labour & did not have contraindications to planned VBAC (including previous uterine body incision, placenta praevia or abnormal pelvimetry with a breech presentation), identified at a single hospital	248 (all induction of labour with oxytocin)	165	Uterine rupture, defined as a symptomatic rupture involving the full thickness of the uterine wall & requiring surgical repair, identified from medical records	Planned VBAC where labour induced with oxytocin vs. ERCS	3.23% vs. 0.00%	*uOR 11.70 (0.67-204.07)§*	--
Young, 2018[126] Canada 2003-2015	Population-based cohort Women with 1 prior CS only, who gave birth to a singleton infant at 37-43 weeks' gestation, identified from a database covering ~98% of all deliveries in the country	58,704	138,836	Uterine rupture not including dehiscence, identified using ICD-10 diagnostic codes	Planned VBAC vs. ERCS	0.33% vs. 0.05%	aOR 6.41 (4.84-8.50)	Adjusted for maternal age, diabetes mellitus, hypertension & labour induction
				Uterine rupture including dehiscence, identified using ICD-10 diagnostic codes	Planned VBAC vs. ERCS	0.99% vs. 0.18%	aOR 5.24 (4.48-6.12)	
Fitzpatrick, 2019[1] Scotland 2002-2015	Population-based cohort Singleton births at 37-41 weeks' gestation to women with ≥ 1 prior CS, excluding antepartum stillbirths & women with contraindications to planned VBAC (including non-cephalic presentation at birth, placenta previa, abdominal pregnancy, known or suspected disproportion of maternal &/or fetal origin, tumour of corpus uteri, or birth by pre-labour non-elective caesarean section), identified from linked routinely-collected data including birth registration & hospital discharge data	28,464 (23,119 labour not induced; 5,245 labour induced)	45,579	Uterine rupture identified using ICD-10 diagnostic codes (O710-O711)	Planned VBAC vs. ERCS	0.24% vs. 0.04%	aOR 7.33 (3.88-13.88)	Adjusted for year of delivery, maternal age, mother's country of birth, marital status/registration type, socioeconomic status, number of previous caesarean sections, any prior vaginal birth, interpregnancy interval, maternal smoking status & maternal BMI at booking
					Planned VBAC without labour induction vs. ERCS	0.23% vs. 0.04%	aOR 6.85 (3.55-13.19)	
					Planned VBAC with labour induction vs. ERCS	0.31% vs. 0.04%	aOR 10.06 (4.65-21.72)	

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Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Huisman, 2019[127] Netherlands 2011-2012	Multicentre cohort Women with 1 prior CS, who gave birth to a live singleton infant in cephalic presentation at 37-41 weeks' gestation & had an unfavourable cervix & an indication for delivery, excluding contraindications for VB such as placenta previa, previous classical uterine incision or obstructing cervical fibroids, identified from 51 hospitals	993 (all had labour induced with a balloon catheter)	321	Uterine rupture, defined as clinical symptoms such as abdominal pain, abnormal fetal heart rate pattern, acute loss of contractions or vaginal blood loss that led to an emergency caesarean section, at which the presumed diagnosis of uterine rupture with complete rupture of the uterine wall & serosa was confirmed, identified from medical records	Planned VBAC where labour induced with a balloon catheter vs. ERCS	1.11% vs. 0.32%	aOR 3.01 (0.36-25.03)	Adjusted for maternal age, BMI, prior vaginal birth, unplanned previous caesarean section, reasons for labour induction & prolonged rupture of membranes
Modzelewski, 2019[129] Poland 2010-2017	Single centre cohort Women with 2 prior CS, who gave birth to a singleton infant at term, excluding those with placenta previa, identified from a single tertiary hospital	35	377	Uterine rupture, defined as any detected caesarean scar dehiscence, independently of size or clinical symptoms, identified from hospital database	Planned VBAC vs. ERCS	0.00% vs. 2.92%	*uOR 0.49 (0.03-7.78)§*	--
Yao, 2019[131] USA 2011-2014	Population-based cohort Obese (BMI≥30kg/m^2) women with 1 or 2 prior CSs, who gave birth to a singleton infant without congenital anomalies at 37-42 weeks' gestation, identified from a database capturing all births in the country	81,257	457,007	Uterine rupture (not defined), identified from national database	Planned VBAC vs. ERCS	0.21% vs. 0.02%	aOR 8.89 (6.99-11.32)	Adjusted for maternal age, diabetes & hypertension

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Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Rotem, 2020[133] Israel 2005-2019	Single centre cohort Women with 2 prior CSs, giving birth between 24-42 weeks' gestation, excluding those with contraindications to VB (including non-vertex presentation, placenta previa, placenta accreta, mullerian uterine anomalies, multifetal gestation other than twins, & women without at least 1 previous VB), identified from a single tertiary hospital	485	2,234	Complete uterine scar rupture, defined as involving the occurrence of a full-thickness defect with direct connection between peritoneal space & uterine cavity, identified from hospital database	Planned VBAC vs. ERCS	0.62% vs. 0.13%	*uOR 4.62 (1.05-20.42)§*	--
Takeya, 2020[134] Japan 2013-2015	Population-based cohort Women with 1 prior CS, who gave birth to a singleton at 37-41 weeks' gestation, excluding those with placenta previa, intrauterine fetal death or non-cephalic presentation, identified from a nationwide institution-based registry	1,730	32,739	Uterine rupture (not defined) identified from a nationwide institution-based registry	Planned VBAC vs. ERCS	0.46% vs. 0.22%	*uRR 2.10 (1.01-4.36)§*	--
					Planned VBAC with spontaneous labour onset vs. ERCS	0.26% vs. 0.22%	*uOR 1.32 (0.51-3.43)§*	
					Planned VBAC with induction or augmentation of labour vs. ERCS	2.05% vs. 0.22%	*uOR 10.58 (4.04-27.72)§*	
					Planned VBAC with induction or augmentation of labour with oxytocin alone vs. ERCS	1.74% vs. 0.22%	*uOR 9.30 (3.15-27.48)§*	
					Planned VBAC with induction or augmentation of labour with any prostaglandins with or without oxytocin vs. ERCS	4.76% vs. 0.22%	*uOR 32.96 (6.18-175.75)§*	

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Table B.2 (continued). Studies investigating risk of uterine rupture for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Uno, 2020[135] Japan 2005-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton without lethal congenital anomalies at ≥34 weeks' gestation, excluding those who had an antepartum stillbirth or contraindications to VB (including former caesarean not low transverse, obstetric contraindications, non-vertex presentation, history of myomectomy, CS for any condition that potentially threatened maternal life or incited non-reassuring fetal status before labour onset), identified from a single hospital	471	264	Uterine rupture (not defined) identified from medical records	Planned VBAC vs. ERCS	0.64% vs. 0.00%	*uOR 3.95 (0.20-76.80)§*	--

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; ECS, elective caesarean section; EDD, estimated date of delivery; ERCS, elective repeat caesarean section; ICD-9, International Classification of Diseases 9th revision; ICD-10, International Classification of Diseases 10th revision; IVF, in vitro fertilisation; RCT, randomised control trial; VB, vaginal birth; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.3. Studies investigating risk of hysterectomy for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **USA (6 studies) & Canada (2 studies)** **Ranged from 1980-2002**	**Systematic review & meta-analysis of 8 identified cohort studies - 3 single, 2 multicentre & 3 population-based (3 confined to women who gave birth at ≥37 weeks' gestation)** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant in a developed country**	**167,710 (155,763 who gave birth at ≥37 weeks' gestation)**	**234,349 (227,479 who gave birth at ≥37 weeks' gestation)**	**Hysterectomy**	**Planned VBAC vs. ERCS in women who gave birth at any gestational age**	**0.17% (95% CI 0.12–0.26%) vs. 0.28% (95% CI 0.12–0.67%)**	**uRR 0.65 (0.40-1.06)**	**--**
					Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation	**0.14% (95% CI 0.08-0.22%) vs. 0.16% (95% CI 0.07-0.36%)**	**Not reported but states p-value=0.672**	
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Hysterectomy for any complications resulting from birth, identified from medical records	Planned VBAC vs. ERCS	0.08% vs. 0.00%	*uOR 2.69 (0.11-66.09)*§	--

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Table B.3 (continued). Studies investigating risk of hysterectomy for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Gilbert, 2012[96] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 prior CS eligible to plan VBAC, who gave birth to a live, vertex presenting singleton infant without aneuploidy or congenital malformations at ≥ 37 weeks' gestation by ERCS (without indication other than prior CS) or planned VBAC where labour began spontaneously, identified from 19 centres of the Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	3,981 (all spontaneous labour onset)	3,981	Peripartum hysterectomy, identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	0.08% vs. 0.30%	aOR 0.25 (0.07-0.88)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, marital status, antenatal care, private medical payment, BMI, maternal age, prior CS indication, interval since last CS, whether had prior VB or prior VBAC, EDD confirmed by 1st trimester ultrasound, diabetes, asthma, thyroid disease, seizure disorder, chronic hypertension, heart disease, cigarette use, alcohol use, street drug use, preterm labour requiring tocolysis, infection, antepartum antibiotic administration, gestational hypertension/ preeclampsia, other maternal comorbidity & recruitment centre)
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Hysterectomy, identified from hospital database	Planned VBAC vs. ERCS	0.03% vs. 0.16%	*uOR 0.23 (0.05-1.19)*§	--
					Planned VBAC with spontaneous labour onset vs. ERCS	0.02% vs. 0.16%	*uOR 0.19 (0.03-1.30)*§	
					Planned VBAC with induced labour onset vs. ERCS	0.06% vs. 0.16%	*uOR 0.52 (0.08-3.53)*§	

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Table B.3 (continued). Studies investigating risk of hysterectomy for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province	11,340 (7,614 after 1-2 prior CSs only; 3,726 after 1-2 prior CSs & ≥ 1 prior VB; 7,504 after 1 prior CS only; 3,623 after 1 prior CS & ≥ 1 prior VB)	22,472 (20,792 after 1-2 prior CSs only; 1,680 after 1-2 prior CSs & ≥ 1 prior VB; 16,913 after 1 prior CS only; 1,406 after 1 prior CS & ≥ 1 prior VB)	Hysterectomy, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.03% vs. 0.11%	uRR 0.24 (0.06–1.01)	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.03% vs. 0.06%	uRR 0.45 (0.03–7.20)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.03% vs. 0.11%	uRR 0.24 (0.06–1.02)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.03% vs. 0.07%	uRR 0.39 (0.02–6.20)	
Miller, 2015[95] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 -2 prior CSs via low transverse or unknown incision & no contraindication to VB, who gave birth to a singleton infant with no anomaly, excluding antenatal stillbirths, identified from 19 centres of Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	4,252 (all induction of labour; 4,100 had 1 prior CS; 152 had 2 prior CSs)	6,010 (all after 2 prior CSs)	Hysterectomy, identified from medical records	Planned VBAC with induction of labour vs. ERCS in women with 2 prior CSs	0.00% vs. 0.37%	*uOR 0.87 (0.05-14.45)*§	--

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Table B.3 (continued). Studies investigating risk of hysterectomy for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Nair, 2015[110] UK Peripartum hysterectomy study: 2005-2006	Population-based nested cohort All women who had a peripartum hysterectomy, severe sepsis, major obstetric haemorrhage resulting in massive transfusion or failed tracheal intubation, excluding those without a prior history of CS & those with placenta praevia/accreta/percreta diagnosed before birth, identified in 4 previous national studies conducted at different time periods using a prospective national surveillance system covering all obstetrician-led maternity units in country. Control women also available for peripartum hysterectomy, severe sepsis, & failed tracheal intubation studies (no further details given)	Peripartum hysterectomy study - estimated number: 48,036	Peripartum hysterectomy study - estimated number: 61,136	Any woman giving birth to an infant & having a hysterectomy during the same clinical episode, identified from medical records	Planned VBAC vs. ERCS	0.07% vs. 0.05%	aOR 1.09 (0.52-2.22)	Adjusted for current & previous pregnancy problems, number of previous CSs, pre-existing medical problems, parity, smoking status, socioeconomic status, ethnic background, marital status, BMI & maternal age
Stattmiller, 2016[112] USA 2003-2011	Population-based cohort Women with prior CS (number not stated), excluding those with indication for ERCS (including diabetes, hypertension, preterm, soft-tissue disorders, malpresentation, mental health disorders, asthma, thyroid abnormalities, isoimmunisation, antenatal bleed, oligohydramnios, herpes, multiple pregnancy, intra-uterine growth restriction, polyhydramnios, cardiovascular diseases, stillbirth, unengaged fetal head, substance use, uterine scar not from previous CS, renal abnormalities, congenital fetal anomalies, systemic lupus erythematosus, liver abnormalities, cerebral haemorrhage), identified using database of nationwide sample of hospital inpatient stays	144, 066	541, 071	Hysterectomy, identified using ICD-9 procedure codes (68.3, 68.4, 68.5, 68.6, 68.7, 68.8, 68.9)	Planned VBAC vs. ERCS	0.11% vs. 0.09%	aOR 1.21 (1.01-1.45)	Adjusted for maternal age, race, median household income, hospital, region, primary payer & year
				Severe postpartum haemorrhage requiring hysterectomy, identified using ICD-9 diagnostic & procedure codes (459.0x, 641.9, 666.0, 666.1, 666.2, 998.11, 68.3, 68.4, 68.5, 68.6, 68.7, 68.8, 68.9)	Planned VBAC vs. ERCS	0.09% vs. 0.07%	aOR 1.25 (1.02-1.53)	

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Table B.3 (continued). Studies investigating risk of hysterectomy for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Vigorito, 2016[113] Italy 2011-2015	Single centre cohort Women with 3 prior CSs & ≥ 1 prior VB, who gave birth to a singleton vertex presenting infant at term not including those who had a CS for medical reasons (e.g. placenta praevia, non-reassuring patterns in the intrapartum or antepartum fetal heart monitoring, medical condition precluding a VBAC), referred to a single centre	10 (all without induction of labour or oxytocin)	40	Hysterectomy, identified from medical records	Planned VBAC without induction of labour or oxytocin vs. ERCS	No cases	--	--
Colmorn, 2017[123] Denmark, Finland, Norway & Sweden 2009-2012	Multicountry population-based case-cohort study Women having their second birth who had complete uterine rupture, abnormally invasive placenta, peripartum hysterectomy, or severe blood loss, identified from prospective surveillance system covering 91% of all Nordic births cross-checked with national medical birth registers, hospital discharge registers & transfusion databases. Data on denominators collected from national medical birth registers	24,366	11,084	Any emergency hysterectomy performed within 7 days of birth, excluding malignant indications, identified from medical records cross-checked with registers	Planned VBAC vs. ERCS	0.10% vs. 0.13%	aOR 1.0 (0.5–2.0)	Adjusted for maternal age, BMI & multiple pregnancy at the second pregnancy
Gobillot, 2018[124] France 2013-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton infant after 37 weeks' gestation, who did not go spontaneously into labour & did not have contraindications to planned VBAC (including previous uterine body incision, placenta praevia or abnormal pelvimetry with a breech presentation), identified at a single hospital	248 (all induction of labour with oxytocin)	165	Hysterectomy, identified from medical records	Planned VBAC where labour induced with oxytocin vs. ERCS	0.00% vs. 0.61%	*uOR 0.22 (0.01-5.45)*§	--

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Table B.3 (continued). Studies investigating risk of hysterectomy for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Young, 2018[126] Canada 2003-2015	Population-based cohort Women with 1 prior CS only, who gave birth to a singleton infant at 37-43 weeks' gestation, identified from a database covering ~98% of all deliveries in the country.	58,704	138,836	Postpartum haemorrhage requiring hysterectomy, identified using ICD-10 diagnostic & procedure codes	Planned VBAC vs. ERCS	0.06% vs. 0.06%	aOR 1.05 (0.68-1.62)	Adjusted for maternal age, diabetes mellitus, hypertension & labour induction
Fitzpatrick, 2019[1] Scotland 2002-2015	Population-based cohort Singleton births at 37-41 weeks' gestation to women with ≥ 1 prior CS, excluding antepartum stillbirths & women with contraindications to planned VBAC (including non-cephalic presentation at birth, placenta previa, abdominal pregnancy, known or suspected disproportion of maternal &/or fetal origin, tumour of corpus uteri, or birth by pre-labour non-elective caesarean section), identified from linked routinely-collected data including birth registration & hospital discharge data	28,464 (23,119 labour not induced; 5,245 labour induced)	45,579	Hysterectomy, identified using OPCS-4 codes within 6 weeks of delivery date (Q071-Q075, Q08, R251)	Planned VBAC vs. ERCS	0.02% vs. 0.04%	aOR 0.47 (0.19-1.16)	Only adjusted for year of delivery because of low number of events
					Planned VBAC without labour induction vs. ERCS	0.02% vs. 0.04%	aOR 0.39 (0.13-1.12)	
					Planned VBAC with labour induction vs. ERCS	# vs. 0.04%	aOR 0.85 (0.20-3.64)	
Modzelewski, 2019[129] Poland 2010-2017	Single centre cohort Women with 2 prior CS, who gave birth to a singleton infant at term, excluding those with placenta previa, identified from a single tertiary hospital.	35	377	Hysterectomy, identified from hospital database	Planned VBAC vs. ERCS	No cases	--	--

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Table B.3 (continued). Studies investigating risk of hysterectomy for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Yao, 2019[131] USA 2011-2014	Population-based cohort Obese (BMI≥30kg/m^2) women with 1 or 2 prior CSs, who gave birth to a singleton infant without congenital anomalies at 37-42 weeks' gestation, identified from a database capturing all births in the country	81,257	457,007	Hysterectomy, identified from national database	Planned VBAC vs. ERCS	0.06% vs. 0.05%	aOR 1.03 (0.75-1.41)	Adjusted for maternal age, diabetes & hypertension
Takeya, 2020[134] Japan 2013-2015	Population-based cohort Women with 1 prior CS, who gave birth to a singleton at 37-41 weeks' gestation, excluding those with placenta previa, intrauterine fetal death or non-cephalic presentation, identified from a nationwide institution-based registry	1,730	32,739	Hysterectomy identified from a nationwide institution-based registry	Planned VBAC vs. ERCS	0.12% vs. 0.06%	*uOR 2.20 (0.59-8.16)§*	--

Abbreviations: aOR, adjusted odds ratio; BMI, body mass index; CS, caesarean section; EDD, estimated date of delivery; ERCS, elective repeat caesarean section; ICD-9, International Classification of Diseases 9th revision; ICD-10, International Classification of Diseases 10th revision; OPCS-4, Office of Population Census and Survey Operations and Procedures 4th revision; RCT, randomised control trial; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study; # - percentage not shown to protect against potential disclosure risks

Table B.4. Studies investigating risk of haemorrhage for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **USA (3 studies), Netherlands (1 study), Japan (1 study) & Israel (1 study)** **Ranged from 1980-2006**	**Systematic review with 6 identified cohort studies - 4 single, 1 multicentre & 1 population-based (1 confined to women who gave birth at ≥37 weeks' gestation)** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant in a developed country**	**14,138**	**31,440**	**Variably defined**	**Planned VBAC vs. ERCS in women who gave birth at any gestational age**	**Insufficient data to evaluate risks**		**--**
Fruscalzo, 2012[119] Italy 2007-2008	Single centre cohort Women with 1 prior CS not including those with a prior T incision or previous full thickness uterotomy, metroplasty or myomectomy, presenting with a singleton pregnancy with the foetus in cephalic presentation or twin pregnancy with the foetuses in cephalic-cephalic presentation, identified at a single hospital	170	24	Blood loss >500 ml, identified from hospital database	Planned VBAC vs. ERCS	4.12% vs. 4.17%	*uOR 0.72 (0.12-4.37)*§	--

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Table B.4. (continued). Studies investigating risk of haemorrhage for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Blood loss ≥1,500mL &/or requiring blood transfusion, identified from medical records	Planned VBAC vs. ERCS	2.34% vs. 0.81%	aRR 2.70 (1.25-5.88)	Adjusted for key prognostic variables where there was an imbalance between the comparison groups: maternal socioeconomic status, BMI & indication for previous CS
				Blood loss >500ml, identified from medical records	Planned VBAC vs. ERCS	17.46% vs. 16.79%	aRR 1.10 (0.92-1.32)	
Studsgaard, 2013[120] Denmark 2003-2010	Single centre cohort Women with 1 prior CS & no diabetes, who gave birth to a singleton infant at ≥37 weeks' gestation by planned VBAC or ERCS without contraindications to VBAC, not including antepartum stillbirths, identified at a single University hospital	1,161	622	Blood loss ≥1,000mL, identified from hospital database	Planned VBAC vs. ERCS	9.47% vs. 2.25%	aOR 5.4 (2.8-10.5)	Adjusted for prior VB, age of mother, pre-pregnancy BMI & birth weight
Schmitz, 2013[107] France 1988-2010	Single centre cohort Women with 1 prior CS not including those with a prior classical uterine incision, who gave birth to a cephalic presenting singleton infant at ≥ 37 weeks' gestation, identified at a single University hospital	3,544 (1,828 spontaneous labour; 1,716 induction or augmentation of labour; 1,201 oxytocin only; 274 prostaglandins only; 241 prostaglandins & oxytocin; 251 labour induced with oxytocin; 950 labour augmented with oxytocin)	593	Surgery (compression sutures, artery ligation & hysterectomy) for postpartum haemorrhage, identified from hospital database	Planned VBAC vs. ERCS	0.08% vs. 0.00%	*uOR 1.17 (0.06-22.74)*§	--
				Prostaglandins for postpartum haemorrhage, identified from hospital database	Planned VBAC vs. ERCS	3.39% vs. 3.54%	*uRR 0.96 (0.61-1.51)*§	

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Table B.4. (continied). Studies investigating risk of haemorrhage for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Melamed, 2013[106] Israel 1996-2011	Single centre cohort Women with 1 prior CS at ≥37 weeks' gestation following a failed trial of operative VB, who gave birth to a subsequent singleton infant at ≥37 weeks' gestation, excluding those with a prior vertical uterine incision & those who needed an urgent CS prior to labour onset in the subsequent pregnancy because of maternal &/or neonatal complications or major fetal anomalies, identified at a single university-affiliated tertiary medical centre	93	111	Postpartum haemorrhage (not defined), identified from patient files & hospital electronic records	Planned VBAC vs. ERCS	2.15% vs.10.81%	*uOR 0.22 (0.05-0.87)*§	--
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Haemorrhage (not defined), identified from hospital database	Planned VBAC vs. ERCS	0.99% vs. 0.52%	*uRR 1.90 (0.97-3.72)*§	--
					Planned VBAC with spontaneous labour onset vs. ERCS	0.82% vs. 0.52%	*uRR 1.57 (0.78-3.17)*§	
					Planned VBAC with induced labour onset vs. ERCS	1.46% vs. 0.52%	*uRR 2.80 (1.33-5.86)*§	

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Table B.4. (continued). Studies investigating risk of haemorrhage for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province	11,340 (7,614 after 1-2 prior CSs only; 3,726 after 1-2 prior CSs & ≥ 1 prior VB; 7,504 after 1 prior CS only; 3,623 after 1 prior CS & ≥ 1 prior VB)	22,472 (20,792 after 1-2 prior CSs only; 1,680 after 1-2 prior CSs & ≥ 1 prior VB; 16,913 after 1 prior CS only; 1,406 after 1 prior CS & ≥ 1 prior VB)	Surgical control of bleeding (not defined), identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	1.2% vs. 0.2%	uRR 5.40 (3.78-7.72)	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	1.4% vs. 0.2%	uRR 7.67 (2.40-24.52)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	1.2% vs. 0.2%	uRR 5.83 (3.93-8.66)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	1.4% vs. 0.1%	uRR 9.90 (2.42-40.59)	
Kok, 2015[121] Netherlands 2000-2007	Population-based cohort Women with 1 prior CS at ≥37 weeks' gestation, having a second birth of a live singleton cephalic presenting infant without congenital abnormalities by ERCS at ≥39 weeks' gestation or spontaneous planned VBAC at ≥37 weeks' gestation, identified using a national perinatal registry	4,109 (all with spontaneous onset of labour)	4,109	Blood loss >1,000mL, identified from national database of data entered by clinicians	Planned VBAC with spontaneous labour onset vs. ERCS	5.28% vs. 3.36%	aOR 1.67 (1.43-2.00)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, socio-economic status; 1st pregnancy history: IVF, maternal age, non-gestational diabetes, pre-existing hypertension, pregnancy induced hypertensive disorder, spontaneous labour, malpresentation, ECS, gestational age, birth weight, Apgar score at 5 min, male gender, haemorrhage, transfusion; 2nd pregnancy: pregnancy interval <15 months, IVF, maternal age, gestational age)

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Table B.4. (continued). Studies investigating risk of haemorrhage for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Nair, 2015[110] UK Peripartum haemorrhage study: 2007-2009	Population-based nested cohort All women who had a peripartum hysterectomy, severe sepsis, major obstetric haemorrhage resulting in massive transfusion or failed tracheal intubation, excluding those without a prior history of CS & those with placenta praevia/accreta/percreta diagnosed before birth, identified in 4 previous national studies conducted at different time periods using a prospective national surveillance system covering all obstetrician-led maternity units in country. Control women also available for peripartum hysterectomy, severe sepsis, & failed tracheal intubation studies (no further details given)	Peripartum haemorrhage study - estimated number: 67,269	Peripartum haemorrhage study - estimated number: 85,616	Any woman giving birth & undergoing treatment for postpartum haemorrhage with following: uterine compression sutures, rFVIIa, interventional radiology, including intra-arterial balloon occlusion & arterial embolisation, or pelvic vessel ligation, identified from medical records	Planned VBAC vs. ERCS	0.05% vs. 0.06%	uRR 0.77 (CI 0.48-1.23)	No
Stattmiller, 2016[112] USA 2003-2011	Population-based cohort Women with prior CS (number not stated), excluding those with indication for ERCS (including diabetes, hypertension, preterm, soft-tissue disorders, malpresentation, mental health disorders, asthma, thyroid abnormalities, isoimmunisation, antenatal bleed, oligohydramnios, herpes, multiple pregnancy, intra-uterine growth restriction, polyhydramnios, cardiovascular diseases, stillbirth, unengaged fetal head, substance use, uterine scar not from previous CS, renal abnormalities, congenital fetal anomalies, systemic lupus erythematosus, liver abnormalities, cerebral haemorrhage), identified using database of nationwide sample of hospital inpatient stays	144, 066	541, 071	Severe postpartum haemorrhage requiring hysterectomy identified using ICD-9 diagnostic & procedure codes (459.0x, 641.9, 666.0, 666.1, 666.2, 998.11, 68.3, 68.4, 68.5, 68.6, 68.7, 68.8, 68.9)	Planned VBAC vs. ERCS	0.09% vs. 0.07%	aOR 1.25 (1.02-1.53)	Adjusted for maternal age, race, median household income, hospital, region, primary payer & year
				Severe postpartum haemorrhage identified using ICD-9 diagnostic codes (459.0x, 641.9, 666.0, 666.1, 666.2, 998.11)	Planned VBAC vs. ERCS	2.28% vs. 0.92%	aOR 2.43 (2.32-2.54)	

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Table B.4. (continued). Studies investigating risk of haemorrhage for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Tsai, 2017[116] Taiwan 2006-2015	Single centre cohort Women with 1 prior CS not including those with a classical or inverted-T incision, history of myomectomy, major brain lesions, major cardiac diseases, & severe pelvic trauma history, who gave birth at ≥37 weeks' gestation by planned VBAC or ERCS, identified at a single hospital	73	204	Postpartum haemorrhage (not defined), identified from medical records	Planned VBAC vs. ERCS	2.74% vs. 2.45%	*uOR 1.27 (0.28-5.79)*§	--
Gobillot, 2018[124] France 2013-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton infant after 37 weeks' gestation, who did not go spontaneously into labour & did not have contraindications to planned VBAC (including previous uterine body incision, placenta praevia or abnormal pelvimetry with a breech presentation), identified at a single hospital	248 (all induction of labour with oxytocin)	165	Blood loss >500ml, identified from medical records	Planned VBAC where labour induced with oxytocin vs. ERCS	15.73% vs. 17.58%	*uRR 0.89 (0.58-1.39)*§	--
Young, 2018[126] Canada 2003-2015	Population-based cohort Women with 1 prior CS only, who gave birth to a singleton infant at 37-43 weeks' gestation, identified from a database covering ~98% of all deliveries in the country.	58,704	138,836	Postpartum haemorrhage requiring hysterectomy, identified using ICD-10 diagnostic & procedure codes	Planned VBAC vs. ERCS	0.06% vs. 0.06%	aOR 1.05 (0.68-1.62)	Adjusted for maternal age, diabetes mellitus, hypertension & labour induction
				Postpartum haemorrhage requiring procedures to control bleeding, identified using ICD-10 diagnostic & procedure codes	Planned VBAC vs. ERCS	0.21% vs. 0.15%	aOR 1.44 (1.15-1.82)	
				Postpartum haemorrhage requiring blood transfusion, identified using ICD-10 diagnostic & procedure codes	Planned VBAC vs. ERCS	0.45% vs. 0.16%	aOR 2.80 (2.33-3.37)	

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Table B.4. (continued). Studies investigating risk of haemorrhage for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Huisman, 2019[127] Netherlands 2011-2012	Multicentre cohort Women with 1 prior CS, who gave birth to a live singleton infant in cephalic presentation at 37-41 weeks' gestation & had an unfavourable cervix & an indication for delivery, excluding contraindications for VB such as placenta previa, previous classical uterine incision or obstructing cervical fibroids, identified from 51 hospitals	993 (all had labour induced with a balloon catheter)	321	Postpartum haemorrhage defined as blood loss >2000mL or blood transfusion, identified from medical records	Planned VBAC where labour induced with a balloon catheter vs. ERCS	3.02% vs. 1.60%	aOR 1.34 (0.49-3.68)	Adjusted for maternal age, BMI, prior vaginal birth, unplanned previous caesarean section, reasons for labour induction & prolonged rupture of membranes
Modzelewski, 2019[129] Poland 2010-2017	Single centre cohort Women with 2 prior CS, who gave birth to a singleton infant at term, excluding those with placenta previa, identified from a single tertiary hospital.	35	377	Postpartum haemorrhage defined as estimated blood loss of ≥500ml after vaginal or ≥1000ml after caesarean, identified from hospital database	Planned VBAC vs. ERCS	11.43% vs. 1.33%	uOR 9.6 (2.45-37.59)	No
Pont, 2019[130] Australia 2000-2012	Population-based cohort Women with 1 prior CS, who had a subsequent singleton birth at ≥37 weeks' gestation, excluding those with contraindications to VBAC (including non-cephalic presentation, grand multipara, fetal anomalies recorded during pregnancy requiring maternal care, placenta accreta or previa, women with any hospital admissions noting a blood disorder, women with pre-existing hypertension or diabetes, other chronic medical conditions, evidence of previous uterine surgery or uterine rupture or prior classical caesarean or birth weight ≥5 kg at the prior caesarean), identified using perinatal data collection & hospital discharge data in 1 state	25,497	60,471	Postpartum haemorrhage, identified using identified using ICD-10 diagnostic codes (072)	Planned VBAC vs. ERCS	8.59% vs. 2.31%	aRR 3.15 (2.86-3.47)	Adjusted for maternal age, country of birth, number of prior vaginal births, gestational diabetes, history of postpartum haemorrhage, other pregnancy complications, gestational age, small-for-gestational-age, large-for-gestational-age, socioeconomic indexes for areas, & hospital type

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Table B.4. (continued). Studies investigating risk of haemorrhage for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Rotem, 2020[133] Israel 2005-2019	Single centre cohort Women with 2 prior CSs, giving birth between 24-42 weeks' gestation, excluding those with contraindications to VB (including non-vertex presentation, placenta previa, placenta accreta, mullerian uterine anomalies, multifetal gestation other than twins, & women without at least 1 previous VB), identified from a single tertiary hospital	485	2,234	Postpartum haemorrhage, defined as estimated blood loss of >500ml after vaginal or >1000ml after caesarean birth or transfusion of blood products &/or haemoglobin drop ≥4g/dL, identified from hospital database	Planned VBAC vs. ERCS	7.22% vs. 7.48%	*uRR 0.97 (0.68-1.37)*§	--
Takeya, 2020[134] Japan 2013-2015	Population-based cohort Women with 1 prior CS, who gave birth to a singleton at 37-41 weeks' gestation, excluding those with placenta previa, intrauterine fetal death or non-cephalic presentation, identified from a nationwide institution-based registry	1,730	32,739	Haemorrhage, defined as ≥1000ml, identified from a nationwide institution-based registry	Planned VBAC vs. ERCS	8.50% vs. 24.71%	*uRR 0.34 (0.29-0.40)*§	--
				Haemorrhage, defined as ≥2000ml, identified from a nationwide institution-based registry	Planned VBAC vs. ERCS	0.46% vs. 1.79%	*uRR 0.25 (0.13-0.51)*§	

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; ECS, elective caesarean section; ERCS, elective repeat caesarean section; ICD-9, International Classification of Diseases 9th revision; ICD-10, International Classification of Diseases 10th revision; IVF, in vitro fertilisation; RCT, randomised control trial; rFVIIa, recombinant factor VIIa; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.5. Studies investigating risk of blood transfusion for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **USA (5 studies), Canada (2 studies), Netherlands (1 study) & Israel (1 study)** **Ranged from 1986-2006**	**Systematic review with 9 identified cohort studies - 4 single, 2 multicentre & 3 population-based (4 confined to women who gave birth at ≥37 weeks' gestation)** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant in a developed country**	**167,423 (156,690 who gave birth at ≥37 weeks' gestation)**	**233,884 (227,960 who gave birth at ≥37 weeks' gestation)**	**Blood transfusion**	**Planned VBAC vs. ERCS in women who gave birth at any gestational age**	**0.9% (95% CI 0.4–2.0%) vs. 1.2% (95% CI 0.5–2.6%)**	**uRR 0.81 (0.57-1.15)**	**--**
					Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation	**0.7% (95% CI 0.2–2.2%) vs. 0.5% (95% CI 0.2–1.3%)**	**uRR 1.30 (1.15-1.47)**	
Cahill, 2010[100] USA 1996-2000	Multicentre cohort Women with ≥ 1 prior CS, identified from 17 tertiary & community birth centres	13,706 (12,535 after 1 prior CS; 1,082 after 2 prior CSs; 89 after ≥3 prior CSs)	771 (all after ≥3 prior CSs)	Blood transfusion, identified from medical records	Planned VBAC vs. ERCS in women with ≥3 prior CSs	2.2% vs. 2.2%	uRR 1.02 (0.24–4.34)	No
Holm, 2012[103] Denmark 2001-2008	Population-based cohort Births at all hospitals using local electronic transfusion databases at the time of birth, identified using a national birth registry linked to a national transfusion database	14,173	8,955	Red blood transfusion within 7 days of birth, identified from local transfusion databases	Planned VBAC vs. ERCS	3.23% vs. 2.18%	uOR 1.49 (1.27-1.79)	No

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Table B.5 (continued). Studies investigating risk of blood transfusion for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Fruscalzo, 2012[119] Italy 2007-2008	Single centre cohort Women with 1 prior CS not including those with a prior T incision or previous full thickness uterotomy, metroplasty or myomectomy, presenting with a singleton pregnancy with the foetus in cephalic presentation or twin pregnancy with the foetuses in cephalic-cephalic presentation, identified at a single hospital	170	24	Blood transfusion, identified from hospital database	Planned VBAC vs. ERCS	No cases	--	--
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Blood transfusion, identified from hospital database	Planned VBAC vs. ERCS	2.00% vs. 2.14%	*uRR 0.94 (0.66-1.33)*§	--
					Planned VBAC with spontaneous labour onset vs. ERCS	2.02% vs. 2.14%	*uRR 0.94 (0.65-1.36)*§	
					Planned VBAC with induced labour onset vs. ERCS	1.97% vs. 2.14%	*uRR 0.68 (0.41-1.13)*§	

Table continued overleaf

Table B.5 (continued). Studies investigating risk of blood transfusion for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province	11,340 (7,614 after 1-2 prior CSs only; 3,726 after 1-2 prior CSs & ≥ 1 prior VB; 7,504 after 1 prior CS only; 3,623 after 1 prior CS & ≥ 1 prior VB)	22,472 (20,792 after 1-2 prior CSs only; 1,680 after 1-2 prior CSs & ≥ 1 prior VB; 16,913 after 1 prior CS only; 1,406 after 1 prior CS & ≥ 1 prior VB)	Blood transfusion, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.60% vs. 0.42%	uRR 1.44 (1.01–2.06)	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.51% vs. 0.71%	uRR 0.71 (0.35–1.47)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.61% vs. 0.43%	uRR 1.42 (0.98–2.05)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.50% vs. 0.71%	uRR 0.66 (0.30–1.44)	
Kok, 2015[121] Netherlands 2000-2007	Population-based cohort Women with 1 prior CS at ≥37 weeks' gestation, having a second birth of a live singleton cephalic presenting infant without congenital abnormalities by ERCS at ≥39 weeks' gestation or spontaneous planned VBAC at ≥37 weeks' gestation, identified using a national perinatal registry	4,109 (all with spontaneous onset of labour)	4,109	Blood transfusion, identified from national database of data entered by clinicians	Planned VBAC with spontaneous labour onset vs. ERCS	0.39% vs. 0.37%	aOR 1.11 (0.45-2.5)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, socio-economic status; 1st pregnancy history: IVF, maternal age, non-gestational diabetes, pre-existing hypertension, pregnancy induced hypertensive disorder, spontaneous labour, malpresentation, ECS, gestational age, birth weight, Apgar score at 5 min, male gender, haemorrhage, transfusion; 2nd pregnancy: pregnancy interval <15 months, IVF, maternal age, gestational age)

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Table B.5 (continued). Studies investigating risk of blood transfusion for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Miller, 2015[95] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1-2 prior CSs via low transverse or unknown incision & no contraindication to VB, who gave birth to a singleton infant with no anomaly, excluding antenatal stillbirths, identified from 19 centres of Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	4,252 (all induction of labour; 4,100 had 1 prior CS; 152 had 2 prior CSs)	6,010 (all after 2 prior CSs)	Blood transfusion, identified from medical records	Planned VBAC with induction of labour vs. ERCS in women with 2 prior CSs	1.97% vs. 1.75%	uOR 1.13 (0.36-3.61)	No
Stattmiller, 2016[112] USA 2003-2011	Population-based cohort Women with prior CS (number not stated), excluding those with indication for ERCS (including diabetes, hypertension, preterm, soft-tissue disorders, malpresentation, mental health disorders, asthma, thyroid abnormalities, isoimmunisation, antenatal bleed, oligohydramnios, herpes, multiple pregnancy, intra-uterine growth restriction, polyhydramnios, cardiovascular diseases, stillbirth, unengaged fetal head, substance use, uterine scar not from previous CS, renal abnormalities, congenital fetal anomalies, systemic lupus erythematosus, liver abnormalities, cerebral haemorrhage), identified using database of nationwide sample of hospital inpatient stays	144, 066	541, 071	Blood transfusion identified using ICD-9 procedure codes (99.0x)	Planned VBAC vs. ERCS	0.90% vs. 0.80%	aOR 1.14 (1.07-1.21)	Adjusted for maternal age, race, median household income, hospital, region, primary payer & year

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Table B.5 (continued). Studies investigating risk of blood transfusion for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Vigorito, 2016[113] Italy 2011-2015	Single centre cohort Women with 3 prior CSs & ≥ 1 prior VB, who gave birth to a singleton vertex presenting infant at term not including those who had a CS for medical reasons (e.g. placenta praevia, non-reassuring patterns in the intrapartum or antepartum fetal heart monitoring, medical condition precluding a VBAC), referred to a single centre	10 (all without induction of labour or oxytocin)	40	Blood transfusion, identified from medical records	Planned VBAC without induction of labour or oxytocin vs. ERCS	0.00% vs. 5.00%	*uOR 0.73 (0.03-16.48)*§	--
Colmorn, 2017[123] Denmark, Finland, Norway & Sweden 2009-2012	Multicountry population-based case-cohort study Women having their second birth who had complete uterine rupture, abnormally invasive placenta, peripartum hysterectomy, or severe blood loss, identified from prospective surveillance system covering 91% of all Nordic births cross-checked with national medical birth registers, hospital discharge registers & transfusion databases. Data on denominators collected from national medical birth registers	24,366	11,084	Blood loss resulting in red blood cell transfusion with ≥6 units within a week after birth, identified from medical records cross-checked with registers	Planned VBAC vs. ERCS	0.37% vs. 0.30%	aOR 1.4 (0.8–2.2)	Adjusted for maternal age, BMI & multiple pregnancy at the second pregnancy
Gobillot, 2018[124] France 2013-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton infant after 37 weeks' gestation, who did not go spontaneously into labour & did not have contraindications to planned VBAC (including previous uterine body incision, placenta praevia or abnormal pelvimetry with a breech presentation), identified at a single hospital	248 (all induction of labour with oxytocin)	165	Blood transfusion, identified from medical records	Planned VBAC where labour induced with oxytocin vs. ERCS	1.61% vs. 1.82%	*uOR 0.85 (0.21-3.50)*§	--

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Table B.5 (continued). Studies investigating risk of blood transfusion for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Young, 2018[126] Canada 2003-2015	Population-based cohort Women with 1 prior CS only, who gave birth to a singleton infant at 37-43 weeks' gestation, identified from a database covering ~98% of all deliveries in the country.	58,704	138,836	Postpartum haemorrhage requiring blood transfusion, identified using ICD-10 diagnostic & procedure codes	Planned VBAC vs. ERCS	0.45% vs. 0.16%	aOR 2.80 (2.33-3.37)	Adjusted for maternal age, diabetes mellitus, hypertension & labour induction
Fitzpatrick, 2019[1] Scotland 2002-2015	Population-based cohort Singleton births at 37-41 weeks' gestation to women with ≥ 1 prior CS, excluding antepartum stillbirths & women with contraindications to planned VBAC (including non-cephalic presentation at birth, placenta previa, abdominal pregnancy, known or suspected disproportion of maternal &/or fetal origin, tumour of corpus uteri, or birth by pre-labour non-elective caesarean section), identified from linked routinely-collected data including birth registration & hospital discharge data	28,464 (23,119 labour not induced; 5,245 labour induced)	45,579	Blood transfusion, identified using OPCS-4 codes in delivery episode (X331-X333, X337-X339, X341)	Planned VBAC vs. ERCS	1.14% vs. 0.50%	aOR 2.29 (1.88-2.79)	Adjusted for year of delivery, maternal age, mother's country of birth, marital status/registration type, socioeconomic status, number of previous caesarean sections, any prior vaginal birth, interpregnancy interval, maternal smoking status, maternal BMI at booking & hypertensive disorder
					Planned VBAC without labour induction vs. ERCS	1.11% vs. 0.50%	aOR 2.22 (1.81-2.72)	
					Planned VBAC with labour induction vs. ERCS	1.30% vs. 0.50%	aOR 2.67 (1.99-3.58)	
Modzelewski, 2019[129] Poland 2010-2017	Single centre cohort Women with 2 prior CS, who gave birth to a singleton infant at term, excluding those with placenta previa, identified from a single tertiary hospital.	35	377	Blood transfusion, identified from hospital database	Planned VBAC vs. ERCS	2.86% vs. 0.80%	uOR 3.67 (0.37-36.22)	No

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Table B.5 (continued). Studies investigating risk of blood transfusion for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Pont, 2019[130] Australia 2000-2012	Population-based cohort Women with 1 prior CS, who had a subsequent singleton birth at ≥37 weeks' gestation, excluding those with contraindications to VBAC (including non-cephalic presentation, grand multipara, fetal anomalies recorded during pregnancy requiring maternal care, placenta accreta or previa, women with any hospital admissions noting a blood disorder, women with pre-existing hypertension or diabetes, other chronic medical conditions, evidence of previous uterine surgery or uterine rupture or prior classical caesarean or birth weight ≥5 kg at the prior caesarean), identified using perinatal data collection & hospital discharge data in 1 state	25,497	60,471	Blood transfusion, identified using Australian Classification of Health Interventions procedure codes (13706-01, 13706-02)	Planned VBAC vs. ERCS	1.43% vs. 0.33%	aRR 3.73 (2.90-4.78)	Adjusted for maternal age, country of birth, number of prior vaginal births, pregnancy hypertension, history of postpartum haemorrhage, other pregnancy complications, gestational age, large-for-gestational-age, socioeconomic indexes for areas, & hospital type
Yao, 2019[131] USA 2011-2014	Population-based cohort Obese (BMI≥30kg/m^2) women with 1 or 2 prior CSs, who gave birth to a singleton infant without congenital anomalies at 37-42 weeks' gestation, identified from a database capturing all births in the country	81,257	457,007	Blood transfusion (not defined), identified from national database	Planned VBAC vs. ERCS	0.36% vs. 0.27%	aOR 1.32 (1.16-1.50)	Adjusted for maternal age, diabetes & hypertension
Rotem, 2020[133] Israel 2005-2019	Single centre cohort Women with 2 prior CSs, giving birth between 24-42 weeks' gestation, excluding those with contraindications to VB (including non-vertex presentation, placenta previa, placenta accreta, mullerian uterine anomalies, multifetal gestation other than twins, & women without at least 1 previous VB), identified from a single tertiary hospital	485	2,234	Blood transfusion, identified from hospital database	Planned VBAC vs. ERCS	1.65% vs. 2.60%	*uRR 0.64 (0.31-1.32)§*	--

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; ECS, elective caesarean section; ERCS, elective repeat caesarean section; ICD-9, International Classification of Diseases 9th revision; ICD-10, International Classification of Diseases 10th revision; IVF, in vitro fertilisation; OPCS-4, Office of Population Census and Survey Operations and Procedures 4th revision; RCT, randomised control trial; VB, vaginal birth; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue. ¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.6. Studies investigating risk of maternal infection for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **USA (7 studies), Canada (2 studies) & Israel (1 studies)** **Ranged from 1980-2006**	**Systematic review & meta-analysis of 10 identified cohort studies - 6 single, 2 multicentre & 2 population-based** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant in a developed country**	**151,522**	**202,538**	**Variably defined**	**Planned VBAC vs. ERCS in women who gave birth at any gestational age**	**4.6% (95% CI 1.5–13.5%) vs. 3.2% (95% CI 1.3–7.3%)**	**Not reported but states no significant difference found**	**--**
Cahill, 2010[100] USA 1996-2000	Multicentre cohort Women with ≥ 1 prior CS, identified from 17 tertiary & community birth centres	13,706 (12,535 after 1 prior CS; 1,082 after 2 prior CSs; 89 after ≥3 prior CSs)	771 (all after ≥3 prior CSs)	Fever defined as temperature of > 38^0C, identified from medical records	Planned VBAC vs. ERCS in women with ≥3 prior CSs	15.7% vs. 15.7%	uOR 1.00 (0.60-1.67)	No
Fruscalzo, 2012[119] Italy 2007-2008	Single centre cohort Women with 1 prior CS not including those with a prior T incision or previous full thickness uterotomy, metroplasty or myomectomy, presenting with a singleton pregnancy with the foetus in cephalic presentation or twin pregnancy with the foetuses in cephalic-cephalic presentation, identified at a single hospital	170	24	Puerperal fever (not defined), identified from hospital database	Planned VBAC vs. ERCS	0.59% vs. 0.00%	*uOR 0.43 (0.02-10.95)*§	--

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Table B.6 (continued). Studies investigating risk of maternal infection for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Postpartum infection (not defined), identified from medical records	Planned VBAC vs. ERCS	0.24% vs. 0.36%	aRR 0.67 (0.15-3.03)	Adjusted for key prognostic variables where there was an imbalance between the comparison groups: maternal socioeconomic status, BMI & indication for previous CS
Gilbert, 2012[96] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 prior CS eligible to plan VBAC, who gave birth to a live, vertex presenting singleton infant without aneuploidy or congenital malformations at ≥ 37 weeks' gestation by ERCS (without indication other than prior CS) or planned VBAC where labour began spontaneously, identified from 19 centres of the Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	3,981 (all spontaneous labour onset)	3,981	Endometritis defined as clinical diagnosis of puerperal uterine infection in the absence of findings suggesting another source, identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	3.62% vs. 2.14%	aOR 1.75 (1.33-2.33)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, marital status, antenatal care, private medical payment, BMI, maternal age, prior CS indication, interval since last CS, whether had prior VB or prior VBAC, EDD confirmed by 1st trimester ultrasound, diabetes, asthma, thyroid disease, seizure disorder, chronic hypertension, heart disease, cigarette use, alcohol use, street drug use, preterm labour requiring tocolysis, infection, antepartum antibiotic administration, gestational hypertension/ preeclampsia, other maternal comorbidity & recruitment centre)

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Table B.6 (continued). Studies investigating risk of maternal infection for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Postpartum infection (not defined), identified from hospital database	Planned VBAC vs. ERCS	1.11% vs. 0.78%	*uRR 1.42 (0.81-2.49)*§	--
					Planned VBAC with spontaneous labour onset vs. ERCS	0.80% vs. 0.78%	*uRR 1.02 (0.56-1.87)*§	
					Planned VBAC with induced labour onset vs. ERCS	1.97% vs. 0.78%	*uRR 2.51 (1.36-4.64)*§	
				Endometritis defined as postpartum fever with clinical signs of tenderness above uterine fundus or during cervical manipulation, foul vaginal discharge & positive endometrial culture, identified from hospital database	Planned VBAC vs. ERCS	0.58% vs. 0.84%	*uRR 0.70 (0.39-1.26)*§	
					Planned VBAC with spontaneous labour onset vs. ERCS	0.52% vs. 0.84%	*uRR 0.62 (0.33-1.17)*§	
					Planned VBAC with induced labour onset vs. ERCS	0.76% vs. 0.84%	*uRR 0.91 (0.43-1.92)*§	
				Postpartum fever defined as temperature ≥38^{0}C that developed ≥24h after birth recorded in 2 different measurements ≥4h apart or 1 measurement of temperature of ≥38.5^{0}C regardless of time after birth, identified from hospital database	Planned VBAC vs. ERCS	0.91% vs. 1.36%	*uRR 0.67 (0.42-1.06)*§	
					Planned VBAC with spontaneous labour onset vs. ERCS	0.70% vs. 1.36%	*uRR 0.52 (0.31-0.87)*§	
					Planned VBAC with induced labour onset vs. ERCS	1.46% vs. 1.36%	*uRR 1.08 (0.62-1.88)*§	

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Table B.6 (continued). Studies investigating risk of maternal infection for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province	11,340 (7,614 after 1-2 prior CSs only; 3,726 after 1-2 prior CSs & ≥ 1 prior VB; 7,504 after 1 prior CS only; 3,623 after 1 prior CS & ≥ 1 prior VB)	22,472 (20,792 after 1-2 prior CSs only; 1,680 after 1-2 prior CSs & ≥ 1 prior VB; 16,913 after 1 prior CS only; 1,406 after 1 prior CS & ≥ 1 prior VB)	Obstetric surgical wound infection (not defined), identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.66% vs. 1.21%	uRR 0.54 (0.40-0.73)	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.46% vs. 1.73%	uRR 0.26 (0.15-0.48)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.61% vs. 1.16%	uRR 0.53 (0.38-0.73)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.47% vs. 1.71%	uRR 0.27 (0.15-0.51)	
				Puerperal infection (not defined), identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.25% vs. 0.64%	uRR 0.39 (0.24-0.63)	
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.21% vs. 0.89%	uRR 0.24 (0.10-0.57)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.23% vs. 0.68%	uRR 0.34 (0.20-0.56)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.22% vs. 0.92%	uRR 0.24 (0.10-0.57)	

Table continued overleaf

Table B.6 (continued). Studies investigating risk of maternal infection for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Bickford, 2015[109] continued				Puerperal sepsis (not defined), identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.12% vs. 0.11%	uRR 1.07 (0.49-2.31)	
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.03% vs. 0.18%	uRR 0.15 (0.02-1.44)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.12% vs. 0.12%	uRR 1.01 (0.46-2.23)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.03% vs. 0.21%	uRR 0.13 (0.01-1.24)	
Miller, 2015[95] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 -2 prior CSs via low transverse or unknown incision & no contraindication to VB, who gave birth to a singleton infant with no anomaly, excluding antenatal stillbirths, identified from 19 centres of Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	4,252 (all induction of labour; 4,100 had 1 prior CS; 152 had 2 prior CSs)	6010 (all after 2 prior CSs)	Endometritis (not defined), identified from medical records	Planned VBAC with induction of labour vs. ERCS in women with 2 prior CSs	2.63% vs. 2.38%	uOR 1.11 (0.41-3.03)	No

Table continued overleaf

Table B.6 (continued). Studies investigating risk of maternal infection for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Nair, 2015[110] UK Sepsis study: 2011-2012	Population-based nested cohort All women who had a peripartum hysterectomy, severe sepsis, major obstetric haemorrhage resulting in massive transfusion or failed tracheal intubation, excluding those without a prior history of CS & those with placenta praevia/accreta/percreta diagnosed before birth, identified in 4 previous national studies conducted at different time periods using a prospective national surveillance system covering all obstetrician-led maternity units in country. Control women also available for peripartum hysterectomy, severe sepsis, & failed tracheal intubation studies (no further details given)	Sepsis study - estimated number: 45,861	Sepsis study - estimated number: 58,370	Severe maternal sepsis identified from medical records defined as any pregnant woman (up to 6 weeks postpartum) in 1 of following groups: 1. Death related to infection or suspected infection 2. Any women requiring level 2 or level 3 critical care or obstetric high dependency unit type care due to severe or suspected severe sepsis 3. Clinical diagnosis of severe sepsis—based on ≥ 2 of following: A. Temperature >38°C or <36°C measured on 2 occasions at least 4 hours apart B. Heart rate >100 beats/minute measured on 2 occasions ≥4 hours apart C. Respiratory rate >20/minute measured on 2 occasions ≥4 hours apart D. White cell count >17×10^9/L or <4×10^9/L or with >10% immature band forms, measured on 2 occasions	Planned VBAC vs. ERCS	0.05% vs. 0.03%	aOR 1.96 (0.84-4.55)	Adjusted for current & previous pregnancy problems, number of previous CS's, pre-existing medical problems, parity, smoking status, socioeconomic status, ethnic background, marital status, BMI & maternal age

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Table B.6 (continued). Studies investigating risk of maternal infection for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Stattmiller, 2016[112] USA 2003-2011	Population-based cohort Women with prior CS (number not stated), excluding those with indication for ERCS (including diabetes, hypertension, preterm, soft-tissue disorders, malpresentation, mental health disorders, asthma, thyroid abnormalities, isoimmunisation, antenatal bleed, oligohydramnios, herpes, multiple pregnancy, intra-uterine growth restriction, polyhydramnios, cardiovascular diseases, stillbirth, unengaged fetal head, substance use, uterine scar not from previous CS, renal abnormalities, congenital fetal anomalies, systemic lupus erythematosus, liver abnormalities, cerebral haemorrhage), identified using database of nationwide sample of hospital inpatient stays	144, 066	541, 071	Chorioamnionitis identified using ICD-9 diagnostic codes (658.4)	Planned VBAC vs. ERCS	1.52% vs. 0.15%,	aOR 10.04 (9.26-10.90)	Adjusted for maternal age, race, median household income, hospital, region, primary payer & year
				Major puerperal infection identified using ICD-9 diagnostic codes (670.x)	Planned VBAC vs. ERCS	0.38% vs. 0.21%	aOR 1.68 (1.52-1.86)	
				Puerperal sepsis identified using ICD-9 diagnostic codes (670.2, 670.3 995.91, 995.92)	Planned VBAC vs. ERCS	0.02% vs. 0.01%	aOR 1.99 (1.18-3.34)	
Gobillot, 2018[124] France 2013-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton infant after 37 weeks' gestation, who did not go spontaneously into labour & did not have contraindications to planned VBAC (including previous uterine body incision, placenta praevia or abnormal pelvimetry with a breech presentation), identified at a single hospital	248 (all induction of labour with oxytocin)	165	Postpartum fever, defined as temperature >38.5^{0}C, identified from medical records	Planned VBAC where labour induced with oxytocin vs. ERCS	4.44% vs. 2.42%	*uOR 1.74 (0.57-5.26)*§	--

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Table B.6 (continued). Studies investigating risk of maternal infection for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Gundersen, 2018[125] Denmark 2004-2010	Population-based cohort All live births, identified using a national birth registry	30,734	21,741	Postpartum urinary tract infection within 30 days postpartum, defined as either a hospital discharge diagnosis of urinary tract infection (ICD-10 codes DN10, DN12, DN30) or redemption of a prescription for a urinary tract infection specific antibiotic	Planned VBAC vs. ERCS	4.56% vs. 4.68%	aOR 0.93 (0.85-1.02)	Adjusted for age at delivery, smoking, BMI, educational level, gestational diabetes mellitus, infection during pregnancy, low birth weight, preterm birth, preterm prelabour rupture of membranes, pre-eclampsia & parity
Fitzpatrick, 2019[1] Scotland 2002-2015	Population-based cohort Singleton births at 37-41 weeks' gestation to women with ≥ 1 prior CS, excluding antepartum stillbirths & women with contraindications to planned VBAC (including non-cephalic presentation at birth, placenta previa, abdominal pregnancy, known or suspected disproportion of maternal &/or fetal origin, tumour of corpus uteri, or birth by pre-labour non-elective caesarean section), identified from linked routinely-collected data including birth registration & hospital discharge data	28,464 (23,119 labour not induced; 5,245 labour induced)	45,579	Puerperal sepsis, identified using ICD-10 code within 6 weeks of delivery date (O85)	Planned VBAC vs. ERCS	0.27% vs. 0.17%	aOR 1.82 (1.25-2.65)	Adjusted for year of delivery, maternal age, mother's country of birth, marital status/registration type, socioeconomic status, number of previous caesarean sections, any prior vaginal birth, interpregnancy interval, maternal smoking status, maternal BMI at booking, diabetes & prelabour rupture of membranes
					Planned VBAC without labour induction vs. ERCS	0.23% vs. 0.17%	aOR 1.60 (1.07-2.39)	
					Planned VBAC with labour induction vs. ERCS	0.40% vs. 0.17%	aOR 2.59 (1.52-4.44)	
				Other puerperal infection, identified using ICD-10 code within 6 weeks of delivery date (O86)	Planned VBAC vs. ERCS	2.32% vs. 2.23%	aOR 1.22 (1.09-1.36)	
					Planned VBAC vs. ERCS in women with no prior VB	2.89% vs. 2.28%	aOR 1.38 (1.22-1.55)	
					Planned VBAC vs. ERCS in women with ≥1 prior VB	1.41% vs. 1.97%	aOR 0.74 (0.59-0.93)	
					Planned VBAC without labour induction vs. ERCS	2.27% vs. 2.23%	aOR 1.19 (1.06-1.34)	
					Planned VBAC with labour induction vs. ERCS	2.57% vs. 2.23%	aOR 1.34 (1.11-1.62)	

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Table B.6 (continued). Studies investigating risk of maternal infection for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Huisman, 2019[127] Netherlands 2011-2012	Multicentre cohort Women with 1 prior CS, who gave birth to a live singleton infant in cephalic presentation at 37-41 weeks' gestation & had an unfavourable cervix & an indication for delivery, excluding contraindications for VB such as placenta previa, previous classical uterine incision or obstructing cervical fibroids, identified from 51 hospitals	993 (all had labour induced with a balloon catheter)	321	Postpartum infection, defined as treated urinary tract infection, endometritis, pneumonia, wound infection or other unspecified suspected maternal infection (defined as fever of ≥38^{0}C during labour or fetal tachycardia & start of broad-spectrum intravenous antibiotics for suspected infection), identified from medical records	Planned VBAC where labour induced with a balloon catheter vs. ERCS	3.73% vs. 2.56%	aOR 1.66 (0.73-3.81)	Adjusted for maternal age, BMI, prior vaginal birth, unplanned previous caesarean section, reasons for labour induction & prolonged rupture of membranes
				Fever during labour, defined as temperature ≥38.5^{0}C, identified from medical records	Planned VBAC where labour induced with a balloon catheter vs. ERCS	8.4% vs. 1.6%	aOR 7.00 (2.73-17.95)	

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; EDD, estimated date of delivery; ERCS, elective repeat caesarean section; ICD-9, International Classification of Diseases 9th revision; ICD-10, International Classification of Diseases 10th revision; RCT, randomised control trial; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.7. Studies investigating risk of maternal surgical injury for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **USA (3 studies) & Canada (1 study)** **Ranged from 1986-2002**	**Systematic review with seven articles of 4 unique cohort studies - 1 single, 2 multicentre & 1 population-based** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant in a developed country**	**24,540**	**22,662**	**Variably defined**	**Planned VBAC vs. ERCS in women who gave birth at any gestational age**	**Insufficient data to evaluate risks**		**--**
Cahill, 2010[100] USA 1996-2000	Multicentre cohort Women with ≥ 1 prior CS, identified from 17 tertiary & community birth centres	13,706 (12,535 after 1 prior CS; 1,082 after 2 prior CSs; 89 after ≥3 prior CSs)	771 (all after ≥3 prior CSs)	Surgical injury (not defined), identified from medical records	Planned VBAC vs. ERCS in women with ≥3 prior CSs	0.00% vs. 0.9%	*uOR 0.57 (0.03-10.05)*§	--
				Bladder injury, identified from medical records	Planned VBAC vs. ERCS in women with ≥3 prior CSs	0.00% vs. 1.6%	*uOR 0.34 (0.02-5.78)*§	
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Organ damage requiring repair defined as damage to bladder, ureter or bowel requiring repair or cervical laceration extending to lower uterine segment or abnormal extension of uterine incision, identified from medical records	Planned VBAC vs. ERCS	1.21% vs. 0.54%	aRR 2.17 (0.83-5.88)	Adjusted for key prognostic variables where there was an imbalance between the comparison groups: maternal socioeconomic status, BMI & indication for previous CS

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Table B.7 (continued). Studies investigating risk of maternal surgical injury for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Gilbert, 2012[96] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 prior CS eligible to plan VBAC, who gave birth to a live, vertex presenting singleton infant without aneuploidy or congenital malformations at ≥ 37 weeks' gestation by ERCS (without indication other than prior CS) or planned VBAC where labour began spontaneously, identified from 19 centres of the Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	3,981 (all spontaneous labour onset)	3,981	Operative injury defined as broad ligament hematoma, cystotomy, or bowel or ureteral injury, identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	0.50% vs. 0.15%	aOR 3.33 (1.33-8.33)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, marital status, antenatal care, private medical payment, BMI, maternal age, prior CS indication, interval since last CS, whether had prior VB or prior VBAC, EDD confirmed by 1st trimester ultrasound, diabetes, asthma, thyroid disease, seizure disorder, chronic hypertension, heart disease, cigarette use, alcohol use, street drug use, preterm labour requiring tocolysis, infection, antepartum antibiotic administration, gestational hypertension/ preeclampsia, other maternal comorbidity & recruitment centre)
Schmitz, 2013[107] France 1988-2010	Single centre cohort Women with 1 prior CS not including those with a prior classical uterine incision, who gave birth to a cephalic presenting singleton infant at ≥ 37 weeks' gestation, identified at a single University hospital	3,544 (1,828 spontaneous labour; 1,716 induction or augmentation of labour; 1,201 oxytocin only; 274 prostaglandins only; 241 prostaglandins & oxytocin; 251 labour induced with oxytocin; 950 labour augmented with oxytocin)	593	Bladder injury, identified from hospital database	Planned VBAC vs. ERCS	0.19% vs. 0.00%	*uOR 2.52 (0.14-44.12)*§	--

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Table B.7 (continued). Studies investigating risk of maternal surgical injury for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Melamed, 2013[106] Israel 1996-2011	Single centre cohort Women with 1 prior CS at ≥37 weeks' gestation following a failed trial of operative VB, who gave birth to a subsequent singleton infant at ≥37 weeks' gestation, excluding those with a prior vertical uterine incision & those who needed an urgent CS prior to labour onset in the subsequent pregnancy because of maternal &/or neonatal complications or major fetal anomalies, identified at a single university-affiliated tertiary medical centre	93	111	Bladder injury identified from patient files & hospital electronic records	Planned VBAC vs. ERCS	No cases	--	--
Miller, 2015[95] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 -2 prior CSs via low transverse or unknown incision & no contraindication to VB, who gave birth to a singleton infant with no anomaly, excluding antenatal stillbirths, identified from 19 centres of Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	4,252 (all induction of labour; 4,100 had 1 prior CS; 152 had 2 prior CSs)	6010 (all after 2 prior CSs)	Operative injury defined as broad ligament hematoma, cystotomy, bowel injury, or ureteral injury, identified from medical records	Planned VBAC with induction of labour vs. ERCS in women with 2 prior CSs	0.00% vs. 0.47%	*uOR 0.69 (0.04-11.32)*§	--

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Table B.7 (continued). Studies investigating risk of maternal surgical injury for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Gobillot, 2018[124] France 2013-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton infant after 37 weeks' gestation, who did not go spontaneously into labour & did not have contraindications to planned VBAC (including previous uterine body incision, placenta praevia or abnormal pelvimetry with a breech presentation), identified at a single hospital	248 (all induction of labour with oxytocin)	165	Operative injury (not defined), identified from medical records	Planned VBAC where labour induced with oxytocin vs. ERCS	0.40% vs. 0.61%	*uOR 0.66 (0.07-6.44)*§	--
Fitzpatrick, 2019[1] Scotland 2002-2015	Population-based cohort Singleton births at 37-41 weeks' gestation to women with ≥ 1 prior CS, excluding antepartum stillbirths & women with contraindications to planned VBAC (including non-cephalic presentation at birth, placenta previa, abdominal pregnancy, known or suspected disproportion of maternal &/or fetal origin, tumour of corpus uteri, or birth by pre-labour non-elective caesarean section), identified from linked routinely-collected data including birth registration & hospital discharge data	28,464 (23,119 labour not induced; 5,245 labour induced)	45,579	Surgical injury defined as damage to bowel, bladder or ureter requiring surgical repair, identified using OPCS-4 codes within 6 weeks of delivery date (H04-H11, H14-H15, H29, H32, H50, H57, M18-M23, M25-M27, M29, M33-M38)	Planned VBAC vs. ERCS	0.17% vs. 0.09%	aOR 2.96 (1.83-4.77)	Adjusted for year of delivery, maternal age, mother's country of birth, marital status/registration type, socioeconomic status, number of previous caesarean sections, any prior vaginal birth, interpregnancy interval, maternal smoking status & maternal BMI at booking
					Planned VBAC without labour induction vs. ERCS	0.18% vs. 0.09%	aOR 3.10 (1.91-5.04)	
					Planned VBAC with labour induction vs. ERCS	# vs. 0.09%	aOR 2.22 (0.90-5.47)	
Modzelewski, 2019[129] Poland 2010-2017	Single centre cohort Women with 2 prior CS, who gave birth to a singleton infant at term, excluding those with placenta previa, identified from a single tertiary hospital.	35	377	Surgical complications defined as intraoperative damage of bladder or intestine, postoperative hematoma, impaired wound healing or need for relaparotomy, identified from hospital database	Planned VBAC vs. ERCS	2.86% vs. 2.92%	uOR 0.98 (0.12-7.81)	No

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; EDD, estimated date of delivery; ERCS, elective repeat caesarean section; OPCS-4, Office of Population Census and Survey Operations and Procedures 4th revision; RCT, randomised control trial; uOR, unadjusted odds ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study; # - percentage not shown to protect against potential disclosure control risks

Table B.8. Studies investigating risk of perinatal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **UK (1 study), USA (1 study), Canada (1 study), France (1 study) & Germany (1 study)** **Ranged from 1991-2003**	**Systematic review & meta-analysis of 5 identified cohort studies - 2 single, 1 multicentre & 2 population-based (all only included women who gave birth at ≥37 weeks' gestation)** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant with no congenital or lethal anomalies in a developed country**	**41,213**	**35,686**	**Death occurring at 20 weeks' gestation or more up to 28 days of life**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**1.3 per 1,000 (95% CI 0.6–3.0 per 1,000) vs. 0.5 per 1,000 (95% CI 0.1–3.8 per 1,000)**	**uRR 1.82 (1.24-2.67)**	**--**
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Stillbirths or neonatal deaths before hospital discharge, identified from medical records	Planned VBAC vs. ERCS	1.6 per 1,000 vs. 0.0 per 1,000	*uOR 4.49 (0.22-93.54)*§	--

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Table B.8 (continued). Studies investigating risk of perinatal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Intrapartum or postpartum death (time period not defined), identified from hospital database	Planned VBAC vs. ERCS	3.1 per 1,000 vs. 1.0 per 1,000	*uOR 2.43 (0.65-9.13)*§	--
					Planned VBAC with spontaneous labour onset vs. ERCS	3.8 per 1,000 vs. 1.0 per 1,000	*uOR 2.97 (0.79-11.26)*§	
					Planned VBAC with induced labour onset vs. ERCS	1.3 per 1,000 vs. 1.0 per 1,000	*uOR 1.22 (0.21-7.03)*§	
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province. Infants with congenital anomalies excluded from analyses of neonatal outcomes	11,051 (7,417 after 1-2 prior CSs only; 3,634 after 1-2 prior CSs & ≥ 1 prior VB; 7,310 after 1 prior CS only; 3,533 after 1 prior CS & ≥ 1 prior VB)	21,851 (20,212 after 1-2 prior CSs only; 1,639 after 1-2 prior CSs & ≥ 1 prior VB; 16,442 after 1 prior CS only; 1,374 after 1 prior CS & ≥ 1 prior VB)	Intrapartum stillbirth or death at ≤ 7 days of birth, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.7 per 1,000 vs 0.1 per 1,000	*uOR 6.00 (1.34-26.76)*§	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	No deaths	--	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.7 per 1,000 vs 0.1 per 1,000	*uOR 4.95 (1.11-22.08)*§	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	No deaths	--	

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Table B.8 (continued). Studies investigating risk of perinatal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Bickford, 2015[109] continued				Intrapartum stillbirth or death up to 28 days of birth, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.7 per 1,000 vs. 0.4 per 1,000	*uRR 1.70 (0.56-5.20)*§	
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	No deaths	--	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.7 per 1,000 vs. 0.4 per 1,000	*uRR 1.61 (0.51-5.06)*§	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	No deaths	--	
Fitzpatrick, 2019[1] Scotland 2002-2015	Population-based cohort Singleton births at 37-41 weeks' gestation to women with ≥ 1 prior CS, excluding antepartum stillbirths & women with contraindications to planned VBAC (including non-cephalic presentation at birth, placenta previa, abdominal pregnancy, known or suspected disproportion of maternal &/or fetal origin, tumour of corpus uteri, or birth by pre-labour non-elective caesarean section), identified from linked routinely-collected data including birth registration & hospital discharge data. Deaths due to congenital abnormalities excluded from all perinatal outcomes	28,464 (23,119 labour not induced; 5,245 labour induced)	45,579	Intrapartum stillbirth or death within 4 weeks of birth, identified from death registration data	Planned VBAC vs. ERCS	0.70 per 1,000 vs. 0.11 per 1,000	aOR 6.59 (2.43-17.87)	Only adjusted for year of delivery because of low number of events
					Planned VBAC without labour induction vs. ERCS	0.70 per 1,000 vs. 0.11 per 1,000	aOR 6.90 (2.48-19.19)	
					Planned VBAC with labour induction vs. ERCS	0.60 per 1,000 vs. 0.11 per 1,000	aOR 5.35 (1.29-22.12)	

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Table B.8 (continued). Studies investigating risk of perinatal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Lehmann, 2019[128] Norway 1989-2009	Population-based cohort Singleton cephalic second births at ≥37 weeks' gestation to women with 1 prior CS, identified using a national birth registry	30,176 (15,765 classified as "low-risk" & 14,411 classified as "high-risk" women)	12,249 (4,658 classified as "low-risk" & 7,591 classified as "high-risk" women)	Intrapartum stillbirth, death within 28 days of birth, time of death unknown & pre-labour stillbirths delivered after 39 weeks' gestation, identified from birth registry data	Planned VBAC vs. ERCS in "low-risk" women without particular medical problems, pregnancy complications, a record of assisted reproduction or an infant with a birth weight percentile < 5 or >95 or major congenital malformations in the second pregnancy & no record of stillbirth, cephalopelvic disproportion or prolonged labour in the first pregnancy	2.31 per 1,000 vs. 0.87 per 1,000	aRR 4.05 (1.17-13.97)	Adjusted for year of delivery, maternal age, education, country of origin, geographical region, & size of maternity unit
					Planned VBAC vs. ERCS in "high-risk" women, excluding major malformations	3.63 per 1,000 vs. 0.84 per 1,000	aRR 4.34 (1.83-10.33)	
				Intrapartum stillbirth, death within 28 days of birth, & time of death unknown identified from birth registry data	Planned VBAC vs. ERCS in "low-risk" women without particular medical problems, pregnancy complications, a record of assisted reproduction or an infant with a birth weight percentile < 5 or >95 or major congenital malformations in the second pregnancy & no record of stillbirth, cephalopelvic disproportion or prolonged labour in the first pregnancy	1.22 per 1,000 vs. 0.90 per 1,000	aRR 1.59 (0.51-4.97)	
					Planned VBAC vs. ERCS in "high-risk" women, excluding major malformations	1.63 per 1,000 vs. 0.80 per 1,000	aRR 2.24 (0.86-5.83)	

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; EDD, estimated date of delivery; ERCS, elective repeat caesarean section; RCT, randomised control trial; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue. ¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.9. Studies investigating risk of neonatal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **UK (2 studies), USA (3 studies) & France (1 study)** **Ranged from 1988-2003**	**Systematic review & meta-analysis of 6 identified cohort studies - 1 single, 3 multicentre & 2 population-based** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant at ≥37 weeks' gestation with no congenital or lethal anomalies in a developed country**	**44,485**	**63,843**	**Death occurring in the first 28 days of life**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**1.1 per 1,000 (95% CI 0.6–2.0 per 1,000) vs. 0.6 (95% CI 0.2–1.5 per 1,000)**	**uRR 2.06 (1.35-3.13)**	**--**
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Neonatal death before hospital discharge, identified from medical records	Planned VBAC vs. ERCS	No deaths	--	--

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Table B.9 (continued). Studies investigating risk of neonatal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Gilbert, 2012[96] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 prior CS eligible to plan VBAC, who gave birth to a live, vertex presenting singleton infant without aneuploidy or congenital malformations at ≥ 37 weeks' gestation by ERCS (without indication other than prior CS) or planned VBAC where labour began spontaneously, identified from 19 centres of the Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	3,981 (all spontaneous labour onset)	3,981	Neonatal death (time period not defined), identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	0.5 per 1,000 vs. 0.3 per 1,000	aOR 2.00 (0.18-20)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, marital status, antenatal care, private medical payment, BMI, maternal age, prior CS indication, interval since last CS, whether had prior VB or prior VBAC, EDD confirmed by 1st trimester ultrasound, diabetes, asthma, thyroid disease, seizure disorder, chronic hypertension, heart disease, cigarette use, alcohol use, street drug use, preterm labour requiring tocolysis, infection, antepartum antibiotic administration, gestational hypertension/ preeclampsia, other maternal comorbidity & recruitment centre)
Wen, 2012[104] USA 1995-2002	Population-based cohort Women with 1 prior CS, who gave birth to a live singleton infant in their second pregnancy, identified using national linked live birth-infant death data	557,772	1,275,635	All cause neonatal death (time period not defined), identified from national database	Planned VBAC vs. ERCS in "low-risk" women without pre-existing medical problems, pregnancy complications, preterm birth or an infant with low birth weight or congenital anomaly	Not reported	aOR 1.10 (0.93-1.30)	Adjusted for maternal age, race, marital status, education, cigarette smoking during pregnancy, first trimester visit, & infant sex
				Asphyxia associated neonatal death (time period not defined), identified from national database	Planned VBAC vs. ERCS in "low-risk" women without pre-existing medical problems, pregnancy complications, preterm birth or an infant with low birth weight or congenital anomaly	Not reported	aOR 2.16 (1.54-3.04)	

Table continued overleaf

Table B.9 (continued). Studies investigating risk of neonatal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Postpartum death (time period not defined), identified from hospital database	Planned VBAC vs. ERCS	2.6 per 1,000 vs. 1.0 per 1,000	*uOR 2.04 (0.54-7.76)*§	--
					Planned VBAC with spontaneous labour onset vs. ERCS	3.0 per 1,000 vs. 1.0 per 1,000	*uOR 2.43 (0.63-9.39)*§	
					Planned VBAC with induced labour onset vs. ERCS	1.3 per 1,000 vs. 1.0 per 1,000	*uOR 1.22 (0.21-7.03)*§	
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province. Infants with congenital anomalies excluded from analyses of neonatal outcomes	11,051 (7,417 after 1-2 prior CSs only; 3,634 after 1-2 prior CSs & ≥ 1 prior VB; 7,310 after 1 prior CS only; 3,533 after 1 prior CS & ≥ 1 prior VB)	21,851 (20,212 after 1-2 prior CSs only; 1,639 after 1-2 prior CSs & ≥ 1 prior VB; 16,442 after 1 prior CS only; 1,374 after 1 prior CS & ≥ 1 prior VB)	Death at ≤ 28 days of birth, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.4 per 1,000 vs. 0.4 per 1,000	*uOR 1.12 (0.32-3.90)*§	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	No deaths	--	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.4 per 1,000 vs. 0.4 per 1,000	*uOR 1.05 (0.30-3.73)*§	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	No deaths	--	

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Table B.9 (continued). Studies investigating risk of neonatal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Bickford, 2015[109] continued				Death at ≤ 7 days of birth, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.4 per 1,000 vs. 0.1 per 1,000	uRR 4.09 (0.68-24.46)	
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	No deaths	--	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.4 per 1,000 vs. 0.1 per 1,000	uRR 3.37 (0.56-20.19)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	No deaths	--	
				Death at 8-28 days of birth, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.0 per 1,000 vs. 0.3 per 1,000	*uOR 0.21 (0.01-3.72)*§	
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	No deaths	--	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.0 per 1,000 vs. 0.3 per 1,000	*uOR 0.20 (0.01-3.70)*§	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	No deaths	--	

Table continued overleaf

Table B.9 (continued). Studies investigating risk of neonatal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Kok, 2015[121] Netherlands 2000-2007	Population-based cohort Women with 1 prior CS at ≥37 weeks' gestation, having a second birth of a live singleton cephalic presenting infant without congenital abnormalities by ERCS at ≥39 weeks' gestation or spontaneous planned VBAC at ≥37 weeks' gestation, identified using a national perinatal registry	4,109 (all with spontaneous onset of labour)	4,109	Death within 28 days of birth, identified from national database of data entered by clinicians	Planned VBAC with spontaneous labour onset vs. ERCS	1.2 per 1,000 vs. 0.2 per 1,000	aOR 5.00 (0.56-250)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, socio-economic status; 1st pregnancy history: IVF, maternal age, non-gestational diabetes, preexisting hypertension, pregnancy induced hypertensive disorder, spontaneous labour, malpresentation, ECS, gestational age, birth weight, Apgar score at 5 min, male gender, haemorrhage, transfusion; 2nd pregnancy: pregnancy interval <15 months, IVF, maternal age, gestational age)
Litwin, 2017[114] USA 2011-2013	Population-based cohort Women with ≥ 1 prior CS, who gave birth to a live singleton cephalic presenting infant without congenital malformations at 37-40 weeks' gestation, identified using national linked live birth-infant death data	181,566	854,988	Death at < 28 days of birth, identified from national database	Planned VBAC vs. ERCS	0.7 per 1,000 vs. 0.6 per 1,000	aOR 1.10 (0.87-1.40)	Adjusted for maternal age, race, education, marital status, smoking, birth weight, characteristic of labour (induced, augmented or artificial rupture of membrane) & comorbidities (gestational diabetes, pre-pregnancy hypertension, gestational hypertension)
O'Neill, 2017[115] Denmark 1982-2010	Population-based cohort Women with 1 prior CS, having a second birth of a singleton cephalic presenting infant by planned VBAC or ERCS at 37-42 weeks' gestation, excluding deaths due to congenital anomalies, identified using national routinely available data	40,685	20,941	Death at ≤ 28 days of birth, identified using national routinely available data	Planned VBAC vs. ERCS	1.8 per 1,000 vs. 1.0 per 1,000	aOR 1.87 (1.12-3.12)	Adjusted for maternal age, maternal country of origin, educational attainment, mother & father's gross income, marital status, infant birthplace, infant birth weight, history of pregnancy loss, & birth year
				Death at ≤ 7 days of birth, identified using national routinely available data	Planned VBAC vs. ERCS	1.7 per 1,000 vs. 0.9 per 1,000	aOR 2.06 (1.19-3.56)	
				Death at 8-28 days of birth, identified using national routinely available data	Planned VBAC vs. ERCS	0.1 per 1,000 vs. 0.1 per 1,000	aOR 0.97 (0.22-4.32)	

Table continued overleaf

Table B.9 (continued). Studies investigating risk of neonatal mortality for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Young, 2018[126] Canada 2003-2015	Population-based cohort Women with 1 prior CS only, who gave birth to a singleton infant at 37-43 weeks' gestation, identified from a database covering ~98% of all deliveries in the country. Infants with congenital anomalies excluded from analyses of neonatal outcomes	58,704	138,836	Neonatal death (time period not defined), identified from hospital discharge data	Planned VBAC vs. ERCS	0.22 per 1,000 vs. 0.08 per 1,000	aOR 2.32 (0.99-5.48)	Adjusted for maternal age, diabetes mellitus, hypertension & labour induction
Modzelewski, 2019[129] Poland 2010-2017	Single centre cohort Women with 2 prior CS, who gave birth to a singleton infant at term, excluding those with placenta previa, identified from a single tertiary hospital. Infants with abnormal karyotype or major congenital anomalies excluded from neonatal outcomes	35	377	Neonatal death (time period not defined), identified from hospital database	Planned VBAC vs. ERCS	No cases	--	--
Yao, 2019[131] USA 2011-2014	Population-based cohort Obese (BMI≥30kg/m^2) women with 1 or 2 prior CSs, who gave birth to a singleton infant without congenital anomalies at 37-42 weeks' gestation, identified from a database capturing all births in the country	81,257	457,007	Neonatal death Neonatal death (time period not defined), identified from national database	Planned VBAC vs. ERCS	0.73 per 1,000 vs. 0.53 per 1,000	aOR 1.37 (1.03-1.82)	Adjusted for maternal age, gestational age, diabetes & hypertension

Abbreviations: aOR, adjusted odds ratio; BMI, body mass index; CS, caesarean section; ECS, elective caesarean section; EDD, estimated date of delivery; ERCS, elective repeat caesarean section; IVF, in vitro fertilisation; RCT, randomised control trial; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean
Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.10. Studies investigating risk of respiratory intervention/morbidity for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **USA (2 studies) & Canada (1 study)** **Ranged from 1992-2008**	**Systematic review with 4 identified cohort studies - 3 single & 1 multicentre (3 reported on bag-&-mask ventilation, 2 on intubation for meconium & 3 on transient tachypnoea of the newborn)** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant at ≥37 weeks' gestation in a developed country**	**1134**	**976**	**Bag-&-mask ventilation**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**5.4% (95% CI 3.5–7.6%) vs. 2.5% (95% CI 1.6–3.6%)**	**Not reported but states risk difference 2.5% (95% CI 0.72-5.0%)**	--
		805	**633**	**Intubation for meconium**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**11.5% vs. 1.5%**	**Not reported but states p≤0.001**	
		3,451	**1,476**	**Transient tachypnoea of the newborn**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**3.6% (95% CI 0.9–8.0%) vs. 4.2% (95% CI 1.9–7.3%)**	**Not reported but states risk difference -0.83% (95% CI -3.35-1.7%)**	
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Severe neonatal lung disease defined as mean airway pressure > 10 &/or fraction of inspired oxygen >0.80 with need for ventilation, identified from medical records	Planned VBAC vs. ERCS	0.08% vs. 0.18%	aRR 0.45 (0.04-5.00)	Adjusted for key prognostic variables where there was an imbalance between the comparison groups: maternal socioeconomic status, BMI & indication for previous CS

Table continued overleaf

Table B.10 (continued). Studies investigating risk of respiratory intervention/morbidity for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Gilbert, 2012[96] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 prior CS eligible to plan VBAC, who gave birth to a live, vertex presenting singleton infant without aneuploidy or congenital malformations at ≥ 37 weeks' gestation by ERCS (without indication other than prior CS) or planned VBAC where labour began spontaneously, identified from 19 centres of the Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	3,981 (all spontaneous labour onset)	3,981	Transient tachypnoea of the newborn, identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	2.69% vs. 2.99%	aOR 0.89 (0.68-1.16)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, marital status, antenatal care, private medical payment, BMI, maternal age, prior CS indication, interval since last CS, whether had prior VB or prior VBAC, EDD confirmed by 1st trimester ultrasound, diabetes, asthma, thyroid disease, seizure disorder, chronic hypertension, heart disease, cigarette use, alcohol use, street drug use, preterm labour requiring tocolysis, infection, antepartum antibiotic administration, gestational hypertension/ preeclampsia, other maternal comorbidity & recruitment centre)
Wen, 2012[104] USA 1995-2002	Population-based cohort Women with 1 prior CS, who gave birth to a live singleton infant in their second pregnancy, identified using national linked live birth-infant death data	557,772	1,275,635	>30 min of assisted ventilation, identified from national database	Planned VBAC vs. ERCS	Not reported	aOR 0.85 (0.82-0.88)	Adjusted for maternal age, race, marital status, education, cigarette smoking during pregnancy, first trimester visit, & infant sex
					Planned VBAC vs. ERCS in "low-risk" women without pre-existing medical problems, pregnancy complications, preterm birth or an infant with low birth weight or congenital anomaly	Not reported	aOR 1.17 (1.10-1.25)	

Table continued overleaf

Table B.10 (continued). Studies investigating risk of respiratory intervention/morbidity for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Schmitz, 2013[107] France 1988-2010	Single centre cohort Women with 1 prior CS not including those with a prior classical uterine incision, who gave birth to a cephalic presenting singleton infant at ≥ 37 weeks' gestation, identified at a single University hospital	3,544 (1,828 spontaneous labour; 1,716 induction or augmentation of labour; 1,201 oxytocin only; 274 prostaglandins only; 241 prostaglandins & oxytocin; 251 labour induced with oxytocin; 950 labour augmented with oxytocin)	593	Intubation in delivery room (reason unspecified), identified from hospital database	Planned VBAC vs. ERCS	0.82% vs. 1.18%	*uRR 0.69 (0.31-1.58)*§	--
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province. Infants with congenital anomalies excluded from analyses of neonatal outcomes	11,051 (7,417 after 1-2 prior CSs only; 3,634 after 1-2 prior CSs & ≥ 1 prior VB; 7,310 after 1 prior CS only; 3,533 after 1 prior CS & ≥ 1 prior VB)	21,851 (20,212 after 1-2 prior CSs only; 1,639 after 1-2 prior CSs & ≥ 1 prior VB; 16,442 after 1 prior CS only; 1,374 after 1 prior CS & ≥ 1 prior VB)	Ventilation required, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.24% vs. 0.17%	uRR 1.40 (0.79–2.47)	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.17% vs. 0.2%	uRR 0.45 (0.15–1.40)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.25% vs. 0.16%	uRR 1.56 (0.85–2.84)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.17% vs. 0.36%	uRR 0.47 (0.14–1.53)	

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Table B.10 (continued). Studies investigating risk of respiratory intervention/morbidity for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Bickford, 2015[109] continued				>24h of oxygen required, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.40% vs. 0.64%	uRR 0.63 (0.43–0.94)	
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.28% vs. 0.79%	uRR 0.35 (0.15–0.79)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.40 vs. 0.57%	uRR 0.7 (0.46–1.06)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.25% vs. 0.95%	uRR 0.27 (0.12–0.63)	
Kok, 2015[121] Netherlands 2000-2007	Population-based cohort Women with 1 prior CS at ≥37 weeks' gestation, having a second birth of a live singleton cephalic presenting infant without congenital abnormalities by ERCS at ≥39 weeks' gestation or spontaneous planned VBAC at ≥37 weeks' gestation, identified using a national perinatal registry	4,109 (all with spontaneous onset of labour)	4,109	Transient tachypnoea of the newborn, identified from national database of data entered by clinicians	Planned VBAC with spontaneous labour onset vs. ERCS	0.66% vs. 1.10%	aOR 0.59 (0.36-1.0), reported as significant	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, socio-economic status; 1st pregnancy history: IVF, maternal age, non-gestational diabetes, pre-existing hypertension, pregnancy induced hypertensive disorder, spontaneous labour, malpresentation, ECS, gestational age, birth weight, Apgar score at 5 min, male gender, haemorrhage, transfusion; 2nd pregnancy: pregnancy interval <15 months, IVF, maternal age, gestational age)

Table continued overleaf

Table B.10 (continued). Studies investigating risk of respiratory intervention/morbidity for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Litwin, 2017[114] USA 2011-2013	Population-based cohort Women with ≥ 1 prior CS, who gave birth to a live singleton cephalic presenting infant without congenital malformations at 37-40 weeks' gestation, identified using national linked live birth-infant death data	181,566	854,988	Assisted ventilation, identified from national database	Planned VBAC vs. ERCS	2.54% vs. 2.29%	aOR 1.07 (1.03-1.12)	Adjusted for maternal age, race, education, marital status, smoking, birth weight, characteristic of labour (induced, augmented or artificial rupture of membrane) & comorbidities (gestational diabetes, pre-pregnancy hypertension, gestational hypertension)
				Assisted ventilation > 6 h, identified from national database	Planned VBAC vs. ERCS	0.42% vs. 0.44%	aOR 0.95 (0.86-1.04)	
Young, 2018[126] Canada 2003-2015	Population-based cohort Women with 1 prior CS only, who gave birth to a singleton infant at 37-43 weeks' gestation, identified from a database covering ~98% of all deliveries in the country. Infants with congenital anomalies excluded from analyses of neonatal outcomes	58,704	138,836	Assisted ventilation requiring endotracheal intubation or continuous positive air-way pressure, identified from hospital discharge data	Planned VBAC vs. ERCS	2.00% vs. 1.40%	aOR 1.49 (1.38-1.62)	Adjusted for maternal age, diabetes mellitus, hypertension & labour induction
				Assisted ventilation requiring endotracheal intubation excluding assisted ventilation requiring continuous positive air-way pressure, identified from hospital discharge data	Planned VBAC vs. ERCS	0.65% vs. 0.30%	aOR 2.15 (1.85-2.49)	

Table continued overleaf

Table B.10 (continued). Studies investigating risk of respiratory intervention/morbidity for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Fitzpatrick, 2019[2] Scotland 2002-2015	Population-based cohort Singleton births at 37-41 weeks' gestation to women with ≥ 1 prior CS, excluding antepartum stillbirths & women with contraindications to planned VBAC (including non-cephalic presentation at birth, placenta previa, abdominal pregnancy, known or suspected disproportion of maternal &/or fetal origin, tumour of corpus uteri, or birth by pre-labour non-elective caesarean section), identified from linked routinely-collected data including birth registration & hospital discharge data. Deaths due to congenital abnormalities excluded from all perinatal outcomes	28,464 (23,119 labour not induced; 5,245 labour induced)	45,579	Resuscitation requiring drugs &/or intubation, identified from hospital discharge database	Planned VBAC vs. ERCS	1.63% vs. 0.33%	aOR 5.22 (4.19-6.50)	Adjusted for year of delivery, maternal age, mother's country of birth, marital status/registration type, socioeconomic status, number of previous caesarean sections, any prior vaginal birth, interpregnancy interval, maternal smoking status, maternal BMI at booking, hypertensive disorder, diabetes, & prelabour rupture of membranes
					Planned VBAC without labour induction vs. ERCS	1.57% vs. 0.33%	aOR 5.34 (4.27-6.68)	
					Planned VBAC with labour induction vs. ERCS	1.89% vs. 0.33%	aOR 6.27 (4.66-8.45)	
Yao, 2019[131] USA 2011-2014	Population-based cohort Obese (BMI≥30kg/m^2) women with 1 or 2 prior CSs, who gave birth to a singleton infant without congenital anomalies at 37-42 weeks' gestation, identified from a database capturing all births in the country	81,257	457,007	Assisted ventilation > 6 h, identified from national database	Planned VBAC vs. ERCS	0.56% vs. 0.53%	aOR 1.17 (1.06-1.30)	Adjusted for maternal age, gestational age, diabetes & hypertension
Rotem, 2020[133] Israel 2005-2019	Single centre cohort Women with 2 prior CSs, giving birth between 24-42 weeks' gestation, excluding those with contraindications to VB (including non-vertex presentation, placenta previa, placenta accreta, mullerian uterine anomalies, multifetal gestation other than twins, & women without at least 1 previous VB), identified from a single tertiary hospital	485	2,234	Transient tachypnoea of the newborn, identified from hospital database	Planned VBAC vs. ERCS	2.06% vs. 2.33%	*uRR 0.89 (0.45-1.73)§*	--
				Mechanical ventilation, identified from hospital database	Planned VBAC vs. ERCS	2.47% vs. 1.61%	*uRR 1.54 (0.80-2.93)§*	

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; ECS, elective caesarean section; EDD, estimated date of delivery; ERCS, elective repeat caesarean section; IVF, in vitro fertilisation; RCT, randomised control trial; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.11. Studies investigating risk of hypoxic-ischaemic encephalopathy/asphyxia for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Guise, 2010[67]¥ **USA (2 studies) & Canada (1 study)** **Ranged from 1992-2002**	**Systematic review with 3 identified cohort studies - 1 single, 1 multicentre & 1 population-based** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant at ≥37 weeks' gestation in a developed country**	**14,570**	**36,428**	**Variably defined**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**Insufficient data to evaluate risks**		**--**
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Neonatal encephalopathy stage 3 (not defined), identified from medical records	Planned VBAC vs. ERCS	No cases	--	--
				Arterial or venous cord blood pH< 7.0), identified from medical records	Planned VBAC vs. ERCS	0.49% vs. 0.09%	aRR 5.26 (0.65-50)	Adjusted for key prognostic variables where there was an imbalance between the comparison groups: maternal socioeconomic status, BMI & indication for previous CS
				Cord blood base deficit ≥12 mmol/l, identified from medical records	Planned VBAC vs. ERCS	0.73% vs. 0.09%	aRR 7.69 (0.94-50)	

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Table B.11 (continued). Studies investigating risk of hypoxic-ischaemic encephalopathy/asphyxia for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Gilbert, 2012[96] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 prior CS eligible to plan VBAC, who gave birth to a live, vertex presenting singleton infant without aneuploidy or congenital malformations at ≥ 37 weeks' gestation by ERCS (without indication other than prior CS) or planned VBAC where labour began spontaneously, identified from 19 centres of the Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	3,981 (all spontaneous labour onset)	3,981	Hypoxic-ischaemic encephalopathy (not defined), identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	0.08% vs. 0.00%	*aOR 7.01 (0.36-135.67)*§	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, marital status, antenatal care, private medical payment, BMI, maternal age, prior CS indication, interval since last CS, whether had prior VB or prior VBAC, EDD confirmed by 1st trimester ultrasound, diabetes, asthma, thyroid disease, seizure disorder, chronic hypertension, heart disease, cigarette use, alcohol use, street drug use, preterm labour requiring tocolysis, infection, antepartum antibiotic administration, gestational hypertension/ preeclampsia, other maternal comorbidity & recruitment centre)
				Arterial cord pH < 7.0, identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	0.63% vs. 0.35%	aOR 1.79 (0.93-3.45)	
Studsgaard, 2013[120] Denmark 2003-2010	Single centre cohort Women with 1 prior CS & no diabetes, who gave birth to a singleton infant at ≥37 weeks' gestation by planned VBAC or ERCS without contraindications to VBAC, not including antepartum stillbirths, identified at a single University hospital	1,161	622	Umbilical cord pH < 7.0, identified from hospital database	Planned VBAC vs. ERCS	1.14% vs. 0.00%	*uOR 14.92 (0.89-251.41)*§	--
Schmitz, 2013[107] France 1988-2010	Single centre cohort Women with 1 prior CS not including those with a prior classical uterine incision, who gave birth to a cephalic presenting singleton infant at ≥ 37 weeks' gestation, identified at a single University hospital	3,544 (1,828 spontaneous labour; 1,716 induction or augmentation of labour; 1,201 oxytocin only; 274 prostaglandins only; 241 prostaglandins & oxytocin; 251 labour induced with oxytocin; 950 labour augmented with oxytocin)	593	Umbilical cord arterial pH < 7.0, identified from hospital database	Planned VBAC vs. ERCS	0.28% vs. 0.52%	*uOR 0.50 (0.15-1.69)*§	--

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Table B.11 (continued). Studies investigating risk of hypoxic-ischaemic encephalopathy/asphyxia for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Birth asphyxia (not defined), identified from hospital database	Planned VBAC vs. ERCS	0.22% vs. 0.21%	*uOR 0.98 (0.34-2.87)*§	--
					Planned VBAC with spontaneous labour onset vs. ERCS	0.21% vs. 0.21%	*uOR 0.95 (0.31-2.92)*§	
					Planned VBAC with induced labour onset vs. ERCS	0.25% vs. 0.21%	*uOR 1.22 (0.33-4.50)*§	
Sananès, 2014[108] Strasbourg, France 2007-2012	Multicentre cohort Women with 1 prior CS, who gave birth to a singleton infant at a level 2 & a level 3 maternity hospital	1,269 (1,045 spontaneous onset of labour; 89 labour induced with oxytocin & amniotomy; 135 labour induced with Foley catheter)	806	Cord pH< 7.0, identified from computerised medical dossier	Planned VBAC vs. ERCS	*5.99% vs.* 8.81%	*uRR 0.70 (0.50-0.93)*§	--
					Planned VBAC with spontaneous labour onset vs. ERCS	6.32% vs. 8.81%	*uRR 0.72 (0.52-0.99)*§	
					Planned VBAC with induction of labour with oxytocin & amniotomy vs. ERCS	2.25 vs. 8.81%	*uOR 0.29 (0.08-1.06)*§	
					Planned VBAC with induction of labour with foley catheter vs. ERCS	5.93% vs. 8.81%	*uRR 0.67 (0.33-1.37)*§	

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Table B.11 (continued). Studies investigating risk of hypoxic-ischaemic encephalopathy/asphyxia for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province. Infants with congenital anomalies excluded from analyses of neonatal outcomes	11,051 (7,417 after 1-2 prior CSs only; 3,634 after 1-2 prior CSs & ≥ 1 prior VB; 7,310 after 1 prior CS only; 3,533 after 1 prior CS & ≥ 1 prior VB)	21,851 (20,212 after 1-2 prior CSs only; 1,639 after 1-2 prior CSs & ≥ 1 prior VB; 16,442 after 1 prior CS only; 1,374 after 1 prior CS & ≥ 1 prior VB)	Hypoxic-ischaemic encephalopathy (not defined), identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.01% vs. 0.00%	*uOR 8.18 (0.33-200.73)*§	--
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	No cases	--	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.01% vs. 0.00%	*uOR 6.75 (0.27-165.68)*§	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	No cases	--	
Miller, 2015[95] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 -2 prior CSs via low transverse or unknown incision & no contraindication to VB, who gave birth to a singleton infant with no anomaly, excluding antenatal stillbirths, identified from 19 centres of Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	4,252 (all induction of labour; 4,100 had 1 prior CS; 152 had 2 prior CSs)	6,010 (all after 2 prior CSs)	Hypoxic-ischaemic encephalopathy (not defined), identified from medical records	Planned VBAC with induction of labour vs. ERCS in women with 2 prior CSs	0.00% vs. 0.03%	*uOR 7.88 (0.38-164.83)*§	--

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Table B.11 (continued). Studies investigating risk of hypoxic-ischaemic encephalopathy/asphyxia for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Gobillot, 2018[124] France 2013-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton infant after 37 weeks' gestation, who did not go spontaneously into labour & did not have contraindications to planned VBAC (including previous uterine body incision, placenta praevia or abnormal pelvimetry with a breech presentation), identified at a single hospital	248 (all induction of labour with oxytocin)	165	Arterial cord blood pH< 7.15), identified from medical records	Planned VBAC where labour induced with oxytocin vs. ERCS	7.93% vs. 1.27%	*uOR 5.23 (1.45-21.04)*§	--
Huisman, 2019[127] Netherlands 2011-2012	Multicentre cohort Women with 1 prior CS, who gave birth to a live singleton infant in cephalic presentation at 37-41 weeks' gestation & had an unfavourable cervix & an indication for delivery, excluding contraindications for VB such as placenta previa, previous classical uterine incision or obstructing cervical fibroids, identified from 51 hospitals	993 (all had labour induced with a balloon catheter)	321	Arterial cord blood pH<7.10, identified from medical records	Planned VBAC where labour induced with a balloon catheter vs. ERCS	5.9% vs. 3.7%	aOR 1.08 (0.46-2.55)	Adjusted for gestational age, maternal age, reasons for labour induction, known fetal congenital disease & prolonged rupture of membranes
Modzelewski, 2019[129] Poland 2010-2017	Single centre cohort Women with 2 prior CS, who gave birth to a singleton infant at term, excluding those with placenta previa, identified from a single tertiary hospital. Infants with abnormal karyotype or major congenital anomalies excluded from neonatal outcomes	35	377	Birth asphyxia (not defined), identified from hospital database	Planned VBAC vs. ERCS	0.00% vs. 0.27%	*uOR 3.48 (0.14-86.99)*§	--

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Table B.11 (continued). Studies investigating risk of hypoxic-ischaemic encephalopathy/asphyxia for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Rotem, 2020[133] Israel 2005-2019	Single centre cohort Women with 2 prior CSs, giving birth between 24-42 weeks' gestation, excluding those with contraindications to VB (including non-vertex presentation, placenta previa, placenta accreta, mullerian uterine anomalies, multifetal gestation other than twins, & women without at least 1 previous VB), identified from a single tertiary hospital	485	2,234	Neonatal asphyxia (not defined), identified from hospital database	Planned VBAC vs. ERCS	0.00% vs. 0.13%	*uOR 0.66 (0.03-12.73)§*	--
Uno, 2020[135] Japan 2005-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton without lethal congenital anomalies at ≥34 weeks' gestation, excluding those who had an antepartum stillbirth or contraindications to VB (including former caesarean not low transverse, obstetric contraindications, non-vertex presentation, history of myomectomy, CS for any condition that potentially threatened maternal life or incited non-reassuring fetal status before labour onset), identified from a single hospital	471	264	Arterial cord blood pH<7.0, identified from medical records	Planned VBAC vs. ERCS	0.63% vs. 0.00%	*uOR 3.95 (0.20-76.80)§*	--

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; EDD, estimated date of delivery; ERCS, elective repeat caesarean section; RCT, randomised control trial; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.12. Studies investigating risk of neonatal sepsis for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **USA** **Ranged from 1992-1998**	**Systematic review with 3 identified cohort studies - 2 single & 1 multicentre** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant at ≥37 weeks' gestation in a developed country**	**1,732**	**1,114**	**Variably defined**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**Insufficient data to evaluate risks**		**--**
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Proven systemic infection in first 48 h of life treated with antibiotics, identified from medical records	Planned VBAC vs. ERCS	0.32% vs. 0.09%	aRR 3.57 (0.40-33.33)	Adjusted for key prognostic variables where there was an imbalance between the comparison groups: maternal socioeconomic status, BMI & indication for previous CS
Gilbert, 2012[96] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 prior CS eligible to plan VBAC, who gave birth to a live, vertex presenting singleton infant without aneuploidy or congenital malformations at ≥ 37 weeks' gestation by ERCS (without indication other than prior CS) or planned VBAC where labour began spontaneously, identified from 19 centres of the Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	3,981 (all spontaneous labour onset)	3,981	Suspected or confirmed neonatal sepsis (not defined), identified from medical records	Planned VBAC with spontaneous labour onset vs. ERCS	5.30% vs. 3.11%	aOR 1.72 (1.39-2.17)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, marital status, antenatal care, private medical payment, BMI, maternal age, prior CS indication, interval since last CS, whether had prior VB or prior VBAC, EDD confirmed by 1st trimester ultrasound, diabetes, asthma, thyroid disease, seizure disorder, chronic hypertension, heart disease, cigarette use, alcohol use, street drug use, preterm labour requiring tocolysis, infection, antepartum antibiotic administration, gestational hypertension/ preeclampsia, other maternal comorbidity & recruitment centre)

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Table B.12 (continued). Studies investigating risk of neonatal sepsis for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Kok, 2015[121] Netherlands 2000-2007	Population-based cohort Women with 1 prior CS at ≥37 weeks' gestation, having a second birth of a live singleton cephalic presenting infant without congenital abnormalities by ERCS at ≥39 weeks' gestation or spontaneous planned VBAC at ≥37 weeks' gestation, identified using a national perinatal registry	4,109 (all with spontaneous onset of labour)	4,109	Neonatal infection (not defined), identified from national database of data entered by clinicians	Planned VBAC with spontaneous labour onset vs. ERCS	0.24% vs. 0.17%	aOR 1.43 (0.5-5)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, socio-economic status; 1st pregnancy history: IVF, maternal age, non-gestational diabetes, pre-existing hypertension, pregnancy induced hypertensive disorder, spontaneous labour, malpresentation, ECS, gestational age, birth weight, Apgar score at 5 min, male gender, haemorrhage, transfusion; 2nd pregnancy: pregnancy interval <15 months, IVF, maternal age, gestational age)
Modzelewski, 2019[129] Poland 2010-2017	Single centre cohort Women with 2 prior CS, who gave birth to a singleton infant at term, excluding those with placenta previa, identified from a single tertiary hospital. Infants with abnormal karyotype or major congenital anomalies excluded from neonatal outcomes	35	377	Neonatal sepsis (not defined), identified from hospital database	Planned VBAC vs. ERCS	No cases	--	--

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; ECS, elective caesarean section; EDD, estimated date of delivery; ERCS, elective repeat caesarean section; IVF, in vitro fertilisation; RCT, randomised control trial; VB, vaginal birth; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review

Table B.13. Studies investigating risk of birth trauma for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Guise, 2010[67]¥ **USA** **Ranged from 1994-2002**	**Systematic review with 2 identified cohort studies - 1 single & 1 population-based** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant at ≥37 weeks' gestation in a developed country**	**11,793**	**30,106**	**Variably defined**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**Insufficient data to evaluate risks**		**--**
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Subdural or intracerebral haemorrhage, spinal cord injury, basal skull fracture, other fracture, peripheral nerve injury present at discharge from hospital, identified from medical records	Planned VBAC vs. ERCS	0.24% vs. 0.00%	*uOR 6.29 (0.32-121.82)*§	--
Wen, 2012[104] USA 1995-2002	Population-based cohort Women with 1 prior CS, who gave birth to a live singleton infant in their second pregnancy, identified using national linked live birth-infant death data	557,772	1,275,635	Birth injury (not defined), identified from national database	Planned VBAC vs. ERCS	Not reported	aOR 4.66 (4.33-5.01)	Adjusted for maternal age, race, marital status, education, cigarette smoking during pregnancy, first trimester visit, & infant sex
					Planned VBAC vs. ERCS in "low-risk" women without pre-existing medical problems, pregnancy complications, preterm birth or an infant with low birth weight or congenital anomaly	Not reported	aOR 5.34 (4.80-5.93)	

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Table B.13 (continued). Studies investigating risk of birth trauma for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Melamed, 2013[106] Israel 1996-2011	Single centre cohort Women with 1 prior CS at ≥37 weeks' gestation following a failed trial of operative VB, who gave birth to a subsequent singleton infant at ≥37 weeks' gestation, excluding those with a prior vertical uterine incision & those who needed an urgent CS prior to labour onset in the subsequent pregnancy because of maternal &/or neonatal complications or major fetal anomalies, identified at a single university-affiliated tertiary medical centre	93	111	Cephalohematoma, skull fracture, subdural/cerebral hematoma, intraventricular haemorrhage, or facial nerve injury, identified from patient files & hospital electronic records	Planned VBAC vs. ERCS	No cases	--	--
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Birth trauma (not defined), identified from hospital database	Planned VBAC vs. ERCS	0.02% vs. 0.00%	*uOR 0.98 (0.04-24.14)*§	--
					Planned VBAC with spontaneous labour onset vs. ERCS	0.02% vs. 0.00%	*uOR 1.25 (0.05-33.13)*§	
					Planned VBAC with induced labour onset vs. ERCS	No cases	--	

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Table B.13 (continued). Studies investigating risk of birth trauma for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province. Infants with congenital anomalies excluded from analyses of neonatal outcomes	11,051 (7,417 after 1-2 prior CSs only; 3,634 after 1-2 prior CSs & ≥ 1 prior VB; 7,310 after 1 prior CS only; 3,533 after 1 prior CS & ≥ 1 prior VB)	21,851 (20,212 after 1-2 prior CSs only; 1,639 after 1-2 prior CSs & ≥ 1 prior VB; 16,442 after 1 prior CS only; 1,374 after 1 prior CS & ≥ 1 prior VB)	Erb palsy or other facial nerve injury, ocular damage, liver hematoma, or fracture of the clavicle, long bones or skull, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.35% vs. 0.09%	uRR 3.94 (2.16-7.18)	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.50% vs. 0.18%	uRR 2.71 (0.80-9.17)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.36% vs. 0.08%	uRR 4.18 (2.18-7.99)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.51% vs. 0.07%	uRR 7.00 (0.94-52.39)	
Kok, 2015[121] Netherlands 2000-2007	Population-based cohort Women with 1 prior CS at ≥37 weeks' gestation, having a second birth of a live singleton cephalic presenting infant without congenital abnormalities by ERCS at ≥39 weeks' gestation or spontaneous planned VBAC at ≥37 weeks' gestation, identified using a national perinatal registry	4,109 (all with spontaneous onset of labour)	4,109	Intracerebral bleeding, cephalic hematoma, brachial plexus lesions & facial nerve lesions, identified from national database of data entered by clinicians	Planned VBAC with spontaneous labour onset vs. ERCS	0.32% vs. 0.02%	aOR 12.5 (2.0-500.0)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, socio-economic status; 1st pregnancy history: IVF, maternal age, non-gestational diabetes, pre-existing hypertension, pregnancy induced hypertensive disorder, spontaneous labour, malpresentation, ECS, gestational age, birth weight, Apgar score at 5 min, male gender, haemorrhage, transfusion; 2nd pregnancy: pregnancy interval <15 months, IVF, maternal age, gestational age)

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Table B.13 (continued). Studies investigating risk of birth trauma for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Litwin, 2017[114] USA 2011-2013	Population-based cohort Women with ≥ 1 prior CS, who gave birth to a live singleton cephalic presenting infant without congenital malformations at 37-40 weeks' gestation, identified using national linked live birth-infant death data	181,566	854,988	Birth injury (not defined), identified from national database	Planned VBAC vs. ERCS	0.06% vs. 0.02%	aOR 3.12 (2.27-4.27)	Adjusted for maternal age, race, education, marital status, smoking, birth weight, characteristic of labour (induced, augmented or artificial rupture of membrane) & comorbidities (gestational diabetes, pre-pregnancy hypertension, gestational hypertension)

Abbreviations: aOR, adjusted odds ratio; BMI, body mass index; CS, caesarean section; ECS, elective caesarean section; ERCS, elective repeat caesarean section; IVF, in vitro fertilisation; RCT, randomised control trial; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean

Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.14. Studies investigating risk of neonatal intensive care unit admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **USA (7 studies) & Canada (1 study)** **Ranged from 1992-2008**	**Systematic review with 8 identified cohort studies - 4 single & 4 multicentre** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant at ≥37 weeks' gestation in a developed country**	**48,517**	**16,604**	**Neonatal intensive care unit admission**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**Insufficient data to evaluate risks**		**--**
Homer, 2011[69] Australia 1998-2006	Population-based cohort Women with 1 prior CS, who gave birth to a vertex presenting singleton infant at ≥ 37 weeks' gestation, identified from the perinatal data collection of one state	21,832	31,622	Admission to special care nursery or neonatal intensive care, identified from regional perinatal data collection	Planned VBAC vs. ERCS	Not reported	uOR 0.89 (0.83-0.97)	No
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Admission to neonatal intensive care unit > 4d, identified from medical records	Planned VBAC vs. ERCS	0.57% vs. 0.36%	aRR 1.56 (0.44-5.56)	Adjusted for key prognostic variables where there was an imbalance between the comparison groups: maternal socioeconomic status, BMI & indication for previous CS

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Table B.14 (continued). Studies investigating risk of neonatal intensive care unit admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Fruscalzo, 2012[119] Italy 2007-2008	Single centre cohort Women with 1 prior CS not including those with a prior T incision or previous full thickness uterotomy, metroplasty or myomectomy, presenting with a singleton pregnancy with the foetus in cephalic presentation or twin pregnancy with the foetuses in cephalic-cephalic presentation, identified at a single hospital	170	24	Admission to neonatal intensive care unit, identified from hospital database	Planned VBAC vs. ERCS	0.59% vs. 0.00%	*uOR 0.43 (0.02-10.95)*§	--
Schmitz, 2013[107] France 1988-2010	Single centre cohort Women with 1 prior CS not including those with a prior classical uterine incision, who gave birth to a cephalic presenting singleton infant at ≥ 37 weeks' gestation, identified at a single University hospital	3,544 (1,828 spontaneous labour; 1,716 induction or augmentation of labour; 1,201 oxytocin only; 274 prostaglandins only; 241 prostaglandins & oxytocin; 251 labour induced with oxytocin; 950 labour augmented with oxytocin)	593	Admission to neonatal intensive care unit, identified from hospital database	Planned VBAC vs. ERCS	0.96% vs. 1.52%	*uRR 0.63 (0.33-1.31)*§	--
Melamed, 2013[106] Israel 1996-2011	Single centre cohort Women with 1 prior CS at ≥37 weeks' gestation following a failed trial of operative VB, who gave birth to a subsequent singleton infant at ≥37 weeks' gestation, excluding those with a prior vertical uterine incision & those who needed an urgent CS prior to labour onset in the subsequent pregnancy because of maternal &/or neonatal complications or major fetal anomalies, identified at a single university-affiliated tertiary medical centre	93	111	Admission to neonatal intensive care unit, identified from patient files & hospital electronic records	Planned VBAC vs. ERCS	5.38% vs. 6.31%	*uRR 0.85 (0.28-2.60)*§	--

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Table B.14 (continued). Studies investigating risk of neonatal intensive care unit admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Studsgaard, 2013[120] Denmark 2003-2010	Single centre cohort Women with 1 prior CS & no diabetes, who gave birth to a singleton infant at ≥37 weeks' gestation by planned VBAC or ERCS without contraindications to VBAC, not including antepartum stillbirths, identified at a single University hospital	1,161	622	Admission to neonatal intensive care unit within 28 d of birth, identified from hospital database	Planned VBAC vs. ERCS	10.42% vs. 7.07%	aOR 1.9 (1.3-2.8)	Adjusted for prior VB, age of mother, pre-pregnancy BMI & birth weight
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province. Infants with congenital anomalies excluded from analyses of neonatal outcomes	11,051 (7,417 after 1-2 prior CSs only; 3,634 after 1-2 prior CSs & ≥ 1 prior VB; 7,310 after 1 prior CS only; 3,533 after 1 prior CS & ≥ 1 prior VB)	21,851 (20,212 after 1-2 prior CSs only; 1,639 after 1-2 prior CSs & ≥ 1 prior VB; 16,442 after 1 prior CS only; 1,374 after 1 prior CS & ≥ 1 prior VB)	Admission to neonatal intensive care unit because baby had high acuity or was at risk of high acuity & required multispecialty care, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.54% vs. 0.35%	uRR 1.54 (1.04-2.26)	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.22% vs. 0.49%	uRR 0.45 (0.17-1.20)	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.55% vs. 0.36%	uRR 1.52 (1.02-2.28)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.20% vs. 0.58%	uRR 0.34 (0.12-0.94)	

Table continued overleaf

Table B.14 (continued). Studies investigating risk of neonatal intensive care unit admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Miller, 2015[95] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 -2 prior CSs via low transverse or unknown incision & no contraindication to VB, who gave birth to a singleton infant with no anomaly, excluding antenatal stillbirths, identified from 19 centres of Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	4,252 (all induction of labour; 4,100 had 1 prior CS; 152 had 2 prior CSs)	6,010 (all after 2 prior CSs)	Admission to neonatal intensive care unit, identified from medical records	Planned VBAC with induction of labour vs. ERCS in women with 2 prior CSs	18.7% vs. 13.6%	uOR 1.25 (0.81-1.93)	No
Vigorito, 2016[113] Italy 2011-2015	Single centre cohort Women with 3 prior CSs & ≥ 1 prior VB, who gave birth to a singleton vertex presenting infant at term not including those who had a CS for medical reasons (e.g. placenta praevia, non-reassuring patterns in the intrapartum or antepartum fetal heart monitoring, medical condition precluding a VBAC), referred to a single centre	10 (all without induction of labour or oxytocin)	40	Admission to neonatal intensive care unit, identified from medical records	Planned VBAC without induction of labour or oxytocin vs. ERCS	0.00% vs. 2.50%	*uOR 1.25 (0.05-33.06)*§	--
Litwin, 2017[114] USA 2011-2013	Population-based cohort Women with ≥ 1 prior CS, who gave birth to a live singleton cephalic presenting infant without congenital malformations at 37-40 weeks' gestation, identified using national linked live birth-infant death data	181,566	854,988	Admission to neonatal intensive care unit, identified from national database	Planned VBAC vs. ERCS	4.67% vs. 4.11%	aOR 1.12 (1.09-1.16)	Adjusted for maternal age, race, education, marital status, smoking, birth weight, characteristic of labour (induced, augmented or artificial rupture of membrane) & comorbidities (gestational diabetes, pre-pregnancy hypertension, gestational hypertension)

Table continued overleaf

Table B.14 (continued). Studies investigating risk of neonatal intensive care unit admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Gobillot, 2018[124] France 2013-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton infant after 37 weeks' gestation, who did not go spontaneously into labour & did not have contraindications to planned VBAC (including previous uterine body incision, placenta praevia or abnormal pelvimetry with a breech presentation), identified at a single hospital	248 (all induction of labour with oxytocin)	165	Admission to neonatal intensive care unit, identified from medical records	Planned VBAC where labour induced with oxytocin vs. ERCS	2.49% vs. 2.52%	*uOR 0.95 (0.28-3.23)§*	--
Fitzpatrick, 2019[1] Scotland 2002-2015	Population-based cohort Singleton births at 37-41 weeks' gestation to women with ≥ 1 prior CS, excluding antepartum stillbirths & women with contraindications to planned VBAC (including non-cephalic presentation at birth, placenta previa, abdominal pregnancy, known or suspected disproportion of maternal &/or fetal origin, tumour of corpus uteri, or birth by pre-labour non-elective caesarean section), identified from linked routinely-collected data including birth registration & hospital discharge data. Deaths due to congenital abnormalities excluded from all perinatal outcomes	28,464 (23,119 labour not induced; 5,245 labour induced)	45,579	Admission to a neonatal unit, identified from hospital discharge database	Planned VBAC vs. ERCS	5.45% vs. 5.27%	aOR 1.31 (1.22-1.41)	Adjusted for year of delivery, maternal age, mother's country of birth, marital status/registration type, socioeconomic status, number of previous caesarean sections, any prior vaginal birth, interpregnancy interval, maternal smoking status, maternal BMI at booking, hypertensive disorder, diabetes, & prelabour rupture of membranes
					Planned VBAC without labour induction vs. ERCS	5.17% vs. 5.27%	aOR 1.24 (1.15-1.35)	
					Planned VBAC with labour induction vs. ERCS	6.62% vs. 5.27%	aOR 1.66 (1.46-1.89)	
Huisman, 2019[127] Netherlands 2011-2012	Multicentre cohort Women with 1 prior CS, who gave birth to a live singleton infant in cephalic presentation at 37-41 weeks' gestation & had an unfavourable cervix & an indication for delivery, excluding contraindications for VB such as placenta previa, previous classical uterine incision or obstructing cervical fibroids, identified from 51 hospitals	993 (all had labour induced with a balloon catheter)	321	Admission to neonatal intensive care unit, identified from medical records	Planned VBAC where labour induced with a balloon catheter vs. ERCS	2.62% vs. 0.64%	aOR 6.20 (1.31-29.38)	Adjusted for gestational age, maternal age, reasons for labour induction, known fetal congenital disease & prolonged rupture of membranes

Table continued overleaf

Table B.14 (continued). Studies investigating risk of neonatal intensive care unit admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Lehmann, 2019[128] Norway 1989-2009	Population-based cohort Singleton cephalic second births at ≥37 weeks' gestation to women with 1 prior CS, identified using a national birth registry	30,176 (15,765 classified as "low-risk" & 14,411 classified as "high-risk" women)	12,249 (4,658 classified as "low-risk" & 7,591 classified as "high-risk" women)	Admission to neonatal intensive care unit, identified from birth registry data	Planned VBAC vs. ERCS	7.41% vs. 7.98%	aRR 0.89 (0.80-0.97)	Adjusted for year of delivery, maternal age, education, country of origin, geographical region, & size of maternity unit
					Planned VBAC vs. ERCS in "low-risk" women without particular medical problems, pregnancy complications, a record of assisted reproduction or an infant with a birth weight percentile < 5 or >95 or major congenital malformations in the second pregnancy & no record of stillbirth, cephalopelvic disproportion or prolonged labour in the first pregnancy	5.35% vs. 5.05%	aRR 1.00 (0.82-1.21)	
					Planned VBAC vs. ERCS in "high-risk" women	9.49% vs. 9.63%	aRR 0.94 (0.84-1.05)	
Yao, 2019[131] USA 2011-2014	Population-based cohort Obese (BMI≥30kg/m^2) women with 1 or 2 prior CSs, who gave birth to a singleton infant without congenital anomalies at 37-42 weeks' gestation, identified from a database capturing all births in the country	81,257	457,007	Admission to neonatal intensive care unit, identified from national database	Planned VBAC vs. ERCS	5.31% vs. 4.59%	aOR 1.29 (1.25-1.33)	Adjusted for maternal age, gestational age, diabetes & hypertension

Table continued overleaf

Table B.14 (continued). Studies investigating risk of neonatal intensive care unit admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Dombrowski, 2020[132] USA 2010-2012	Population-based cohort Women with 2 prior CSs, who gave birth to a live singleton infant without congenital anomalies at 37-42 weeks' gestation, excluding those with clear contraindications to planned VBAC (including malpresentation, genital herpes, placenta previa, vasa previa), identified from linked hospital discharge & birth certificate data in 1 state	847	25,030	Admission to neonatal intensive care unit, identified from birth certificate data	Planned VBAC vs. ERCS	4.84% vs. 2.96%	aOR 1.35 (0.91-1.99)	Propensity score matching approach used to identify ERCS & planned VBAC groups with comparable characteristics
Rotem, 2020[133] Israel 2005-2019	Single centre cohort Women with 2 prior CSs, giving birth between 24-42 weeks' gestation, excluding those with contraindications to VB (including non-vertex presentation, placenta previa, placenta accreta, mullerian uterine anomalies, multifetal gestation other than twins, & women without at least 1 previous VB), identified from a single tertiary hospital	485	2,234	Admission to neonatal intensive care unit, identified from hospital database	Planned VBAC vs. ERCS	4.74% vs. 8.55%	*uRR 0.55 (0.36-0.85)§*	--

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; ERCS, elective repeat caesarean section; IVF, in vitro fertilisation; RCT, randomised control trial; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean
Literature at the start of this thesis is highlighted in blue.

¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Table B.15. Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Guise, 2010[67]¥ **UK (1 study), USA (2 studies) & Canada (1 study)** **Ranged from 1992-2002**	**Systematic review with 4 identified cohort studies - 2 single, 1 multicentre & 1 population-based (1 reported on Apgar score of <4 at 5 minutes & 3 reported on Apgar score < 7 at 5 minutes)** **Women with ≥ 1 prior CSs, who gave birth to a singleton infant at ≥37 weeks' gestation in a developed country**	**15,515**	**9,014**	**Apgar score <4 at 5 minutes**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**0.68% vs. 0.44%**	**Not reported, but states p-value=0.02**	**--**
		3,451	**1,476**	**Apgar score <7 at 5 minutes**	**Planned VBAC vs. ERCS in women who gave birth at ≥37 weeks' gestation**	**1-1.5% vs. 0-1%**	**Not reported, but states that none of the 3 studies found a significant difference**	
Crowther, 2012[98] Australia 2002-2007	Multicentre patient preference cohort with nested RCT Women with 1 prior CS, presenting with a live cephalic presenting singleton fetus at ≥37 weeks' gestation not including those with a prior vertical, inverted T or unknown uterine incision, previous uterine rupture, previous uterine surgery, previous uterine perforation, any contraindication to VB, cephalo-pelvic disproportion, lethal congenial anomaly or fetal anomaly associated with mechanical difficulties at birth, recruited from 14 maternity hospitals	1,237 (1,225 patient preference & 12 randomised)	1,108 (1,098 patient preference & 10 randomised)	Apgar score <4 at 5 minutes, identified from medical records	Planned VBAC vs. ERCS	0.08% vs. 0.00%	*uOR 2.69 (0.11-66.09)*§	--
				Apgar score <7 at 5 minutes, identified from medical records	Planned VBAC vs. ERCS	0.65% vs. 0.27%	aRR 2.08 (0.54-8.33)	Adjusted for key prognostic variables where there was an imbalance between the comparison groups: maternal socioeconomic status, BMI & indication for previous CS

Table continued overleaf

Table B.15 (continued). Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Wen, 2012[104] USA 1995-2002	Population-based cohort Women with 1 prior CS, who gave birth to a live singleton infant in their second pregnancy, identified using national linked live birth-infant death data	557,772	1,275,635	Apgar score <7 at 5 minutes, identified from national database	Planned VBAC vs. ERCS	Not reported	aOR 1.46 (1.42-1.51)	Adjusted for maternal age, race, marital status, education, cigarette smoking during pregnancy, first trimester visit, & infant sex
					Planned VBAC vs. ERCS in "low-risk" women without pre-existing medical problems, pregnancy complications, preterm birth or an infant with low birth weight or congenital anomaly	Not reported	aOR 2.20 (2.08-2.33)	
Schmitz, 2013[107] France 1988-2010	Single centre cohort Women with 1 prior CS not including those with a prior classical uterine incision, who gave birth to a cephalic presenting singleton infant at ≥ 37 weeks' gestation, identified at a single University hospital	3,544 (1,828 spontaneous labour; 1,716 induction or augmentation of labour; 1,201 oxytocin only; 274 prostaglandins only; 241 prostaglandins & oxytocin; 251 labour induced with oxytocin; 950 labour augmented with oxytocin)	593	Apgar score <4 at 5 minutes, identified from hospital database	Planned VBAC vs. ERCS	0.37% vs. 0.00%	*uOR 4.54 (0.27-76.43)*§	--

Table continued overleaf

Table B.15 (continued). Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Melamed, 2013[106] Israel 1996-2011	Single centre cohort Women with 1 prior CS at ≥37 weeks' gestation following a failed trial of operative VB, who gave birth to a subsequent singleton infant at ≥37 weeks' gestation, excluding those with a prior vertical uterine incision & those who needed an urgent CS prior to labour onset in the subsequent pregnancy because of maternal &/or neonatal complications or major fetal anomalies, identified at a single university-affiliated tertiary medical centre	93	111	Apgar score <7 at 5 minutes, identified from patient files & hospital electronic records	Planned VBAC vs. ERCS	No cases	--	--
Shatz, 2013[117] Israel 1988-2005	Single centre cohort Women with 1 prior CS via low transverse incision, who gave birth to a singleton vertex presenting infant without chromosomal abnormalities or structural defects, excluding those with contraindications to VBAC (including previous classical or inverted T uterine incision, placenta praevia, placenta accreta, placental abruption, antepartum death, severe preeclampsia, & non-reassuring fetal heart rate monitoring at presentation), identified at a single tertiary University Medical centre	5,839 (4,263 spontaneous labour; 1,576 induced labour)	1,916	Apgar score <7 at 5 minutes, identified from hospital database	Planned VBAC vs. ERCS	1.75% vs. 1.20%	*uRR 1.46 (0.93-2.28)*§	--
					Planned VBAC with spontaneous labour onset vs. ERCS	1.81% vs. 1.20%	*uRR 1.50 (0.95-2.39)*§	
					Planned VBAC with induced labour onset vs. ERCS	1.59% vs. 1.20%	*uRR 1.32 (0.75-2.32)*§	

Table continued overleaf

Table B.15 (continued). Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Fagerberg, 2013[105] Sweden 1992-2007	Population-based cohort Women having their second birth, excluding multiple pregnancies, identified using a national birth registry	41,450 (Indication for 1st CS: multiple gestation – 1,296; preterm birth - 6,144; breech or other malpresentation ≥37 weeks' gestation - 8,652; significant congenital malformation – 782; rupture of uterus – 7; placenta praevia – 225; diabetes mellitus/gestational diabetes – 442; small for gestational age /suspected intrauterine growth restriction - 1,725; large for gestational age/suspected large for gestational age/birth weight>4500g - 1,684; prolonged pregnancy ≥42 weeks' gestation - 3,843; severe pregnancy complications/severe maternal disease - 1,125; complications during labour/birth – 9,337; fetal distress/death unexplained by indications above - 3,697; no indication listed above/mild conditions not classified elsewhere - 1,446; no diagnosis available for indication for first CS - 1,045)	18,193 (Indication for 1st CS: multiple gestation – 202; preterm birth - 1,902; breech or other malpresentation ≥37 weeks' gestation - 2,224; significant congenital malformation – 393; rupture of uterus – 15; placenta praevia – 47; diabetes mellitus/gestational diabetes – 372; small for gestational age /suspected intrauterine growth restriction - 610; large for gestational age/suspected large for gestational age/birth weight>4500g - 1,404; prolonged pregnancy ≥42 weeks' gestation – 2,030; severe pregnancy complications/severe maternal disease - 373; complications during labour/birth - 5,364; fetal distress/death unexplained by indications above – 1,209; no indication listed above/mild conditions not classified elsewhere – 1,694; no diagnosis available for indication for first CS - 354)	Apgar score <7 at 5 minutes, identified from medical records	Planned VBAC vs. ERCS in all women with one prior CS	1.78% vs. 1.10%	aOR 1.8 (1.5-2.1)	Where indicated adjusted for year of birth, maternal characteristics, preterm birth, breech presentation, & birth weight standard deviation scores
					Planned VBAC vs. ERCS in women whose indication for 1st CS multiple gestation	1.62% vs. 0.99%	aOR 1.6 (0.4-6.7)	
					Planned VBAC vs. ERCS in women whose indication for 1st CS preterm birth (<37 weeks' gestation)	1.46% vs. 3.00%	aOR 0.90 (0.7-1.4)	
					Planned VBAC vs. ERCS in women whose indication for 1st CS breech or other malpresentation ≥37 weeks' gestation	1.54% vs. 1.08%	aOR 1.4 (0.9-2.2)	
					Planned VBAC vs. ERCS in women whose indication for 1st CS significant congenital malformation	2.43% vs. 0.51%	aOR 5.4 (1.2-23.6)	
					Planned VBAC vs. ERCS in women whose indication for 1st CS rupture of uterus	No cases	--	

Table continued overleaf

B.15 (continued). Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Fagerberg, 2013[105] continued				Apgar score <7 at 5 minutes, identified from medical records	Planned VBAC vs. ERCS in women whose indication for 1st CS placenta praevia	0.44% vs. 0.00%	*uOR 0.63 (0.03-15.82)*§	
					Planned VBAC vs. ERCS in women whose indication for 1st CS diabetes mellitus/gestational diabetes	3.17% vs. 1.08%	uOR 3.0 (1.0–9.2), reported as not significant	
					Planned VBAC vs. ERCS in women whose indication for 1st CS small for gestational age /suspected intrauterine growth restriction	2.20% vs. 1.97%	aOR 1.7 (0.8–3.5)	
					Planned VBAC vs. ERCS in women whose indication for 1st CS large for gestational age/suspected large for gestational age /birth weight>4500g	1.54% vs. 0.64%	aOR 2.0 (0.9–4.5)	
					Planned VBAC vs. ERCS in women whose indication for 1st CS prolonged pregnancy ≥42 weeks' gestation	1.90% vs. 0.74%	aOR 2.6 (1.5–4.6)	
					Planned VBAC vs. ERCS in women whose indication for 1st CS severe pregnancy complications/severe maternal disease	2.76% vs. 1.88%	aOR 2.3 (1.0–5.6), reported as not significant	

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B.15 (continued). Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Fagerberg, 2013[105] continued				Apgar score <7 at 5 minutes, identified from medical records	Planned VBAC vs. ERCS in women whose indication for 1st CS complications during labour/birth	1.95% vs. 0.75%	aOR 2.4 (1.7–3.4)	
					Planned VBAC vs. ERCS in women whose indication for 1st CS fetal distress/death unexplained by indications above	2.11% vs. 0.91%	aOR 2.9 (1.5–5.5)	
					Planned VBAC vs. ERCS in women whose indication for 1st CS no indication listed above/mild conditions not classified elsewhere	0.90% vs. 0.89%	aOR 0.7 (0.2–2.1)	
					Planned VBAC vs. ERCS in women who had no diagnosis available for indication for 1st CS	1.82% vs. 0.56%	aOR 1.5 (0.4–5.0)	
Studsgaard 2013[120] Denmark 2003-2010	Single centre cohort Women with 1 prior CS & no diabetes, who gave birth to a singleton infant at ≥37 weeks' gestation by planned VBAC or ERCS without contraindications to VBAC, not including antepartum stillbirths, identified at a single University hospital	1,161	622	Apgar score <7 at 5 minutes, identified from hospital database	Planned VBAC vs. ERCS	1.21% vs. 0.48%	*uOR 2.24 (0.69-7.22)*§	

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B.15 (continued). Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Bickford, 2015[109] Canada 2000-2008	Population-based cohort Women with 1 or 2 prior CSs, who gave birth to a singleton cephalic presenting infant at 37-41 weeks' gestation, excluding those with gestational hypertension, pre-existing diabetes & cardiac disease, identified using the perinatal data registry of 1 province. Infants with congenital anomalies excluded from analyses of neonatal outcomes	11,051 (7,417 after 1-2 prior CSs only; 3,634 after 1-2 prior CSs & ≥ 1 prior VB; 7,310 after 1 prior CS only; 3,533 after 1 prior CS & ≥ 1 prior VB)	21,851 (20,212 after 1-2 prior CSs only; 1,639 after 1-2 prior CSs & ≥ 1 prior VB; 16,442 after 1 prior CS only; 1,374 after 1 prior CS & ≥ 1 prior VB)	Apgar score <4 at 5 minutes, identified from birth records linked to diagnostic & procedural codes from hospital discharge data	Planned VBAC vs. ERCS in women with 1-2 prior CSs only	0.18% vs. 0.02%	uRR 8.85 (2.89-27.14)	Reported that sequential removal from full multivariate model of the following covariates did not alter RRs by more than 10% so RRs are unadjusted: maternal age, BMI, number of previous CSs, augmentation of labour, induction of labour, hospital size, whether single parent & birth weight
					Planned VBAC vs. ERCS in women with 1-2 prior CSs & ≥ 1 prior VB	0.03% vs. 0.00%	*uOR 1.35 (0.06-33.25)*§	
					Planned VBAC vs. ERCS in women with 1 prior CS only	0.18% vs. 0.02%	uRR 7.31 (2.38-22.41)	
					Planned VBAC vs. ERCS in women with 1 prior CS & ≥ 1 prior VB	0.03% vs. 0.00%	*uOR 1.17 (0.05-28.67)*§	
Miller, 2015[95] USA 1999-2002	Secondary analysis of multicentre cohort Women with 1 -2 prior CSs via low transverse or unknown incision & no contraindication to VB, who gave birth to a singleton infant with no anomaly, excluding antenatal stillbirths, identified from 19 centres of Eunice Kennedy Shriver National Institute of Child Health & Human Development Maternal–Fetal Medicine Units Network	4,252 (all induction of labour; 4,100 had 1 prior CS; 152 had 2 prior CSs)	6,010 (all after 2 prior CSs)	Apgar score <7 at 5 minutes, identified from medical records	Planned VBAC with induction of labour vs. ERCS in women with 2 prior CSs	1.97% vs. 0.85%	uOR 2.35 (0.73-7.62)	No

Table continued overleaf

B.15 (continued). Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Kok, 2015[121] Netherlands 2000-2007	Population-based cohort Women with 1 prior CS at ≥37 weeks' gestation, having a second birth of a live singleton cephalic presenting infant without congenital abnormalities by ERCS at ≥39 weeks' gestation or spontaneous planned VBAC at ≥37 weeks' gestation, identified using a national perinatal registry	4,109 (all with spontaneous onset of labour)	4,109	Apgar score <7 at 5 minutes, identified from national database of data entered by clinicians	Planned VBAC with spontaneous labour onset vs. ERCS	2.46% vs. 0.83%	aOR 3.33 (2.00-5.00)	Propensity score method used to identify ERCS & planned VBAC groups with comparable characteristics (including race, socio-economic status; 1st pregnancy history: IVF, maternal age, non-gestational diabetes, pre-existing hypertension, pregnancy induced hypertensive disorder, spontaneous labour, malpresentation, ECS, gestational age, birth weight, Apgar score at 5 min, male gender, haemorrhage, transfusion; 2nd pregnancy: pregnancy interval <15 months, IVF, maternal age, gestational age)
Litwin, 2017[114] USA 2011-2013	Population-based cohort Women with ≥ 1 prior CS, who gave birth to a live singleton cephalic presenting infant without congenital malformations at 37-40 weeks' gestation, identified using national linked live birth-infant death data	181,566	854,988	Apgar score <4 at 5 minutes, identified from national database	Planned VBAC vs. ERCS	0.31% vs. 0.14%	aOR 2.13 (1.88-2.42)	Adjusted for maternal age, race, education, marital status, smoking, birth weight, characteristic of labour (induced, augmented or artificial rupture of membrane) & comorbidities (gestational diabetes, pre-pregnancy hypertension, gestational hypertension)
				Apgar score <7 at 5 minutes, identified from national database	Planned VBAC vs. ERCS	1.25% vs. 0.71%	*uRR 1.76 (1.68-1.85)*§	--
Gobillot, 2018[124] France 2013-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton infant after 37 weeks' gestation, who did not go spontaneously into labour & did not have contraindications to planned VBAC (including previous uterine body incision, placenta praevia or abnormal pelvimetry with a breech presentation), identified at a single hospital	248 (all induction of labour with oxytocin)	165	Apgar score <7 at 5 minutes, identified from medical records	Planned VBAC where labour induced with oxytocin vs. ERCS	0.81% vs. 2.44%	*uOR 0.36 (0.08-1.72)*§	--

Table continued overleaf

B.15 (continued). Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number Planned VBAC	 ERCS	Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
Fitzpatrick, 2019[1] Scotland 2002-2015	Population-based cohort Singleton births at 37-41 weeks' gestation to women with ≥ 1 prior CS, excluding antepartum stillbirths & women with contraindications to planned VBAC (including non-cephalic presentation at birth, placenta previa, abdominal pregnancy, known or suspected disproportion of maternal &/or fetal origin, tumour of corpus uteri, or birth by pre-labour non-elective caesarean section), identified from linked routinely-collected data including birth registration & hospital discharge data. Deaths due to congenital abnormalities excluded from all perinatal outcomes	28,464 (23,119 labour not induced; 5,245 labour induced)	45,579	Apgar score <7 at 5 minutes, identified from hospital discharge database	Planned VBAC vs. ERCS	1.44% vs. 0.42%	aOR 3.84 (3.15-4.68)	Adjusted for year of delivery, maternal age, mother's country of birth, marital status/registration type, socioeconomic status, number of previous caesarean sections, any prior vaginal birth, interpregnancy interval, maternal smoking status, maternal BMI at booking, hypertensive disorder, diabetes, & prelabour rupture of membranes
					Planned VBAC without labour induction vs. ERCS	1.35% vs. 0.42%	aOR 3.66 (2.99-4.50)	
					Planned VBAC with labour induction vs. ERCS	1.83% vs. 0.42%	aOR 4.87 (3.69-6.43)	
Huisman, 2019[127] Netherlands 2011-2012	Multicentre cohort Women with 1 prior CS, who gave birth to a live singleton infant in cephalic presentation at 37-41 weeks' gestation & had an unfavourable cervix & an indication for delivery, excluding contraindications for VB such as placenta previa, previous classical uterine incision or obstructing cervical fibroids, identified from 51 hospitals	993 (all had labour induced with a balloon catheter)	321	Apgar score <7 at 5 minutes, identified from medical records	Planned VBAC where labour induced with a balloon catheter vs. ERCS	2.11% vs. 1.28%	aOR 1.31 (0.41-4.17)	Adjusted for gestational age, maternal age, reasons for labour induction, known fetal congenital disease & prolonged rupture of membranes

Table continued overleaf

B.15 (continued). Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Lehmann, 2019[128] Norway 1989-2009	Population-based cohort Singleton cephalic second births at ≥37 weeks' gestation to women with 1 prior CS, identified using a national birth registry	30,176 (15,765 classified as "low-risk" & 14,411 classified as "high-risk" women)	12,249 (4,658 classified as "low-risk" & 7,591 classified as "high-risk" women)	Apgar score <4 at 5 minutes, identified from birth registry data	Planned VBAC vs. ERCS	0.26% vs. 0.09%	aRR 2.88 (1.50-5.54)	Adjusted for year of delivery, maternal age, education, country of origin, geographical region, & size of maternity unit
					Planned VBAC vs. ERCS in "low-risk" women without particular medical problems, pregnancy complications, a record of assisted reproduction or an infant with a birth weight percentile < 5 or >95 or major congenital malformations in the second pregnancy & no record of stillbirth, cephalopelvic disproportion or prolonged labour in the first pregnancy	0.21% vs. 0.09%	aRR 2.67 (0.93-7.71)	
					Planned VBAC vs. ERCS in "high-risk" women	0.31% vs. 0.09%	aRR 3.32 (1.46-7.55)	
				Apgar score <7 at 5 minutes, identified from birth registry data	Planned VBAC vs. ERCS	1.33% vs. 0.44%	aRR 3.07 (2.30-4.10)	
					Planned VBAC vs. ERCS in "low-risk" women without particular medical problems, pregnancy complications, a record of assisted reproduction or an infant with a birth weight percentile < 5 or >95 or major congenital malformations in the second pregnancy & no record of stillbirth, cephalopelvic disproportion or prolonged labour in the first pregnancy	1.08% vs. 0.41%	aRR 2.71 (1.67-4.41)	
					Planned VBAC vs. ERCS in "high-risk" women	1.60% vs. 0.46%	aRR 3.49 (2.44-5.01)	

Table continued overleaf

B.15 (continued). Studies investigating risk of low Apgar score admission for planned VBAC vs. ERCS

First author, Year published (reference) Country Recruitment period	Study design Population description	Total number		Outcome	Comparison	Absolute risks	Relative effect (95% CI)	Considered/adjusted for potential confounders
		Planned VBAC	ERCS					
Modzelewski, 2019[129] Poland 2010-2017	Single centre cohort Women with 2 prior CS, who gave birth to a singleton infant at term, excluding those with placenta previa, identified from a single tertiary hospital. Infants with abnormal karyotype or major congenital anomalies excluded from neonatal outcomes	35	377	Apgar score <7 at 5 minutes, identified from hospital database	Planned VBAC vs. ERCS	No cases	--	--
Yao, 2019[131] USA 2011-2014	Population-based cohort Obese (BMI≥30kg/m^2) women with 1 or 2 prior CSs, who gave birth to a singleton infant without congenital anomalies at 37-42 weeks' gestation, identified from a database capturing all births in the country	81,257	457,007	Apgar score <7 at 5 minutes, identified from national database	Planned VBAC vs. ERCS	1.61% vs. 0.95%	aOR 1.82 (1.71-1.94)	Adjusted for maternal age, gestational age, diabetes & hypertension
Takeya, 2020[134] Japan 2013-2015	Population-based cohort Women with 1 prior CS, who gave birth to a singleton at 37-41 weeks' gestation, excluding those with placenta previa, intrauterine fetal death or non-cephalic presentation, identified from a nationwide institution-based registry	1,730	32,739	Apgar score <7 at 5 minutes, identified from a nationwide institution-based registry	Planned VBAC vs. ERCS	0.52% vs. 0.50%	*uRR 1.04 (0.53-2.03)§*	--
Uno, 2020[135] Japan 2005-2017	Single centre cohort Women with 1 prior CS, who gave birth to a singleton without lethal congenital anomalies at ≥34 weeks' gestation, excluding those who had an antepartum stillbirth or contraindications to VB (including former caesarean not low transverse, obstetric contraindications, non-vertex presentation, history of myomectomy, CS for any condition that potentially threatened maternal life or incited non-reassuring fetal status before labour onset), identified from a single hospital	471	264	Apgar score <7 at 5 minutes, identified from medical records	Planned VBAC vs. ERCS	1.06% vs. 0.00%	*uOR 6.24 (0.34-113.24)§*	--

Abbreviations: aOR, adjusted odds ratio; aRR, adjusted risk ratio; BMI, body mass index; CS, caesarean section; ECS, elective caesarean section; ERCS, elective repeat caesarean section; IVF, in vitro fertilisation; RCT, randomised control trial; uOR, unadjusted odds ratio; uRR, unadjusted risk ratio; VB, vaginal birth; VBAC, vaginal birth after previous caesarean
Literature at the start of this thesis is highlighted in blue. ¥ - AHRQ systematic review; § – relative effect not reported by study but calculated from information provided by study

Appendix C: Supporting information for study methods (Chapter 3)

C.1. Data validation

C.1.1. Delivery records to women with one or more previous caesarean section

Of the 96,527 singleton births in Scotland between 2002-2015 linked to a delivery record in SMR02 identified as belonging to a woman with one or more previous caesarean section (see **Figure 4.1**) using the method outlined in Chapter 3:

- 73% (n=70,429) were identified on the basis of both the previous caesarean section field value and the information in the previous delivery records
- 14% (n=13,172) were identified on the basis of the previous caesarean section field value alone
- 13% (n=12,926) were identified on the basis of the information in the previous delivery records alone

Over 90% of women identified on the basis of the previous caesarean section field value alone, were women whose recorded parity value was higher than the number of previous delivery records found for the woman in SMR02. This implies that most of this apparent discrepancy could simply be the result of not all women having all their previous delivery records present in SMR02, which could occur if she, for example, had a previous birth outside of Scotland or in a non-NHS Scottish hospital. Of the women identified on the basis of the information in the previous delivery records alone, most were classified as having a prior caesarean section according to the mode of delivery field or the mode of delivery field and operation codes in one or more previous delivery records, with only 34 identified by

operation codes alone. The previous caesarean section field was missing for 2% of the women identified on the basis of the information in the previous delivery records alone.

The proportion of singleton births in Scotland between 2002-2015 identified as belonging to a woman with one or more previous caesarean sections using the method outlined in Chapter 3 (13%, 96,527/767,758 – see **Figure 4.1**) was the same as the average rate observed in control women comparable in characteristic to the available national data on women giving birth in the UK, identified through the UK Obstetric Surveillance System in a series of UK-wide studies conducted over various time periods ranging from 2005-2014[49-53]. This provides further confidence in the method used to identify deliveries to women with prior caesarean section.

C.1.2. Consistency in the reporting of some common data items between SMR02 and NRS live and stillbirths

Multiple births

Multiple birth status was discordant between the SMR02 and NRS live and stillbirth records for 0.04% of all the delivery episodes in the SMR02 file that linked with a NRS live and stillbirth record. Of the 74,043 births identified as meeting the eligibility criteria for study one, multiple birth status was discordant between the SMR02 and NRS live and stillbirth records for 0.007% of the births. Examining the ICD diagnostic codes in the SMR02 record of some of the discordant records, more often than not supported the multiple birth status recorded in the NRS record. For example, ICD codes related to multiple pregnancy/birth found in a SMR02 record which was classified as a multiple birth only according to the NRS live and stillbirth record, or ICD code indicating continuing pregnancy after intrauterine death of one fetus or more found in a SMR02 record which was classified as a multiple birth only according to the SMR02 record. The later may reflect cases of late fetal deaths before

24 weeks of gestation being counted in the number of births in this pregnancy field in SMR02, with such births not included in NRS due to being less than 24 weeks of gestation.

Sex of child

The recorded sex of the child was discordant between the SMR02 and NRS live and stillbirth records for 0.4% of all the delivery episodes in the SMR02 file that linked with a NRS live and stillbirth record and were identified as singleton births according to the NRS record. Of the 74,043 births identified as meeting the eligibility criteria for study one, the sex of the child was also discordant between the SMR02 and NRS live and stillbirth records for 0.4% of the births.

Live birth or a stillbirth

Information on whether a pregnancy ended in a live birth or stillbirth was available in both the SMR02 and NRS live and stillbirth records, with this information discordant for 0.008% of all the delivery episodes in the SMR02 file that linked with a NRS live and stillbirth record and were identified as singleton births according to the NRS record. None of the 74,043 births identified as meeting the eligibility criteria for study one were discordant for this information.

C.1.3. Comparison of the characteristics of the derived cohorts with published UK data

In the absence of national data on the characteristics of women giving birth after one or more previous caesarean sections, the literature was searched to identify relevant UK studies. The characteristics of the derived study populations were largely comparable to the available data identified on the characteristics of women who gave birth after previous caesarean section reported in previous UK studies[79,195]. However, the proportion of women identified as having a lower socio-economic status or a planned VBAC were lower in the derived study populations than in previous UK studies (**Table C.1**). However, these

differences may reflect methodological differences including differences in the studies eligibility criteria (detailed in the footnotes of the table). For example, the higher planned VBAC rate reported in Knight et al's study[195] may simply reflect the fact that this study was restricted to women having their second baby after only one previous caesarean section, while the derived study populations included women with one or more prior caesarean sections. As seen in all the studies caried out as part of this thesis, women who have a planned VBAC are more likely than those who have an ERCS to have just one prior caesarean section. Similarly, in contrast to the derived study populations, women who experienced an antepartum stillbirth or preterm births – situations where planned VBAC is likely to be more common - were not excluded from Fitzpatrick et al's study[79].

Table C.1. Characteristics of the derived study populations compared to the available data on the characteristics of women who gave birth after previous caesarean section in previous UK studies

Characteristic	Study one population[a] n (%)* (n=74,043)	Study two population[b] n (%)* (n=31,131)	Study three population[c] n (%)* (n=44,892)	Data on a sample of women giving birth in the UK after ≥1 prior caesarean section[d] n(%)* (n=448)	Data on women who had a second birth after a first live birth by caesarean section[e] n(%)* (n=143,970)
Maternal age (years)					
Less than 35	50,568 (68)	21,197 (68)	30,751 (69)	313 (70)	n not reported (71)
35 or more	23,475 (32)	9,934 (32)	14,141 (32)	134 (30)	n not reported (29)
Socio-economic status					
Managerial & professional	35,181 (48)	15,619 (50)	20,572 (46)	108 (32)	Not available
Other	38,862 (52)	15,512 (50)	24,320 (54)	226 (68)	
Planned mode of birth					
ERCS	45,579 (62)	20,911 (67)	26,041 (58)	250 (56)	68,884 (48)
Planned VBAC	28,464 (38)	10,220 (33)	18,851 (42)	198 (44)	75,086 (52)
Number of prior caesarean sections					
1	61,465 (83)	25,817 (83)	37,545 (84)	368 (82)	N/A (Only women with 1 prior caesarean included in study)
2 or more	12,578 (17)	5,314 (17)	7,347 (16)	79 (18)	
Any prior vaginal birth					
No	54,903 (74)	23,483 (75)	33,163 (74)	331 (74)	N/A (Only women having a second birth after first birth by caesarean included in study)
Yes	18,871 (26)	7,648 (25)	11,525 (26)	115 (26)	
Maternal BMI at booking (Kg/m^2)					
Less than 25	20,698 (40)	11,789 (38)	10,389 (39)	173 (40)	Not available
25-29.9	15,919 (31)	8,762 (28)	8,219 (31)	132 (31)	
30 or more	15,488 (30)	8,502 (27)	7,808 (30)	127 (29)	

[a] included singleton births at term (37-41 completed weeks' gestation) in Scotland, UK, between 1st January 2002 and 31st December 2015 to women with one or more previous caesarean sections. Excluded women considered clinically ineligible to have a planned VBAC, those who had an antepartum stillbirth, & those who had missing or inconsistent data for key variables as detailed in section 4.3.1

[b] included women with one or more previous caesarean sections who gave birth to a singleton at term (37-41 completed weeks' gestation) in Scotland, UK, between 1st January 2010 & 31st December 2015. The same exclusions as those used in study one were applied in addition to excluding those with a history of psychotropic drug use in the year before birth, & those who migrated to Scotland less than one year before birth.

[C] included live singleton births at term (37-41 completed weeks' gestation) in Scotland, UK, between 1st January 2002 & 31st December 2011 to women with one or more previous caesarean sections. The same exclusions as those used in study one were applied in addition to excluding children who died before the age of 4 years old.

[d] sample of women giving birth after one or more previous caesarean sections identified in a previous UK Obstetric Surveillance System study from a random sample of obstetrician-led maternity units in the UK in July 2009 & March 2010, weighted by the total number of births[79]

[e] women who had their first live singleton birth by caesarean section between April 2004 & March 2011, & who had a second birth before March 2012 identified using an administrative database of all deliveries in English NHS hospitals (hospital episode statistics). Excluded women who for their second birth were considered clinically ineligible for planned VBAC & those who had a preterm birth[195]

Abbreviations: BMI, body mass index; ERCS, elective repeat caesarean section; N/A, not applicable; VBAC, vaginal birth after previous caesarean

C.2. Approvals

RESEARCH SERVICES
Clinical Trials and Research Governance
Joint Research Office
Block 60
Churchill Hospital
Headington
Oxford
OX3 7LE

To whom it may concern

30 August 2016

Dear Sir/Madam,

Reference: DRF-2016-09-078

Research Title: Short and Longer-term Outcomes for Women and Their Children According to Intended Mode of Delivery after Previous Caesarean Section

I have been asked to assess the above referenced fellowship, from lead applicant Kate Fitzpatrick with regard to the need for a NHS research ethics committee opinion.

I can confirm we do not consider any parts of this project to require NRES approval.

Yours faithfully,

Ms H House
Head of Research Governance

Tel: +44 (0)1865 572221 · Fax: +44 (0)1865 572228 · Web: www.admin.ox.ac.uk/researchsupport/ctrg/
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Public Benefit and Privacy Panel for Health and Social Care
nss.PBPP@nhs.net
www.informationgovernance.scot.nhs.uk

Ms Kathryn Fitzpatrick
National Perinatal Unit
Nuffield Department of Population Health
University of Oxford
Old Road Campus
Oxford
OX3 7LF

Date: 26th April 2017
Your Ref:
Our Ref: 1516-0196

Dear Ms Fitzpatrick

Re: Application 1516-0196/Fitzpatrick: Short and longer-term outcomes for women and their children according to intended mode of delivery after previous caesarean section
Version: v1

Thank you for your application for consideration by the Public Benefit and Privacy Panel for Health and Social Care. Your application has undergone proportionate governance review and has been approved.

This approval is given to process data as specified in the approved application form, and is limited to this. Approval is valid for the period specified in your application until 30th September 2021. You are required to notify the Panel Manager of any proposed change to any aspect of your proposal, including purpose or method of processing, data or data variables being processed, study cohorts, individuals accessing and processing data, timescales, technology/infrastructure, or any other relevant change.

I would take this opportunity to remind you of the declaration you have made in your application form committing you to undertakings in respect of information governance, confidentiality and data protection. In particular you should be aware that once personal data (irrespective of de-identification or other controls applied) has been extracted from NHSS Board(s) and transferred to you, that you will then become the Data Controller as defined by the Data Protection Act (1998). Requests for access to NHS Scotland data as part of this approved application should be supported by evidencing a copy of your approval letter and application form to the relevant local board contacts/data providers.

Please note that summary information about your application and its approval, including the title and nature of your proposal, will be published on the panel website (www.informationgovernance.scot.nhs.uk).

I hope that your proposal progresses well,

Yours Sincerely

Ashley Gray
Panel Manager
NHS Scotland Public Benefit and Privacy Panel for Health and Social Care
Email: nss.PBPP@nhs.net

Appendix D: Supporting information for planned mode of birth and short-term maternal and perinatal outcomes study (Chapter 4)

Table D.1. Complete case analysis of maternal and perinatal outcomes following planned VBAC compared to ERCS

	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Maternal outcomes				
Uterine rupture	**6.26 (3.64-10.76) P<0.001**	**6.28 (3.62-10.89) P<0.001**	NC	-
Peripartum hysterectomy	0.47 (0.19-1.16) P=0.102	NC	NC	-
Blood transfusion†	**2.12 (1.78-2.52) P<0.001**	**2.09 (1.76-2.49) P<0.001**	**2.74 (2.08-3.60) P<0.001**	-
Puerperal sepsis‡¥	**1.73 (1.25-2.38) P=0.001**	**1.69 (1.22-2.33) P=0.001**	1.22 (0.73-2.01) P=0.447	-
Other puerperal infection‡¥	1.00 (0.90-1.11) P=0.986	0.99 (0.89-1.10) P=0.855	1.00 (0.85-1.18) P=0.994	-
Surgical injury	**1.96 (1.29-2.98) P=0.002**	**2.01 (1.33-3.05) P=0.001**	NC	-
Postnatal hospital stay >5 days†‡¥	**0.88 (0.81-0.97) P=0.007**	**0.89 (0.82-0.98) P=0.013**	0.92 (0.79-1.06) P=0.252	-
Readmission to hospital within 42 days of birth†‡¥	**0.88 (0.80-0.96) P=0.006**	**0.87 (0.79-0.96) P=0.004**	1.01 (0.88-1.16) P=0.838	-
Any breastfeeding at birth or hospital discharge	**1.18 (1.16-1.20) P<0.001**	**1.19 (1.18-1.21) P<0.001**	**1.18 (1.16-1.20) P<0.001**	**1.15 (1.13-1.17) P<0.001**
Exclusive breastfeeding at 6-8 week review	**1.34 (1.31-1.38) P<0.001**	**1.37 (1.34-1.41) P<0.001**	**1.38 (1.33-1.42) P<0.001**	**1.31 (1.26-1.35) P<0.001**
Any breastfeeding at 6-8 week review	**1.27 (1.24-1.30) P<0.001**	**1.29 (1.26-1.31) P<0.001**	**1.29 (1.26-1.33) P<0.001**	**1.24 (1.21-1.27) P<0.001**
Perinatal outcomes				
Adverse perinatal outcome[a]†‡¥	**1.22 (1.15-1.30) P<0.001**	**1.22 (1.15-1.30) P<0.001**	**1.37 (1.25-1.50) P<0.001**	**1.59 (1.45-1.75) P<0.001**
Intrapartum stillbirth or neonatal death	**6.59 (2.43-17.87) P<0.001**	NC	NC	NC
Admitted to a neonatal unit†‡¥	1.00 (0.93-1.07) P=0.967	1.00 (0.94-1.07) P=0.960	**1.13 (1.02-1.25) P=0.015**	**1.33 (1.20-1.47) P<0.001**
Resuscitation requiring drugs &/or intubation†‡¥	**4.67 (3.84-5.68) P<0.001**	**4.68 (3.84-5.70) P<0.001**	**4.74 (3.48-6.45) P<0.001**	**4.71 (3.48-6.37) P<0.001**
Apgar score <7 at 5 minutes†‡¥	**3.45 (2.90-4.09) P<0.001**	**3.46 (2.91-4.11) P<0.001**	**3.37 (2.63-4.32) P<0.001**	**3.73 (2.90-4.80) P<0.001**

[1] Base model adjusted for year of birth.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status/registration type, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder where † is shown, diabetes where ‡ is shown & pre-labour rupture of membranes where ¥ is shown).

[4] Model C adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).

[a] Includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation or an Apgar score <7 at 5 minutes.

Bold text indicates statistically significant findings at the 5% level. Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; NC, not calculated because of low number of events; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean

Table D.2. Complete case analysis of maternal and perinatal outcomes following planned VBAC with and without labour induction compared to ERCS

	Planned VBAC without labour induction vs. ERCS				Planned VBAC with labour induction vs. ERCS			
	Base model[1] OR or RR (95% CI)	**Model A[2] OR or RR (95% CI)**	**Model B[3] OR or RR (95% CI)**	**Model C[4] OR or RR (95% CI)**	**Base model[1] OR or RR (95% CI)**	**Model A[2] OR or RR (95% CI)**	**Model B[3] OR or RR (95% CI)**	**Model C[4] OR or RR (95% CI)**
Maternal outcomes								
Uterine rupture	**5.92 (3.38-10.37) P<0.001**	**5.89 (3.34-10.41) P<0.001**	NC	-	**7.89 (3.99-15.61) P<0.001**	**8.17 (4.08-16.35) P<0.001**	NC	-
Peripartum hysterectomy	0.39 (0.13-1.12) P=0.080	NC	NC	-	0.85 (0.20-3.64) P=0.828	NC	NC	-
Blood transfusion†	**2.06 (1.72-2.47) P<0.001**	**2.04 (1.70-2.45) P<0.001**	**2.59 (1.95-3.44) P<0.001**	-	**2.42 (1.83-3.19) P<0.001**	**2.38 (1.81-3.14) P<0.001**	**3.70 (2.42-5.68) P<0.001**	-
Puerperal sepsis‡¥	**1.51 (1.06-2.14) P=0.021**	**1.48 (1.04-2.10) P=0.028**	1.06 (0.63-1.81) P=0.821	-	**2.55 (1.56-4.16) P<0.001**	**2.49 (1.53-4.06) P<0.001**	2.0 (0.90-4.49) P=0.091	-
Other puerperal infection‡¥	0.98 (0.88-1.10) P=0.757	0.97 (0.87-1.09) P=0.639	0.97 (0.82-1.16) P=0.759	-	1.10 (0.91-1.32) P=0.325	1.08 (0.90-1.30) P=0.415	1.16 (0.86-1.56) P=0.326	-
Surgical injury	**2.12 (1.38-3.25) P<0.001**	**2.17 (1.42-3.32) P<0.001**	NC	-	1.33 (0.56-3.15) P=0.518	1.37 (0.58-3.26) P=0.470	NC	-
Postnatal hospital stay >5 days†‡¥	**0.83 (0.76-0.92) P<0.001**	**0.84 (0.77-0.93) P=0.001**	0.88 (0.75-1.03) P=0.118	-	1.11 (0.96-1.30) P=0.167	1.11 (0.95-1.29) P=0.189	1.08 (0.83-1.40) P=0.554	-
Readmission to hospital within 42 days of birth†‡¥	**0.81 (0.73-0.89) P<0.001**	**0.80 (0.72-0.89) P<0.001**	0.92 (0.79-1.06) P=0.246	-	**1.19 (1.01-1.39) P=0.036**	**1.18 (1.00-1.38) P=0.045**	**1.51 (1.21-1.89) P<0.001**	-
Any breastfeeding at birth or hospital discharge	**1.19 (1.17-1.20) P<0.001**	**1.19 (1.17-1.21) P<0.001**	**1.18 (1.16-1.20) P<0.001**	**1.15 (1.13-1.18) P<0.001**	**1.15 (1.12-1.18) P<0.001**	**1.20 (1.17-1.23) P<0.001**	**1.17 (1.13-1.21) P<0.001**	**1.12 (1.08-1.16) P<0.001**
Exclusive breastfeeding at 6-8 week review	**1.38 (1.34-1.42) P<0.001**	**1.39 (1.36-1.43) P<0.001**	**1.39 (1.34-1.44) P<0.001**	**1.32 (1.28-1.37) P<0.001**	**1.20 (1.14-1.26) P<0.001**	**1.29 (1.24-1.35) P<0.001**	**1.31 (1.22-1.40) P<0.001**	**1.20 (1.12-1.29) P<0.001**
Any breastfeeding at 6-8 week review	**1.29 (1.26-1.32) P<0.001**	**1.29 (1.27-1.32) P<0.001**	**1.29 (1.36-1.33) P<0.001**	**1.25 (1.21-1.28) P<0.001**	**1.17 (1.13-1.22) P<0.001**	**1.25 (1.21-1.30) P<0.001**	**1.30 (1.23-1.37) P<0.001**	**1.21 (1.15-1.28) P<0.001**

Table continued overleaf

Table D.2. (continued). Complete case analysis of maternal and perinatal outcomes following planned VBAC with and without labour induction compared to ERCS

	Planned VBAC without labour induction vs. ERCS				Planned VBAC with labour induction vs. ERCS			
	Base model[1] OR or RR (95% CI)	**Model A[2] OR or RR (95% CI)**	**Model B[3] OR or RR (95% CI)**	**Model C[4] OR or RR (95% CI)**	**Base model[1] OR or RR (95% CI)**	**Model A[2] OR or RR (95% CI)**	**Model B[3] OR or RR (95% CI)**	**Model C[4] OR or RR (95% CI)**
Perinatal outcomes								
Adverse perinatal outcome[a]†‡¥	**1.15 (1.08-1.23) P<0.001**	**1.16 (1.08-1.24) P<0.001**	**1.33 (1.20-1.46) P<0.001**	**1.52 (1.38-1.68) P<0.001**	**1.51 (1.36-1.68) P<0.001**	**1.49 (1.34-1.66) P<0.001**	**1.58 (1.34-1.87) P<0.001**	**2.03 (1.71-2.40) P<0.001**
Intrapartum stillbirth or neonatal death	**6.90 (2.48-19.19) P<0.001**	NC	NC	NC	**5.35 (1.29-22.12) P=0.021**	NC	NC	NC
Admitted to a neonatal unit†‡¥	0.94 (0.88-1.02) P=0.126	0.95 (0.88-1.02) P=0.182	**1.11 (1.00-1.24) P=0.049**	**1.28 (1.15-1.42) P<0.001**	**1.23 (1.09-1.39) P<0.001**	**1.21 (1.08-1.37) P=0.002**	**1.24 (1.03-1.49) P=0.023**	**1.60 (1.32-1.94) P<0.001**
Resuscitation requiring drugs &/or intubation†‡¥	**4.69 (3.83-5.75) P<0.001**	**4.72 (3.85-5.78) P<0.001**	**4.50 (3.28-6.16) P<0.001**	**4.53 (3.33-6.16) P<0.001**	**5.66 (4.32-7.40) P<0.001**	**5.59 (4.27-7.33) P<0.001**	**6.13 (3.93-9.58) P<0.001**	**6.07 (3.85-9.58) P<0.001**
Apgar score <7 at 5 minutes†‡¥	**3.24 (2.70-3.88) P<0.001**	**3.26 (2.72-3.91) P<0.001**	**3.26 (2.52-4.21) P<0.001**	**3.57 (2.75-4.63) P<0.001**	**4.39 (3.43-6.62) P<0.001**	**4.31 (3.37-5.53) P<0.001**	**4.03 (2.77-5.86) P<0.001**	**4.77 (3.24-7.01) P<0.001**

[1] Base model adjusted for year of birth.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status/registration type, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder where † is shown, diabetes where ‡ is shown & pre-labour rupture of membranes where ¥ is shown).

[4] Model C adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).

[a] Includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation or an Apgar score <7 at 5 minutes.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; NC, not calculated because of low number of events; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean

Table D.3. Complete case analysis of maternal and perinatal outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS

	Planned and actually had VBAC vs. ERCS				Planned VBAC but had in-labour non-elective repeat caesarean section vs. ERCS			
	Base model[1] OR or RR (95% CI)	**Model A[2] OR or RR (95% CI)**	**Model B[3] OR or RR (95% CI)**	**Model C[4] OR or RR (95% CI)**	**Base model[1] OR or RR (95% CI)**	**Model A[2] OR or RR (95% CI)**	**Model B[3] OR or RR (95% CI)**	**Model C[4] OR or RR (95% CI)**
Maternal outcomes								
Uterine rupture	1.14 (0.51-2.56) P=0.744	1.16 (0.51-2.60) P=0.727	NC	-	**19.28 (11.09-33.53) P<0.001**	**19.28 (10.97-33.88) P<0.001**	NC	-
Peripartum hysterectomy	0.33 (0.10-1.10) P=0.071	NC	NC	-	0.82 (0.24-2.76) P=0.752	**NC**	NC	-
Blood transfusion†	**1.95 (1.61-2.36) P<0.001**	**1.93 (1.59-2.34) P<0.001**	**2.37 (1.74-3.22) P<0.001**	-	**2.54 (2.02-3.21) P<0.001**	**2.51 (1.99-3.17) P<0.001**	**3.60 (2.56-5.07) P<0.001**	-
Puerperal sepsis‡¥	1.17 (0.79-1.73) P=0.430	1.15 (0.78-1.70) P=0.489	0.99 (0.55-1.78) P=0.968	-	**3.14 (2.12-4.66) P<0.001**	**3.08 (2.08-4.57) P<0.001**	**1.84 (0.95-3.57) P=0.071**	-
Other puerperal infection‡¥	**0.66 (0.58-0.75) P<0.001**	**0.65 (0.57-0.74) P<0.001**	**0.63 (0.51-0.77) P<0.001**	-	**1.88 (1.65-2.13) P<0.001**	**1.87 (1.65-2.13) P<0.001**	**1.99 (1.64-2.41) P<0.001**	-
Surgical injury	**0.11 (0.03-0.47) P=0.003**	**0.12 (0.03-0.48) P=0.003**	**NC**	-	**6.67 (4.37-10.18) P<0.001**	**6.92 (4.56-10.49) P<0.001**	**NC**	-
Postnatal hospital stay >5 days†‡¥	**0.60 (0.53-0.67) P<0.001**	**0.60 (0.53-0.67) P<0.001**	**0.64 (0.54-0.76) P<0.001**	-	**1.63 (1.46-1.82) P<0.001**	**1.67 (1.50-1.87) P<0.001**	**1.73 (1.44-2.08) P<0.001**	-
Readmission to hospital within 42 days of birth†‡¥	**0.82 (0.74-0.92) P<0.001**	**0.82 (0.73-0.91) P<0.001**	0.95 (0.81-1.11) P=0.495	-	1.02 (0.88-1.17) P=0.835	1.01 (0.88-1.16) P=0.899	1.20 (0.98-1.48) P=0.078	-
Any breastfeeding at birth or hospital discharge	**1.17 (1.15-1.19) P<0.001**	**1.19 (1.17-1.21) P<0.001**	**1.19 (1.17-1.21) P<0.001**	**1.16 (1.14-1.19) P<0.001**	**1.21 (1.19-1.24) P<0.001**	**1.20 (1.18-1.22) P<0.001**	**1.15 (1.12-1.18) P<0.001**	**1.12 (1.09-1.15) P<0.001**
Exclusive breastfeeding at 6-8 week review	**1.34 (1.30-1.38) P<0.001**	**1.40 (1.36-1.44) P<0.001**	**1.40 (1.35-1.45) P<0.001**	**1.33 (1.28-1.38) P<0.001**	**1.34 (1.29-1.39) P<0.001**	**1.32 (1.27-1.37) P<0.001**	**1.31 (1.25-1.38) P<0.001**	**1.25 (1.18-1.31) P<0.001**
Any breastfeeding at 6-8 week review	**1.25 (1.22-1.28) P<0.001**	**1.29 (1.26-1.32) P<0.001**	**1.31 (1.27-1.35) P<0.001**	**1.26 (1.22-1.30) P<0.001**	**1.31 (1.27-1.35) P<0.001**	**1.27 (1.24-1.31) P<0.001**	**1.24 (1.19-1.30) P<0.001**	**1.19 (1.15-1.24) P<0.001**

Table continued overleaf

Table D.3. (continued). Complete case analysis of maternal and perinatal outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS

	Planned and actually had VBAC vs. ERCS				Planned VBAC but had in-labour non-elective repeat caesarean section vs. ERCS			
	Base model[1] OR or RR (95% CI)	**Model A[2] OR or RR (95% CI)**	**Model B[3] OR or RR (95% CI)**	**Model C[4] OR or RR (95% CI)**	**Base model[1] OR or RR (95% CI)**	**Model A[2] OR or RR (95% CI)**	**Model B[3] OR or RR (95% CI)**	**Model C[4] OR or RR (95% CI)**
Perinatal outcomes								
Adverse perinatal outcome[a]†‡¥	1.07 (1.00-1.15) P=0.065	1.06 (0.99-1.14) P=0.085	**1.23 (1.11-1.36) P<0.001**	**1.45 (1.30-1.61) P<0.001**	**1.61 (1.48-1.76) P<0.001**	**1.65 (1.51-1.80) P<0.001**	**1.76 (1.54-2.02) P<0.001**	**1.98 (1.73-2.26) P<0.001**
Intrapartum stillbirth or neonatal death	**4.60 (1.55-13.64) P=0.006**	NC	NC	NC	**11.63 (3.89-34.75) P<0.001**	NC	NC	NC
Admitted to a neonatal unit†‡¥	**0.85 (0.79-0.92) P<0.001**	**0.85 (0.78-0.92) P<0.001**	**1.01 (0.90-1.13) P=0.926**	**1.19 (1.06-1.34) P=0.003**	**1.38 (1.26-1.52) P<0.001**	**1.42 (1.29-1.56) P<0.001**	**1.49 (1.29-1.73) P<0.001**	**1.68 (1.45-1.94) P<0.001**
Resuscitation requiring drugs &/or intubation†‡¥	**4.62 (3.76-5.68) P<0.001**	**4.61 (3.74-5.67) P<0.001**	**4.37 (3.13-6.10) P<0.001**	**4.32 (3.11-6.00) P<0.001**	**5.58 (4.39-7.09) P<0.001**	**5.70 (4.48-7.26) P<0.001**	**5.76 (3.95-8.40) P<0.001**	**5.72 (3.94-8.29) P<0.001**
Apgar score <7 at 5 minutes†‡¥	**2.76 (2.28-3.33) P<0.001**	**2.74 (2.26-3.32) P<0.001**	**2.55 (1.94-3.35) P<0.001**	**2.83 (2.14-3.73) P<0.001**	**5.22 (4.24-6.42) P<0.001**	**5.36 (4.35-6.60) P<0.001**	**5.41 (4.05-7.23) P<0.001**	**5.80 (4.33-7.77) P<0.001**

[1] Base model adjusted for year of birth.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status/registration type, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder where † is shown, diabetes where ‡ is shown & pre-labour rupture of membranes where ¥ is shown).

[4] Model C adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).

[a] Includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation or an Apgar score <7 at 5 minutes.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; NC, not calculated because of low number of events; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean

Table D.4. Maternal and perinatal outcomes following planned VBAC compared to ERCS at ≥39 weeks' gestation

	ERCS n outcome events/total n (%)	Planned VBAC n outcome events/total n (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Maternal outcomes						
Uterine rupture	16/31,880 (0.05)	57/22,758 (0.25)	**4.65 (2.61-8.29) P<0.001**	**4.69 (2.61-8.43) P<0.001**	**5.95 (2.94-12.04) P<0.001**	-
Peripartum hysterectomy	9/31,880 (0.03)	# (0.02)	0.49 (0.15-1.61) P=0.244	NC	NC	-
Blood transfusion†	149/31,880 (0.47)	268/22,758 (1.18)	**2.23 (1.81-2.75) P<0.001**	**2.19 (1.78-2.69) P<0.001**	**2.39 (1.90-3.01) P<0.001**	-
Puerperal sepsis‡¥	48/31,880 (0.15)	57/22,758 (0.25)	**1.96 (1.32-2.89) P<0.001**	**1.91 (1.29-2.82) P=0.001**	**1.91 (1.21-2.99) P=0.005**	-
Other puerperal infection‡¥	660/31,880 (2.07)	540/22,758 (2.37)	1.09 (0.97-1.23) P=0.143	1.08 (0.96-1.22) P=0.193	**1.30 (1.14-1.49) P<0.001**	-
Surgical injury	24/31,880 (0.08)	# (0.17)	**2.41 (1.45-4.00) P<0.001**	**2.44 (1.47-4.03) P<0.001**	NC	-
Postnatal hospital stay >5 days†‡¥	729/31,880 (2.29)	620/22,758 (2.72)	1.02 (0.91-1.14) P=0.761	1.03 (0.92-1.15) P=0.644	1.11 (0.97-1.26) P=0.124	-
Readmission to hospital within 42 days of birth[a]†‡¥	822/31,879 (2.58)	554/22,757 (2.43)	0.97 (0.86-1.08) P=0.553	0.96 (0.86-1.08) P=0.528	1.04 (0.92-1.18) P=0.528	-
Any breastfeeding at birth or hospital discharge[b]	15,556/27,804 (55.95)	12,243/18,696 (65.48)	**1.19 (1.17-1.21) P<0.001**	**1.2 (1.18-1.21) P<0.001**	**1.19 (1.17-1.21) P<0.001**	**1.15 (1.13-1.17) P<0.001**
Exclusive breastfeeding at 6-8 week review[c]	7,185/27,573 (26.06)	6,793/19,247 (35.29)	**1.36 (1.32-1.40) P<0.001**	**1.38 (1.34-1.42) P<0.001**	**1.38 (1.34-1.43) P<0.001**	**1.31 (1.26-1.35) P<0.001**
Any breastfeeding at 6-8 week review[c]	9,883/27,573 (35.84)	8,752/19,247 (45.47)	**1.28 (1.25-1.31) P<0.001**	**1.29 (1.26-1.32) P<0.001**	**1.30 (1.26-1.33) P<0.001**	**1.24 (1.20-1.27) P<0.001**

Table continued overleaf

Table D.4. (continued). Maternal and perinatal outcomes following planned VBAC compared to ERCS at ≥39 weeks' gestation

	ERCS n outcome events/total n (%)	Planned VBAC n outcome events/total n (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Perinatal outcomes[d]						
Adverse perinatal outcome[e]†‡¥	1,282/28,065 (4.57)	1,475/20,588 (7.16)	**1.52 (1.41-1.65) P<0.001**	**1.52 (1.41-1.65) P<0.001**	**1.58 (1.45-1.72) P<0.001**	**1.65 (1.50-1.81) P<0.001**
Intrapartum stillbirth or neonatal death	# (0.01)	14/22,748 (0.06)	**10.27 (2.35-44.81) P=0.002**	NC	NC	NC
Admitted to a neonatal unit†‡¥	1,155/31,530 (3.66)	1,043/22,243 (4.69)	**1.25 (1.15-1.37) P<0.001**	**1.26 (1.15-1.37) P<0.001**	**1.31 (1.19-1.44) P<0.001**	**1.37 (1.24-1.53) P<0.001**
Resuscitation requiring drugs &/or intubation†‡¥	78/28,399 (0.27)	348/21,137 (1.65)	**5.3 (4.12-6.81) P<0.001**	**5.31 (4.12-6.85) P<0.001**	**5.73 (4.41-7.46) P<0.001**	**5.66 (4.32-7.42) P<0.001**
Apgar score <7 at 5 minutes†‡¥	110/31,630 (0.35)	307/22,482 (1.37)	**3.93 (3.16-4.90) P<0.001**	**3.92 (3.14-4.89) P<0.001**	**3.75 (2.93-4.79) P<0.001**	**3.56 (2.76-4.60) P<0.001**

[1] Base model adjusted for year of birth.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status/registration type, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder where † is shown, diabetes where ‡ is shown & pre-labour rupture of membranes where ¥ is shown).

[4] Model C adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).

[a] Women who died before discharge or were not discharged within 42 days of birth excluded from analysis of overnight readmission to hospital (n=2).

[b] Intrapartum stillbirths (n=4) & births missing data on feeding at birth & hospital discharge (n=8,134, 14.9%) excluded from analysis of breastfeeding at birth or hospital discharge.

[c] Intrapartum stillbirths (n=4), neonatal deaths (31) & births missing infant feeding data at 6-8 week review (n=7,783, 14.3%) excluded from analysis of breastfeeding outcomes at 6-8 weeks.

[d] All perinatal outcomes exclude deaths due to congenital abnormalities (n=19) & any remaining intrapartum stillbirths (n=4) & births missing the outcome in question (n=842, 1.5% for admission to a neonatal unit; n=5,079, 9.3% for resuscitation; n=503, 0.9% for Apgar score) additionally excluded from analysis of neonatal unit admission, resuscitation & Apgar score.

[e] Includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation or an Apgar score <7 at 5 minutes.

– numbers have not been shown to protect against potential disclosure risks. Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; NC, not calculated because of low number of events; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean

Table D.5. Maternal and perinatal outcomes following planned VBAC with and without labour induction compared to ERCS at ≥39 weeks' gestation

	ERCS	Planned VBAC without labour induction					Planned VBAC with labour induction				
	n outcome events/total N (%)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Maternal outcomes						-					-
Uterine rupture	16/31,880 (0.05)	44/18,340 (0.24)	**4.46 (2.45-8.12) P<0.001**	**4.47 (2.44-8.19) P<0.001**	**5.63 (2.73-11.63) P<0.001**	-	13/4,338 (0.30)	**5.57 (2.66-11.65) P<0.001**	**5.77 (2.72-12.20) P<0.001**	**7.57 (3.24-17.68) P<0.001**	-
Peripartum hysterectomy	9/31,880 (0.03)	# (0.02)	0.46 (0.12-1.75) P=0.255	NC	NC	-	#	0.64 (0.08-4.87) P=0.667	NC		-
Blood transfusion†	149/31,880 (0.47)	207/18,340 (1.13)	**2.14 (1.72-2.66) P<0.001**	**2.1 (1.69-2.61) P<0.001**	**2.29 (1.81-2.91) P<0.001**	-	61/4,338 (1.41)	**2.66 (1.96-3.62) P<0.001**	**2.6 (1.91-3.53) P<0.001**	**2.86 (2.07-3.95) P<0.001**	-
Puerperal sepsis‡¥	48/31,880 (0.15)	41/18,340 (0.22)	**1.74 (1.15-2.65) P=0.009**	**1.7 (1.12-2.58) P=0.013**	**1.71 (1.06-2.75) P=0.028**	-	15/4,338 (0.35)	**2.66 (1.47-4.80) P=0.001**	**2.59 (1.44-4.66) P=0.002**	**2.46 (1.31-4.63) P=0.005**	-
Other puerperal infection‡¥	660/31,880 (2.07)	421/18,340 (2.30)	1.06 (0.93-1.20) P=0.393	1.05 (0.92-1.19) P=0.466	**1.27 (1.10-1.46) P=0.001**	-	119/4,338 (2.74)	**1.27 (1.03-1.55) P=0.022**	**1.25 (1.02-1.53) P=0.033**	**1.48 (1.20-1.84) P<0.001**	-
Surgical injury	24/31,880 (0.08)	34/18,340 (0.19)	**2.61 (1.56-4.39) P<0.001**	**2.64 (1.58-4.41) P<0.001**	NC	-	#	1.62 (0.62-4.26) P=0.329	1.63 (0.62-4.30) P=0.323	NC	-
Postnatal hospital stay >5 days†‡¥	729/31,880 (2.29)	464/18,340 (2.53)	0.94 (0.83-1.07) P=0.366	0.96 (0.84-1.08) P=0.484	1.04 (0.91-1.20) P=0.551	-	154/4,338 (3.55)	**1.33 (1.11-1.60) P=0.002**	**1.33 (1.11-1.60) P=0.002**	**1.38 (1.14-1.68) P=0.001**	-
Readmission to hospital within 42 days of birth[a]†‡¥	822/31,879 (2.58)	420/18,339 (2.29)	0.91 (0.80-1.02) P=0.116	0.91 (0.80-1.02) P=0.111	0.99 (0.87-1.14) P=0.901	-	131/4,338 (3.02)	1.2 (1.00-1.46) P=0.054	1.2 (0.99-1.45) P=0.057	**1.24 (1.02-1.52) P=0.032**	-
Any breastfeeding at birth or hospital discharge[b]	15,556/27,804 (55.95)	9,933/15,094 (65.81)	**1.2 (1.18-1.22) P<0.001**	**1.2 (1.18-1.21) P<0.001**	**1.19 (1.17-1.21) P<0.001**	**1.15 (1.13-1.17) P<0.001**	2,262/3,538 (63.93)	**1.16 (1.13-1.19) P<0.001**	**1.2 (1.17-1.2) P<0.001**	**1.18 (1.14-1.22) P<0.001**	**1.11 (1.08-1.15) P<0.001**
Exclusive breastfeeding at 6-8 week review[c]	7,185/27,573 (26.06)	5,605/15,479 (36.21)	**1.39 (1.35-1.43) P<0.001**	**1.4 (1.36-1.44) P<0.001**	**1.39 (1.35-1.44) P<0.001**	**1.32 (1.27-1.37) P<0.001**	1,164/3,694 (31.51)	**1.21 (1.15-1.28) P<0.001**	**1.29 (1.23-1.36) P<0.001**	**1.33 (1.25-1.41) P<0.001**	**1.21 (1.14-1.29) P<0.001**
Any breastfeeding at 6-8 week review[c]	9,883/27,573 (35.84)	7,165/15,479 (46.29)	**1.3 (1.27-1.34) P<0.001**	**1.3 (1.27-1.33) P<0.001**	**1.30 (1.26-1.33) P<0.001**	**1.24 (1.21-1.28) P<0.001**	1,557/3,694 (42.15)	**1.19 (1.14-1.24) P<0.001**	**1.26 (1.21-1.31) P<0.001**	**1.28 (1.22-1.35) P<0.001**	**1.19 (1.13-1.25) P<0.001**

Table continued overleaf

Table D.5. (continued). Maternal and perinatal outcomes following planned VBAC with and without labour induction compared to ERCS at ≥39 weeks' gestation

	ERCS	Planned VBAC without labour induction					Planned VBAC with labour induction				
	n outcome events/total N (%)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Perinatal outcomes[d]											
Adverse perinatal outcome[e]†‡¥	1,282/28,065 (4.57)	1,122/16,615 (6.75)	**1.42 (1.31-1.55) P<0.001**	**1.43 (1.32-1.56) P<0.001**	**1.50 (1.37-1.64) P<0.001**	**1.58 (1.43-1.74) P<0.001**	346/3,925 (8.82)	**1.91 (1.69-2.16) P<0.001**	**1.89 (1.67-2.14) P<0.001**	**1.90 (1.67-2.17) P<0.001**	**2.07 (1.79-2.39) P<0.001**
Intrapartum stillbirth or neonatal death	# (0.01)	# (0.06)	**10.02 (2.21-45.43) P=0.003**	NC	NC	NC	# (0.07)	**11.53 (2.02-65.99) P=0.006**	NC	NC	NC
Admitted to a neonatal unit†‡¥	1,155/31,530 (3.66)	796/17,949 (4.43)	**1.18 (1.07-1.30) P=0.001**	**1.19 (1.08-1.31) P<0.001**	**1.25 (1.13-1.39) P<0.001**	**1.32 (1.18-1.47) P<0.001**	242/4,242 (5.70)	**1.54 (1.33-1.78) P<0.001**	**1.53 (1.32-1.77) P<0.001**	**1.54 (1.32-1.79) P<0.001**	**1.67 (1.42-1.97) P<0.001**
Resuscitation requiring drugs &/or intubation†‡¥	78/28,399 (0.27)	266/17,069 (1.56)	**4.98 (3.85-6.45) P<0.001**	**4.99 (3.85-6.47) P<0.001**	**5.44 (4.16-7.13) P<0.001**	**5.47 (4.15-7.20) P<0.001**	79/4,011 (1.97)	**6.36 (4.62-8.75) P<0.001**	**6.35 (4.60-8.75) P<0.001**	**6.80 (4.86-9.50) P<0.001**	**6.89 (4.81-9.87) P<0.001**
Apgar score <7 at 5 minutes†‡¥	110/31,630 (0.35)	232/18,108 (1.28)	**3.68 (2.93-4.63) P<0.001**	**3.69 (2.93-4.65) P<0.001**	**3.57 (2.77-5.61) P<0.001**	**3.45 (2.65-4.48) P<0.001**	74/4,298 (1.72)	**4.97 (3.70-6.69) P<0.001**	**4.88 (3.62-6.58) P<0.001**	**4.56 (3.31-6.28) P<0.001**	**4.32 (3.07-6.09) P<0.001**

[1] Base model adjusted for year of birth.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status/registration type, & socio-economic status).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder where † is shown, diabetes where ‡ is shown & pre-labour rupture of membranes where ¥ is shown).
[4] Model C adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[a] Women who died before discharge or were not discharged within 42 days of birth excluded from analysis of overnight readmission to hospital (n=2).
[b] Intrapartum stillbirths (n=4) & births missing data on feeding at birth & hospital discharge (n=8,118, 14.9%) excluded from analysis of breastfeeding at birth or hospital discharge.
[c] Intrapartum stillbirths (n=4), neonatal deaths (31) & births missing infant feeding data at 6-8 week review (n=7,777, 14.3%) excluded from analysis of breastfeeding outcomes at 6-8 weeks.
[d] All perinatal outcomes exclude deaths due to congenital abnormalities (n=19) & any remaining intrapartum stillbirths (n=4) & births missing the outcome in question (n=814, 1.5% for admission to a neonatal unit; n=5,056, 9.3% for resuscitation; n=499, 0.9% for Apgar score) additionally excluded from analysis of neonatal unit admission, resuscitation & Apgar score.
[e] Includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation or an Apgar score <7 at 5 minutes.
– numbers or numbers & percentages have not been shown to protect against potential disclosure risks
Bold text indicates statistically significant findings at the 5% level.
Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; NC, not calculated because of low number of events; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean

Table D.6. Maternal and perinatal outcomes according to actual mode of birth – planned and actually had a VBAC and planned but had in-labour non-elective repeat caesarean section compared to ERCS at ≥39 weeks' gestation

	ERCS	Planned and actually had VBAC					Planned VBAC but had in-labour non-elective repeat caesarean section				
	n outcome events/total N (%)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Maternal outcomes											
Uterine rupture	16/31,880 (0.05)	8/16,441 (0.05)	0.91 (0.39-2.13) P=0.825	0.92 (0.39-2.17) P=0.854	0.95 (0.39-2.34) P=0.916	-	49/6,317 (0.78)	**14.52 (8.02-26.28) P<0.001**	**14.66 (8.01-26.84) P<0.001**	**15.36 (7.94-29.69) P<0.001**	-
Peripartum hysterectomy	9/31,880 (0.03)	# (0.02)	0.52 (0.14-1.92) P=0.325	NC	NC	-	#	0.44 (0.06-3.44) P=0.433	NC	NC	-
Blood transfusion†	149/31,880 (0.47)	180/16,441 (1.09)	**2.08 (1.66-2.60) P<0.001**	**2.04 (1.63-2.56) P<0.001**	**2.29 (1.77-2.96) P<0.001**	-	88/6,317 (1.39)	**2.63 (2.00-3.45) P<0.001**	**2.56 (1.95-3.36) P<0.001**	**2.58 (1.96-3.41) P<0.001**	-
Puerperal sepsis‡¥	48/31,880 (0.15)	31/16,441 (0.19)	1.47 (0.94-2.31) P=0.094	1.44 (0.92-2.25) P=0.116	1.47 (0.87-2.46) P=0.147	-	26/6,317 (0.41)	**3.23 (1.97-5.28) P<0.001**	**3.16 (1.95-5.13) P<0.001**	**2.81 (1.67-4.71) P<0.001**	-
Other puerperal infection‡¥	660/31,880 (2.07)	258/16,441 (1.57)	**0.72 (0.62-0.83) P<0.001**	**0.71 (0.61-0.82) P<0.001**	0.87 (0.74-1.03) P=0.105	-	282/6,317 (4.46)	**2.1 (1.81-2.43) P<0.001**	**2.1 (1.81-2.44) P<0.001**	**2.19 (1.88-2.56) P<0.001**	-
Surgical injury	24/31,880 (0.08)	# (0.01)	**0.17 (0.04-0.71) P=0.015**	**0.17 (0.04-0.72) P=0.016**	NC	-	37/6,317 (0.59)	**8.31 (4.97-13.91) P<0.001**	**8.56 (5.18-14.15) P<0.001**	NC	-
Postnatal hospital stay >5 days†‡¥	729/31,880 (2.29)	294/16,441 (1.79)	**0.66 (0.57-0.77) P<0.001**	**0.67 (0.58-0.77) P<0.001**	**0.69 (0.59-0.81) P<0.001**	-	326/6,317 (5.16)	**1.97 (1.71-2.26) P<0.001**	**2.04 (1.77-2.34) P<0.001**	**2.06 (1.78-2.38) P<0.001**	-
Readmission to hospital within 42 days of birth[a]†‡¥	822/31,879 (2.58)	380/16,440 (2.31)	0.92 (0.81-1.04) P=0.173	0.91 (0.80-1.04) P=0.157	1.00 (0.87-1.16) P=0.973	-	174/6,317 (2.75)	1.10 (0.93-1.30) P=0.270	1.1 (0.93-1.30) P=0.258	1.13 (0.95-1.35) P=0.179	-
Any breastfeeding at birth or hospital discharge[b]	15,556/27,804 (55.95)	8,619/13,374 (64.45)	**1.17 (1.15-1.19) P<0.001**	**1.19 (1.17-1.21) P<0.001**	**1.20 (1.18-1.22) P<0.001**	**1.16 (1.14-1.18) P<0.001**	3,624/5,322 (68.09)	**1.24 (1.21-1.27) P<0.001**	**1.22 (1.19-1.24) P<0.001**	**1.17 (1.14-1.20) P<0.001**	**1.12 (1.09-1.15) P<0.001**
Exclusive breastfeeding at 6-8 week review[c]	7,185/27,573 (26.06)	4,827/13,752 (35.10)	**1.35 (1.30-1.39) P<0.001**	**1.4 (1.35-1.44) P<0.001**	**1.39 (1.34-1.44) P<0.001**	**1.32 (1.27-1.36) P<0.001**	1,966/5,495 (35.78)	**1.37 (1.32-1.43) P<0.001**	**1.34 (1.29-1.39) P<0.001**	**1.36 (1.30-1.43) P<0.001**	**1.27 (1.21-1.34) P<0.001**
Any breastfeeding at 6-8 week review[c]	9,883/27,573 (35.84)	6,153/13,752 (44.74)	**1.26 (1.23-1.29) P<0.001**	**1.29 (1.26-1.32) P<0.001**	**1.30 (1.27-1.34) P<0.001**	**1.25 (1.21-1.28) P<0.001**	2,599/5,495 (47.30)	**1.33 (1.29-1.38) P<0.001**	**1.29 (1.25-1.33) P<0.001**	**1.28 (1.23-1.33) P<0.001**	**1.21 (1.16-1.26) P<0.001**

Table continued overleaf

Table D.6 (continued). Maternal and perinatal outcomes according to actual mode of birth – planned and actually had a VBAC and planned but had in-labour non-elective repeat caesarean section compared to ERCS at ≥39 weeks' gestation

	ERCS	Planned and actually had VBAC					Planned VBAC but had in-labour non-elective repeat caesarean section				
	n outcome events/total N (%)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	n outcome events/total N (%)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)
Perinatal outcomes[d]											
Adverse perinatal outcome[e]†‡¥	1,282/28,065 (4.57)	957/14,898 (6.42)	**1.36 (1.24-1.48) P<0.001**	**1.35 (1.23-1.47) P<0.001**	**1.40 (1.27-1.54) P<0.001**	**1.48 (1.33-1.64) P<0.001**	518/5,690 (9.10)	**1.97 (1.77-2.19) P<0.001**	**2.02 (1.81-2.25) P<0.001**	**1.98 (1.76-2.21) P<0.001**	**2.06 (1.83-2.32) P<0.001**
Intrapartum stillbirth or neonatal death	# (0.01)	8/16,434 (0.05)	**8.12 (1.74-37.93) P=0.008**	NC	NC	NC	6/6,314 (0.10)	**15.9 (3.23-78.25) P<0.001**	NC	NC	NC
Admitted to a neonatal unit†‡¥	1,155/31,530 (3.66)	659/16,145 (4.08)	1.08 (0.98-1.20) P=0.110	1.08 (0.98-1.20) P=0.128	**1.13 (1.01-1.26) P=0.032**	**1.20 (1.07-1.35) P=0.003**	384/6,098 (6.30)	**1.71 (1.52-1.93) P<0.001**	**1.76 (1.56-1.98) P<0.001**	**1.72 (1.52-1.95) P<0.001**	**1.80 (1.58-2.06) P<0.001**
Resuscitation requiring drugs &/or intubation†‡¥	78/28,399 (0.27)	239/15,237 (1.57)	**5.06 (3.90-6.58) P<0.001**	**5.04 (3.87-6.56) P<0.001**	**5.55 (4.20-7.33) P<0.001**	**5.50 (4.15-7.30) P<0.001**	109/5,900 (1.85)	**5.9 (4.39-7.93) P<0.001**	**6.05 (4.48-8.15) P<0.001**	**6.07 (4.49-8.21) P<0.001**	**5.98 (4.35-8.23) P<0.001**
Apgar score <7 at 5 minutes†‡¥	110/31,630 (0.35)	181/16,228 (1.12)	**3.21 (2.53-4.07) P<0.001**	**3.17 (2.50-4.03) P<0.001**	**2.90 (2.22-3.78) P<0.001**	**2.81 (2.14-3.70) P<0.001**	126/6,254 (2.01)	**5.84 (4.51-7.57) P<0.001**	**6.00 (4.61-7.80) P<0.001**	**5.61 (4.26-7.38) P<0.001**	**5.38 (4.02-7.21) P<0.001**

[1] Base model adjusted for year of birth.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status/registration type, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder where † is shown, diabetes where ‡ is shown & pre-labour rupture of membranes where ¥ is shown).

[4] Model C adjusted for variables in Model b & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).

[a] Women who died before discharge or were not discharged within 42 days of birth excluded from analysis of overnight readmission to hospital (n=2).

[b] Intrapartum stillbirths (n=4) & births missing data on feeding at birth & hospital discharge (n=8,134, 14.9%) excluded from analysis of breastfeeding at birth or hospital discharge.

[c] Intrapartum stillbirths (n=4), neonatal deaths (31) & births missing infant feeding data at 6-8 week review (n=7,783, 14.3%) excluded from analysis of breastfeeding outcomes at 6-8 weeks.

[d] All perinatal outcomes exclude deaths due to congenital abnormalities (n=19) & any remaining intrapartum stillbirths (n=4) & births missing the outcome in question (n=842, 1.5% for admission to a neonatal unit; n=5,079, 9.3% for resuscitation; n=503, 0.9% for Apgar score) additionally excluded from analysis of neonatal unit admission, resuscitation & Apgar score.

[e] Includes intrapartum stillbirth or neonatal death, admission to a neonatal unit, resuscitation requiring drugs &/or intubation or an Apgar score <7 at 5 minutes.

– numbers or numbers & percentages have not been shown to protect against potential disclosure risks

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; NC, not calculated because of low number of events; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean

Table D.7. E-values for the observed assocations between planned mode of birth after previous caesarean section (planned VBAC vs. ERCS) and short-term maternal and perinatal outcomes*

	E-value for OR or RR point estimate[a]	E-value for CI limit of OR or RR[b]
Maternal outcomes		
Uterine rupture	14.14	7.22
Blood transfusion	4.01	3.17
Puerperal sepsis	3.04	1.81
Other puerperal infection	1.74	1.40
Surgical injury	5.37	3.06
Any breastfeeding at birth or hospital discharge	1.57	1.51
Exclusive breastfeeding at 6-8 week review	1.95	1.86
Any breastfeeding at 6-8 week review	1.79	1.71
Perinatal outcomes		
Adverse perinatal outcome	2.52	2.28
Intrapartum stillbirth or neonatal death	12.66	4.29
Admitted to a neonatal unit	1.95	1.74
Resuscitation requiring drugs &/or intubation	9.91	7.85
Apgar score <7 at 5 minutes	7.14	5.75

*The observed associations are the fully adjusted OR or RRs shown in Table 4.4. See VanderWeele & Ding[193] for formula used to calculate E-values.

[a] The E-values for the point estimates are the minimum strength of association on the OR or RR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to fully explain the observed associations between planned mode of birth after previous caesarean section (planned VBAC vs. ERCS) & the various short-term maternal & perinatal outcomes.

[b] The E-values for the limit of the 95% CI closest to the null covey the minimum strength of association on the OR or RR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to move the CI to include the null value.

Abbreviations: CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean.

Table D.8. E-values for the observed assocations between planned mode of birth after previous caesarean section (planned VBAC with and without labour induction vs. ERCS) and short-term maternal and perinatal outcomes*

	E-value for OR or RR point estimate[a]	E-value for CI limit of OR or RR[b]
Planned VBAC with labour induction		
Maternal outcomes		
Uterine rupture	19.61	8.77
Blood transfusion	4.78	3.39
Puerperal sepsis	4.62	2.41
Other puerperal infection	2.01	1.46
Readmission to hospital within 42 days of birth	1.69	1.11
Any breastfeeding at birth or hospital discharge	1.51	1.40
Exclusive breastfeeding at 6-8 week review	1.74	1.59
Any breastfeeding at 6-8 week review	1.69	1.54
Perinatal outcomes		
Adverse perinatal outcome	3.41	2.96
Intrapartum stillbirth or neonatal death	10.17	1.90
Admitted to a neonatal unit	2.71	2.28
Resuscitation requiring drugs &/or intubation	12.02	8.79
Apgar score <7 at 5 minutes	9.21	6.84
Planned VBAC without labour induction		
Maternal outcomes		
Uterine rupture	13.18	6.56
Blood transfusion	3.87	3.02
Puerperal sepsis	2.58	1.34
Other puerperal infection	1.67	1.31
Surgical injury	5.65	3.23
Readmission to hospital within 42 days of birth	1.53	1.16
Any breastfeeding at birth or hospital discharge	1.57	1.51
Exclusive breastfeeding at 6-8 week review	1.97	1.88
Any breastfeeding at 6-8 week review	1.81	1.74
Perinatal outcomes		
Adverse perinatal outcome	2.34	2.10
Intrapartum stillbirth or neonatal death	13.28	4.40
Admitted to a neonatal unit	1.79	1.57
Resuscitation requiring drugs &/or intubation	10.15	8.01
Apgar score <7 at 5 minutes	6.78	5.43

*The observed associations are the fully adjusted OR or RRs shown in Table 4.5. See VanderWeele & Ding[193] for formula used to calculate E-values.

[a] The E-values for the point estimates are the minimum strength of association on the OR or RR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to fully explain the observed associations between planned mode of birth after previous caesarean section (planned VBAC with & without labour induction vs. ERCS) & the various short-term maternal & perinatal outcomes.

[b] The E-values for the limit of the 95% CI closest to the null covey the minimum strength of association on the OR or RR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to move the CI to include the null value.

Abbreviations: CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean.

Table D.9. E-values for the observed assocations between actual mode of birth after previous caesarean section (planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared vs. ERCS) and short-term maternal and perinatal outcomes*

	E-value for OR or RR point estimate[a]	E-value for CI limit of OR or RR[b]
Planned and actually had VBAC		
Maternal outcomes		
Blood transfusion	3.72	2.83
Other puerperal infection	1.77	1.36
Surgical injury	12.81	2.78
Length of postnatal hospital stay >5 days	2.61	2.17
Any breastfeeding at birth or hospital discharge	1.59	1.54
Exclusive breastfeeding at 6-8 week review	1.99	1.90
Any breastfeeding at 6-8 week review	1.81	1.74
Perinatal outcomes		
Adverse perinatal outcome	2.08	1.83
Intrapartum stillbirth or neonatal death	8.67	2.47
Admitted to a neonatal unit	1.46	1.11
Resuscitation requiring drugs &/or intubation	10.03	7.83
Apgar score <7 at 5 minutes	5.29	4.13
Planned VBAC but had in-labour non-elective repeat caesarean section		
Maternal outcomes		
Uterine rupture	36.65	20.09
Blood transfusion	4.54	3.41
Puerperal sepsis	5.29	3.23
Other puerperal infection	3.54	3.00
Surgical injury	15.72	9.99
Length of postnatal hospital stay >5 days	2.87	2.47
Any breastfeeding at birth or hospital discharge	1.46	1.37
Exclusive breastfeeding at 6-8 week review	1.83	1.71
Any breastfeeding at 6-8 week review	1.69	1.59
Perinatal outcomes		
Adverse perinatal outcome	3.39	3.04
Intrapartum stillbirth or neonatal death	22.75	7.24
Admitted to a neonatal unit	2.90	2.54
Resuscitation requiring drugs &/or intubation	11.14	8.49
Apgar score <7 at 5 minutes	10.76	8.51

* The observed associations are the fully adjusted OR or RRs shown in Table 4.6. See VanderWeele & Ding[193] for formula used to calculate E-values.

[a] The E-values for the point estimates are the minimum strength of association on the OR or RR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to fully explain the observed associations between actual mode of birth after previous caesarean section (planned & actually had a VBAC & planned VBAC but had in-labour non-elective repeat caesarean section vs. ERCS) & the various short-term maternal & perinatal outcomes.

[b] The E-values for the limit of the 95% CI closest to the null covey the minimum strength of association on the OR or RR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to move the CI to include the null value.

Abbreviations: CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; VBAC, vaginal birth after previous caesarean.

Table D.10. SSBID identified intrapartum stillbirth or neonatal death excluding deaths from congenital abnormalities by planned and actual mode of birth after previous cesarean section

Exposure	n outcome events/total n (%)	Base model[1] OR or RR (95% CI)
ERCS	# (0.01)	1
Planned VBAC	12/18,958 (0.06)	**8.16 (1.82-36.60) P=0.006**
ERCS	# (0.01)	1
Planned VBAC without labour induction	# (0.06)	**7.45 (1.60-34.58) P=0.010**
Planned VBAC with labour induction	# (0.09)	**11.75 (1.95-70.92) P=0.007**
ERCS	# (0.01)	1
Planned & actually had VBAC	7/13,593 (0.05)	**6.63 (1.37-32.02) P=0.018**
Planned VBAC but had in-labour non-elective repeat caesarean section	5/5,365 (0.09)	**12.13 (2.34-62.92) P=0.003**

[1] Base model adjusted for year of birth.

numbers have not been shown to protect against potential disclosure risks.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SSBID, Scottish Stillbirth & Infant Death Survey; VBAC, vaginal birth after previous caesarean

Appendix E: Supporting information for women's use of psychotropic medication study (Chapter 5)

Table E.1. Complete case analysis of outcomes following planned VBAC compared to ERCS

Outcomes	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	**0.80 (0.75-0.87) P<0.001**	**0.80 (0.75-0.86) P<0.001**	**0.85 (0.78-0.93) P<0.001**	**0.88 (0.80-0.97) P=0.008**
Dispensed an antidepressant	**0.78 (0.72-0.85) P<0.001**	**0.78 (0.72-0.84) P<0.001**	**0.82 (0.74-0.90) P<0.001**	**0.86 (0.78-0.95) P=0.003**
Dispensed at least two consecutive prescriptions for an antidepressant	**0.76 (0.69-0.83) P<0.001**	**0.76 (0.69-0.83) P<0.001**	**0.82 (0.74-0.92) P<0.001**	**0.88 (0.79-0.99) P=0.034**
Dispensed a hypnotic &/or anxiolytic	**0.85 (0.74-0.99) P=0.032**	0.87 (0.75-1.00) P=0.054	0.95 (0.80-1.12) P=0.517	0.96 (0.80-1.15) P=0.688
Dispensed an antipsychotic &/or related drug	1.54 (0.94-2.52) P=0.088	1.50 (0.90-2.49) P=0.116	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

Table E.2. Complete case analysis of outcomes following planned VBAC with and without labour induction compared to ERCS

Outcomes	Planned VBAC without labour induction vs. ERCS				Planned VBAC with labour induction vs. ERCS			
	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	**0.79 (0.73-0.85) P<0.001**	**0.80 (0.73-0.86) P<0.001**	**0.84 (0.77-0.93) P<0.001**	**0.88 (0.80-0.97) P=0.010**	0.87 (0.76-1.01) P=0.060	**0.83 (0.72-0.96) P=0.012**	0.88 (0.75-1.04) P=0.139	0.90 (0.76-1.08) P=0.261
Dispensed an antidepressant	**0.76 (0.70-0.83) P<0.001**	**0.76 (0.70-0.83) P<0.001**	**0.81 (0.73-0.90) P<0.001**	**0.85 (0.77-0.95) P=0.003**	0.87 (0.74-1.01) P=0.065	**0.82 (0.71-0.96) P=0.011**	0.86 (0.71-1.03) P=0.094	0.88 (0.72-1.07) P=0.188
Dispensed at least two consecutive prescriptions for an antidepressant	**0.74 (0.67-0.82) P<0.001**	**0.75 (0.68-0.83) P<0.001**	**0.82 (0.73-0.93) P=0.001**	0.89 (0.79-1.01) P=0.065	**0.82 (0.68-0.98) P=0.026**	**0.78 (0.66-0.94) P=0.008**	0.82 (0.66-1.01) P=0.066	0.85 (0.67-1.07) P=0.157
Dispensed a hypnotic &/or anxiolytic	**0.85 (0.73-0.99) P=0.042**	0.87 (0.75-1.02) P=0.088	0.94 (0.78-1.13) P=0.517	0.95 (0.78-1.15) P=0.606	0.89 (0.67-1.17) P=0.405	0.87 (0.66-1.15) P=0.332	0.98 (0.71-1.35) P=0.912	1.04 (0.74-1.46) P=0.816
Dispensed an antipsychotic &/or related drug	1.56 (0.92-2.64) P=0.098	1.54 (0.90-2.63) P=0.117	NC	NC	1.48 (0.58-3.78) P=0.412	1.39 (0.54-3.58) P=0.493	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

Table E.3. Complete case analysis of outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS

Outcomes	Planned and actually had VBAC vs. ERCS				Planned VBAC but had in-labour non-elective repeat caesarean section vs. ERCS			
	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	**0.80 (0.73-0.87) P<0.001**	**0.79 (0.72-0.85) P<0.001**	**0.80 (0.73-0.88) P<0.001**	**0.83 (0.75-0.92) P=0.001**	**0.82 (0.73-0.92) P=0.001**	**0.85 (0.75-0.96) P=0.007**	1.00 (0.87-1.15) P=0.992	1.03 (0.89-1.20) P=0.666
Dispensed an antidepressant	**0.76 (0.70-0.84) P<0.001**	**0.75 (0.68-0.82) P<0.001**	**0.76 (0.68-0.84) P<0.001**	**0.79 (0.71-0.89) P<0.001**	**0.83 (0.73-0.94) P=0.004**	**0.85 (0.75-0.97) P=0.017**	1.00 (0.86-1.17) P=0.951	1.06 (0.90-1.24) P=0.503
Dispensed at least two consecutive prescriptions for an antidepressant	**0.73 (0.66-0.81) P<0.001**	**0.72 (0.65-0.80) P<0.001**	**0.76 (0.67-0.86) P<0.001**	**0.81 (0.71-0.92) P=0.002**	**0.83 (0.71-0.96) P=0.013**	0.86 (0.74-1.00) P=0.052	1.02 (0.86-1.22) P=0.791	1.10 (0.92-1.32) P=0.297
Dispensed a hypnotic &/or anxiolytic	0.89 (0.75-1.04) P=0.137	0.88 (0.75-1.04) P=0.135	0.93 (0.77-1.12) P=0.431	0.94 (0.77-1.15) P=0.558	**0.78 (0.61-1.00) P=0.046**	0.83 (0.64-1.06) P=0.130	1.00 (0.75-1.34) P=0.983	1.03 (0.76-1.40) P=0.841
Dispensed an antipsychotic &/or related drug	1.27 (0.71-2.28) P=0.417	1.22 (0.67-2.20) P=0.512	NC	NC	**2.20 (1.12-4.32) P=0.022**	**2.27 (1.14-4.52) P=0.020**	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

Table E.4. Outcomes following planned VBAC compared to ERCS at ≥39 weeks' gestation

Outcomes	ERCS Number of events/person-years (Rate per 100 person-years)	Planned VBAC Number of events/person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	1,871/15,052 (12.43)	802/7,762 (10.33)	**0.83 (0.77-0.91) P<0.001**	**0.83 (0.77-0.90) P<0.001**	**0.82 (0.74-0.89) P<0.001**	**0.87 (0.79-0.95) P=0.002**
Dispensed an antidepressant	1,629/15,167 (10.74)	678/7,827 (8.66)	**0.81 (0.74-0.89) P<0.001**	**0.81 (0.74-0.88) P<0.001**	**0.79 (0.72-0.87) P<0.001**	**0.84 (0.76-0.93) P=0.001**
Dispensed at least two consecutive prescriptions for an antidepressant	1,250/15,379 (8.13)	491/7,925 (6.20)	**0.77 (0.69-0.85) P<0.001**	**0.77 (0.69-0.86) P<0.001**	**0.76 (0.68-0.86) P<0.001**	**0.82 (0.73-0.92) P=0.001**
Dispensed a hypnotic &/or anxiolytic	437/15,848 (2.76)	208/8,075 (2.58)	0.93 (0.79-1.10) P=0.385	0.95 (0.80-1.12) P=0.506	0.93 (0.78-1.11) P=0.419	0.99 (0.83-1.19) P=0.940
Dispensed an antipsychotic &/or related drug	20/16,032 (0.12)	20/8,163 (0.25)	**1.97 (1.07-3.63) P=0.030**	**1.94 (1.04-3.64) P=0.038**	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

Table E.5. Outcomes following planned VBAC with and without labour induction compared to ERCS at ≥39 weeks' gestation

Outcomes	ERCS	Planned VBAC without labour induction					Planned VBAC with labour induction				
	Number of events/ person-years (Rate per 100 person-years)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	1,871/15,052 (12.43)	630/6,221 (10.13)	**0.82 (0.75-0.89) P<0.001**	**0.82 (0.75-0.90) P<0.001**	**0.81 (0.74-0.90) P<0.001**	**0.87 (0.78-0.96) P=0.004**	169/1,509 (11.20)	0.90 (0.77-1.06) P=0.199	0.86 (0.74-1.01) P=0.069	**0.82 (0.70-0.97) P=0.021**	0.88 (0.75-1.04) P=0.126
Dispensed an antidepressant	1629/15,167 (10.74)	529/6,272 (8.43)	**0.79 (0.72-0.87) P<0.001**	**0.79 (0.72-0.88) P<0.001**	**0.78 (0.70-0.87) P<0.001**	**0.83 (0.75-0.93) P=0.001**	146/1,522 (9.59)	0.89 (0.75-1.06) P=0.195	0.85 (0.72-1.01) P=0.061	**0.82 (0.69-0.98) P=0.026**	0.87 (0.73-1.04) P=0.133
Dispensed at least two consecutive prescriptions for an antidepressant	1,250/15,379 (8.13)	388/6,342 (6.12)	**0.76 (0.68-0.85) P<0.001**	**0.77 (0.69-0.86) P<0.001**	**0.77 (0.68-0.87) P<0.001**	**0.83 (0.73-0.94) P=0.003**	101/1,551 (6.51)	**0.80 (0.65-0.98) P=0.034**	**0.77 (0.63-0.95) P=0.013**	**0.75 (0.61-0.92) P=0.007**	**0.80 (0.65-0.99) P=0.043**
Dispensed a hypnotic &/or anxiolytic	437/15,848 (2.76)	165/6,464 (2.55)	0.92 (0.77-1.10) P=0.352	0.94 (0.79-1.13) P=0.527	0.94 (0.77-1.14) P=0.516	1.00 (0.83-1.22) P=0.978	43/1,577 (2.73)	0.99 (0.72-1.35) P=0.938	0.97 (0.71-1.33) P=0.867	0.91 (0.66-1.27) P=0.592	0.98 (0.71-1.36) P=0.910
Dispensed an antipsychotic &/or related drug	20/16,032 (0.12)	16/6,531 (0.24)	**1.97 (1.03-3.77) P=0.040**	**1.95 (1.00-3.80) P=0.049**	NC	NC	4/1,598 (0.25)	2.01 (0.69-5.87) P=0.203	1.94 (0.66-5.74) P=0.229	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

Table E.6. Outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS at ≥39 weeks' gestation

Outcomes	ERCS	Planned and actually had VBAC					Planned VBAC but had in-labour non-elective repeat caesarean section				
	Number of events/ person-years (Rate per 100 person-years)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	1,871/15,052 (12.43)	585/5,560 (10.52)	**0.85 (0.77-0.93) P<0.001**	**0.84 (0.76-0.92) P<0.001**	**0.81 (0.73-0.90) P<0.001**	**0.86 (0.78-0.96) P=0.005**	217/2,202 (9.86)	**0.79 (0.69-0.91) P=0.001**	**0.82 (0.71-0.95) P=0.007**	**0.82 (0.71-0.94) P=0.006**	0.88 (0.76-1.02) P=0.079
Dispensed an antidepressant	1,629/15,167 (10.74)	487/5,609 (8.68)	**0.81 (0.73-0.90) P=0.001**	**0.80 (0.72-0.88) P<0.001**	**0.78 (0.69-0.87) P<0.001**	**0.82 (0.74-0.92) P=0.001**	191/2,218 (8.61)	**0.80 (0.69-0.94) P=0.005**	**0.83 (0.71-0.96) P=0.015**	**0.82 (0.71-0.96) P=0.013**	0.89 (0.76-1.03) P=0.126
Dispensed at least two consecutive prescriptions for an antidepressant	1,250/15,379 (8.13)	349/5,685 (6.14)	**0.76 (0.68-0.86) P<0.001**	**0.75 (0.67-0.85) P<0.001**	**0.75 (0.65-0.85) P<0.001**	**0.80 (0.70-0.91) P=0.001**	142/2,240 (6.34)	**0.78 (0.66-0.93) P=0.006**	**0.82 (0.69-0.97) P=0.025**	**0.81 (0.68-0.97) P=0.021**	0.88 (0.74-1.05) P=0.166
Dispensed a hypnotic &/or anxiolytic	437/15,848 (2.76)	157/5,787 (2.71)	0.98 (0.81-1.17) P=0.797	0.97 (0.81-1.17) P=0.783	0.96 (0.78-1.17) P=0.672	1.02 (0.83-1.25) P=0.850	51/2,288 (2.23)	0.80 (0.60-1.08) P=0.142	0.86 (0.65-1.16) P=0.328	0.86 (0.64-1.15) P=0.315	0.93 (0.69-1.25) P=0.621
Dispensed an antipsychotic &/or related drug	20/16,032 (0.12)	12/5,853 (0.21)	1.65 (0.82-3.32) P=0.163	1.60 (0.78-3.27) P=0.199	NC	NC	8/2,310 (0.35)	**2.78 (1.22-6.32) P=0.015**	**2.87 (1.24-6.66) P=0.014**	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

Table E.7. E-values for the observed associations between planned mode of birth after previous caesarean section (planned VBAC vs. ERCS) and psychotropic medication outcomes*

Outcome	E-value for HR point estimate[a]	E-value for CI limit of HR[b]
Dispensed any psychotropic medication	1.63	1.39
Dispensed an antidepressant	1.70	1.46
Dispensed at least two consecutive prescriptions for an antidepressant	1.70	1.43

* The observed associations are the fully adjusted HRs shown in Table 5.4. See VanderWeele & Ding[193] for formula used to calculate E-values.

[a] The E-values for the point estimates are the minimum strength of association on the HR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to fully explain the observed associations between planned mode of birth after previous caesarean section (planned VBAC vs. ERCS) & the psychotropic medication outcomes.

[b] The E-values for the limit of the 95% CI closest to the null covey the minimum strength of association on the HR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to move the CI to include the null value.

Abbreviations: CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; VBAC, vaginal birth after previous caesarean

Table E.8. E-values for the observed associations between planned mode of birth after previous caesarean section (planned VBAC with and without labour induction vs. ERCS) and psychotropic medication outcomes*

	E-value for HR point estimate[a]	E-value for CI limit of HR[b]
Planned VBAC with labour induction		
Dispensed any psychotropic medication	1.60	1.00
Planned VBAC without labour induction		
Dispensed any psychotropic medication	1.63	1.39
Dispensed an antidepressant	1.74	1.46
Dispensed at least two consecutive prescriptions for an antidepressant	1.74	1.39

* The observed associations are the fully adjusted HRs shown in Table 5.5. See VanderWeele & Ding[193] for formula used to calculate E-values.

[a] The E-values for the point estimates are the minimum strength of association on the HR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to fully explain the observed associations between planned mode of birth after previous caesarean section (planned VBAC with & without labour induction vs. ERCS) & the psychotropic medication outcomes.

[b] The E-values for the limit of the 95% CI closest to the null covey the minimum strength of association on the HR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to move the CI to include the null value.

Abbreviations: CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; VBAC, vaginal birth after previous caesarean

Table E.9. E-values for the observed associations between actual mode of birth after previous caesarean section (planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared vs. ERCS) and psychotropic medication outcomes*

	E-value for HR point estimate[a]	E-value for CI limit of HR[b]
Planned and actually had VBAC		
Dispensed any psychotropic medication	1.74	1.46
Dispensed an antidepressant	1.85	1.56
Dispensed at least two consecutive prescriptions for an antidepressant	1.88	1.56

* The observed associations are the fully adjusted HRs shown in Table 5.6. See VanderWeele & Ding[193] for formula used to calculate E-values.

[a] The E-values for the point estimates are the minimum strength of association on the HR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to fully explain the observed associations between actual mode of birth after previous caesarean section (planned & actually had a VBAC & planned VBAC but had in-labour non-elective repeat caesarean section vs. ERCS & the psychotropic medication outcomes.

[b] The E-values for the limit of the 95% CI closest to the null covey the minimum strength of association on the HR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to move the CI to include the null value.

Abbreviations: CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; VBAC, vaginal birth after previous caesarean

Table E.10. Outcomes following planned VBAC compared to ERCS in women without a history of being dispensed psychotropic medication in the two years before they gave birth

Outcomes	ERCS Number of events/person-years (Rate per 100 person-years)	Planned VBAC Number of events/person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	1,600/15,096 (10.60)	645/7,394 (8.72)	**0.83 (0.75-0.91) P<0.001**	**0.82 (0.75-0.90) P<0.001**	**0.82 (0.74-0.91) P=0.001**	**0.87 (0.79-0.96) P=0.007**
Dispensed an antidepressant	1,381/15,196 (9.09)	546/7,442 (7.34)	**0.81 (0.74-0.90) P<0.001**	**0.81 (0.73-0.89) P<0.001**	**0.80 (0.72-0.89) P<0.001**	**0.85 (0.76-0.95) P=0.004**
Dispensed at least two consecutive prescriptions for an antidepressant	1,060/15,370 (6.90)	410/7,517 (5.45)	**0.80 (0.71-0.89) P<0.001**	**0.80 (0.71-0.89) P<0.001**	**0.81 (0.72-0.91) P=0.001**	**0.86 (0.76-0.98) P=0.019**
Dispensed a hypnotic &/or anxiolytic	381/15,751 (2.42)	160/7,651 (2.09)	0.87 (0.72-1.04) P=0.125	0.88 (0.73-1.06) P=0.173	0.86 (0.71-1.05) P=0.131	0.91 (0.75-1.11) P=0.354
Dispensed an antipsychotic &/or related drug	14/15,910 (0.09)	15/7,714 (0.19)	**2.20 (1.07-4.53) P=0.032**	**2.11 (1.01-4.42) P=0.047**	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

Table E.11. Outcomes following planned VBAC with and without labour induction compared to ERCS in women without a history of being dispensed psychotropic medication in the two years before they gave birth

Outcomes	ERCS	Planned VBAC without labour induction					Planned VBAC with labour induction				
	Number of events/ person-years (Rate per 100 person-years)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	1,600/15,096 (10.60)	499/5,909 (8.45)	**0.80 (0.72-0.89) P<0.001**	**0.80 (0.73-0.89) P<0.001**	**0.81 (0.73-0.90) P=0.001**	**0.86 (0.77-0.96) P=0.006**	143/1,450 (9.86)	0.93 (0.78-1.11) P=0.409	0.90 (0.75-1.07) P=0.213	0.87 (0.72-1.03) P=0.112	0.92 (0.77-1.10) P=0.357
Dispensed an antidepressant	1,381/15,196 (9.09)	417/5,948 (7.01)	**0.78 (0.70-0.87) P<0.001**	**0.78 (0.70-0.87) P<0.001**	**0.78 (0.69-0.88) P<0.001**	**0.83 (0.74-0.93) P=0.002**	126/1,459 (8.64)	0.95 (0.79-1.14) P=0.581	0.91 (0.76-1.09) P=0.312	0.88 (0.73-1.07) P=0.201	0.94 (0.78-1.14) P=0.523
Dispensed at least two consecutive prescriptions for an antidepressant	1,060/15,370 (6.90)	311/6,002 (5.18)	**0.76 (0.67-0.86) P<0.001**	**0.77 (0.67-0.87) P<0.001**	**0.78 (0.68-0.90) P<0.001**	**0.83 (0.73-0.96) P=0.009**	97/1,479 (6.56)	0.95 (0.77-1.17) P=0.630	0.92 (0.74-1.13) P=0.432	0.91 (0.73-1.13) P=0.392	0.97 (0.78-1.20) P=0.774
Dispensed a hypnotic &/or anxiolytic	381/15,751 (2.42)	127/6,105 (2.08)	0.86 (0.70-1.05) P=0.145	0.88 (0.72-1.08) P=0.217	0.87 (0.71-1.08) P=0.216	0.93 (0.75-1.15) P=0.483	33/1,510 (2.19)	0.90 (0.63-1.29) P=0.576	0.90 (0.63-1.28) P=0.548	0.83 (0.57-1.19) P=0.302	0.88 (0.61-1.26) P=0.481
Dispensed an antipsychotic &/or related drug	14/15,910 (0.09)	12/6,153 (0.20)	**2.21 (1.03-4.73) P=0.042**	2.14 (0.99-4.64) P=0.053	NC	NC	3/1,524 (0.20)	2.24 (0.64-7.80) P=0.206	2.05 (0.57-7.44) P=0.273	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

Table E.12. Outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS in women without history of being dispensed psychotropic medication in the two years before they gave birth

Outcomes	ERCS	Planned and actually had VBAC					Planned VBAC but had in-labour non-elective repeat caesarean section				
	Number of events/ person-years (Rate per 100 person-years)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)	Number of events/ person-years (Rate per 100 person-years)	Base model[1] HR (95% CI)	Model A[2] HR (95% CI)	Model B[3] HR (95% CI)	Model C[4] HR (95% CI)
Dispensed any psychotropic medication	1,600/15,096 (10.60)	454/5,256 (8.64)	**0.82 (0.74-0.91) P<0.001**	**0.81 (0.73-0.89) P<0.001**	**0.80 (0.71-0.89) P=0.001**	**0.84 (0.75-0.94) P=0.003**	191/2,138 (8.93)	**0.84 (0.73-0.98) P=0.028**	0.87 (0.75-1.01) P=0.068	0.87 (0.75-1.02) P=0.083	0.94 (0.80-1.09) P=0.405
Dispensed an antidepressant	1,381/15,196 (9.09)	377/5,291 (7.12)	**0.79 (0.70-0.88) P<0.001**	**0.77 (0.69-0.87) P<0.001**	**0.76 (0.67-0.86) P<0.001**	**0.81 (0.71-0.91) P<0.001**	169/2,150 (7.86)	0.87 (0.74-1.02) P=0.083	0.89 (0.76-1.05) P=0.156	0.89 (0.76-1.05) P=0.179	0.96 (0.82-1.13) P=0.648
Dispensed at least two consecutive prescriptions for an antidepressant	1,060/1,537 (6.90)	277/5,349 (5.18)	**0.76 (0.66-0.86) P<0.001**	**0.75 (0.65-0.85) P<0.001**	**0.75 (0.65-0.87) P<0.001**	**0.80 (0.69-0.92) P=0.002**	133/2,168 (6.13)	0.89 (0.75-1.07) P=0.220	0.93 (0.77-1.11) P=0.417	0.93 (0.78-1.12) P=0.470	1.01 (0.84-1.21) P=0.943
Dispensed a hypnotic &/or anxiolytic	381/15,751 (2.42)	121/5,433 (2.23)	0.92 (0.75-1.13) P=0.436	0.92 (0.75-1.13) P=0.446	0.90 (0.72-1.13) P=0.368	0.95 (0.76-1.19) P=0.679	39/2,219 (1.76)	0.73 (0.52-1.01) P=0.058	0.77 (0.55-1.07) P=0.115	0.76 (0.54-1.06) P=0.103	0.81 (0.58-1.13) P=0.215
Dispensed an antipsychotic &/or related drug	14/15,910 (0.09)	9/5,479 (0.16)	1.86 (0.81-4.25) P=0.142	1.75 (0.75-4.07) P=0.192	NC	NC	6/2,235 (0.27)	**3.04 (1.17-7.91) P=0.022**	**3.06 (1.16-8.08) P=0.024**	NC	NC

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, & socio-economic status).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, any prior stillbirth or neonatal death, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, & diabetes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; HR, Hazard ratio; NC, not calculated because of low number of events; VBAC, vaginal birth after previous caesarean

Appendix F. Supporting information for special educational needs study (Chapter 6)

Table F.1. Characteristics of children included in the study compared to those not included because they did not link to any pupil census records between 2007-2016 when child was aged 4-11 years and attending a primary or special school

	Not included in study as no pupil census records n (%)[a] unless otherwise stated (n=5,133)	Included in study n (%)[a] unless otherwise stated (n=44,892)
Socio-demographic characteristics		
Maternal age (years)		
Less than 25	411 (8.0)	5,207 (11.6)
25-29	1,078 (21.0)	10,009 (22.3)
30-34	1,881 (36.6)	15,535 (34.6)
35-39	1,407 (27.4)	11,628 (25.9)
40 or more	356 (6.9)	2,513 (5.6)
Median (IQR) maternal age (years)	33 (29-36)	32 (28-35)
Mother's country of birth		
UK	3,719 (72.5)	41,194 (91.8)
Non-UK	1,414 (27.5)	3,698 (8.2)
Marital status/registration type		
Married or joint registration same address	4,757 (92.7)	40,174 (89.5)
Joint registration different address	221 (4.3)	3,103 (6.9)
Sole registration	155 (3.0)	1,615 (3.6)
Socioeconomic status[b]		
Managerial & professional	3,140 (61.2)	20,572 (45.8)
Intermediate	806 (15.7)	10,230 (22.8)
Routine & manual	870 (16.9)	12,268 (27.3)
Other[c]	317 (6.2)	1,822 (4.1)
Maternal medical & pregnancy-related characteristics		
Planned mode of birth		
Planned VBAC	2,130 (41.5)	18,851 (42.0)
ERCS	3,003 (58.5)	26,041 (58.0)
Number of prior caesarean sections		
1	4,258 (83.0)	37,545 (83.6)
2 or more	875 (17.0)	7,347 (16.4)
Median (IQR) number of previous caesarean sections	1 (1-1)	1 (1-1)
Any prior vaginal birth[d]		
No	3,806 (74.7)	33,163 (74.2)
Yes	1,291 (25.3)	11,525 (25.8)
Parity[d]		
1	3,082 (60.6)	27,463 (61.5)
2 or more	2,008 (39.4)	17,164 (38.5)
Median (IQR) parity	1 (1-2)	1 (1-2)
Inter-pregnancy interval (months)[d]		
24 or more	1,880 (49.0)	24,264 (58.9)
12-23	1,262 (32.9)	10,768 (26.1)
Less than 12	693 (18.1)	6,152 (14.9)
Median (IQR) inter-pregnancy interval (months)[d]	23.7 (14.4-39.9)	28.7 (16.5-49.5)
Mother smoked at booking[c]		
No	3,989 (86.1)	32,282 (79.3)
Yes	643 (13.9)	8,427 (20.7)
Maternal BMI at booking (Kg/m2)[d]		
Less than 25	1,254 (44.0)	10,389 (39.3)
25-29.9	868 (30.5)	8,219 (31.1)
30 or more	725 (25.5)	7,808 (29.6)
Median (IQR) BMI at booking (Kg/m2)[d]	25.8 (22.8-30.1)	26.4 (23.3-31.2)
Hypertensive disorder	270 (5.3)	2,819 (6.3)

Table continued overleaf

Table F.1 (continued). Characteristics of children included in the study compared to those not included because they did not link to any pupil census records between 2007-2016 when child was aged 4-11 years and attending a primary or special school

	Not included in study as no pupil census records n (%)[a] unless otherwise stated (n=5,133)	Included in study n (%)[a] unless otherwise stated (n=44,892)
Diabetes	113 (2.2)	1,096 (2.4)
Prelabour rupture of membranes	187 (3.6)	1,751 (3.9)
Infant-related characteristics		
Male infant	2,649 (51.6)	22,889 (51.0)
Gestational age at birth (weeks)		
39-41	3,677 (71.6)	32,289 (71.9)
37-38	1,456 (28.4)	12,603 (28.1)
Median (IQR) gestational age at birth (weeks)	39 (38-40)	39 (38-40)
Birth weight centile[d]		
10-90th	4,105 (80.4)	35,415 (79.3)
Less than 10th	397 (7.8)	3,547 (7.9)
More than 90th	605 (11.8)	5,709 (12.8)
Other characteristics		
Adverse perinatal outcome[d,e]		
No	4,178 (92.6)	36,045 (92.7)
Yes	324 (7.4)	2,854 (7.3)
Maternal intrapartum or postpartum complication[f]		
No	4,899 (95.4)	42,856 (95.5)
Yes	234 (4.6)	2,036 (4.5)
Any breastfeeding at 6-8 week review[d]		
No	1,756 (44.5)	23,787 (64.0)
Yes	2,190 (55.5)	13,381 (36.0)

[a] Percentage of those with complete data.

[b] Socioeconomic status of mother for sole registered birth or highest of mother's or father's socioeconomic status for births registered inside marriage or jointly registered by both parents outside marriage. Socioeconomic status defined by NS-SEC based on occupation & employment status.

[C] Other includes never worked/long-term unemployed, student, not stated, or not classifiable.

[d] Missing data: any prior vaginal birth 240 (0.48%); parity 308 (0.62%); interpregnancy interval 5,006 (10.01%); maternal smoking status 4,684 (9.36%); maternal BMI 20,762 (41.50%); birth weight centile 247 (0.49%); adverse perinatal outcome 6,614 (13.22); any breastfeeding at 6-8 weeks 8,911 (17.81%)

[e] Adverse perinatal outcome includes admission to a neonatal unit, resuscitation with drugs &/or intubation or an Apgar score < 7 at 5 minutes.

[f] Intrapartum or postpartum complication includes uterine rupture, peripartum hysterectomy, blood transfusion, puerperal sepsis, other puerperal infection, surgical injury (damage to bowel, bladder or ureter requiring surgical repair), or third- or fourth-degree perineal tear

Abbreviations: BMI, body mass index; ERCS, elective repeat caesarean section; IQR, interquartile range; NS-SEC, National Statistics Socio-Economic Classification; VBAC, vaginal birth after previous caesarean

Table F.2. Complete case analysis of outcomes following planned VBAC compared to ERCS

Outcomes	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	1.03 (0.99-1.07) P=0.194	1.01 (0.97-1.05) P=0.742	1.05 (0.99-1.13) P=0.108	1.06 (0.99-1.13) P=0.112	1.05 (0.97-1.13) P=0.253
Learning disability	1.02 (0.91-1.14) P=0.754	0.99 (0.89-1.11) P=0.906	1.09 (0.88-1.36) P=0.416	1.14 (0.90-1.42) P=0.273	1.16 (0.90-1.48) P=0.252
Dyslexia	1.02 (0.89-1.17) P=0.765	1.04 (0.91-1.19) P=0.543	0.98 (0.76-1.25) P=0.845	1.01 (0.78-1.30) P=0.959	0.94 (0.70-1.25) P=0.652
Other specific or moderate learning difficulty	1.02 (0.95-1.09) P=0.658	0.99 (0.92-1.07) P=0.855	1.09 (0.97-1.22) P=0.164	1.10 (0.97-1.24) P=0.131	1.11 (0.97-1.28) P=0.129
Sensory impairment	1.05 (0.85-1.30) P=0.633	1.04 (0.84-1.29) P=0.707	0.93 (0.65-1.34) P=0.709	1.03 (0.71-1.51) P=0.865	1.07 (0.72-1.60) P=0.732
Physical or motor impairment	1.03 (0.86-1.24) P=0.731	1.04 (0.86-1.25) P=0.696	1.00 (0.71-1.40) P=0.996	1.15 (0.81-1.62) P=0.435	1.04 (0.71-1.54) P=0.829
Language or speech disorder	1.02 (0.92-1.12) P=0.762	0.99 (0.89-1.10) P=0.850	1.13 (0.97-1.31) P=0.122	1.10 (0.93-1.29) P=0.262	1.11 (0.92-1.32) P=0.271
Autistic spectrum disorder	0.97 (0.84-1.13) P=0.732	0.96 (0.82-1.12) P=0.620	1.01 (0.78-1.31) P=0.945	0.97 (0.74-1.27) P=0.827	0.90 (0.68-1.20) P=0.483
Social, emotional & behavioural difficulty or mental health problem	**1.12 (1.02-1.22) P=0.017**	1.05 (0.95-1.15) P=0.340	1.11 (0.96-1.29) P=0.157	1.10 (0.94-1.29) P=0.218	1.04 (0.87-1.24) P=0.647
Physical health problem	0.98 (0.84-1.15) P=0.822	0.97 (0.83-1.14) P=0.727	1.16 (0.90-1.49) P=0.241	1.14 (0.88-1.48) P=0.315	1.12 (0.83-1.50) P=0.464

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).

[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.3. Complete case analysis of outcomes following planned VBAC with and without labour induction compared to ERCS

Outcomes	Planned VBAC without labour induction vs. ERCS					Planned VBAC with labour induction vs. ERCS				
	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	1.01 (0.96-1.05) P=0.767	0.99 (0.95-1.04) P=0.740	1.04 (0.98-1.12) P=0.205	1.04 (0.97-1.12) P=0.225	1.03 (0.96-1.12) P=0.412	**1.13 (1.05-1.21) P=0.001**	**1.07 (1.00-1.15) P=0.049**	1.12 (1.00-1.27) P=0.056	**1.15 (1.01-1.30) P=0.028**	1.13 (0.99-1.30) P=0.073
Learning disability	1.01 (0.89-1.14) P=0.910	0.99 (0.88-1.11) P=0.841	1.13 (0.90-1.41) P=0.281	1.16 (0.92-1.46) P=0.213	1.18 (0.92-1.52) P=0.203	1.09 (0.89-1.33) P=0.432	1.03 (0.84-1.27) P=0.753	0.91 (0.61-1.37) P=0.665	1.00 (0.66-1.53) P=0.984	1.03 (0.65-1.64) P=0.900
Dyslexia	1.00 (0.86-1.15) P=0.955	1.01 (0.88-1.17) P=0.854	0.99 (0.76-1.29) P=0.952	1.02 (0.78-1.33) P=0.886	0.93 (0.69-1.25) P=0.641	1.11 (0.88-1.40) P=0.361	1.16 (0.92-1.46) P=0.221	0.84 (0.51-1.39) P=0.502	0.88 (0.53-1.47) P=0.630	0.91 (0.52-1.58) P=0.737
Other specific or moderate learning difficulty	1.00 (0.92-1.07) P=0.928	0.98 (0.91-1.06) P=0.652	1.07 (0.94-1.20) P=0.303	1.08 (0.95-1.22) P=0.244	1.09 (0.94-1.26) P=0.238	1.11 (0.98-1.27) P=0.097	1.05 (0.92-1.20) P=0.470	1.22 (0.98-1.52) P=0.069	**1.26 (1.01-1.57) P=0.043**	**1.29 (1.00-1.65) P=0.048**
Sensory impairment	0.97 (0.77-1.22) P=0.794	0.96 (0.76-1.20) P=0.703	0.86 (0.58-1.27) P=0.444	0.95 (0.64-1.41) P=0.791	0.98 (0.64-1.49) P=0.913	1.38 (0.97-1.97) P=0.072	1.38 (0.97-1.96) P=0.075	1.36 (0.75-2.49) P=0.312	1.63 (0.87-3.05) P=0.127	1.74 (0.90-3.37) P=0.098
Physical or motor impairment	1.03 (0.85-1.26) P=0.734	1.04 (0.85-1.27) P=0.708	1.00 (0.71-1.43) P=0.983	1.13 (0.79-1.62) P=0.501	0.99 (0.65-1.49) P=0.958	1.01 (0.71-1.44) P=0.947	1.02 (0.72-1.46) P=0.907	1.00 (0.53-1.88) P=0.996	1.28 (0.67-2.44) P=0.451	1.46 (0.74-2.89) P=0.273
Language or speech disorder	1.01 (0.90-1.12) P=0.895	0.99 (0.89-1.10) P=0.816	1.13 (0.96-1.32) P=0.142	1.09 (0.93-1.29) P=0.287	1.09 (0.90-1.31) P=0.376	1.06 (0.88-1.28) P=0.528	1.01 (0.83-1.22) P=0.917	1.13 (0.85-1.51) P=0.404	1.11 (0.81-1.51) P=0.512	1.22 (0.88-1.71) P=0.237
Autistic spectrum disorder	0.95 (0.81-1.11) P=0.519	0.94 (0.80-1.11) P=0.471	1.05 (0.80-1.36) P=0.736	1.00 (0.76-1.31) P=0.998	0.91 (0.68-1.23) P=0.534	1.09 (0.83-1.45) P=0.522	1.06 (0.80-1.40) P=0.700	0.81 (0.48-1.39) P=0.448	0.79 (0.46-1.37) P=0.405	0.86 (0.49-1.52) P=0.608
Social, emotional & behavioural difficulty or mental health problem	1.09 (0.99-1.20) P=0.078	1.04 (0.94-1.14) P=0.454	1.11 (0.95-1.29) P=0.192	1.09 (0.93-1.28) P=0.283	1.05 (0.87-1.26) P=0.612	**1.26 (1.08-1.48) P=0.004**	1.10 (0.94-1.29) P=0.249	1.17 (0.89-1.54) P=0.259	1.20 (0.90-1.60) P=0.207	1.03 (0.74-1.43) P=0.873
Physical health problem	0.95 (0.80-1.12) P=0.526	0.94 (0.79-1.11) P=0.454	1.10 (0.85-1.44) P=0.460	1.09 (0.83-1.43) P=0.544	1.06 (0.78-1.44) P=0.707	1.16 (0.88-1.53) P=0.290	1.15 (0.87-1.52) P=0.324	1.53 (1.00-2.35) P=0.052	1.55 (0.99-2.42) P=0.056	1.53 (0.93-2.53) P=0.098

[1] Base model adjusted for year of birth only.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level. Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.4. Complete case analysis of outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS

Outcomes	Planned and actually had VBAC vs. ERCS					Planned VBAC but had in-labour non-elective repeat caesarean section vs. ERCS				
	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	**1.05 (1.01-1.10) P=0.026**	1.02 (0.98-1.07) P=0.360	1.07 (1.00-1.15) P=0.063	**1.08 (1.00-1.16) P=0.043**	1.07 (0.99-1.16) P=0.105	0.96 (0.91-1.03) P=0.249	0.97 (0.91-1.03) P=0.335	1.01 (0.91-1.12) P=0.803	1.00 (0.90-1.11) P=0.956	0.98 (0.87-1.10) P=0.727
Learning disability	1.05 (0.93-1.19) P=0.462	1.01 (0.89-1.14) P=0.891	1.07 (0.85-1.36) P=0.547	1.12 (0.87-1.42) P=0.380	1.12 (0.85-1.48) P=0.406	0.94 (0.79-1.13) P=0.535	0.95 (0.79-1.14) P=0.597	1.15 (0.83-1.59) P=0.413	1.19 (0.85-1.65) P=0.316	1.24 (0.87-1.77) P=0.230
Dyslexia	0.98 (0.84-1.14) P=0.769	0.99 (0.86-1.15) P=0.926	0.96 (0.72-1.27) P=0.755	1.00 (0.75-1.32) P=0.991	0.99 (0.72-1.36) P=0.955	1.12 (0.93-1.36) P=0.234	1.16 (0.96-1.41) P=0.123	1.02 (0.71-1.48) P=0.909	1.03 (0.70-1.50) P=0.896	0.81 (0.52-1.28) P=0.371
Other specific or moderate learning difficulty	1.07 (0.99-1.15) P=0.101	1.03 (0.95-1.11) P=0.516	1.13 (1.00-1.29) P=0.053	**1.15 (1.01-1.32) P=0.036**	1.15 (0.99-1.34) P=0.061	**0.89 (0.80-0.99) P=0.038**	0.91 (0.81-1.02) P=0.089	0.96 (0.79-1.16) P=0.678	0.96 (0.79-1.17) P=0.695	1.01 (0.81-1.26) P=0.942
Sensory impairment	1.08 (0.85-1.36) P=0.521	1.05 (0.83-1.33) P=0.663	0.90 (0.59-1.36) P=0.612	1.00 (0.65-1.53) P=0.984	1.05 (0.67-1.65) P=0.836	0.99 (0.70-1.39) P=0.943	1.01 (0.72-1.42) P=0.949	1.03 (0.61-1.76) P=0.904	1.14 (0.66-1.95) P=0.643	1.14 (0.64-2.02) P=0.665
Physical or motor impairment	1.04 (0.85-1.27) P=0.711	1.04 (0.84-1.28) P=0.719	1.02 (0.70-1.49) P=0.911	1.19 (0.81-1.75) P=0.372	1.06 (0.68-1.64) P=0.805	1.02 (0.76-1.36) P=0.909	1.04 (0.78-1.39) P=0.807	0.95 (0.57-1.58) P=0.835	1.04 (0.62-1.76) P=0.878	1.01 (0.57-1.80) P=0.961
Language or speech disorder	**1.12 (1.01-1.25) P=0.034**	1.09 (0.97-1.21) P=0.140	**1.20 (1.02-1.42) P=0.029**	1.18 (0.99-1.40) P=0.065	1.21 (0.99-1.46) P=0.058	**0.74 (0.62-0.88) P=0.001**	**0.73 (0.61-0.88) P=0.001**	0.92 (0.70-1.20) P=0.521	0.88 (0.67-1.16) P=0.360	0.85 (0.63-1.15) P=0.297
Autistic spectrum disorder	0.89 (0.75-1.06) P=0.178	0.87 (0.73-1.04) P=0.115	0.89 (0.66-1.20) P=0.429	0.86 (0.64-1.18) P=0.353	0.76 (0.55-1.07) P=0.118	1.19 (0.96-1.49) P=0.111	1.21 (0.97-1.51) P=0.097	1.33 (0.94-1.89) P=0.104	1.23 (0.86-1.77) P=0.251	1.24 (0.85-1.81) P=0.270
Social, emotional & behavioural difficulty or mental health problem	**1.17 (1.06-1.29) P=0.002**	1.08 (0.98-1.20) P=0.121	1.12 (0.95-1.32) P=0.172	1.12 (0.94-1.33) P=0.189	1.07 (0.88-1.30) P=0.525	0.98 (0.85-1.13) P=0.778	0.95 (0.82-1.10) P=0.468	1.09 (0.87-1.38) P=0.449	1.05 (0.83-1.34) P=0.668	0.98 (0.75-1.29) P=0.893
Physical health problem	0.95 (0.79-1.13) P=0.545	0.93 (0.78-1.11) P=0.403	1.13 (0.85-1.49) P=0.398	1.11 (0.84-1.48) P=0.464	1.09 (0.78-1.50) P=0.620	1.07 (0.85-1.35) P=0.567	1.09 (0.86-1.38) P=0.476	1.25 (0.86-1.81) P=0.243	1.22 (0.83-1.78) P=0.310	1.19 (0.78-1.82) P=0.423

[1] Base model adjusted for year of birth only.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level. Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.5. Outcomes following planned VBAC compared to ERCS at ≥39 weeks' gestation

Outcomes	ERCS n outcome events (%) (n=17,110)	Planned VBAC n outcome events (%) (n=15,179)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	2,788 (16.29)	2,818 (18.57)	1.04 (0.99-1.10) P=0.088	1.01 (0.97-1.06) P=0.612	1.02 (0.97-1.08) P=0.461	1.02 (0.97-1.08) P=0.437	1.03 (0.97-1.09) P=0.373
Learning disability	427 (2.50)	439 (2.89)	0.99 (0.86-1.14) P=0.888	0.95 (0.83-1.09) P=0.503	0.97 (0.83-1.14) P=0.740	1.02 (0.86-1.21) P=0.803	1.04 (0.87-1.23) P=0.665
Dyslexia	291 (1.70)	355 (2.34)	1.04 (0.88-1.22) P=0.649	1.05 (0.90-1.23) P=0.516	1.13 (0.94-1.35) P=0.196	1.14 (0.94-1.38) P=0.183	1.12 (0.93-1.36) P=0.236
Other specific or moderate learning difficulty	1,237 (7.23)	1,281 (8.44)	1.05 (0.96-1.14) P=0.301	1.00 (0.92-1.09) P=0.967	1.01 (0.92-1.11) P=0.896	1.01 (0.91-1.12) P=0.848	1.02 (0.92-1.13) P=0.756
Sensory impairment	106 (0.62)	123 (0.81)	1.21 (0.92-1.58) P=0.171	1.18 (0.90-1.54) P=0.222	1.15 (0.86-1.55) P=0.343	1.13 (0.82-1.55) P=0.472	1.11 (0.81-1.53) P=0.515
Physical or motor impairment	143 (0.84)	149 (0.98)	1.07 (0.85-1.35) P=0.552	1.07 (0.85-1.35) P=0.577	1.10 (0.85-1.42) P=0.483	1.01 (0.77-1.34) P=0.920	1.01 (0.76-1.34) P=0.933
Language or speech disorder	619 (3.62)	553 (3.64)	1.02 (0.90-1.15) P=0.765	1.00 (0.89-1.13) P=0.990	0.98 (0.86-1.11) P=0.728	0.93 (0.80-1.07) P=0.298	0.94 (0.81-1.08) P=0.394
Autistic spectrum disorder	249 (1.46)	233 (1.54)	1.03 (0.85-1.23) P=0.776	1.01 (0.84-1.22) P=0.876	1.05 (0.85-1.29) P=0.648	1.04 (0.84-1.30) P=0.709	1.04 (0.83-1.29) P=0.735
Social, emotional & behavioural difficulty or mental health problem	711 (4.16)	760 (5.01)	1.10 (0.99-1.23) P=0.082	1.04 (0.93-1.16) P=0.448	1.01 (0.90-1.14) P=0.864	1.03 (0.91-1.18) P=0.613	1.04 (0.92-1.19) P=0.519
Physical health problem	233 (1.36)	222 (1.46)	1.00 (0.83-1.20) P=0.973	1.00 (0.83-1.21) P=0.980	1.09 (0.89-1.34) P=0.402	1.12 (0.89-1.40) P=0.322	1.13 (0.90-1.42) P=0.286

[1] Base model adjusted for year of birth only.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level.
Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.6. Outcomes following planned VBAC with and without labour induction compared to ERCS at ≥39 weeks' gestation

Outcomes	ERCS	Planned VBAC without labour induction						Planned VBAC with labour induction					
	n outcome events (%) (n=17,110)	n outcome events (%) (n=12,381)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)	n outcome events (%) (n=2,752)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	2,788 (16.29)	2,238 (18.08)	1.02 (0.97-1.08) P=0.412	1.0 (0.95-1.05) P=0.908	1.01 (0.96-1.07) P=0.730	1.01 (0.96-1.07) P=0.659	1.02 (0.96-1.08) P=0.575	572 (20.78)	**1.14 (1.05-1.24) P=0.001**	1.06 (0.98-1.15) P=0.164	1.05 (0.96-1.14) P=0.300	1.06 (0.97-1.16) P=0.191	1.06 (0.97-1.16) P=0.171
Learning disability	427 (2.50)	353 (2.85)	0.99 (0.86-1.14) P=0.882	0.96 (0.83-1.11) P=0.572	0.99 (0.84-1.16) P=0.860	1.02 (0.86-1.22) P=0.799	1.04 (0.87-1.24) P=0.659	86 (3.13)	1.01 (0.80-1.28) P=0.937	0.95 (0.75-1.20) P=0.658	0.94 (0.73-1.21) P=0.629	1.04 (0.78-1.37) P=0.807	1.05 (0.79-1.39) P=0.738
Dyslexia	291 (1.70)	276 (2.23)	1.01 (0.85-1.20) P=0.897	1.03 (0.87-1.22) P=0.751	1.10 (0.91-1.33) P=0.327	1.12 (0.92-1.36) P=0.267	1.10 (0.90-1.34) P=0.337	77 (2.80)	1.13 (0.87-1.46) P=0.365	1.15 (0.88-1.49) P=0.306	1.21 (0.92-1.60) P=0.170	1.23 (0.92-1.67) P=0.168	1.22 (0.90-1.65) P=0.194
Other specific or moderate learning difficulty	1,237 (7.23)	1,013 (8.18)	1.02 (0.93-1.11) P=0.689	0.99 (0.90-1.08) P=0.784	1.00 (0.90-1.10) P=0.930	1.00 (0.90-1.11) P=0.984	1.01 (0.91-1.12) P=0.885	264 (9.59)	**1.17 (1.01-1.35) P=0.032**	1.06 (0.92-1.23) P=0.419	1.05 (0.91-1.22) P=0.496	1.07 (0.91-1.26) P=0.408	1.08 (0.92-1.26) P=0.375
Sensory impairment	106 (0.62)	92 (0.74)	1.11 (0.84-1.48) P=0.459	1.09 (0.82-1.45) P=0.558	1.07 (0.78-1.47) P=0.666	1.05 (0.76-1.47) P=0.753	1.04 (0.75-1.46) P=0.805	30 (1.09)	**1.58 (1.03-2.41) P=0.035**	**1.55 (1.02-2.35) P=0.042**	1.52 (0.97-2.37) P=0.065	1.50 (0.92-2.45) P=0.106	1.49 (0.91-2.43) P=0.113
Physical or motor impairment	143 (0.84)	120 (0.97)	1.07 (0.84-1.36) P=0.606	1.06 (0.83-1.36) P=0.626	1.09 (0.83-1.43) P=0.521	1.02 (0.76-1.35) P=0.903	1.02 (0.76-1.35) P=0.917	28 (1.02)	1.07 (0.71-1.62) P=0.740	1.06 (0.70-1.61) P=0.772	1.07 (0.70-1.62) P=0.766	0.94 (0.59-1.51) P=0.806	0.94 (0.59-1.50) P=0.800
Language or speech disorder	619 (3.62)	450 (3.63)	1.01 (0.89-1.15) P=0.841	1.00 (0.88-1.14) P=0.990	0.98 (0.86-1.13) P=0.822	0.94 (0.81-1.08) P=0.378	0.95 (0.82-1.10) P=0.491	101 (3.67)	1.05 (0.84-1.30) P=0.685	1.00 (0.81-1.24) P=0.987	0.95 (0.76-1.18) P=0.623	0.88 (0.69-1.12) P=0.300	0.89 (0.69-1.13) P=0.341
Autistic spectrum disorder	249 (1.46)	181 (1.46)	0.98 (0.81-1.19) P=0.845	0.97 (0.80-1.18) P=0.779	1.02 (0.82-1.27) P=0.869	1.02 (0.81-1.28) P=0.879	1.01 (0.81-1.27) P=0.908	52 (1.89)	1.26 (0.92-1.71) P=0.146	1.23 (0.90-1.67) P=0.197	1.21 (0.87-1.68) P=0.259	1.22 (0.86-1.72) P=0.266	1.21 (0.86-1.72) P=0.275
Social, emotional & behavioural difficulty or mental health problem	711 (4.16)	597 (4.82)	1.07 (0.95-1.20) P=0.273	1.03 (0.91-1.15) P=0.659	1.00 (0.88-1.14) P=0.990	1.02 (0.89-1.17) P=0.743	1.03 (0.90-1.18) P=0.641	163 (5.92)	**1.27 (1.07-1.52) P=0.008**	1.13 (0.94-1.36) P=0.184	1.07 (0.89-1.29) P=0.482	1.13 (0.91-1.39) P=0.263	1.14 (0.92-1.40) P=0.230
Physical health problem	233 (1.36)	173 (1.40)	0.96 (0.78-1.17) P=0.671	0.97 (0.79-1.18) P=0.739	1.06 (0.85-1.32) P=0.591	1.09 (0.86-1.37) P=0.470	1.10 (0.87-1.39) P=0.423	49 (1.78)	1.19 (0.87-1.63) P=0.280	1.18 (0.86-1.62) P=0.310	1.25 (0.90-1.73) P=0.184	1.34 (0.94-1.93) P=0.110	1.35 (0.94-1.95) P=0.102

[1] Base model adjusted for year of birth only.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level. Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.7. Outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS at ≥39 weeks' gestation

Outcomes	ERCS	Planned and actually had VBAC						Planned VBAC but had in-labour non-elective repeat caesarean section					
	n outcome events (%) (n=17,110)	n outcome events (%) (n=11,049)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)	n outcome events (%) (n=4,130)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	2,788 (16.29)	2,105 (19.05)	**1.08 (1.02-1.13) P=0.006**	1.04 (0.98-1.09) P=0.184	1.04 (0.99-1.11) P=0.145	1.05 (0.99-1.11) P=0.118	1.05 (0.99-1.12) P=0.093	713 (17.26)	0.96 (0.89-1.03) P=0.233	0.94 (0.87-1.01) P=0.107	0.96 (0.89-1.04) P=0.323	0.95 (0.88-1.03) P=0.253	0.96 (0.88-1.04) P=0.284
Learning disability	427 (2.50)	330 (2.99)	1.04 (0.89-1.20) P=0.642	0.98 (0.85-1.14) P=0.836	1.00 (0.85-1.19) P=0.980	1.05 (0.87-1.25) P=0.632	1.06 (0.89-1.28) P=0.508	109 2.64)	0.87 (0.70-1.08) P=0.218	0.87 (0.70-1.08) P=0.217	0.91 (0.72-1.14) P=0.423	0.97 (0.76-1.23) P=0.784	0.98 (0.77-1.25) P=0.871
Dyslexia	291 (1.70)	237 (2.14)	0.97 (0.81-1.16) P=0.762	0.98 (0.82-1.17) P=0.815	1.06 (0.87-1.29) P=0.580	1.08 (0.88-1.33) P=0.441	1.07 (0.87-1.31) P=0.533	118 (2.86)	1.20 (0.96-1.50) P=0.103	**1.25 (1.00-1.56) P=0.049**	**1.26 (1.00-1.60) P=0.049**	1.25 (0.98-1.60) P=0.078	1.24 (0.96-1.58) P=0.096
Other specific or moderate learning difficulty	1,237 (7.23)	980 (8.87)	**1.11 (1.02-1.22) P=0.022**	1.06 (0.96-1.16) P=0.256	1.06 (0.96-1.18) P=0.251	1.07 (0.96-1.19) P=0.242	1.07 (0.96-1.20) P=0.198	301 (7.29)	**0.87 (0.76-0.99) P=0.041**	**0.86 (0.75-0.98) P=0.026**	0.88 (0.77-1.02) P=0.082	0.88 (0.76-1.02) P=0.079	0.88 (0.76-1.02) P=0.093
Sensory impairment	106 (0.62)	95 (0.86)	1.29 (0.97-1.71) P=0.081	1.25 (0.94-1.66) P=0.120	1.23 (0.89-1.70) P=0.202	1.19 (0.85-1.68) P=0.315	1.18 (0.83-1.67) P=0.350	28 (0.68)	0.99 (0.63-1.54) P=0.964	0.99 (0.64-1.53) P=0.947	0.98 (0.63-1.54) P=0.932	0.96 (0.60-1.53) P=0.865	0.95 (0.60-1.51) P=0.832
Physical or motor impairment	143 (0.84)	113 (1.02)	1.13 (0.88-1.44) P=0.351	1.12 (0.87-1.43) P=0.390	1.15 (0.87-1.54) P=0.329	1.08 (0.80-1.47) P=0.620	1.08 (0.79-1.46) P=0.631	36 (0.87)	0.93 (0.65-1.35) P=0.714	0.94 (0.65-1.36) P=0.748	0.97 (0.67-1.40) P=0.877	0.87 (0.59-1.29) P=0.483	0.87 (0.59-1.28) P=0.476
Language or speech disorder	619 (3.62)	458 (4.15)	**1.16 (1.02-1.32) P=0.022**	1.13 (0.99-1.28) P=0.065	1.11 (0.97-1.28) P=0.140	1.06 (0.91-1.23) P=0.457	1.08 (0.92-1.25) P=0.351	95 (2.30)	**0.64 (0.51-0.80) P<0.001**	**0.64 (0.51-0.80) P<0.001**	**0.66 (0.52-0.82) P<0.001**	**0.60 (0.48-0.77) P<0.001**	**0.61 (0.48-0.77) P<0.001**
Autistic spectrum disorder	249 (1.46)	155 (1.40)	0.94 (0.76-1.16) P=0.557	0.93 (0.75-1.14) P=0.465	0.96 (0.76-1.21) P=0.738	0.97 (0.76-1.23) P=0.794	0.96 (0.76-1.23) P=0.765	78 (1.89)	1.26 (0.97-1.64) P=0.078	1.26 (0.97-1.63) P=0.083	1.24 (0.95-1.64) P=0.117	1.21 (0.91-1.62) P=0.192	1.21 (0.91-1.61) P=0.200
Social, emotional & behavioural difficulty or mental health problem	711 (4.16)	571 (5.17)	**1.15 (1.02-1.29) P=0.022**	1.07 (0.95-1.21) P=0.247	1.03 (0.90-1.18) P=0.637	1.07 (0.93-1.23) P=0.356	1.08 (0.94-1.24) P=0.287	189 (4.58)	0.98 (0.83-1.16) P=0.825	0.96 (0.81-1.14) P=0.664	0.96 (0.81-1.15) P=0.660	0.95 (0.79-1.15) P=0.623	0.96 (0.80-1.16) P=0.684
Physical health problem	233 (1.36)	158 (1.43)	0.98 (0.80-1.21) P=0.847	0.98 (0.79-1.20) P=0.834	1.08 (0.86-1.36) P=0.513	1.1 (0.86-1.40) P=0.444	1.11 (0.87-1.42) P=0.399	64 (1.55)	1.04 (0.79-1.38) P=0.775	1.07 (0.81-1.42) P=0.640	1.12 (0.84-1.49) P=0.449	1.17 (0.86-1.59) P=0.320	1.18 (0.86-1.61) P=0.297

[1] Base model adjusted for year of birth only.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level. Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.8. E-values for the observed associations between planned mode of birth after previous caesarean section (planned VBAC with and without labour induction vs. ERCS) and SENs*

	E-value for OR or RR point estimate[a]	E-value for CI limit of OR or RR[b]
Planned VBAC with labour induction		
Any SEN	1.40	1.11
Sensory impairment	2.58	1.40

* The observed associations are the fully adjusted HRs shown in Table 6.5. See VanderWeele & Ding[193] for formula used to calculate E-values.

[a] The E-values for the point estimates are the minimum strength of association on the OR or RR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to fully explain the observed associations between planned mode of birth after previous caesarean section (planned VBAC with & without labour induction vs. ERCS) & the SEN outcomes.

[b] The E-values for the limit of the 95% CI closest to the null covey the minimum strength of association on the OR or RR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to move the CI to include the null value.

Abbreviations: CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean.

Table F.9. E-values for the observed associations between actual mode of birth after previous caesarean section (planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared vs. ERCS) and SENs*

	E-value for OR or RR point estimate[a]	E-value for CI limit of OR or RR[b]
Planned and actually had VBAC		
Any SEN	1.31	1.11
Other specific or moderate learning difficulty	1.43	1.00
Language or speech disorder	1.54	1.00
Planned VBAC but had in-labour non-elective repeat caesarean section		
Language or speech disorder	1.96	1.39

* The observed associations are the fully adjusted HRs shown in Table 6.6. See VanderWeele & Ding[193] for formula used to calculate E-values.

[a] The E-values for the point estimates are the minimum strength of association on the OR or RR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to fully explain the observed associations between actual mode of birth after previous caesarean section (planned & actually had a VBAC & planned VBAC but had in-labour non-elective repeat caesarean section vs. ERCS) & the SEN outcomes.

[b] The E-values for the limit of the 95% CI closest to the null covey the minimum strength of association on the OR or RR scale that an unmeasured confounder would need to have with both the exposure & outcome, above & beyond the measured covariates, to move the CI to include the null value.

Abbreviations: CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean.

Table F.10. Outcomes following planned VBAC compared to ERCS, analysing SEN as a repeated measures yearly outcome*

Outcomes	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	1.03 (0.98-1.09) P=0.189	1.01 (0.96-1.06) P=0.816	1.03 (0.97-1.08) P=0.331	1.04 (0.99-1.10) P=0.149	1.05 (0.99-1.11) P=0.111
Learning disability	0.98 (0.86-1.13) P=0.822	0.94 (0.82-1.08) P=0.411	1.00 (0.87-1.16) P=0.980	1.05 (0.90-1.22) P=0.561	1.06 (0.91-1.24) P=0.471
Dyslexia	1.08 (0.93-1.27) P=0.308	1.10 (0.95-1.29) P=0.208	1.16 (0.97-1.38) P=0.097	1.15 (0.96-1.38) P=0.126	1.14 (0.95-1.37) P=0.153
Other specific or moderate learning difficulty	0.99 (0.91-1.08) P=0.861	0.96 (0.88-1.04) P=0.342	1.00 (0.92-1.10) P=0.934	1.03 (0.93-1.13) P=0.585	1.03 (0.94-1.14) P=0.485
Sensory impairment	1.06 (0.82-1.36) P=0.674	1.04 (0.81-1.33) P=0.781	1.12 (0.85-1.48) P=0.411	1.21 (0.90-1.61) P=0.201	1.20 (0.90-1.60) P=0.214
Physical or motor impairment	1.02 (0.81-1.28) P=0.862	1.01 (0.80-1.27) P=0.920	1.08 (0.84-1.38) P=0.559	1.17 (0.89-1.52) P=0.262	1.16 (0.89-1.52) P=0.265
Language or speech disorder	0.96 (0.85-1.08) P=0.494	0.92 (0.81-1.05) P=0.203	0.93 (0.81-1.07) P=0.297	0.92 (0.80-1.06) P=0.251	0.93 (0.80-1.07) P=0.301
Autistic spectrum disorder	1.00 (0.83-1.20) P=0.983	0.98 (0.81-1.18) P=0.815	0.98 (0.80-1.21) P=0.872	1.05 (0.85-1.30) P=0.655	1.04 (0.84-1.29) P=0.724
Social, emotional & behavioural difficulty or mental health problem	**1.13 (1.01-1.26) P=0.027**	1.06 (0.95-1.18) P=0.292	1.02 (0.90-1.16) P=0.734	1.04 (0.91-1.19) P=0.529	1.05 (0.92-1.20) P=0.468
Physical health problem	1.02 (0.84-1.24) P=0.854	1.00 (0.82-1.21) P=0.971	1.06 (0.86-1.32) P=0.583	1.08 (0.86-1.35) P=0.503	1.09 (0.87-1.36) P=0.458

[1] Base model adjusted for year of birth & age of child at the time of the pupil census.

[2] Model A adjusted for variables in base model & additionally adjusted for, socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).

[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

* Median number of pupil census years per child when they were aged 4-11 years & attending a primary or special school was 5 (IQR 3-7)

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; IQR, Interquartile range; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.11. Outcomes following planned VBAC with and without labour induction compared to ERCS, analysing SEN as a repeated measures yearly outcome*

Outcomes	Planned VBAC without labour induction vs. ERCS					Planned VBAC with labour induction vs. ERCS				
	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	1.01 (0.96-1.06) P=0.769	0.99 (0.94-1.04) P=0.690	1.02 (0.96-1.08) P=0.536	1.03 (0.97-1.09) P=0.327	1.03 (0.98-1.09) P=0.258	**1.15 (1.05-1.26) P=0.002**	1.08 (0.99-1.18) P=0.083	1.07 (0.98-1.17) P=0.151	**1.11 (1.01-1.21) P=0.032**	**1.11 (1.01-1.22) P=0.027**
Learning disability	0.96 (0.83-1.11) P=0.542	0.92 (0.80-1.07) P=0.286	0.99 (0.85-1.15) P=0.871	1.03 (0.87-1.20) P=0.762	1.04 (0.88-1.22) P=0.659	1.13 (0.89-1.43) P=0.305	1.05 (0.83-1.33) P=0.685	1.08 (0.85-1.37) P=0.513	1.18 (0.92-1.53) P=0.196	1.19 (0.92-1.54) P=0.176
Dyslexia	1.04 (0.88-1.23) P=0.628	1.06 (0.90-1.25) P=0.486	1.12 (0.93-1.34) P=0.226	1.12 (0.93-1.35) P=0.241	1.11 (0.92-1.33) P=0.287	1.25 (0.95-1.63) P=0.105	1.28 (0.98-1.68) P=0.074	1.31 (0.98-1.75) P=0.064	1.31 (0.97-1.76) P=0.077	1.30 (0.96-1.75) P=0.084
Other specific or moderate learning difficulty	0.99 (0.90-1.08) P=0.754	0.96 (0.88-1.05) P=0.427	1.01 (0.92-1.12) P=0.759	1.03 (0.94-1.14) P=0.516	1.04 (0.94-1.15) P=0.421	1.03 (0.89-1.20) P=0.657	0.95 (0.82-1.11) P=0.544	0.97 (0.83-1.13) P=0.704	1.01 (0.86-1.20) P=0.866	1.02 (0.87-1.20) P=0.814
Sensory impairment	0.95 (0.72-1.25) P=0.697	0.93 (0.71-1.22) P=0.602	1.02 (0.75-1.37) P=0.922	1.08 (0.80-1.47) P=0.617	1.07 (0.79-1.46) P=0.647	1.50 (0.99-2.27) P=0.057	1.46 (0.97-2.21) P=0.069	**1.55 (1.01-2.38) P=0.044**	**1.76 (1.12-2.76) P=0.014**	**1.75 (1.12-2.74) P=0.014**
Physical or motor impairment	1.05 (0.82-1.33) P=0.717	1.04 (0.82-1.32) P=0.768	1.11 (0.86-1.45) P=0.425	1.19 (0.90-1.56) P=0.219	1.19 (0.90-1.56) P=0.222	0.89 (0.58-1.38) P=0.611	0.88 (0.57-1.37) P=0.578	0.90 (0.58-1.40) P=0.637	1.02 (0.63-1.63) P=0.945	1.02 (0.63-1.63) P=0.948
Language or speech disorder	0.94 (0.82-1.07) P=0.354	0.91 (0.80-1.04) P=0.183	0.93 (0.81-1.08) P=0.339	0.92 (0.79-1.07) P=0.268	0.93 (0.80-1.08) P=0.321	1.03 (0.82-1.31) P=0.795	0.95 (0.75-1.20) P=0.654	0.91 (0.71-1.16) P=0.448	0.91 (0.71-1.18) P=0.478	0.92 (0.71-1.18) P=0.507
Autistic spectrum disorder	0.97 (0.80-1.19) P=0.784	0.96 (0.78-1.17) P=0.673	0.97 (0.79-1.21) P=0.812	1.03 (0.82-1.28) P=0.827	1.01 (0.81-1.27) P=0.901	1.10 (0.79-1.54) P=0.567	1.06 (0.76-1.48) P=0.743	1.01 (0.71-1.43) P=0.970	1.14 (0.80-1.63) P=0.471	1.13 (0.79-1.62) P=0.499
Social, emotional & behavioural difficulty or mental health problem	1.09 (0.97-1.22) P=0.164	1.04 (0.92-1.16) P=0.561	1.01 (0.89-1.16) P=0.840	1.03 (0.90-1.18) P=0.682	1.04 (0.90-1.19) P=0.613	**1.35 (1.12-1.64) P=0.002**	1.19 (0.98-1.44) P=0.075	1.09 (0.87-1.36) P=0.447	1.16 (0.92-1.45) P=0.211	1.16 (0.93-1.46) P=0.195
Physical health problem	0.98 (0.79-1.20) P=0.823	0.96 (0.78-1.18) P=0.694	1.03 (0.82-1.30) P=0.791	1.05 (0.83-1.32) P=0.704	1.06 (0.83-1.34) P=0.650	1.23 (0.87-1.73) P=0.241	1.19 (0.84-1.68) P=0.339	1.22 (0.85-1.75) P=0.274	1.28 (0.88-1.87) P=0.196	1.29 (0.88-1.89) P=0.185

[1] Base model adjusted for year of birth & age of child at the time of the pupil census.
[2] Model A adjusted for variables in base model & additionally adjusted for, socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level. *Median number of pupil census years per child when they were aged 4-11 years & attending a primary or special school was 5 (IQR 3-7). Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; IQR, Interquartile range; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.12. Outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS, analysing SEN as a repeated measures yearly outcome*

Outcomes	Planned and actually had VBAC vs. ERCS					Planned VBAC but had in-labour non-elective repeat caesarean section vs. ERCS				
	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	1.05 (1.00-1.11) P=0.069	1.02 (0.96-1.07) P=0.565	1.03 (0.98-1.10) P=0.254	1.05 (0.99-1.12) P=0.087	1.06 (1.00-1.13) P=0.063	0.99 (0.92-1.07) P=0.847	0.98 (0.91-1.06) P=0.641	1.01 (0.94-1.09) P=0.793	1.02 (0.94-1.10) P=0.688	1.02 (0.94-1.10) P=0.621
Learning disability	1.00 (0.86-1.17) P=0.950	0.95 (0.82-1.11) P=0.530	1.01 (0.86-1.18) P=0.914	1.06 (0.89-1.25) P=0.528	1.07 (0.90-1.26) P=0.440	0.94 (0.76-1.16) P=0.559	0.92 (0.75-1.14) P=0.464	0.99 (0.80-1.22) P=0.910	1.03 (0.82-1.29) P=0.800	1.04 (0.83-1.30) P=0.741
Dyslexia	1.05 (0.89-1.26) P=0.550	1.07 (0.90-1.27) P=0.459	1.13 (0.93-1.37) P=0.217	1.13 (0.92-1.38) P=0.231	1.12 (0.92-1.37) P=0.272	1.15 (0.92-1.43) P=0.215	1.19 (0.95-1.48) P=0.126	1.22 (0.96-1.54) P=0.102	1.19 (0.94-1.52) P=0.146	1.18 (0.93-1.50) P=0.166
Other specific or moderate learning difficulty	1.04 (0.95-1.14) P=0.429	0.99 (0.90-1.09) P=0.841	1.03 (0.94-1.14) P=0.496	1.06 (0.96-1.17) P=0.262	1.07 (0.96-1.18) P=0.205	0.89 (0.79-1.02) P=0.086	0.89 (0.78-1.01) P=0.078	0.94 (0.82-1.07) P=0.368	0.96 (0.84-1.10) P=0.542	0.96 (0.84-1.11) P=0.607
Sensory impairment	1.06 (0.80-1.40) P=0.707	1.02 (0.77-1.36) P=0.870	1.10 (0.80-1.50) P=0.564	1.17 (0.85-1.62) P=0.329	1.17 (0.85-1.61) P=0.347	1.06 (0.72-1.56) P=0.776	1.07 (0.73-1.56) P=0.742	1.18 (0.80-1.75) P=0.405	1.28 (0.86-1.89) P=0.226	1.27 (0.86-1.88) P=0.234
Physical or motor impairment	1.05 (0.82-1.35) P=0.693	1.04 (0.81-1.34) P=0.763	1.11 (0.84-1.48) P=0.453	1.21 (0.90-1.63) P=0.199	1.21 (0.90-1.63) P=0.201	0.95 (0.67-1.34) P=0.771	0.95 (0.67-1.35) P=0.768	1.01 (0.70-1.44) P=0.974	1.07 (0.74-1.55) P=0.713	1.07 (0.74-1.55) P=0.717
Language or speech disorder	1.07 (0.93-1.22) P=0.340	1.02 (0.89-1.17) P=0.729	1.04 (0.90-1.21) P=0.601	1.03 (0.89-1.21) P=0.667	1.04 (0.89-1.22) P=0.587	**0.71 (0.58-0.88) P=0.002**	**0.69 (0.56-0.85) P<0.001**	**0.71 (0.57-0.88) P=0.002**	**0.69 (0.55-0.87) P=0.001**	**0.70 (0.56-0.87) P=0.002**
Autistic spectrum disorder	0.91 (0.73-1.12) P=0.369	0.89 (0.72-1.11) P=0.310	0.90 (0.72-1.14) P=0.397	0.98 (0.77-1.24) P=0.846	0.97 (0.76-1.23) P=0.777	1.20 (0.92-1.57) P=0.169	1.16 (0.89-1.52) P=0.264	1.14 (0.86-1.50) P=0.369	1.19 (0.90-1.57) P=0.234	1.18 (0.89-1.56) P=0.259
Social, emotional & behavioural difficulty or mental health problem	**1.19 (1.06-1.34) P=0.004**	1.11 (0.98-1.25) P=0.100	1.06 (0.92-1.21) P=0.444	1.09 (0.94-1.26) P=0.239	1.10 (0.95-1.27) P=0.204	1.00 (0.85-1.18) P=1.000	0.96 (0.81-1.13) P=0.605	0.93 (0.77-1.14) P=0.504	0.93 (0.76-1.14) P=0.464	0.93 (0.76-1.14) P=0.501
Physical health problem	0.98 (0.78-1.22) P=0.834	0.95 (0.76-1.19) P=0.672	1.03 (0.81-1.31) P=0.820	1.04 (0.81-1.33) P=0.786	1.04 (0.81-1.34) P=0.732	1.11 (0.84-1.47) P=0.458	1.10 (0.83-1.45) P=0.526	1.13 (0.84-1.51) P=0.423	1.17 (0.86-1.58) P=0.312	1.18 (0.87-1.60) P=0.291

[1] Base model adjusted for year of birth & age of child at the time of the pupil census.
[2] Model A adjusted for variables in base model & additionally adjusted for, socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, maternal BMI at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level. *Median number of pupil census years per child when they were aged 4-11 years & attending a primary or special school was 5 (IQR 3-7). Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; IQR, Interquartile range; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.13. Outcomes following planned VBAC compared to ERCS, removing covariate maternal BMI from the analysis

Outcomes	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	1.03 (0.99-1.07) P=0.194	1.01 (0.97-1.05) P=0.788	1.00 (0.96-1.05) P=0.963	1.01 (0.97-1.06) P=0.540	1.02 (0.98-1.07) P=0.385
Learning disability	1.02 (0.91-1.14) P=0.754	0.97 (0.87-1.09) P=0.613	0.96 (0.84-1.09) P=0.487	0.99 (0.86-1.13) P=0.868	1.01 (0.88-1.15) P=0.905
Dyslexia	1.02 (0.89-1.17) P=0.765	1.05 (0.91-1.19) P=0.516	1.09 (0.94-1.27) P=0.232	1.10 (0.94-1.28) P=0.228	1.08 (0.93-1.26) P=0.310
Other specific or moderate learning difficulty	1.02 (0.95-1.09) P=0.658	0.98 (0.91-1.05) P=0.569	0.99 (0.92-1.07) P=0.777	1.01 (0.93-1.10) P=0.771	1.02 (0.94-1.11) P=0.621
Sensory impairment	1.05 (0.85-1.30) P=0.633	1.04 (0.84-1.28) P=0.734	1.07 (0.84-1.36) P=0.578	1.14 (0.89-1.47) P=0.286	1.13 (0.88-1.46) P=0.320
Physical or motor impairment	1.03 (0.86-1.24) P=0.731	1.02 (0.84-1.23) P=0.848	1.00 (0.81-1.24) P=0.978	1.06 (0.85-1.32) P=0.606	1.07 (0.86-1.34) P=0.549
Language or speech disorder	1.02 (0.92-1.12) P=0.762	0.98 (0.88-1.08) P=0.656	0.96 (0.86-1.08) P=0.516	0.95 (0.84-1.06) P=0.365	0.96 (0.85-1.08) P=0.501
Autistic spectrum disorder	0.97 (0.84-1.13) P=0.732	0.96 (0.82-1.12) P=0.595	0.94 (0.79-1.11) P=0.443	0.96 (0.81-1.14) P=0.663	0.96 (0.81-1.15) P=0.673
Social, emotional & behavioural difficulty or mental health problem	**1.12 (1.02-1.22)** P=**0.017**	1.07 (0.97-1.17) P=0.164	1.01 (0.91-1.12) P=0.860	1.03 (0.93-1.14) P=0.597	1.04 (0.94-1.16) P=0.466
Physical health problem	0.98 (0.84-1.15) P=0.822	0.99 (0.84-1.15) P=0.851	1.01 (0.85-1.21) P=0.871	1.04 (0.87-1.24) P=0.698	1.05 (0.87-1.26) P=0.621

[1] Base model adjusted for year of birth only.

[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).

[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).

[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).

[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.

Bold text indicates statistically significant findings at the 5% level.

Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.14. Outcomes following planned VBAC with and without labour induction compared to ERCS, removing covariate maternal BMI from the analysis

Outcomes	Planned VBAC without labour induction vs. ERCS					Planned VBAC with labour induction vs. ERCS				
	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	1.01 (0.96-1.05) P=0.767	0.99 (0.95-1.04) 0.743	0.99 (0.95-1.04) 0.765	1.00 (0.96-1.05) 0.865	1.01 (0.96-1.06) 0.669	**1.13 (1.05-1.21) P=0.001**	1.07 (0.99-1.14) 0.074	1.04 (0.97-1.12) 0.274	1.07 (1.00-1.16) 0.061	**1.08 (1.00-1.16) 0.045**
Learning disability	1.01 (0.89-1.14) P=0.910	0.97 (0.86-1.09) P=0.585	0.96 (0.84-1.09) P=0.521	0.98 (0.86-1.13) P=0.808	1.00 (0.87-1.15) P=0.966	1.09 (0.89-1.33) P=0.432	1.01 (0.82-1.23) 0.959	0.97 (0.78-1.20) 0.750	1.04 (0.83-1.30) 0.741	1.06 (0.84-1.32) 0.636
Dyslexia	1.00 (0.86-1.15) P=0.955	1.02 (0.88-1.17) 0.799	1.07 (0.92-1.25) 0.403	1.08 (0.92-1.26) 0.357	1.06 (0.90-1.24) 0.467	1.11 (0.88-1.40) P=0.361	1.15 (0.91-1.45) P=0.239	1.20 (0.94-1.53) P=0.152	1.21 (0.93-1.56) P=0.152	1.19 (0.92-1.54) P=0.180
Other specific or moderate learning difficulty	1.00 (0.92-1.07) P=0.928	0.97 (0.90-1.05) 0.465	0.98 (0.91-1.07) 0.703	1.01 (0.92-1.09) 0.906	1.01 (0.93-1.10) 0.745	1.11 (0.98-1.27) P=0.097	1.02 (0.89-1.16) P=0.808	1.02 (0.89-1.16) P=0.821	1.06 (0.93-1.22) P=0.391	1.07 (0.93-1.23) P=0.338
Sensory impairment	0.97 (0.77-1.22) P=0.794	0.96 (0.76-1.20) 0.698	0.99 (0.77-1.28) 0.950	1.05 (0.81-1.37) 0.693	1.04 (0.80-1.36) 0.745	1.38 (0.97-1.97) P=0.072	1.36 (0.95-1.93) P=0.089	1.39 (0.96-2.02) P=0.079	**1.56 (1.06-2.29) P=0.023**	**1.55 (1.06-2.27) P=0.025**
Physical or motor impairment	1.03 (0.85-1.26) P=0.734	1.02 (0.84-1.24) 0.838	1.01 (0.81-1.26) 0.940	1.06 (0.84-1.33) 0.627	1.07 (0.85-1.34) 0.569	1.01 (0.71-1.44) P=0.947	0.99 (0.70-1.42) P=0.975	0.96 (0.66-1.38) P=0.806	1.05 (0.71-1.54) P=0.811	1.06 (0.73-1.55) P=0.781
Language or speech disorder	1.01 (0.90-1.12) P=0.895	0.98 (0.88-1.09) P=709	0.97 (0.87-1.09) P=0.650	0.96 (0.85-1.08) P=0.464	0.97 (0.86-1.09) P=0.619	1.06 (0.88-1.28) P=0.528	0.97 (0.80-1.17) P=0.742	0.92 (0.76-1.12) P=0.427	0.91 (0.74-1.12) P=0.364	0.92 (0.75-1.13) P=0.426
Autistic spectrum disorder	0.95 (0.81-1.11) P=0.519	0.94 (0.80-1.10) P=0.434	0.92 (0.77-1.10) P=0.373	0.94 (0.79-1.13) P=0.521	0.94 (0.79-1.13) P=0.528	1.09 (0.83-1.45) P=0.522	1.06 (0.81-1.40) P=0.663	1.00 (0.74-1.33) P=0.979	1.06 (0.79-1.43) P=0.709	1.06 (0.79-1.43) P=0.705
Social, emotional & behavioural difficulty or mental health problem	1.09 (0.99-1.20) P=0.078	1.05 (0.96-1.16) P=0.290	1.00 (0.90-1.11) P=0.955	1.02 (0.91-1.13) P=0.756	1.03 (0.92-1.15) P=0.612	**1.26 (1.08-1.48) P=0.004**	1.15 (0.98-1.35) P=0.092	1.06 (0.90-1.25) P=0.503	1.11 (0.94-1.33) P=0.221	1.13 (0.95-1.34) P=0.182
Physical health problem	0.95 (0.80-1.12) P=0.526	0.95 (0.80-1.12) P=0.553	0.99 (0.82-1.19) P=0.878	1.01 (0.83-1.21) P=0.958	1.02 (0.84-1.23) P=0.874	1.16 (0.88-1.53) P=0.290	1.17 (0.88-1.54) P=0.277	1.18 (0.88-1.57) P=0.270	1.24 (0.92-1.68) P=0.158	1.25 (0.93-1.69) P=0.143

[1] Base model adjusted for year of birth only.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level. Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Table F.15. Outcomes according to actual mode of birth – planned and actually had a VBAC and planned VBAC but had in-labour non-elective repeat caesarean section compared to ERCS, removing covariate maternal BMI from the analysis

Outcomes	Planned and actually had VBAC vs. ERCS					Planned VBAC but had in-labour non-elective repeat caesarean section vs. ERCS				
	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)	Base model[1] OR or RR (95% CI)	Model A[2] OR or RR (95% CI)	Model B[3] OR or RR (95% CI)	Model C[4] OR or RR (95% CI)	Model D[5] OR or RR (95% CI)
Any SEN	**1.05 (1.01-1.10) P=0.026**	1.02 (0.98-1.07) P=0.295	1.01 (0.97-1.06) P=0.597	1.03 (0.98-1.08) P=0.225	1.04 (0.99-1.09) P=0.142	0.96 (0.91-1.03) P=0.249	0.96 (0.90-1.02) P=0.177	0.97 (0.91-1.04) P=0.418	0.98 (0.92-1.04) P=0.481	0.98 (0.92-1.05) P=0.575
Learning disability	1.05 (0.93-1.19) P=0.462	0.99 (0.87-1.12) P=0.860	0.96 (0.84-1.11) P=0.583	0.99 (0.86-1.15) P=0.944	1.02 (0.88-1.18) P=0.827	0.94 (0.79-1.13) P=0.535	0.92 (0.77-1.11) P=0.397	0.94 (0.78-1.14) P=0.537	0.97 (0.80-1.18) P=0.798	0.99 (0.82-1.20) P=0.921
Dyslexia	0.98 (0.84-1.14) P=0.769	0.99 (0.86-1.15) P=0.938	1.05 (0.89-1.23) P=0.597	1.06 (0.89-1.26) P=0.499	1.04 (0.88-1.24) P=0.625	1.12 (0.93-1.36) P=0.234	1.17 (0.97-1.42) P=0.108	1.19 (0.98-1.46) P=0.082	1.18 (0.96-1.45) P=0.122	1.16 (0.95-1.43) P=0.153
Other specific or moderate learning difficulty	1.07 (0.99-1.15) P=0.101	1.02 (0.94-1.10) P=0.670	1.02 (0.94-1.11) P=0.639	1.05 (0.96-1.15) P=0.292	1.06 (0.97-1.16) P=0.209	**0.89 (0.80-0.99) P=0.038**	**0.88 (0.79-0.99) P=0.029**	0.92 (0.82-1.03) P=0.150	0.93 (0.83-1.05) P=0.247	0.94 (0.83-1.06) P=0.298
Sensory impairment	1.08 (0.85-1.36) P=0.521	1.05 (0.83-1.33) P=0.675	1.08 (0.82-1.41) P=0.589	1.15 (0.87-1.52) P=0.320	1.14 (0.86-1.50) P=0.357	0.99 (0.70-1.39) P=0.943	1.00 (0.71-1.40) P=0.996	1.06 (0.75-1.49) P=0.757	1.13 (0.80-1.61) P=0.487	1.13 (0.79-1.60) P=0.511
Physical or motor impairment	1.04 (0.85-1.27) P=0.711	1.02 (0.83-1.26) P=0.837	1.01 (0.80-1.28) P=0.943	1.07 (0.84-1.37) P=0.573	1.08 (0.85-1.39) P=0.516	1.02 (0.76-1.36) P=0.909	1.01 (0.76-1.35) P=0.948	0.99 (0.74-1.33) P=0.949	1.03 (0.76-1.40) P=0.839	1.04 (0.77-1.41) P=0.803
Language or speech disorder	**1.12 (1.01-1.25) P=0.034**	1.08 (0.97-1.20) P=0.177	1.06 (0.94-1.20) P=0.317	1.05 (0.93-1.20) P=0.411	1.07 (0.94-1.22) P=0.290	**0.74 (0.62-0.88) P=0.001**	**0.71 (0.60-0.85) P<0.001**	**0.74 (0.62-0.88) P=0.001**	**0.71 (0.59-0.86) P<0.001**	**0.72 (0.60-0.87) P=0.001**
Autistic spectrum disorder	0.89 (0.75-1.06) P=0.178	0.87 (0.73-1.04) P=0.124	0.85 (0.70-1.03) P=0.093	0.88 (0.73-1.08) P=0.219	0.88 (0.73-1.08) P=0.223	1.19 (0.96-1.49) P=0.111	1.19 (0.95-1.48) P=0.130	1.13 (0.90-1.42) P=0.291	1.13 (0.89-1.42) P=0.315	1.13 (0.89-1.42) P=0.313
Social, emotional & behavioural difficulty or mental health problem	**1.17 (1.06-1.29) P=0.002**	1.10 (1.00-1.22) P=0.055	1.03 (0.92-1.15) P=0.609	1.06 (0.95-1.19) P=0.300	1.08 (0.96-1.21) P=0.217	0.98 (0.85-1.13) P=0.778	0.97 (0.84-1.12) P=0.699	0.96 (0.83-1.12) P=0.615	0.95 (0.82-1.11) P=0.545	0.96 (0.83-1.12) P=0.622
Physical health problem	0.95 (0.79-1.13) P=0.545	0.94 (0.79-1.13) P=0.517	0.98 (0.80-1.19) P=0.840	0.99 (0.81-1.22) P=0.959	1.01 (0.82-1.23) P=0.958	1.07 (0.85-1.35) P=0.567	1.09 (0.86-1.38) P=0.455	1.09 (0.85-1.39) P=0.487	1.13 (0.88-1.44) P=0.342	1.14 (0.89-1.46) P=0.312

[1] Base model adjusted for year of birth only.
[2] Model A adjusted for year of birth & socio-demographic factors (maternal age, mother's country of birth, marital status, socioeconomic status, & child's ethnicity).
[3] Model B adjusted for variables in Model A & additionally adjusted for maternal medical & pregnancy-related factors (number of previous caesarean sections, any prior vaginal birth, inter-pregnancy interval, maternal smoking status at booking, hypertensive disorder, diabetes & prelabour rupture of membranes).
[4] Model C, adjusted for variables in Model B & additionally adjusted for infant-related factors (sex of infant, gestational age at birth & birth weight centile).
[5] Model D, adjusted for variables in Model C & additionally adjusted for any breastfeeding at 6-8 weeks postpartum.
Bold text indicates statistically significant findings at the 5% level. Abbreviations: BMI, body mass index; CI, confidence interval; ERCS, elective repeat caesarean section; OR, odds ratio; RR, risk ratio; SEN, special educational need; VBAC, vaginal birth after previous caesarean

Appendix G. Plain English one page summary and plain English longer leaflet of the research finding produced with the help of PPI representatives

One page summary:

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NPEU

UNIVERSITY OF OXFORD

Planning how to give birth after previous caesarean section – key messages from three large studies:

Whichever way you plan to give birth, birth after previous caesarean section is **generally very safe**.

Out of 10 women planning a vaginal birth after a previous caesarean section (known as a **planned VBAC**), **7 gave birth vaginally** and **3 had an unplanned caesarean section** when they were in labour. In this situation the caesarean section may have to be carried out urgently and be a different experience to a planned caesarean. The most common reasons for an unplanned caesarean section during labour is that the labour progresses too slowly or there are concerns about the wellbeing of the baby.



Planned VBAC compared to planning another birth by caesarean section (known as an Elective Repeat Caesarean Section or **ERCS**) **increased** the chance of the **mother** having various **birth-related complications** such as needing a blood transfusion, womb (uterine) rupture, and experiencing damage to the bowel, bladder or the tube between the kidneys and bladder (ureter) needing an operation to repair. Most of the maternal birth-related complications occurred among the women who needed an unplanned caesarean section carried out during the course of a planned VBAC labour.



ERCS

Nearly **1** in every **100** women having an ERCS experienced serious birth-related maternal complications (or 0.8%)



Planned VBAC

Nearly **2** in every **100** women planning a VBAC experienced serious birth-related maternal complications (or 1.8%)

Planned VBAC compared to ERCS **increased** the chance of the **baby** having various problems during or shortly after birth such as needing to be admitted to a specialist newborn (neonatal) unit for extra care and needing medicine or equipment to help with breathing immediately after birth.



ERCS

Around **6** in every **100** babies born to women having an ERCS had one or more of a range of problems during or shortly after birth (or 6.4%)



Planned VBAC

Around **8** in every **100** babies born to women planning a VBAC had one or more of a range of problems during or shortly after birth (or 8.0%)

Women who planned a VBAC were **more likely** than women who had an ERCS to **breastfeed**.

Women who had an ERCS were **more likely** than women who planned a VBAC to be given **medication to treat mental health problems** in the year after they gave birth. However, this does not necessarily mean that mental health is better in the planned VBAC group, as not all women with mental health problems will seek treatment and not all mental health problems are treated with medication.



ERCS

Around **12** in every **100** women having an ERCS were given any medication to treat mental health problems in the year after giving birth (or 12.3%)



Planned VBAC

Around **10** in every **100** women planning a VBAC were given any medication to treat mental health problems in the year after giving birth (or 10.0%)

Children born following planned VBAC compared to ERCS had a **similar** chance of having **special educational needs** - that is, learning difficulties or disabilities that make it harder for a child to learn compared to other children of the same age such as dyslexia.

More information can be found at: *www.npeu.ox.ac.uk/birth-after-previous-caesarean*

Kathryn Fitzpatrick is funded by a National Institute for Health Research (NIHR) Doctoral Research Fellowship (DRF-2016-09-078) for this research project. This document presents independent research. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

Longer leaflet:

Planning how to give birth after previous caesarean section – information from three large studies

What are my options for birth after a previous caesarean section?

If you have had a baby before by caesarean section, you may be thinking about how to give birth in your next pregnancy.

You should be offered the opportunity to discuss whether to:



plan another birth by caesarean section

or

plan a vaginal birth

Planning another birth after caesarean is sometimes called an **Elective Repeat Caesarean Section** or **ERCS**. Planning a **Vaginal Birth After a Caesarean section** is sometimes called a **VBAC**.

Your individual circumstances may mean that you will be advised to have another caesarean section, for example, if your previous caesarean incision was 'classical', involving the upper part of your womb, or you have pregnancy complications such as low-lying placenta known as placenta praevia.

If planning a VBAC, you may be offered an induction of labour (where labour is started artificially). Induction of labour may be offered if your baby is overdue, if your labour doesn't start after your waters break or you or your baby has a health problem. More information about induction of labour if you have had a previous caesarean birth can be found in the first link provided at the end of this leaflet.

Information that may help you as you plan your next birth

The Royal College of Obstetricians and Gynaecologists and the National Institute for Health and Care Excellence (NICE) have produced information which you may find useful. Links to this information are provided at the end of this leaflet.

We have recently carried out new research and our findings, together with other information, may also help you as you plan your next birth.

We carried out three studies using data from Scotland. The studies compared a range of outcomes for mothers and their babies according to whether women planned a VBAC or planned another caesarean (ERCS). The studies were large, involving up to 74,043 women who gave birth to a single baby (not twins or more) in Scotland following a full-term pregnancy (37-41 weeks gestation) who had previously given birth by caesarean. We excluded women who had been advised for medical reasons not to plan a VBAC.

This leaflet provides a summary of the key findings from the studies.

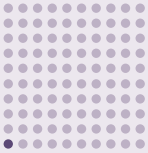
Key messages from the studies:

Whichever way you plan to give birth, birth after previous caesarean section is **generally very safe**.

Out of 10 women planning a VBAC, **7 gave birth vaginally** and **3 had an unplanned caesarean section** when they were in labour. In this situation the caesarean section may have to be carried out urgently and be a different experience to a planned caesarean. The most common reasons for an unplanned caesarean section during labour is that the labour progresses too slowly or there are concerns about the wellbeing of the baby.

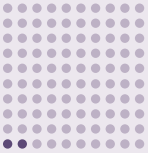


Planned VBAC compared to ERCS **increased** the chance of the mother having various **birth-related complications**. This is explained in more detail on pages 3 and 4. Most of the maternal birth-related complications occurred among the women who needed an unplanned caesarean section carried out during the course of a planned VBAC labour.



ERCS

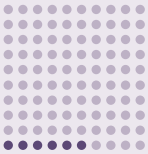
Nearly **1** in every **100** women having an ERCS experienced serious birth-related maternal complications (or 0.8%)



Planned VBAC

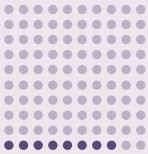
Nearly **2** in every **100** women planning a VBAC experienced serious birth-related maternal complications (or 1.8%)

Planned VBAC compared to ERCS **increased** the chance of the **baby** having various problems during or shortly after birth. This is explained in more detail on pages 5 and 6.



ERCS

Around **6** in every **100** babies born to women having an ERCS had one or more of a range of problems during or shortly after birth (or 6.4%)

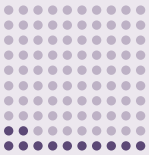


Planned VBAC

Around **8** in every **100** babies born to women planning a VBAC had one or more of a range of problems during or shortly after birth (or 8.0%)

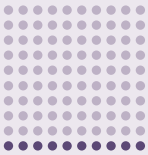
Women who planned a VBAC were **more likely** than women who had an ERCS to **breastfeed**.

Women who had an ERCS were **more likely** than women who planned a VBAC to be given **medication to treat mental health problems** in the year after they gave birth. However, this does not necessarily mean that mental health is better in the planned VBAC group, as not all women with mental health problems will seek treatment and not all mental health problems are treated with medication. This is explained in more detail on page 5.



ERCS

Around **12** in every **100** women having an ERCS were given any medication to treat mental health problems in the year after giving birth (or 12.3%)



Planned VBAC

Around **10** in every **100** women planning a VBAC were given any medication to treat mental health problems in the year after giving birth (or 10.0%)

Children born following planned VBAC compared to ERCS had a **similar** chance of having **special educational needs** - that is, learning difficulties or disabilities that make it harder for a child to learn compared to other children of the same age such as dyslexia.

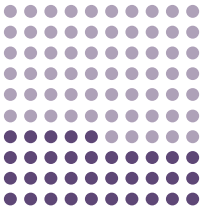
Outcomes for the mother

Birth after previous caesarean section is generally very safe, but occasionally problems can happen. Our research found that some problems or outcomes were more likely to happen depending on whether women planned a VBAC or an ERCS. These differences are explained below. Not all women will view all of these outcomes with the same importance.

You need to decide what is important to you as you make your decision about how to plan your birth.

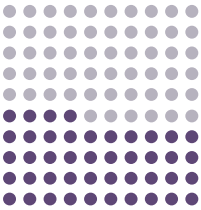
Breastfeeding

Our research found that women who planned a VBAC were more likely than women who had an ERCS to breastfeed. Our research does not allow us to explore the reasons for this. However, our findings suggest that women planning an ERCS might need additional support to breastfeed.



ERCS

Around **35** in every **100** women having an ERCS breastfed their baby (exclusively or mixed) at around 6-8 weeks after birth (or 35%)



Planned VBAC

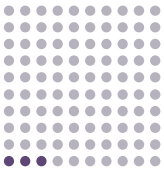
Around **44** in every **100** women planning a VBAC breastfed their baby (exclusively or mixed) at around 6-8 weeks after birth (or 44%)

Large perineal tear (third- or fourth-degree tears)

Giving birth vaginally can sometimes tear the perineum (the area between the vagina and the back passage or anus). Most of the time such tears are small, but they can be large and extend into the back passage/muscle that controls the anus. These larger tears, known as third- or fourth-degree tears, need an operation to repair. Most women make a good recovery and have no lasting complications. However, a small number of women will experience difficulty controlling their bladder or bowel. These women may need further treatment such as physiotherapy. Having an ERCS avoids the risk of having a third- or fourth-degree tear. However, if planning a VBAC, there are a number of things that may help to reduce the risk of having a tear such as perineal massage (see *https://www.rcog.org.uk/en/patients/tears/reducing-risk/* for more information).

ERCS

Not applicable

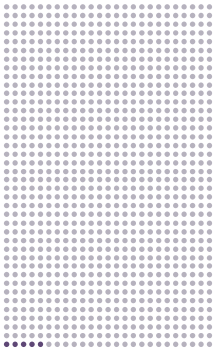


Planned VBAC

Around **3** in every **100** women planning a VBAC had a third- or fourth degree tear (or 2.9%)

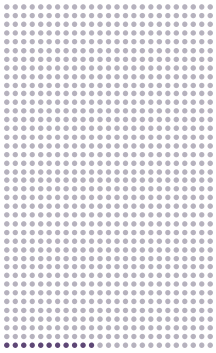
Blood transfusion

Our research found that the chance of the mother needing a blood transfusion was higher for women who planned a VBAC than for women who had an ERCS having taken into account important differences between the women.



ERCS

Around **5** in every **1,000** women having an ERCS needed a blood transfusion (or 0.5%)

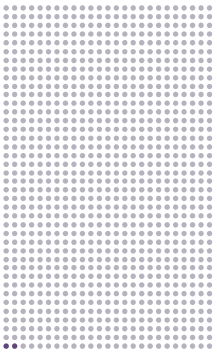


Planned VBAC

Around **11** in every **1,000** women planning a VBAC needed a blood transfusion (or 1.1%)

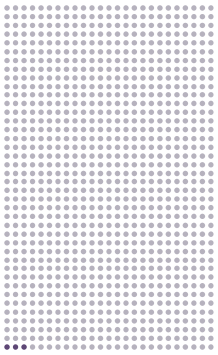
Serious infection

Our research found that the chance of the mother having a serious infection was uncommon but higher for women who planned a VBAC than for women who had an ERCS having taken into account important differences between the women.



ERCS

Nearly **2** in every **1,000** women having an ERCS had a serious infection (or 0.17%)

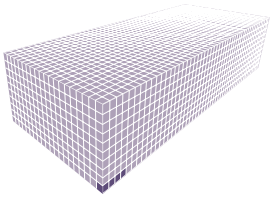


Planned VBAC

Nearly **3** in every **1,000** women planning a VBAC had a serious infection (or 0.27%)

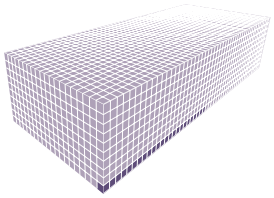
Rupture of the womb (uterus)

Rupture of the womb (uterus) is a rare but serious complication where the wall of the womb tears open. Our research found that the chance of the mother having womb rupture was rare but higher for women who planned a VBAC than for women who had an ERCS having taken into account important differences between the women.



ERCS

Around **4** in every **10,000** women having an ERCS had uterine rupture (or 0.04%)

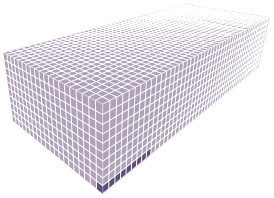


Planned VBAC

Around **24** in every **10,000** women planning a VBAC had uterine rupture (or 0.24%)

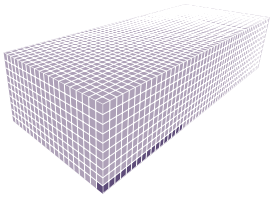
Surgical injury (damage to the bowel, bladder or ureter needing an operation to repair)

Surgical injury, defined as damage to a woman's bowel, bladder or the tube between the kidneys and bladder (ureter) needing an operation to repair, is a rare birth-related complication. Our research found that the chance of the mother having surgical injury was rare but higher for women who planned a VBAC than for women who had an ERCS having taken into account important differences between the women.



ERCS

Around **9** in every **10,000** women having an ERCS had surgical injury (or 0.09%)



Planned VBAC

Around **17** in every **10,000** women planning a VBAC had surgical injury (or 0.17%)

Length of hospital stay after birth

Our research found that the chance of the mother having to stay in hospital for more than 5 days after they gave birth varied according to whether she had any previous vaginal births and the number of previous caesarean sections she had:

Women planning a VBAC were **less** likely than those having an ERCS to have a hospital stay of more than 5 days after birth, but only if they had previously given birth vaginally.

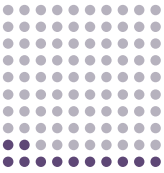
Women planning a VBAC were **more** likely than those having an ERCS to have a hospital stay of more than 5 days after birth if they had two or more previous caesarean sections , but not if they had only one previous caesarean section.

Use of medication to treat certain mental health problems

In the UK up to 1 in 5 women develop mental health problems during pregnancy or in the first year after childbirth. Mental health problems can include anxiety, depression, post-traumatic stress disorder or more rarely psychosis. Various treatments can be offered. Talking treatments, medication such as antidepressants or both talking treatments and medication are the most common types of treatment offered for anxiety or depression. Talking treatments are the main treatment offered for post-traumatic stress disorder and psychosis is usually treated with medication. We only had information on women's use of medication to treat mental health problems. Therefore, our research cannot say anything about mental health problems for which women did not seek treatment or mental health problems that were not treated with medication.

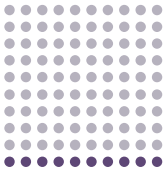
Our research found that women who had an ERCS were more likely than women who planned a VBAC to be given medication to treat mental health problems in the year after they gave birth having taken into account some important differences between the women such as whether they had a history of being given medication to treat mental health problems in the year before birth. Antidepressants were the most common type of medication, with around 1 in 10 women in our study given this medication in the year after they gave birth.

There are a number of possible reasons for our findings. Women who planned a VBAC might have been less likely than women who had an ERCS to seek treatment for mental health problems or might have been less likely to be treated with medication in the year after birth. Alternatively, women giving birth by ERCS might have been more likely to experience certain mental health problems requiring medication in the year after birth. However, this might not be related to having an ERCS. It could, for example, be the case that women who plan an ERCS are more likely to have a fear of childbirth or more anxious personalities that could on their own increase the chances of having mental health problems. More research is needed to understand this.



ERCS

Around **12** in every **100** women having an ERCS were given any medication to treat mental health problems in the year after giving birth (or 12.3%)



Planned VBAC

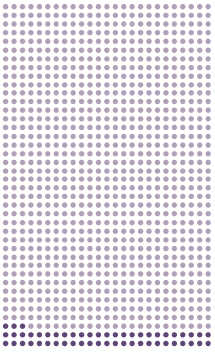
Around **10** in every **100** women planning a VBAC were given any medication to treat mental health problems in the year after giving birth (or 10.0%)

Outcomes for the baby/child

The diagrams below show outcomes for the baby/child according to how women planned to give birth after a previous caesarean section.

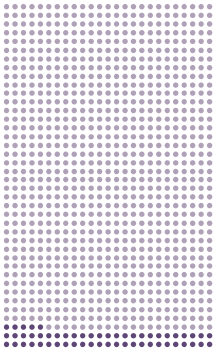
Admission of the baby to a neonatal unit

Sometimes a baby will need to be admitted to a specialist newborn (neonatal) unit for extra care after they are born. Babies can be admitted to a neonatal unit for a number of reasons, such as when they have an infection or a difficult birth. Most babies born after a full-term pregnancy (37-41 weeks gestation) will not need care in a neonatal unit, but for those who do, most will only need a few days of extra care. Our research found that the chance of the baby being admitted to a neonatal unit was slightly higher for women who planned a VBAC than for women who had an ERCS.



ERCS

Around **53** in every **1,000** babies having an ERCS were admitted to a neonatal unit (or 5.3%)

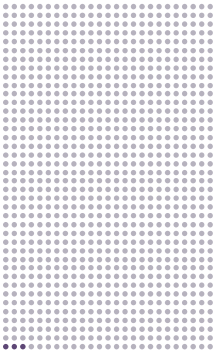


Planned VBAC

Around **55** in every **1,000** babies planning a VBAC were admitted to a neonatal unit (or 5.5%)

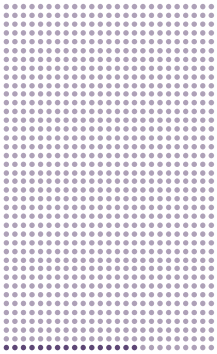
Medicine or equipment to help with breathing immediately after birth

Occasionally a baby will need medicine or equipment to help with breathing. Our research found that the chance of this happening was higher for babies born to women who planned a VBAC than for those born to women who had an ERCS having taken into account important differences between the women and their babies.



ERCS

Around **3** in every **1,000** babies born to women having an ERCS needed medicine or equipment to help with breathing immediately after birth (or 0.3%)

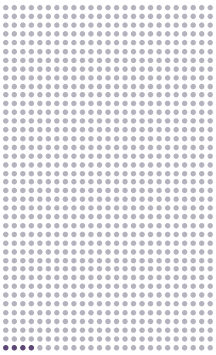


Planned VBAC

Around **16** in every **1,000** babies born to women planning a VBAC needed medicine or equipment to help with breathing immediately after birth (or 1.6%)

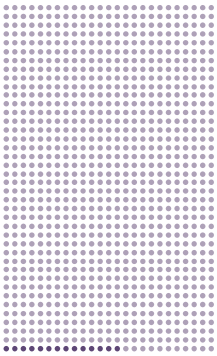
Low Apgar score at 5 minutes after birth

The Apgar score is a way of quickly assessing the health of a baby shortly after birth. It can help medical staff to decide if your baby needs extra care. A score of 7 or more out of 10 at 5 minutes after birth is considered normal. A score of less than 7 at 5 minutes after birth is considered as low, and may indicate that your baby needs extra care. Our research found that the chance of the baby having a low Apgar score (less than 7) at 5 minutes after birth was higher for women who planned a VBAC than for women who had an ERCS having taken into account important differences between the women and their babies.



ERCS

Around **4** in every **1,000** babies born to women having an ERCS had a low Apgar score at 5 minutes after birth (or 0.4%)

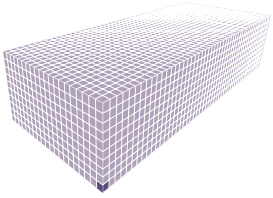


Planned VBAC

Around **14** in every **1,000** babies born to women planning a VBAC had a low Apgar score at 5 minutes after birth (or 1.4%)

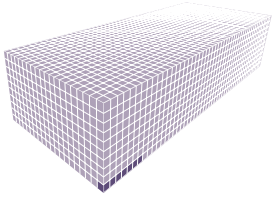
Intrapartum stillbirth or neonatal death

Very occasionally babies can die during birth or shortly after birth. Our research found that the chance of this happening was rare whichever way you plan to give birth, but was higher for babies born to women who planned a VBAC compared to an ERCS. For women who planned a VBAC, the chance of their baby dying during birth or shortly after birth was around the same as if they were having their first baby.



ERCS

Around **1** in every **10,000** babies born to women having an ERCS died during or shortly after birth (or 0.01%)

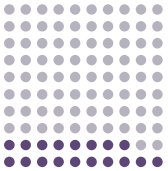


Planned VBAC

Around **7** in every **10,000** babies born to women planning a VBAC died during or shortly after birth (or 0.07%)

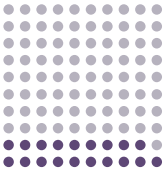
Special educational needs in childhood

The term 'special educational needs' is used to describe learning difficulties or disabilities that make it harder for a child to learn compared to other children of the same age. Our research found that children born following planned VBAC had a similar chance of having any special educational needs or specific types of special educational needs (e.g. dyslexia) to those born by ERCS.



ERCS

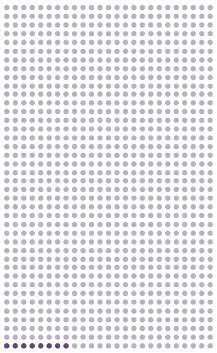
Around **18** in every **100** children born by ERCS had any record of special educational needs when they were aged 4-11 years (or 17.6%)



Planned VBAC

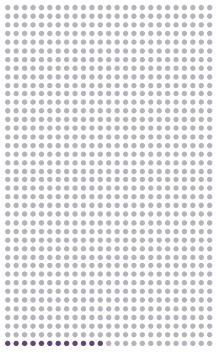
Around **19** in every **100** children born following planned VBAC had any record of special educational needs when they were aged 4-11 years (or 19.2%)

Our research also suggests that children born following planned VBAC with or without labour induction (where labour is started artificially) compared to ERCS had a similar chance of having any special educational needs or most types of special educational needs. However, children born following planned VBAC where labour was induced were more likely than those born by ERCS to have a sensory impairment (a problem with their hearing and/or sight).



ERCS

Around **8** in every **1,000** children born by ERCS had a sensory impairment (or 0.78%)



Planned VBAC with labour induction

Around **12** in every **1,000** children born following planned VBAC with labour induction had a sensory impairment (or 1.18%)

Other factors you may wish to consider

Our research may not include all the information that is important for you as you make this decision. For example, you might wish to consider how many more children you may want to have, as **the chances of having serious complications in future pregnancies increases with each caesarean** section (see below for link to leaflets from the Royal College of Obstetricians and Gynaecologists for more information).

A number of factors are thought to reduce a woman's risk of experiencing some of the complications associated with planned VBAC. For instance, if you have had a previous vaginal birth or your caesarean was over a year ago, your risks of some of the complications of planned VBAC are likely to be lower than average. You may want to discuss this with your doctors or midwife.

There are somethings we were not able to look at in our research that may have influenced outcomes for mothers or their babies. For example, we did not have information about the reason for a woman's previous caesarean section(s).

Most women in our studies had one or two previous births. Our findings may therefore not apply to women who have had a larger number of previous births, particularly if they have had a large number of previous caesareans.

More information

- The Royal College of Obstetricians and Gynaecologists has produced information leaflets on
  - the options for birth for women who have already had a caesarean birth:

    https://bit.ly/2TR3gDt
  - having a planned caesarean section:

    https://bit.ly/3gRwwlw
- The National Institute for Health and Care Excellence (NICE) has produced guidance on having a caesarean section:

  https://www.nice.org.uk/guidance/ng192/resources/caesarean-birth-pdf-66142078788805
- You can listen to women share their experiences of making decisions about birth after previous caesarean:

  https://healthtalk.org/making-decisions-about-birth-after-caesarean/overview
- You can discuss your options for birth further with your doctor or midwife.
- Other sources of support:

  https://maternalmentalhealthalliance.org/resources/mums-and-families/

This document was written by Kathryn Fitzpatrick (NPEU) with input from Charlotte Bevan and Rachel Plachcinski (Co-leads on Parent, Patient and Public Involvement at the NIHR Policy Research Unit in Maternal and Neonatal Health and Care – PRU-MNHC); Hannah Bissett (Maternal Mental Health Alliance – MMHA); Elizabeth Duff (NCT); Jenny Kurinczuk (NPEU); Maria Quigley (NPEU); and Maureen Treadwell (Birth Trauma Association).

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