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The Cascade of Intervention:

Labour Induction and Caesarean Section in the United Kingdom

by

Sarah Anne Carter

Thesis for the degree of Doctor of Philosophy

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ABSTRACT

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Labour induction and caesarean section are childbirth interventions experienced by a growing number of women globally each year. These two medical procedures are often linked in maternal health literature through the cascade of interventions, an intervention pathway defined by labour induction at the start of birth and operative delivery at the end. While the maternal indicators of labour induction have been well documented in countries such as the United States, considerably less research has been done into which women have a higher likelihood of labour induction in the United Kingdom, and how the risk of labour induction is associated with operative delivery in the UK. This project examines the maternal risk factors of labour induction in the United Kingdom and how these indicators are related to the likelihood of operative delivery, using data from the Millennium Cohort Study.

The thesis first uses logistic regression to explore which maternal characteristics are associated with labour induction in the United Kingdom, and determines that maternal educational qualifications and the deprivation of a woman's electoral ward have significant associations with likelihood of labour induction. In the second analysis chapter, this project examines health care context by utilizing multilevel logistic regression to analyse if risk of labour induction varies by NHS Trust. Results from these analyses determine that risk of labour induction does vary by NHS Trust, the influence of maternal educational qualifications on labour induction risk varies by NHS Trust, and country of NHS Trust is a significant predictor of labour induction. Finally, in order to better understand how the cascade of intervention operates in the United Kingdom, the third analysis investigates the link between labour induction and type of delivery using multinomial logistic regression and KHB mediation analysis. This analysis finds that women who are induced are more likely to experience operative delivery, and that this relationship is mediated by epidural anaesthesia. Additionally, maternal height moderates the associations between labour induction, epidural, and delivery type, such that women between 1.60 and 1.69 metres tall are more at risk of operative delivery after labour induction and epidural than women at shorter or taller heights.

This project finds that maternal demographic and socioeconomic indicators influence the risk of labour induction, and that the association between labour induction and operative delivery can be mediated by epidural anaesthesia and moderated by maternal height, within the health care context of the United Kingdom. Determining which women are more likely to experience labour induction and operative delivery in the UK can allow women to make more informed choices about their health care and can help support efforts to provide women with individualized, patient-centred care during their labours and births.

Table of Contents

Table of Tables

Table of Figures

Table of Figures

Academic Thesis: Declaration Of Authorship

I, Sarah Carter, declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

The Cascade of Intervention: Labour Induction and Caesarean Section in the United Kingdom

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission

Signed: ....

Date: ....

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And to Fionn. I love you the most.

Definitions and Abbreviations

NHS	National Health Service
MCS	Millennium Cohort Study
ARM	Artificial Rupture of Membranes
EFM	Electronic Foetal Monitoring
SES	Socioeconomic Status
BMI	Body Mass Index
CPD	Cephalopelvic Disproportion
VBAC	Vaginal Birth after Caesarean
RCOG	Royal College of Obstetricians and Gynaecologists
NICE	National Institute for Health and Care Excellence

Chapter 1 Introduction

Induction of labour, the artificial stimulation of labour, is a childbirth intervention on the rise in the United Kingdom (Department of Health 1988; MacKenzie 2006; Moore et al 2012; CDC.org 2013; ONS 2014; WHO 2018). Used in an effort to begin labours and hasten births, labour induction is often the first childbirth intervention experienced by pregnant women. While labour induction is conceived of as a way to address potentially life-threatening conditions in pregnancy (Koopmans et al 2009; Gulmezoglu et al 2012; Boulvain et al 2015; Smid 2015), inductions themselves are not without risks. Labour induction has been linked to the "cascade of intervention," which refers to the many procedures, including epidural anaesthesia, electronic foetal monitoring, and the use of forceps or ventouse extraction, women may undergo throughout labour and birth (Simpson & Thorman 2005). These compounding interventions can increase health risks to both mother and child, including the risk of caesarean section, a major, often emergency, abdominal surgery viewed as the end of the cascade of intervention (Yudkin et al 1979; Bassett 1996; Dublin 2000; Johanson 2002; Spong et al 2012).

While much recent medical and social research into childbirth has focused on the rising rates of caesarean section, the established link between labour induction and operative delivery, defined in this project as assisted vaginal deliveries and caesarean section, make it a relevant outcome in its own right in the study of maternal and infant health (Yudkin et al 1979; Dublin et al 2000; MacDorman et al 2002; Heffner et al 2003; Simpson & Thorman 2005; Vahratian et al 2005; Christilaw 2006; Betran et al 2007; Wilson 2007; Wilson et al 2010; Moore 2012; Smid et al 2015). After all, in addition to often being the first intervention some women experience during their labours and a potential motivator for rising rates of caesarean section, labour induction is a medical procedure not without its own risks, which can include uterine rupture (Hofmeyr 1999). Bearing that in mind, this project seeks to better understand the maternal indicators that influence the risk of labour induction in the United Kingdom.

As studies have shown that maternal socioeconomic inequalities can influence the risk of caesarean section in high-income countries (Coonrod et al 2000; MacDorman et al 2002; Luthy et al 2004; Leeb et al 2005; Wilson 2007; Wilson et al 2010; Fairley et al 2011; Roth & Henley 2012; Essex et al 2013; Raisanen et al 2014), this thesis examines the socioeconomic and demographic indicators of labour induction in an attempt to determine whether these indicators mirror those associated with caesarean sections. Additionally, much of the published literature on labour induction comes out of the United States, a country in which health care is financed through private health insurance. Therefore, another motivation of the present research is to examine socioeconomic and demographic indicators for labour induction in the context of universal health care coverage in the UK, to determine if the relationships between these indicators and induction of labour in the United Kingdom differs from the associations previously reported. The socioeconomic indicators used throughout the thesis touch on both direct and indirect markers of socioeconomic status, ranging from maternal age, ethnicity, obesity, and education, to maternal feelings of agency and self-efficacy.

Additionally, there is evidence that maternal health care varies across the United Kingdom, and both UK-wide and country-specific reported rates of labour inductions may hide important distinctions in the numbers of inductions performed in different areas. Therefore, the research presented here aims to highlight differences in labour induction risk between NHS Trusts and countries in the United Kingdom (Bragg et al 2010; Gurol-Urganci et al 2011). This will be accomplished by examining how much of the variation in labour induction risk is explained by the NHS Trusts in which births take place.

Finally, given previous research on the demographic and biological indicators of labour induction and caesarean section (Mahmood et al 1989; Cammu et al 2002; Leighton & Halpern 2002; Prasad & al-Taher 2002; Kirchengast & Hartmann 2007; Spong et al 2012), this thesis explores the link between labour induction and operative delivery through a childbirth intervention pathway women might experience as their labours progress to births, and seeks to determine how this pathway is influenced by a woman's socioeconomic status, demographics, and height, as these indicators have been linked to the cascade of intervention in previous studies.

This project refocuses the discussion of childbirth intervention outcomes from caesarean section at the end of the cascade to labour induction at the beginning of the cascade. The aim of this refocussing is to better understand which women are at risk of labour induction, how this risk is influenced by where in the UK a woman receives health care, and how a woman's experience of labour induction is related to her risk of caesarean section.

1.1 Objectives

Using data from the Millennium Cohort Study, this project aims to explore labour induction by maternal demographics in varying contexts in the United Kingdom, and how these demographic indicators influence the association between labour induction and delivery type. One major objective of this study is to investigate which women are at greater risk of labour induction in the United Kingdom and how this risk is influenced by a woman's socioeconomic status, operationalized specifically by her household income quintile, housing tenure, occupation, marital status, and educational qualifications, and the deprivation of the electoral ward in which she lives.

Maternal demographic information such as age and ethnicity will be analysed along with socioeconomic and health variables including maternal body mass index (BMI) and pregnancy complications in order to highlight which women face increased risk of having their labours begun via induction.

Additionally, the present project aims to examine whether there are differences in risk of labour induction between NHS Trusts, and whether this risk varies for women according to their educational qualifications, using multilevel logistic regression. Determining if a woman's risk of induction of labour varies by the NHS Trust in which she gives birth could help highlight disparities in practice between health care providers and yield insight into which women have a higher likelihood of labour induction across contexts.

Finally, this study hopes to better understand the pathways through which labour induction can increase a woman's risk of caesarean section, by using multinomial logistic regression and KHB mediation analysis to define the relationship between labour induction, epidural anaesthesia, and type of delivery, and how this relationship could be moderated by maternal height, a biological indicator of caesarean section. A thorough exploration of how women in the UK move from labour induction at the start of their labours through to operative delivery and caesarean section for their births could help women and health care providers better understand the associations between childbirth interventions, thus providing women with more information with which to make health care decisions.

As mentioned above, most studies concerned with the association between maternal risk factors and childbirth intervention have looked at caesarean section as the outcome of interest. In an effort to determine if the associations between specific maternal indicators and labour induction are the same as those between maternal indicators and operative delivery, ultimately the objective of this thesis is to investigate which women are at greater risk of labour induction and how this induction risk impacts a woman's experience of other childbirth interventions.

1.2 Contribution to Knowledge

A significant amount of recent research into childbirth intervention and its impact on maternal and infant health has focused on the increasing rates of caesarean sections the world over. The research done on caesarean section has attempted to determine which women are at greater risk of caesarean section, and what characteristics of doctors and health care systems lend themselves to more operative deliveries. This focus on operative delivery is sensible, because, as it is a major abdominal surgery, it is a childbirth intervention which, if overused, can contribute to increases in maternal morbidity. However, at the same time there has been an increase in the use of caesarean section in countries like the United Kingdom, there has also been an increase in the induction of labour (Department of Health 1988; MacKenzie 2006; Moore et al 2012; CDC.org 2013; ONS 2014). This concurrent rise in the rates of both labour inductions and caesarean sections indicates that there may be a connection between the two interventions, with induction of labour potentially contributing to rising rates of caesarean sections, making labour induction an outcome of interest.

Comparatively far less research has examined the set of medical procedures that precede caesarean section, defined in this thesis as childbirth interventions. These childbirth interventions, including the administration of epidural anaesthesia and the use of electronic foetal monitoring, can contribute to some of the complications of labour that lead to caesarean sections, such as foetal distress or failure of labour to progress (Yudkin et al 1979; Dublin 2000; Simpson & Thorman 2005). Labour induction is perhaps the most consequential childbirth intervention, as it is often the first intervention pregnant women experience. Those women whose labours are induced can enter the cascade of intervention, through which their induction may require other interventions that may end in caesarean section (Dublin et al 2000; MacDorman et al 2002; Heffner et al 2003; Simpson & Thorman 2005; Vahratian et al 2005; Wilson 2007; Wilson et al 2010; Moore 2012).

Given public health interest in maternal health research addressing the increasing number of labour inductions and caesarean sections (WHO 2018) and the limited published literature concerning labour induction in the United Kingdom, this thesis' focus on indicators of induction risk has potential to contribute considerably to current knowledge. The analyses presented here seek to determine the indicators of labour induction in the United Kingdom. If the results of these analyses indicate that some groups of women undergo labour inductions significantly more frequently than other groups, it will serve as a confirmation of the importance of considering maternal demographics and socioeconomic indicators in the use of labour induction. These results may also help influence policy attempts to slow the increase in the use of childbirth interventions and prevent unnecessary maternal morbidities. For example, knowing that a woman's educational qualifications or household income has a significant relationship with her risk of labour induction could prompt those tasked with updating or creating childbirth guidelines to instruct health care providers to be particularly sensitive to those who fit certain risk profiles.

Additionally, the attempt in this thesis to highlight the influence of the NHS Trust in which a woman gives birth could have implications for health care policy and funding procedures in the United Kingdom. As of this writing in 2018, NHS Trusts are funded through a complex set of algorithms which take into account the deprivation of the area in which they are located, and midwives and obstetricians are advised to make medical information as available and accessible to their disadvantaged patients as possible, in an effort to assure equality of care (Hart & Lockey 2002). If the results of the analyses in this thesis suggest, for instance, that disadvantaged women undergo labour induction more frequently than their more advantaged counterparts in some NHS Trusts, this may indicate the need for better allocation of resources for prenatal screening or improved communication training for the medical professionals employed by the NHS.

The final goal of this thesis, to link the risk of labour induction to operative deliveries via pathways through the cascade of intervention, will contribute to the current discourse on childbirth intervention. If entry into the cascade of intervention is associated with maternal demographics or socioeconomic status, these results could help direct funding or provider education to the most beneficial areas. Outlining a link between labour induction and operative delivery in the United Kingdom could also serve to increase maternal and health care provider understanding of the risks associated with how one intervention could beget another, which, in turn, could help prevent unnecessary labour and birth complications. Using childbirth interventions and operative deliveries only when medically necessary would not only serve to improve maternal and infant health outcomes, but it would also reduce cost burdens on the National Health Service in the UK, as operative deliveries are generally more expensive than unassisted vaginal deliveries (Maslow & Sweeney 2000).

1.3 Organization of the thesis

As the analysis chapters of this thesis utilize the same data, the organization of the thesis seeks to be expedient and straightforward. Therefore, immediately following this introduction chapter (Chapter 1), Chapter 2 serves as a literature review and conceptual motivation for the three analysis chapters presented here, charting the rise of labour induction rates, providing explanations for this increase, and highlighting potential risk factors for mothers, such as maternal age, obesity, socioeconomic status, and health care system. This literature review also describes the relationship between labour induction and operative deliveries.

Chapter 3 details the Millennium Cohort Study (MCS), the dataset used throughout the thesis. In this chapter, the data collected in the MCS is outlined, and its sample design is discussed. In addition, potential limitations of using survey data are considered, and the ways in which the data are used in this project are detailed.

The three analysis chapters that follow are organized as individual papers, and each one includes a methodology section specific to its own analysis. Chapter 4, the first analysis chapter of the thesis, examines how a woman's socioeconomic status influences her risk of labour induction. In this chapter, socioeconomic status is operationalized via proxies such as maternal income, occupation, education, and local area deprivation. In an effort to highlight connections between socioeconomic status and labour induction risk, Chapter 4 uses nested logistic regression models to analyse how maternal socioeconomic factors and local area deprivation are associated with risk of induction and whether these associations are maintained after controlling for medical risk factors.

Chapter 5 builds on the results of the nested logistic regressions run in Chapter 4, and determines how the relationship between a woman's socioeconomic status and her risk of labour induction is influenced by the NHS Trust in which she gives birth. Chapter 5 aims to examine whether some variation in the risk of labour induction across the United Kingdom can be explained by differences between NHS Trusts. In order to do this, Chapter 5 uses multilevel models, with Level 1 set as each individual woman and Level 2 set as NHS Trust of birth. The models fit in Chapter 5 include the maternal and infant explanatory variables utilized in Chapter 4, with the addition of specific NHS Trust explanatory variables.

Chapter 6 is the final analysis chapter of the thesis, and concerns the cascade of interventions described above. This last analysis chapter seeks to both describe a pathway through which labour induction leads women to operative and caesarean section deliveries in the United Kingdom and understand how this pathway is moderated by maternal height, after adjusting for maternal socioeconomic, demographic, and health indicators. By testing the statistical significance of the association between labour induction and type of delivery using multinomial logistic regression and the mediating influence of epidural on this relationship using KHB mediation analysis, Chapter 6 will determine which women are at greater risk of entering and completing the cascade of intervention.

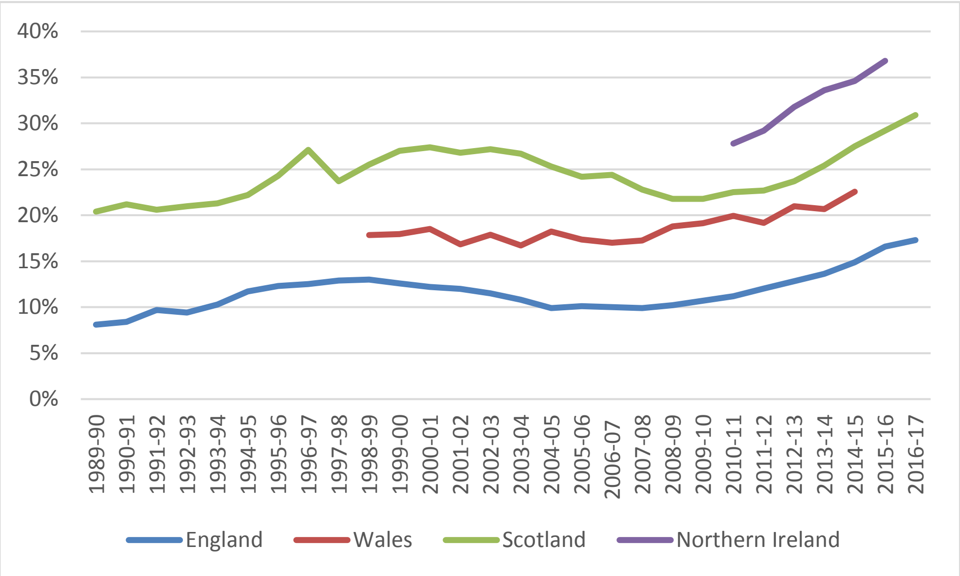
Finally, Chapter 7 serves as a conclusion to the thesis, tying together themes explored both in the literature review and the analysis chapters. This final chapter also discusses limitations faced in the analyses conducted in this project and suggests avenues for future research into childbirth intervention in the United Kingdom.

Chapter 2 Literature Review

2.1 Introduction

Labour induction is "the initiation of uterine contractions for the purpose of birth before the spontaneous onset of labour" (Bonsack et al 2014, p. 606). This initiation of contractions can be performed either manually, through membrane rupture or cervical (Foley) balloon insertion, or with the use of drugs such as misoprostol (vaginally or orally) or intravenous oxytocin (Hofmeyr et al 1999; Kelly & Tan 2001; Esakoff & Kilpatrick 2013). Labour inductions were once reserved for high risk pregnancies or those lasting far longer than full term at 40 weeks, but in 2016, 29.4% of labours in the United Kingdom began as inductions, with the rate of induction continuing to rise (Smid et al 2015; NHS Digital 2017). Figure 2.1 below displays the changing rates of induction in England, Wales, Scotland, and Northern Ireland over the past 30 years. While these rates have fluctuated over time, they have been increasing since 1990 and are currently on the rise. Labour induction, then, is a medical procedure of importance to a growing number of UK women every year.

Figure 2.1: Percentage of Labours Medically Induced in the United Kingdom, 1989-2017[ab]



[a]Data concern medical inductions (via intravenous medication), not total number of inductions
[b]Data from years before 2010 were unavailable for Northern Ireland

Source: NHS Digital, NHS Maternity Statistics, 2016-2017, Health and Social Care Information Centre; Maternity Statistics, Wales, National Assembly for Wales; SMR02 ISD Scotland; Department of Health Statistics, Northern Ireland

As this thesis is an attempt to determine which women are more likely to experience an induction in the United Kingdom, the present chapter examines previously published literature concerning labour induction to outline what is already known about the induction of labour and to provide conceptual justification for the quantitative analyses presented in the following chapters. First, this chapter will detail the many indicators for labour induction, both medical and non-medical, and discuss how these indicators can be influenced by a woman's socioeconomic status. Examining these indicators is necessary in order to understand labour induction and its relationship to other childbirth interventions, a connection which will be explored in the second section of this chapter. This connection is vital, as labour induction and its link to the cascade of interventions is a key motivation for the present research.

After reviewing the association between labour induction and subsequent interventions, advancing maternal age, maternal obesity, changing cultural attitudes, and the medicalization of health care will be highlighted as potential reasons for the increase in the use of labour induction and other childbirth interventions. Additionally, the links between modern health care and socioeconomic status – most crucially, the health inequalities born out of differences in wealth – are presented. As much published research into risk factors for labour induction has been conducted in the United States, this chapter includes a brief discussion of how the health care system differences between the United States and the United Kingdom may result in disparities between the findings of this thesis and those reported in previous studies.

Finally, this chapter ends with a description of the conceptual framework driving the thesis, which ties together the literature and conceptual groundings considered below. This framework serves as a lens through which the analyses in Chapter 4, 5, and 6 can be viewed.

2.2 Pathways to Induction

Attempts to induce post-date labour have been made for hundreds of years in the United Kingdom, using myriad mechanical and non-mechanical (herbal or pharmaceutical) techniques. Historically, methods to induce labour were similar or identical to those used to cause abortions, as in both inductions and abortions, the aim is to begin uterine contractions. Therefore, strenuous activity, the insertion of objects into the uterus, and the use of purgatives were common practices employed to jump start labour (Oakley 1983). In medieval England, labour inductions were performed by inserting iris root into the uterus or plastering a pregnant belly with paste made from artemsia, and by 1794, Denman's "An Introduction to the Practice of Midwifery" outlined the first instance of successful artificial rupture of the membranes (ARM), in which a mechanical labour induction led to the delivery of a live full term infant. Throughout the nineteenth and early twentieth centuries, various devices for dilating the cervix were utilized, including rubber bougies and animal bladders of different sizes, and abortifacients such as ergot and quinine were popular in the early 1900s in both the UK and the US, until an increase in the number of stillbirths led to the discontinuation of their use (Oakley 1983).

Thus, as sociologist Ann Oakley writes, “none of the three main modern methods of inducing labour (ARM, drugs, and mechanical dilation of the cervix) are recent innovations” (Oakley 1983, page 195). However, modern labour induction, as defined by the use of intravenous Pitocin, can be traced back to 1906, when Sir Henry Dale documented an in vitro oxytocic called posterior pituitary extract. A paper by Blair Bell, published in the British Medical Journal in 1909, suggested applying this posterior pituitary extract to the pregnant uterus to induce contractions, and beginning in the early 1900s, this posterior pituitary extract was administered to pregnant women by mouth, nose, under the skin, via the rectum, by intramuscular injection (later abandoned for increasing the risk of maternal death), and eventually, in the 1940s, intravenously. Intravenous oxytocin was heralded for its ability to mimic natural oxytocin and for enabling care providers to stop the drip of the drug at any time. Labour induction was further revolutionized in the 1960s with the invention of titration of oxytocic drugs, which allowed doctors to begin with a low dose and increase the amounts at brief intervals in order to establish regular, strong contractions.

Interestingly, since the introduction of intravenous oxytocic drugs in the 1940s and 1950s, as the use of Pitocin increased, rates of caesarean section also increased in the UK and the US. This is consistent with the idea that there may be a relationship between the medical indicators of labour induction and the use of caesarean section, which ties into one of the motivations for the current project. In order to begin this investigation into labour induction, modern indications for induction will be considered. For the purposes of this study, indicators are classed as medical if they are health factors which can contribute directly to an induction and non-medical if they are maternal characteristics less directly related to health, but which have also been found to be associated with increased risk of labour induction. It is of course possible that a non-medical maternal characteristic could be related to a medical indicator, but in order to clearly define them, they are treated separately in the following sections. Viewing indicators of labour induction as either medical or non-medical is also important to the present study because much of the existing research into labour induction risk has been conducted in the United States, where non-medical indicators such as proxies of socioeconomic status may have different associations with childbirth interventions like labour induction when considered in the United Kingdom.

2.2.1 Medically Indicated Induction

One of the most common medical indications for labour induction is a post-term pregnancy, which occurs when spontaneous labour does not begin on or after 40 completed weeks of pregnancy. In these post-term pregnancies, labour induction is employed in an effort to prevent macrosomia (birth weight equal to or above 4.5kg), meconium aspiration syndrome (which occurs when stool enters foetal lungs), and perinatal death, complications with risks that increase the longer a pregnancy continues after 40 weeks gestation (Gulmezoglu et al 2012; Campbell 2014). Other common medical indications for labour induction include maternal diabetes, maternal obesity, maternal heart disease, preeclampsia, hypertension, foetal growth restriction, and preterm rupture of the membranes (Moore & Low 2012; Bonsack et al 2014). Maternal diabetes, obesity, and heart disease are risk factors for more acutely life threatening conditions like preeclampsia and hypertension, which can necessitate the immediate delivery of a foetus. Studies in high-income countries have shown that medically indicated labour inductions improve maternal and infant birth outcomes (Smid 2015). Benefits of labour induction have been reported in cases of suspected macrosomia and in women with gestational hypertension, and labour induction has been found to reduce the rate of meconium aspiration in infants around 41 weeks gestation (Koopmans et al 2009; Gulmezoglu et al 2012; Boulvain et al 2015).

Several maternal characteristics have been associated with these medical indications for induction of labour. A woman's age, for example, is a key factor in her experience of childbirth intervention. While older women may be more self-confident, educated, and economically stable, granting them access to more complete, better quality care, and allowing them to make more informed decisions about their health care, older women (those over thirty five years old) also have more health problems than younger women, making them more vulnerable to health complications in pregnancy, such as diabetes, heart disease, and hypertension, leading to interventions (Heffner et al 2003; Buescher & Mittal 2006; Wilson 2007). Also influential is maternal BMI, as maternal obesity (and in some cases, maternal underweight) can influence not only maternal health during pregnancy (as obesity is linked to gestational diabetes, pre-eclampsia, and hypertension), but also predicted infant birth weight and macrosomia, clear indications for labour induction (Sebire et al 2001; Dempsey et al 2005; Siega-Riz & Laraia 2006; Denison et al 2008). Additionally, maternal smoking behaviour is often included in studies of pregnancy and birth because smoking in pregnancy can lead to foetal growth restriction. This is of interest to the present research as growth restriction is a medical indication for labour induction (Matijasevich et al 2012). Interestingly, labour induction performed due to concern over a growth restricted foetus will be likely be undertaken before a pregnancy goes post-term, and the infant born may be underweight. Smoking in pregnancy, then, can lead to babies with birth weights on the opposite side of the spectrum from those with macrosomia, but can necessitate induction just the same.

Labour induction has also been linked to traits of the infant shortly before birth. Infant birth weight is a crucial indicator of induction due to the association of infant macrosomia with the induction of labour. Women pregnant with babies who are predicted to be large are sometimes encouraged to have their labours induced before full term in an effort to prevent cephalopelvic disproportion (CPD), a labour complication defined by a baby's head (or body) being too large to pass through the mother's pelvis during birth (O'Driscoll et al 1970; Glantz 2005; Cheng et al 2006). Predicted macrosomia, or larger than average infant size/weight, is a common reason labour inductions are performed. This is, however, a controversial indicator, as macrosomia is often predicted using ultrasound technology, which has a margin of error of +/- 10% in estimating foetal weight (Gherman et al 2006; Francis et al 2011). Furthermore, an infant's gestational age can be a risk factor for labour induction, as the longer a pregnancy goes post-term, the greater the chances a labour will be induced in an effort to protect the foetus from complications associated with late term pregnancies, such as low amniotic fluid (Caughey et al 2009). Conversely, the younger the foetus is, the less likely it is to be born following an induction of labour, as, barring complications, efforts are made to maintain pregnancies until at least 37 weeks.

Previous research into the risk of labour induction has identified parity as an important risk factor for induction of labour. Nulliparous women, those who are experiencing their first pregnancies and births, are at greater risk of induction than multiparous women, those who have had other children (Seyb et al 1999; Cammu et al 2002; Simpson et al 2005). Potential reasons for this difference in induction risk may be that first pregnancies can last longer and go post-term more often and often progress more slowly, both of which are medical indications for labour induction (Kolas et al 2003). This research also indicates that the relationship between labour induction and operative delivery can be influenced by parity. Nulliparous women are at much higher risk of assisted vaginal delivery and caesarean section after induction than are multiparous woman, potentially due to first labours and births being longer and more difficult than subsequent labours and births (Yeast et al 1999; Maslow & Sweeney 2000; Heffner et al 2003; Luthy et al 2004; Wilson 2007). Thus, an increase in the use of induction in nulliparous women might be an explanation for the rise in primary caesarean section deliveries (Wilson et al 2010). Parity is also cited as an influence on labour induction in a study by Humphrey and Tucker (2009), which reports that women who have had inductions in past labours tend to undergo inductions in subsequent labours, an association that remained significant even after controlling for maternal health conditions.

Interestingly, although post-term pregnancy is the one of the most salient medical indications for induction, as the rate of induction in general has increased, the rate of post-term induction has fallen. As the number of post-term inductions has decreased, the rate of induction at term has risen. According to MacDorman et al in 2002, post-term inductions in the United States fell from 19.2% in 1989 to 9.2% in 1998, and the rate of inductions at term rose from 73.4% in 1989 to 82.8% in 1998. Additionally, evidence suggests that rates of labour induction are increasing more quickly than rates of pregnancy complication, which implies that this rise in induction can be partially explained by an increase in potentially medically unnecessary inductions (Caughey et al 2009).

2.2.2 Non-Medically Indicated Labour Induction

Research indicates that two-thirds of inductions in the United States occur without medical indication (Ramsey et al 2000; Simpson & Atterbury 2003). Thus, there are several non-medical indications for labour induction, many of which lead to what the literature calls "elective inductions"; namely, labour inductions that are not medically indicated. One analysis of inductions and spontaneous labours in the United Kingdom found that over 25% of the inductions studied could not be explained by the maternal demographic, economic, and health factors included in the models (Humphrey & Tucker 2009). The authors of that analysis concluded that there must be other influences at work, such as patient choice or clinician preference. Following on from Humphrey and Tucker's conclusions, it is important to outline what non-medical maternal traits may be associated with a woman's childbirth experience.

The paper by Humphrey & Tucker (2009) cited above is one of the only studies available that examines maternal indicators for labour induction in the United Kingdom, controlling for some of the socioeconomic and demographic maternal characteristics discussed in detail below. However, while this paper explores some social indicators (maternal age, BMI, marital status, social class, and parity) and adds to the literature citing BMI and parity as important maternal indicators of labour induction, other demographic indicators (such as maternal ethnicity) and markers of socioeconomic status (maternal income quintile and educational qualifications) are not included in the models. Additionally, maternal age, marital status, and social class are excluded from multivariate analyses as they were determined to be insignificant in Chi-square tests of their relationships with labour induction. While a woman's location in Aberdeen is used as a proxy for her proximity and travel time to the hospital, because the data used by Humphrey & Tucker were collected from one university hospital in Aberdeen, Scotland, this study also does not take into account many contextual influences of local area, NHS Trust, or UK country. The present thesis hopes to build on the information provided by Humphrey and Tucker and help further detail the maternal indicators that increase the likelihood of labour induction in the United Kingdom and how they may vary by context.

According to the literature (including Humphrey and Tucker 2009), a woman's cultural background, education, location, and socioeconomic status may influence her risk of both labour induction specifically and childbirth intervention more broadly. Research in several countries has shown that women who are immigrants are at lower risk of caesarean section, due in part to the protective nature of being from countries in which operative deliveries are less common (Blumenshine et al 2010). However, for women who are not immigrants, but who are ethnic minorities in the countries in which they live, rates of intervention can often be higher, as these women often live in less advantaged places with decreased access to care. This leaves some women in disadvantaged places more vulnerable to health problems and less able to address them. Conversely, research from the United States indicates that women who are college-educated, white, and covered by commercial health insurance are the most likely to have their labours induced (MacDorman et al 2002; Wilson et al 2010). One explanation for this is that more comprehensive, private insurance allows them not only greater access medical interventions, but also the ability to make more choices about those interventions. This autonomy in health care decision making may be bolstered by a woman's educational attainment.

A woman's educational qualifications could impact her health in several ways, as a woman with more qualifications may have greater resources, both personally and professionally, with which to make choices about her health care. The most direct way in which educational attainment can work on health is through income, which can influence a women's diet, housing, and environment (Adler 2002). Additionally, a mother with higher levels of education may have both the information and the confidence required to challenge health care decisions made by her doctors. Furthermore, simply by virtue of the amount of time required to gain qualifications, educated mothers tend to be older, which could contribute their enhanced heath decision-making. In the United Kingdom, "compared with those with no secondary education, individuals attaining at least A-levels have an approximately 1.3 percentage point higher probability of reporting excellent health. This result…suggests that inequalities in education may be key determinants of health inequalities" (Diaz 2009).

Indeed, studies from the United States and Norway have reported that women with higher education experience less childbirth interventions and fewer adverse birth outcomes than women with lower levels of education (Tollånes et al 2007; Nepomnyaschy 2009; Stoll and Hall 2012). A study by Cammu et al (2011) found that maternal education had a large influence on the use of childbirth interventions in Flanders, Northern Belgium; all childbirth interventions, including labour induction, became less frequent as maternal education increased. This educational gradient in the risk of labour induction was evident until 41 weeks gestation, and a greater risk of labour induction contributed to “women in the low educational group being about 30% more likely to give birth before 39 weeks than those with the highest education” (Cammu et al 2011, page 194).

Given the associations found for cultural backgrounds and education, it is perhaps not surprising that marital status, another sociodemographic marker for women, may also be related to childbirth intervention. Research suggests that women who have experienced a divorce or who have been widowed are at greater disadvantage than women who are single or still in committed relationships, and that legal marital status influences the risk of adverse birth outcomes, with women who are single, divorced, or widowed facing more adverse outcomes than women who are legally married (Shah et al 2010). A potential explanation for this is that a change in relationship status is often accompanied by a change in socioeconomic status that can be abrupt and perhaps unexpected. Another explanation is that the trauma of divorce or the death of a spouse can have devastating effects on mental and physical health. Additionally, studies linking marital status and birth outcomes posit that the association between single or cohabiting mothers and poorer birth outcomes could be due to relationship instability, higher levels of risk behaviour, and the social stigmatization of these single or unmarried mothers (Shah et al 2010).

Finally, inductions can be performed for reasons entirely outside a woman’s control. More specifically, an induction that is not medically indicated may be performed as a result of the cost effectiveness of induction. Studies evaluating the monetary benefits of labour induction tend to compare induced labours with pregnancies that are “expectantly managed.” Expectant management involves the serial monitoring of a pregnancy after it has been deemed post-term, with pregnant women undergoing non-stress tests and ultrasound examinations up to three times a week until their babies are born. As both labour induction and expectant management are medical interventions, they are seen as a more appropriate comparison than induction and spontaneous labour, which is not a medical intervention (Kaufman et al 2002). In a 1995 Canadian study juxtaposing the cost of induction with the cost of expectant management in post-term pregnancies, Goeree et al found that induction is a more cost effective technique. Conversely, in 2002, Kaufman et al used a decision-tree model and Markov analysis to determine that inductions were more costly than expectantly managed labours, most specifically those experienced by nulliparous women with unfavourable cervices during the 39th week of pregnancy (or, before the pregnancy is post-term). It is of interest to this project that much of the excess cost associated with induction over expectant management was found to be the result of the increased rate of caesarean section deliveries associated with induced labours. This is a result echoed in a paper by Wilson in 2007, which states that induced labours resulting in caesarean sections are significantly more costly than spontaneous labours or scheduled caesarean deliveries (Wilson 2007). In comparison with spontaneous labour, elective inductions have been found to 17.4% more costly, and medically-indicated inductions can be up to 29.1% more expensive (Seyb et al 1999). Inductions may be more costly even if they do not result in caesarean deliveries, as they require increased use of hospital materials and resources and are associated with longer hospital stays than spontaneous vaginal births (Maslow and Sweeny 2000).

Table 2.1: Medical and Non-Medical Indications for Labour Induction

Medical indications for labour induction	**Non-medical indications for labour induction**
Post-term pregnancy (40+ weeks gestation)	Maternal age
Maternal diabetes	Maternal ethnicity
Maternal obesity	Maternal socioeconomic status
Maternal heart disease	Maternal educational qualifications
Pre-eclampsia	Maternal marital status
Hypertension	
Foetal growth restriction	
Pre-term rupture of the membranes	

Table 2.1 above displays the medical and non-medical indications for labour induction as detailed by Sections 2.2.1 and 2.2.2. It is important to note that the definition of post-term pregnancy as a medical indication for labour induction is dependent on a health care practitioner’s interpretation of when a woman’s pregnancy is post-term. The interpretation of what is post-term can vary from 39 weeks to 42 weeks (Treger et al 2009).

The association of labour induction and subsequent childbirth interventions with maternal indicators, both medical and non-medical, motivates the present study. Labour induction has an established association with assisted vaginal delivery and caesarean section, even in studies that control for medical indications for intervention. Because this project is concerned, in part, with labour induction as a gateway to operative delivery, it is important to detail the indications for and implications of labour inductions, assisted vaginal deliveries, and caesarean sections. In order to understand the relationship between labour induction and operative delivery, it is necessary to discuss the mechanisms of operative delivery, which are outlined in the following section.

2.3 Indications for Operative Delivery

In the present study, operative delivery is defined as a birth that is not a spontaneous, unassisted vaginal delivery. This definition includes both caesarean section deliveries and those vaginal deliveries assisted by the use of forceps, ventouse, or episiotomy. This section will detail the medical indications for operative deliveries, beginning with why assisted vaginal deliveries may occur and moving on to the medical reasons for caesarean section.

Assisted vaginal deliveries - those utilizing forceps, ventouse extraction, or episiotomy to speed the vaginal delivery of a foetus - are a form of operative delivery that is often placed in contrast to caesarean section. As Spong et al (2012), write, "higher rates of operative vaginal delivery are often associated with lower caesarean delivery rates, and vice versa" (Spong et al 2012, page 7). Assisted vaginal deliveries allow women to give birth vaginally and avoid surgical theatre, which sets them apart from caesarean sections. The most commonly utilized assisted vaginal delivery technique is ventouse extraction, during which a small vacuum cup is applied to the foetal head and pressure is applied to help ease the baby through the mother's pelvis for delivery. The indicators for the use of ventouse extraction are prolonged second stage of labour (or elective shortening of the second stage if a woman cannot push), foetal distress or non-reassuring heart rate monitoring, and maternal exhaustion (Ali and Norwitz 2009). As the method includes the application of a vacuum to the foetal head, a ventouse delivery necessitates a vertex (head down) presentation and requires that the foetal head has passed through the pelvic inlet and is engaged in the maternal pelvis (Ali and Norwitz 2009). Forceps are used less frequently than ventouse extraction, but there are still circumstances in which a forceps delivery would be indicated, including the delivery of a second twin, a premature foetus who may incur cranial injuries during a ventouse extraction, or when a mother is unable to push due to the use of epidural anaesthesia.

Although assisted vaginal delivers help women avoid caesarean sections, they are not without potential complications themselves. Women who have their births assisted by forceps are at greater risk of third degree perineal tears, cervical laceration, major haemorrhage, and postpartum infection than women assisted by ventouse (Patel and Murphy 2004). Over the past thirty years, there has been a movement away from forceps, and towards ventouse or caesarean section when vaginal delivery does not appear likely. According to Patel and Murphy (2004), the move away from the use of forceps at delivery is tied to fears of litigation due to lack of thorough training and increased risk of maternal morbidity associated with forceps (as opposed to the use of ventouse extraction). There are fewer maternal morbidities associated with ventouse extractions than with the use of forceps, but this is balanced by there being more potential neonatal injuries associated with ventouse extractions than with forceps. These neonatal complications include scalp defects (abrasions, lacerations, and micro-hemorrhages called chignons), jaundice, retinal hemorrhages, cephalohematomas (accumulations of fluid under the periosteum of the bones of skull), and subgaleal hemorrhages, in which ruptured veins bleed into the space between the skull periosteum and the scalp (McQuivey 2004).

Given the individual, often complex, medical circumstances dictating a labour and birth, a caesarean section can be deemed medically necessary for many reasons. Francome et al (1993) and Mander (2007) organize these reasons into absolute or relative categories: an absolute indication of caesarean section denotes a medical emergency requiring caesarean section, and relative indications are those in which other treatments may also be successful. In cases in which absolute indications of caesarean section are present, a labour induction would either not be performed or would not be considered the impetus for the caesarean section. This means that relative indications of caesarean sections are of particular relevance to the present study, as it is through these indicators that labour induction is associated with caesarean section.

According to Francome et al, absolute indications of caesarean section are placenta previa, intrauterine growth restriction, and cephalopelvic disproportion. Placenta previa occurs when the placenta is located quite low in the uterus, which can increase the risk of haemorrhage during vaginal delivery. This risk is even higher if the placenta obstructs the opening of the cervix in any way (Penn and Ghaem-Maghami 2001; Mander 2007). Placenta previa is an absolute indication of caesarean delivery that is indisputable. Performing a caesarean section in the face of this troubling maternal health concern is not debated in the literature. However, the inclusion of intrauterine growth restriction and cephalopelvic disproportion (CPD) as absolute indicators is more controversial. The controversy lies in the significant variability in care provider ability to correctly estimate foetal size in utero (Penn and Ghaem-Maghami 2001), meaning that it is difficult to know for certain whether a foetus is either growth-restricted or so large as to threaten cephalopelvic disproportion, a condition in which a baby is too big to pass through the birth canal, often leading to shoulder dystocia, physical injury to the infant, or neonatal death. Cephalopelvic disproportion was a significant women’s health crisis in the 19th century, when poor diets led to Vitamin D deficiencies, rickets, and pelvic malformations that resulted in high rates of maternal mortality during childbirth (Mauriello 2008). It has also been the focus of much anthropological research, in the form of the "obstetric dilemma," concerning the perceived birth complications that arise from the conflict between large human infant brains and the necessarily narrow, upright pelvises of bipedal human mothers (Rosenberg 1992). However, recent evidence implies that when a mother has access to a balanced, healthy diet, the risks of CPD are very low. Rouse and Owen (1999) determined that over one thousand caesarean sections would have to be performed before one infant birth injury due to foetal macrosomia was prevented. This was echoed by O'Driscoll et al (2005), who found that in one thousand consecutive births, less than 1% experienced CPD, with no infant trauma reported. According to Mander (2007), because the diagnosis of CPD or growth restriction is neither straightforward nor consistent and because the severity of their symptoms can range from mild to life threatening, it would not be responsible to mandate operative deliveries in all suspected cases.

Relative indications of caesarean section are failure to progress, foetal distress, and adverse foetal position, such as a breech or transverse lie. These conditions are considered relative indications because they are not always immediate dangers to the mother or the foetus and can often be managed without caesarean section if the care provider has the ability to do so. For instance, a foetus presenting in the breech position could be turned using external cephalic version or delivered vaginally breech provided medical personnel know how to successfully employ such techniques (Mander 2007). Failure to progress, a term referring to a stalled or stagnant labour, is an indication most commonly cited in first labours. Thomas and Paranjothy (2001) found that 60% of women diagnosed with labours that were failing to progress were labouring for the first time. Foetal distress, a term referring to the decrease in foetal heart rate (and therefore, a potential decrease in foetal oxygen levels), is a diagnosis that has increased in incidence as the use of electronic foetal monitoring (EFM) has become standard labour care in hospitals. Interestingly, however, as the rates of EFM have increased and the number of foetal distress diagnoses has risen, there has been no equivalent reduction in neonatal mortality rates (Thacker et al 1995; Penn and Ghaem-Maghami 2001; Mander 2007). According to Nelson et al (1996), although rates of caesarean section and maternal morbidity have increased, "more than 20 years [after the introduction of EFM] and 11 randomized trials later, electronic foetal monitoring appears to have little documented benefit…with respect to perinatal mortality or long-term neurologic outcome" (Nelson et al 1996)[1]. The widespread use of EFM may be a contributing factor to rising rates of caesarean section.

[1] Another potential issue with increased use of EFM is that it might not actually measure what is needed to prevent infant morbidity and mortality. Dr. Barry Schifrin, a perinatologist from Los Angeles, California, is an advocate against the use of electronic foetal heart rate monitoring for protecting against neonatal traumatic birth injuries. He argues that EFM trains health care providers to watch for the wrong problems (potentially normal heart rate variations), and that measures of intracranial pressure to avoid ischemia

Failure to progress and foetal distress are the two relative indicators of caesarean section associated with labour induction. Labour inductions by definition begin labours artificially, and a woman's body may not respond immediately, or at all. This is especially true of nulliparous women, who often experience long labours as their bodies prepare to give birth for the first time. Labours which last too long (and therefore fail to progress) or induced labours with strong contractions that prove too stressful for babies during delivery (necessitating caesarean section due to foetal distress) have been frequently cited in the literature as ways in which induction is associated with caesarean section (Luthy et al 2004; Patterson et al 2011). Indeed, Caughey (2015) determined that a way of reducing rising caesarean section rates would be to increase practitioner patience during labour, make sure that obstetricians and childbirth attendants remain skilled in breech presentations, and, most crucially, decrease the use of electronic foetal monitoring and labour induction.

Another relative indication for caesarean delivery is previous caesarean section. Once a caesarean section has been performed and uterine scar tissue has formed, there is an increased risk of uterine rupture during vaginal delivery (Dodd et al 2013), although this rupture may be more closely associated with a classical vertical caesarean incision than with the currently used lower-uterine incision (Penn and Ghaem-Maghami 2001; Halperin et al 2005). Landon (2004) found that 0.7% of women attempting a vaginal birth after caesarean section (or VBAC) suffered a uterine rupture. Furthermore, there is evidence that repeated caesarean sections pose their own risks, including bowel and ureteral injury, hysterectomy, haemorrhage, blood transfusion, and extended hospital stays (Silver et al 2006; Dodd et al 2013). Much like with the relative indications of caesarean section above, it seems that a degree of caution should be employed before performing a caesarean section due to previous operative delivery, as the risks may outweigh the benefits on a case by case basis.

In much the same way as with labour induction, many different maternal characteristics can influence a woman's likelihood of experiencing one of the absolute or relative indications of caesarean section, including maternal age, obesity, and diabetes. For example, a woman with any of those listed conditions may be more likely to have a larger-than-average (or macrosomic) baby at term, meaning she could be at higher risk of CPD, shoulder dystocia, failure to progress, or foetal distress. However, a potential issue in using these maternal characteristics as justification for caesarean section is, as mentioned above, it can be very difficult to determine the size and

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(decreased blood flow to the brain) would be more precise indicators of potential birth trauma (Schifrin & Koos 2017; Schifrin 2017).

weight of a foetus in utero, even using ultrasonic technology (Gaskin 2003). Therefore, it may be that women with characteristics placing them at high risk of birthing macrosomic babies undergo operative deliveries unnecessarily.

Given the operative nature of caesarean sections, when compared to vaginal delivery, caesarean delivery is associated with more post-birth morbidity (Menacker and Hamilton 2010). Women who deliver via caesarean section are at risk of substantial blood loss, hematoma, fever, uterine laceration, thrombosis, pelvic infection, pneumonia, and urinary tract infection. In a study of 2,647 women who delivered by caesarean section, the overall postoperative complication rate was 35.7% (Maaike et al 1997), with complications ranging from minor, such as urinary tract infections and fevers, to major, including haemorrhage, thrombosis, and sepsis.

Having considered which medical factors link labour induction and caesarean section, the next section aims to examine this association more closely, by illustrating the cascade of childbirth interventions leading from induction to delivery.

2.4 The Cascade of Intervention

As discussed above, the rate of labour inductions is increasing in many high-income countries. This increase in labour inductions has occurred alongside an increase in the rates of caesarean sections. According to the World Health Organization, “there is no justification for any region to have caesarean section rates higher than 10-15%,” as caesarean rates both below and above 15% are associated with higher maternal mortality (Betran et al 2007, page 98). However, in many low-, medium-, and high-income countries, rates of caesarean section rise well above that recommendation. In countries all over the world, as income and access to insurance and medical care increase, the incidence of caesarean section increases as well. This is evidenced by a WHO report that worldwide caesarean rates rose from 5-7% in the 1970s to between 25-30% by 2003 (Christilaw 2006). In 2000, 12.2% of labours in England began with medical inductions and 12.7% of births were by emergency caesarean section. By 2017, 17.3% of births in England were begun by medical induction and 15.7% of labours ended in emergency caesarean sections (NHS Digital, NHS Maternity Statistics, 2016-2017). The use of childbirth intervention is rising, especially in high-income countries like the United Kingdom.

In addition to the rate of labour induction increasing as the rate of caesarean section rises, induction has also been linked to some of the same maternal, infant, and care provider characteristics as caesarean sections, such as infant macrosomia, maternal obesity, maternal health problems in pregnancy, and medicalized care. Induction of labour has been associated with childbirth interventions such as epidural anaesthesia, operative vaginal deliveries (use of forceps or ventouse extraction), and caesarean section (Wilson 2007; Glantz 2005), and the link between induction of labour and caesarean section has been established by many studies (Yudkin et al 1979; Dublin et al 2000; MacDorman et al 2002; Heffner et al 2003; Simpson and Thorman 2005; Vahratian et al 2005; Wilson 2007; Wilson et al 2010; Moore 2012).

Therefore, induction is an interesting proxy for childbirth intervention overall. After all, induction, meant to begin labour, is often the first childbirth intervention experienced by women at the ends of their pregnancies. According to Simpson and Thorman in 2005, induction can be viewed as the beginning of the cascade of intervention in childbirth. As discussed in Chapter 1, the cascade of intervention is a term that refers to the potentially cumulative nature of childbirth interventions, such that undergoing one intervention increases the likelihood of experiencing further interventions. This is described in detail below and illustrated in Figure 2.2[2]. This figure was created by the author as a way of synthesizing and illustrating the associations between labour induction and subsequent childbirth interventions cited in the published literature discussed above.

Labour induction often means that a woman will remain supine on a bed, attached to electronic foetal monitors, which observe the reaction of a baby's heartbeat to contractions brought on by labour induction. This inability to move, coupled with powerful medically-induced contractions, may cause increased pain and may influence a mother to have an epidural. While an important pain relief option for women, epidural anaesthesia can prolong the second stage of labour, and this lengthened second stage can increase foetal distress and prompt the use of episiotomy or caesarean section to hasten delivery (Simpson and Thorman 2005). Electronic foetal monitoring can cause similar complications for women, as clear heartbeat monitoring may require women to lay still on their backs (Bassett 1996; Johanson 2002; Spong et al 2012). Indeed, studies have shown that women with induced labours had higher incidences of the use of epidural anaesthesia, electronic foetal monitoring, and eventual operative delivery (Yudkin et al 1979; Dublin 2000) than those who were not induced. In the literature, then, it does appear that labour induction has a relationship with cascading interventions.

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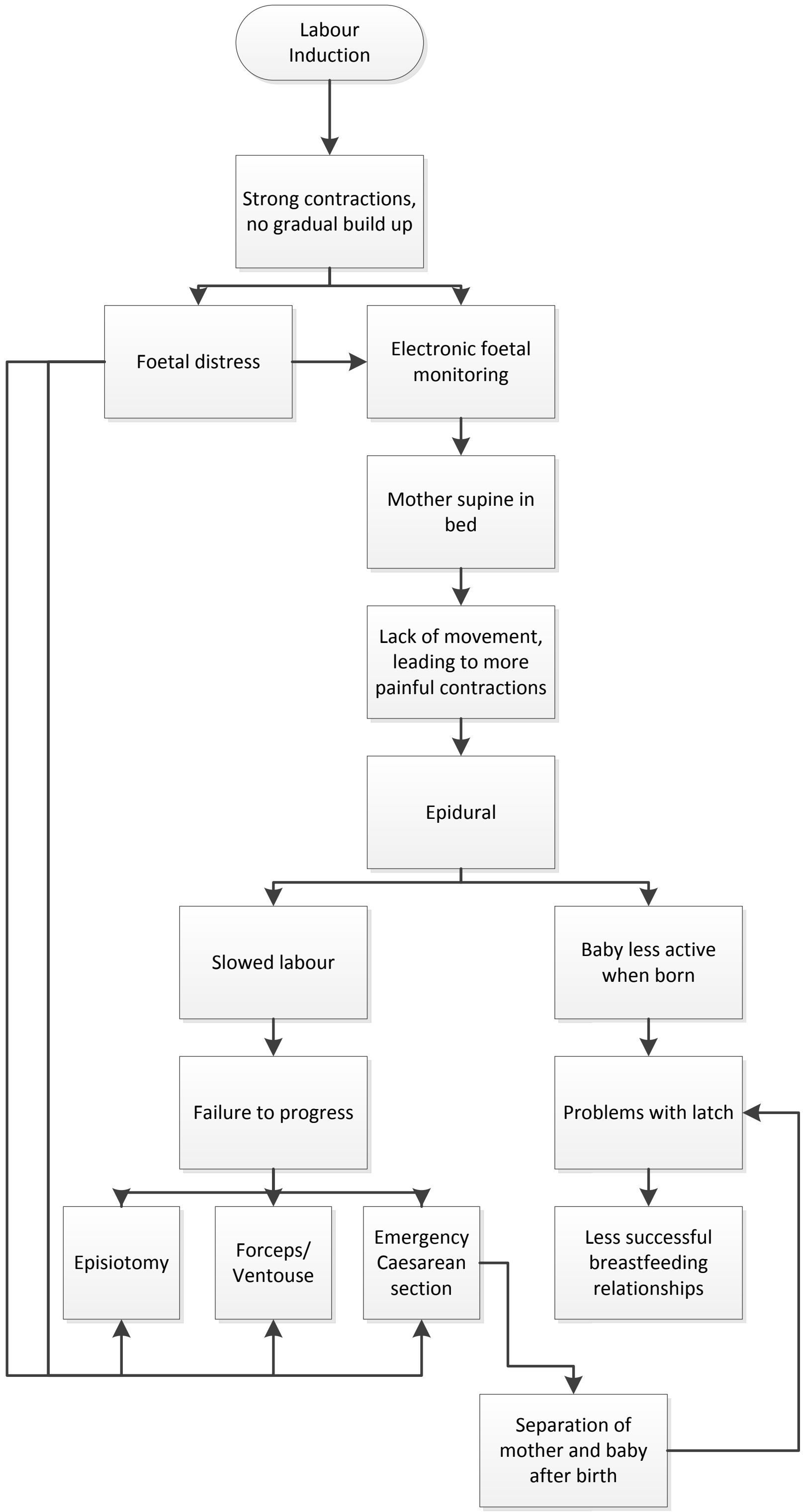
[2]As Figure 2.2 is meant as an illustration of the potential cumulative nature of interventions through cascade of intervention and because the purpose of this figure is to display the mechanisms through which one intervention could lead to another, it does not include the pathway from labour induction to unassisted vaginal delivery without further intervention. It is important to note that this is not meant to be an example of every woman's experience, and that many women are induced and go on to have unassisted vaginal births.

In this section, the cascade of interventions, which links labour induction and caesarean section, was examined as a motivation for the simultaneous rise of the rates of both induction and operative delivery. In Section 2.5 below, potential explanations for the increasing use of childbirth interventions will be explored. These explanations include advancing maternal age, increasing rates of maternal obesity, changing cultural attitudes concerning childbirth, and the medicalization of health care.

Figure 2.2: Cascade of Intervention



Source: Author

2.5 Increasing Utilization of Childbirth Intervention

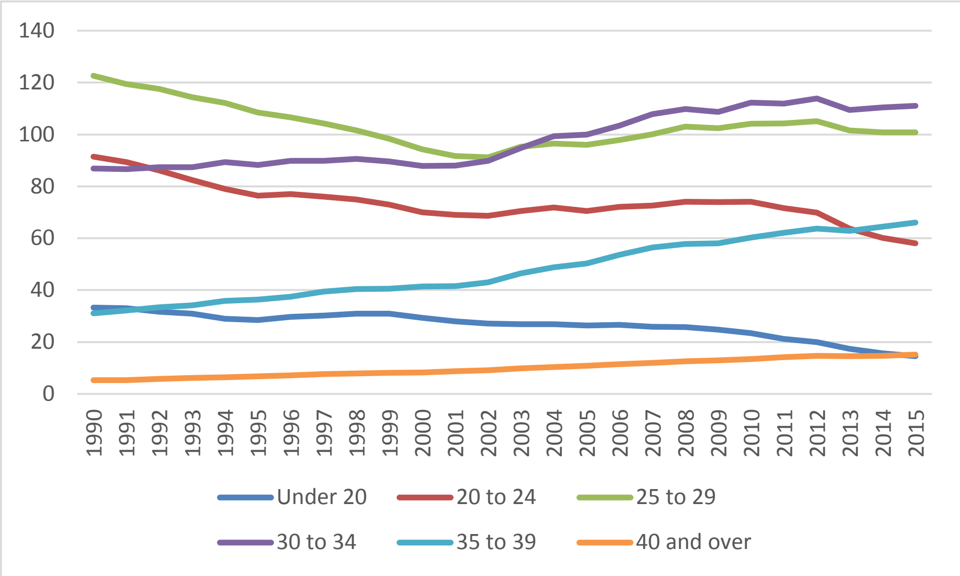
There are several potential reasons why women are experiencing more childbirth interventions. Some of these reasons are broad, institutional and cultural forces such as the medicalization of health care and childbirth, and shifting attitudes toward the use of interventions in birth. Others are more easily quantifiable at the individual level, in that maternal demographics are changing in such a way that the women giving birth may be more prone to intervention due to medical and health complications. This section explores each of these explanations in more detail.

2.5.1 Changing Maternal Demographics

In the literature concerning increasing rates of childbirth interventions, changes in the characteristics of women giving birth are highlighted as an explanation for why more women are experiencing labour inductions and operative deliveries. Two maternal characteristics of relative importance to this discussion are advanced maternal age and maternal obesity, both of which put women at increased risk of obstetric complications that could necessitate intervention.

In a scientific impact paper concerning labour induction at term in older mothers, the Royal College of Obstetricians and Gynaecologists states that “the proportion of maternities in women aged 35 years or over has increased from 8% in 1985-1987 to 20% in 2006-2008 and in women aged 40 years and older has trebled in this time from 1.2% to 3.6%” (Royal College of Obstetricians and Gynaecologists, 2013). This rise in the number of births for women 35 years old or older is also illustrated for women in England and Wales in Figure 2.3 below, with the increase most notable for women between the ages of 35 and 39 years old, beginning around 2002. An increase in the number of mothers giving birth at advanced ages is an important consideration to the present study, because older mothers are at increased risk of pregnancy and birth complications, which in turn increase their risk of many childbirth interventions. Adverse pregnancy and birth outcomes associated with advanced maternal age (considered to be 35 years of age or older) include hypertension in pregnancy, pre-eclampsia, preterm birth, foetal growth restriction, placental abruption, and low birth weight in infants (Carolan 2012; Lean et al 2017). Additionally, for both nulliparous and multiparous women, the risk of stillbirth and neonatal mortality increases with maternal age, particularly for mothers over the age of 40 years (Carolan 2012; Royal College of Obstetricians and Gynaecologists, 2013; Lean et al 2017). Each of the complications associated with advanced maternal age in the literature above are also significantly associated with labour induction and caesarean section, making maternal age a compelling indicator of childbirth intervention for the present project.

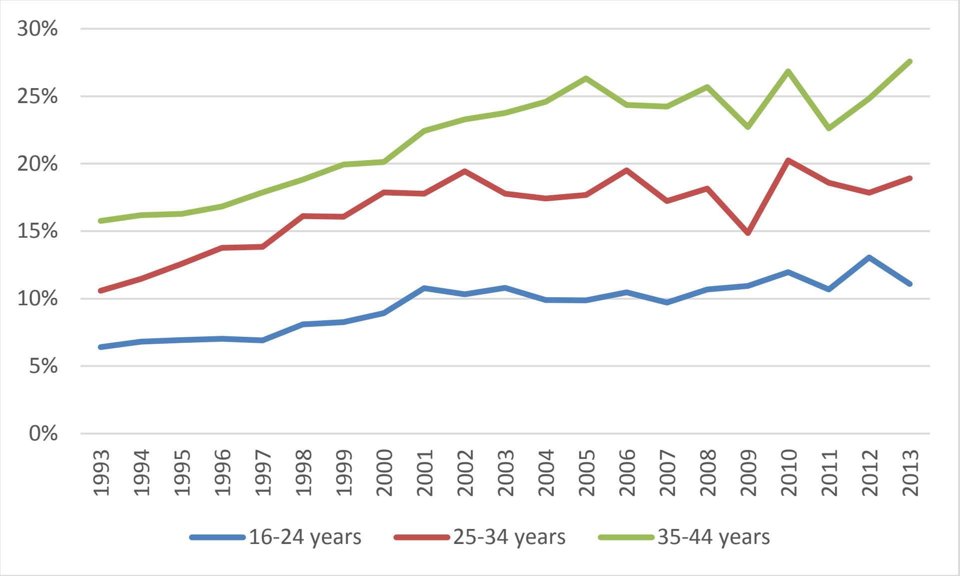
Figure 2.3: Live births per 1,000 women in each age group in England and Wales, 1990-2015



Source: Office for National Statistics, 2015

Another changing maternal characteristic associated with childbirth intervention is the rising rate of maternal obesity. According to the Health Survey for England, in 1993, 12.0% of women of childbearing age were obese. By 2006, this figure had risen to 18.5% (Heslehurst et al 2010). Figure 2.4 below displays the proportion of obese BMI readings reported by the Health Survey for England for the twenty years prior to and including 2013. It is clear in this figure that the proportion of obese BMIs reported in women of childbearing age has risen for all childbearing age groups over the period displayed. Despite some fluctuation in the 25-34 and 35-44 year age groups, older women have seen a larger increase in the proportion of obese BMI reports since 1993 than women between the ages of 16 and 24 years old.

Figure 2.4: Proportion of obese BMI in women of childbearing age in England, 1993-2013



Source: Health Survey for England Trend Tables, 2013

In a study of maternal obesity trends in England over a twenty year period, Heslehurst et al (2010) found that maternal obesity in the first trimester has significantly increased over time, doubling from 7.6% of mothers obese in the first trimester in 1989 to 15.6% in 2007 (Heslehurst et al 2010). By 2015, 20% of pregnant women in the England were classed as obese (Health and Social Care Information Centre, 2015). This increase in maternal obesity has implications for maternal health care because maternal obesity is significantly associated with hypertension in pregnancy, gestational diabetes, increased likelihood of post-term birth, slower cervical dilation, and longer labour duration, making women with higher BMIs more likely to experience birth complications like caesarean section (Nuthalapaty et al 2004; Heslehurst et al 2007; Wolfe et al 2011). In addition, both Pevzner et al (2009) in the United States and Arrowsmith et al (2011) in the United Kingdom reported that obese women were at greater risk of caesarean section after labour induction than women who were not classed as obese.

Given the evidence presented in this section, advancing maternal age and more pregnant women classed as obese may play a role in the increasing numbers of childbirth interventions experienced at birth. These maternal demographic indicators will be controlled for in the analyses conducted in this project. However, these individual-level characteristics do not exist on their own. The following Sections 2.5.2 and 2.5.3 discuss factors at the cultural and societal level (cultural attitudes and the medicalization of childbirth) that could also influence the uptake of interventions during labour and birth.

2.5.2 Cultural Attitudes to Childbirth Intervention

Rates of childbirth intervention may also be increasing because of shifts in cultural attitudes toward these procedures. A qualitative study by Green and Baston (2007) comparing attitudes toward childbirth intervention in England over time determined that women surveyed in 2000 were more willing to accept interventions than those surveyed in 1987. According to Young and Miller (2015), this may be because “available information on birth options is often biased toward promoting the benefits of medicalized birth for low-risk pregnancies across a range of modalities, including health care provider communication, reality television shows, and women’s magazines” (Young & Miller, 2015, page 448). This media information portraying childbirth as inherently dangerous may increase a woman’s fear concerning birth and influence her health care decision making. It is also possible that a woman’s attitude toward childbirth intervention could be influenced by her age and educational qualifications, as demonstrated by Benyamini et al (2017), who found that women in Tel Aviv who were younger, less educated, and from more traditional religious backgrounds had more positive views on medicalized childbirth, greater fear of birth, and higher likelihood of experiencing interventions during labour and birth (Benyamini et al 2017).

This was borne out in Green and Baston (2007), as in the sample surveyed in 2000, a greater willingness to accept obstetric interventions made women almost twice as likely to experience an operative delivery. Interestingly, although adjustment for induction of labour, acceleration of labour, and epidural use removed the significance of the relationship between a woman’s willingness to accept intervention and her mode of delivery, according to Green and Baston (2007), “compared with women who did not have an epidural, women who did had 5.93 times greater odds of an operative or instrumental birth, controlling for parity, age, education, induction, acceleration of labour, and antenatal willingness to accept intervention” (Green and Baston, 2007, page 10). This, then, is a study contemporaneous to the present research and located in the same place that found that one childbirth intervention (epidural anaesthesia) was related to another (operative delivery), even after adjusting for risk factors.

The results of Green and Baston (2007) echoed a study conducted in the Netherlands, which found that for both nulliparous and multiparous women, attitude toward intervention influenced place of birth, with women with a more favourable attitude toward childbirth technology being more likely to give birth in a hospital as opposed to at home. Furthermore, those women who ended up at the hospital after intending to have a home birth were less likely to experience an intervention than those who had always planned to deliver in a hospital (van der Hulst et al 2004).

Thus, the cultural narratives surrounding childbirth can influence the actual experience of birth. If health care in a culture is particularly medicalized, it may stand to reason that attitudes toward childbirth intervention would be more positive, and therefore, more women would experience interventions. The following section provides more detailed discussion on the medicalization of childbirth and how this may play a part in increasing use of childbirth interventions.

2.5.3 Medicalization and Childbirth Intervention

As outlined above, there are several medical indications for childbirth interventions that make these procedures medically necessary in order to save the lives of mothers and their babies. However, there is also evidence that much of the rise in labour induction and caesarean section rates can be attributed to inductions and caesareans performed without medical indication (Meikle 2005; Caughey et al 2009). In addition, in middle- and high-income countries, infant and maternal mortality rates haven't been significantly reduced by an increase in operative deliveries (ACOG 2014). A study conducted in 2006 found that while in low-income countries, an increase in caesarean section rates is associated with a decrease in neonatal and maternal mortality, an increase in the rate of caesarean delivery in medium- and high-income countries does not have a significant effect on infant and maternal mortality rates (Althabe et al 2006). Althabe et al (2006) suggest that the lack of benefit achieved by increases in caesarean rates in medium- and high-income countries could be due to the fact that increases in these countries mean more unnecessary operative deliveries performed on healthy populations. This rise in surgeries without medical indication could even contribute to infant and maternal mortality rates by exposing otherwise healthy women and children to complications associated with operative delivery. If a rising caesarean section rate (and the accompanying rise in childbirth intervention) doesn't reflect more medical indications or reductions in mortality rates, researchers must focus on other potential explanations for the increasing use of intervention.

A compelling explanation for why intervention rates have increased without medical indication or improvement in maternal mortality is that modern societies are feeling the pressure of medicalization. Medicalization, as defined by existing literature, is the "process whereby more and more of everyday life has come under medical dominion, influence, and supervision" (Zola 1983; Conrad 1992). Put simply, medicalization refers to the transition of nonmedical issues into medical problems, which are defined as illnesses and proscribed treatments by medical professionals (Conrad 2007). Over the last century, a whole host of human behaviour, both deviant and natural, has become medicalized, which has implications for a broad range of people, from those suffering from psychosocial disorders such as alcoholism, hyperactivity, or overeating to those facing natural life events, such as menstruation, menopause, or birthing their babies.

A product of medicalization is that healthy people see doctors more frequently (Conrad 1992; Conrad 1997; Cahill et al 2001), due to what Conrad (2007) refers to as the “pathologization of everything,” through which the normal spectrum of human difference is turned into medical indication. This is especially true for pregnant women, who, feeling immense personal responsibility for the health and wellness of their foetuses (Fox and Worts 1999), are particularly willing to be dependent on medical practice to ensure that their pregnancies, labours, and birth are as safe as possible. The definition of childbirth as a dangerous potential medical emergency moves birth from a natural process to an illness or disease, and inspires women to view the experience of labour and birth as something that must be properly managed by medical technology (Fox and Worts 1999). Indeed, labouring women often believe that any childbirth intervention, regardless of the pain or embarrassment involved, is ultimately worth it to ensure the safety of their babies (Cahill et al 2001). This has contributed to pregnancy and childbirth becoming one of the most fully medicalized human conditions in the modern world (Conrad 1992 and 2007).

An increase in the perceived physician control over a medical condition can have large implications for both doctors and patients. In the case of childbirth intervention and caesarean section deliveries, medicalization has contributed to the rise in defensive medicine, which is characterized by the increased use of technology and medical intervention as a result of a rise in physician medico-legal responsibility for the outcomes of labour and birth. Defensive medicine is a reaction to physician fears about potential litigation following an adverse birth outcome, and has been associated with the rising rates of operative delivery specifically and childbirth intervention in general (Sachs 1989; Symon 2000; Bassett et al 2000; Mander 2007).

There are several trends in childbirth practice that illuminate how defensive medicine contributes to increased caesarean section rates, including standard use of electronic foetal monitoring (EFM), lower incidence of forceps use, a decrease in vaginal breech deliveries, and physician perception that the majority of obstetrics lawsuits involve EFM and the failure to perform a caesarean section on time (Sachs 1989). These trends imply that physicians are no longer comfortable allowing labour to progress and childbirth to occur unmanaged. Considering that 90% of obstetric malpractice lawsuits in the United States involve delay or failure in performing caesarean section or the incorrect use of forceps, it may not be surprising that some physicians favour operative deliveries (Rock 1988). In fact, Penna and Arulkumaran (2003) found that many US obstetricians prefer to be accused of over-utilizing medical interventions than to be sued for not intervening on time or at all.

Interviews with health care providers underscore the influence of potential litigation on modern medical practice. Of 151 clinical directors questioned about the rapid increase in caesarean section rates in the UK from 1990 to 2004, 55% cited the fear of litigation as the main reason (Savage and Francome 2007). In a national survey of midwives and obstetricians conducted by Symon (2000) in Scotland, the most commonly cited examples of defensive medicine (for both midwives and obstetricians) were increased use of caesarean section, earlier intervention into labour, more investigations performed during labour, and a rise in labour induction. According to Symon (2000), when faced with a litigious society, medical professionals have two options: risk avoidance, avoiding procedures or even entire specialities that carry high risks of litigation, or risk reduction, using more intervention to counter possible litigation. The increased use of diagnostic testing, foetal monitoring, labour induction, and caesarean section can be seen as evidence of physicians choosing risk reduction strategies in their medical practices (Symon 2000).

According to Kitzinger (2005), the modern medical model of childbirth reflects a “technocratic birth culture,” which relies on machines to monitor, diagnose, and ultimately regulate the care practices associated with labour and childbirth. Kitzinger argues that defensive medicine, in an effort to make childbirth safer for the mother, child, and physician, has also served to pathologize birth, leading to more potentially unnecessary medical interventions for women and their babies. This defensive approach to labour and birth may ultimately fail to protect any of the participants. Despite an increase in the rate of labour inductions and caesarean sections performed on mothers in the last thirty years, there has been no decrease in the rates of adverse birth outcomes like cerebral palsy or in the number of malpractice claims associated with childbirth (Penna and Arulkumaran 2003; Kitzinger 2005). In fact, there is evidence to suggest that rates of cerebral palsy are rising (Odding et al 2006). If caesarean sections were currently being performed as safety measures in high risk pregnancies, research should indicate that hospitals serving mainly low risk women have similarly low rates of caesarean section. However, in the United States, caesarean delivery rates in hospitals with low risk patients vary greatly, from as low as 2.4% to as high as 36.4%, which implies that something other than clinical risk factors are contributing to the rise of caesarean section deliveries (Kozhimannil et al 2013). This variation in childbirth intervention rate by health care provider is documented in the United Kingdom as well, as detailed in Section 2.8.2.

As evidenced by the above, the medicalization of childbirth has transformed the way in which women become mothers in the modern world. This transformation of a woman’s experience has been examined by feminist theorists for the last several decades, many of whom believe that the increased use of technology strips women of their autonomy and influential feelings of control (Oakley 1985; Kitzinger 2005).

Conversely, other research has suggested that rather than disempowering every woman who experiences it, choosing a medicalized childbirth may actually help some women maintain or regain control over their labour and birth. In a study of the importance of social support during childbirth, Fox and Worts (1999) identify a critical issue with the medicalization of childbirth which is often ignored: the way in which it telegraphs to women that they are alone in the pursuit of motherhood. Under the medical model of childbirth, women are hospitalized and removed from their familiar surroundings and social supports. In distancing women from their social support networks, medicalized childbirth privatizes the responsibility of motherhood, leaving labouring women to feel that they are on their own, both in their labours and in child care after birth. The authors report that women who had less support before, during, and after birth were more likely to welcome interventions in their labours and births, and they posit that this is because some women may view medical intervention as an avenue through which to increase the amount of support they receive as they become mothers, even if this support is fleeting and only lasts until their child is born. Counterintuitively, for some women, it seems that medicalization can both remove a sense of control and be the key to regaining it.

Additionally, Fox and Worts (1999) present a critique of the majority of arguments against the medicalization of birth, as many of these arguments ignore the agency of individual women, imply that women necessarily must take control over their childbirth experiences, and assume that control means the same thing for every woman. For some women in their qualitative study, Fox and Worts (1999) found that controlling the amount of pain they felt or the way they behaved during labour was the greatest worry. Other women felt most in control when they had handed medical decision making fully over to their health care providers. Variation in how women define control means that a medical model of birth can actually help some mothers stay in control of their experiences. This implies that a negative, alienated experience of medicalized childbirth is not universal, a statement at odds with much of the theory critical of medicalization. Studies of childbirth intervention may benefit from examining the factors that influence a woman’s sense of control over her labour and birth, rather than by deeming her experience of intervention as either inherently positive or negative.

Changing maternal demographics, shifting cultural attitudes, and the medicalization of health care are explanations for why countries the world over are experiencing increasing rates of childbirth intervention. However, the question of who is experiencing these interventions most frequently and why experience varies by country still remains. In the following section, the relationships between childbirth intervention and socioeconomic status will be examined, in an attempt to address which women may be at greater risk of induction.

2.6 Health Care, Socioeconomic Status, and Childbirth Intervention

The above section outlined explanations for an increase in childbirth interventions. However, there also appears to be a difference in the demographics of women who are more likely to experience childbirth intervention, as some research suggests that the women at risk may change between countries (Hawkins et al 2008; Raleigh et al 2010; Poeran et al 2013). This begs the question: which characteristics impact the type of health care an individual woman receives at the time of labour and delivery? Research indicates that a leading influence on maternal health care quality is socioeconomic status, as evidence from longitudinal studies implies that socioeconomic status is responsible for many differences in health status within countries, as well as between them (Finch 2003; Victoria et al 2003).

In 1971, Julian Tudor Hart published a theoretical explanation for socioeconomic differences in health in countries all over the world. Hart's "Inverse Care Law" states that those who are most in need of medical care are often those who are the least likely to get it. This inverse relationship between medical need and availability of medical care can be exacerbated when health care is exposed to market forces, as this drives quality care away from economically depressed areas where lower-income people may need it most (Hart 1971). According to Hart, "the general conclusion must be that those most able to choose where they will work tend to go to middle-class areas, and that the areas with highest mortality and morbidity tend to get those doctors who are least able to choose where they will work. Such a system is not likely to distribute the doctors with the highest morale to the places where that morale is most needed" (Hart 1971, page 407).

Although Hart focuses his analysis on the availability of good doctors in less wealthy areas, socioeconomic inequality in health care leading to unequal access can be attributed to a complex network of influences, including maternal education, social structure, occupation, and physical, emotional, and transportation barriers to access to clinics and hospitals (Cook et al 1999). Inequalities in Health, also known as The Black Report, published in the United Kingdom in 1980, highlights four possible explanations for social class differences in health: measurement artefact, natural/social selection, cultural/behavioural differences, and materialist causes. Of these four potential explanations, The Black Report highlights the materialist explanation as the most robust theoretical framework, as it is the only one that considers the entirety of the situation in which people live. As Blane (1985) notes, the materialist explanation sees "class differences in health as the result of structurally determined differences in the way the members of these social classes lead their lives," as opposed to being by-products of issues in measurement, inevitable conclusions due to natural differences between people in different social classes, or based purely on the behaviour of different social groups. Rather than being a clean delineation between types of people or lifestyles, social class, as defined by Inequalities in Health, is a part of a dynamic system of advantages and disadvantages which interact to provide or deny people access to health care.

According to Blane (1985), education is a major driver of these social class differences in social structure, as education is linked to purchasing power and social mobility, which are both key determinants of access to health care, especially in countries that do not offer universal health care. This is echoed by Braveman et al (2010), who found that people with the least education and the lowest income in their sample were consistently the least healthy, and that this educational difference in health is reflected even in groups of people with median income and education levels, who are not as healthy as those with the highest income and education.

The work of Michael Marmot has followed on from The Black Report by investigating the social determinants of inequalities in health status both within and between countries. Marmot, tasked with leading the WHO Commission on Social Determinants of Health, argues that there is a relationship between material and social challenges in the study and reduction of health inequities. Material deprivation, defined as the lack of clean water, quality food, or adequate health care, is often socially determined, as those with the necessary financial resources are able to combat material deprivation more successfully than those without the necessary financial resources. According to Marmot, in higher-income countries, where levels of absolute material deprivation are lower, efforts to alleviate health inequities must focus on addressing absolute and relative deprivation. For example, higher income countries may face fewer communicable diseases, but contend with more non-communicable disease, such as obesity, alcoholism, and psychosocial disorders, all of which can contribute to material deprivation and ill health along a social gradient (Marmot 2005, 2007, 2012).

This is true of many countries in Europe, which do not face as many markers absolute material deprivation as do some countries in Africa, and yet also experience marked differences in health along social status (Marmot 2007). An example used by Marmot to highlight social differences in health status within higher income countries is male life expectancy in Glasgow, Scotland, which in 2007, was 54 years of age in the most economically depressed areas and 82 years of age in the least economically deprived areas. Even in relatively wealthy countries with universal health care systems like the United Kingdom, “the place people occupy on the social hierarchy affects their level of exposure to health-damaging factors, their vulnerability to ill health, and the consequences of ill health” (Marmot 2007). This is of particular relevance to this project, as while residents of the United Kingdom may face fewer absolute markers of material deprivation, they may still see their health care tied to their place in the social hierarchy. If this is the case, there will be differences in the likelihood of labour induction and operative delivery between women reporting different socioeconomic statuses.

Research into the relationship between socioeconomic status, health, and access to health care often focuses on the effects of cumulative disadvantage. As defined by Dannefer (2003), cumulative disadvantage is the “systemic tendency for interindividual divergence in a given characteristic (e.g. money, health, or status) with the passage of time” (page S327). Put simply, the theory of cumulative disadvantage posits a cyclical nature to social and economic disadvantage, such that people who are born into disadvantaged families face more life hazards than those who are more advantaged, and the accumulation of these hazards negatively impacts their health throughout their life course. According to the theory of cumulative disadvantage, as people age and accumulate either a multitude of challenges or advantages, differences in health status between advantaged and disadvantages groups widen and magnify (DiPrete and Eirich 2006). In fact, even when early circumstances change later in life, they still have lasting health effects on individuals (Willson et al 2007).

This additive effect of economic disadvantage has implications for both mothers and their children. As Hardie and Landale (2013) discuss, in addition to actual medical conditions or poor access to health care, a child’s health can be damaged by an undue concentration of stressful life events such as family instability, low quality housing, and living in poverty. The Black Report suggests that this “biological programming” of lifelong health begins when children are foetuses and infants (Aber et al 1997), and several studies using data from Canada and the United States have found that differences in child health along social gradients increase as children grow older (Case et al 2002; Currie and Stabile 2003; Condliffe and Link 2008; Murasko 2008). Khanam et al (2009) found that in Australia, there is a strong relationship between parental health, specifically that of mothers, and the health of their children, and suggest that maternal health is the mechanism through which income influences child health throughout their life courses. Gender inequality in health means that women are more vulnerable than men to economic and health inequities, and because child development is influenced by parental socioeconomic background and health status, it may be that women and their children are at an especially high risk of experiencing cumulative disadvantage (DiPrete and Eirich 2006; Marmot 2012).

Broad socioeconomic differences in health care could be reflected in which women are at higher for childbirth intervention, assisted vaginal delivery, and caesarean sections. When compared to the wealthiest women studied, first-time UK mothers with lower socioeconomic status were about one and a half times more likely to experience an assisted vaginal birth and more than twice as likely to have planned caesarean sections. Women with lower educational and occupational statuses were at higher risk of planned caesarean sections than were their more educated, higher status counterparts (Essex et al 2013). Leeb et al (2005) found that after controlling for maternal age, as increasing age increases risk of caesarean section, women living in the lowest income neighbourhoods in Canada had significantly higher rates of caesarean section than those living in the highest income neighbourhoods. In a study by Fairley et al (2011), women from the most deprived areas of Scotland were more likely to experience emergency caesarean sections and less likely to experience elective caesarean sections than women from the least deprived areas of Scotland, implying that perhaps the most disadvantaged women had the least prenatal care. In Finland, nulliparous and multiparous women in lower occupational classes were found to be at higher risk of both planned and unplanned caesarean sections, an outcome the authors conclude might be at least partially explained by differences in behaviour such as smoking during pregnancy between social classes (Raisanen et al 2014).

Although a US study of the relationship between socioeconomic status and caesarean section found that non-Hispanic black, Hispanic, and Native American mothers were more likely to have caesarean sections than non-Hispanic white or Asian mothers (Roth and Henley 2012), most research from the United States indicates that women who are college-educated, white, and covered by commercial health insurance are the most likely to have their labours induced and to experience caesarean section (Coonrod et al 2000; MacDorman et al 2002; Wilson 2007; Wilson et al 2010). The risk of caesarean delivery after induction in the US has also been associated with the increased rate of elective inductions performed by maternal-foetal specialists and obstetricians, who utilize elective induction more readily than do family practice doctors or residents (Luthy et al 2004). Therefore, it has been suggested that women with higher socioeconomic status may deliver their babies via caesarean section more frequently because they are electing to have the procedure performed.

Indeed, Baker et al (1997) found that in the UK, women in highest income quintiles were more likely to elect operative delivery on the NHS than were those in any of the lower income quintiles. This finding was confirmed in a study of NHS elective deliveries from 1996 and 2000 by Alves and Sheikh (2005), which determined that affluent women in the highest income quintile had significantly higher odds of delivering by elective caesarean than women in the other four income quintiles. However, there is very little agreement on how much influence elective caesarean sections actually have on the increasing rates of operative delivery (Tranqulli et al 1997; Wilkinson et al 1998; Kolas et al 2003; Karlstrom et al 2010; Lavender et al 2012), most critically because women do not elect caesareans over spontaneous vaginal birth nearly as often as is sometimes assumed (Bourgeault et al 2008).

Another potential reason research may find more frequent caesarean sections in higher income women is that there is a relationship between maternal age, pregnancy complication, and operative delivery. Older women are often wealthier and more established than younger women, with higher chances of having twin or multiple pregnancies, which puts them at greater risk for complications and caesarean deliveries (Heffner et al 2003; Leeb et al 2005; Patel et al 2005; Buescher et al 2006; Thompson et al 2006; Brick and Layte 2009; Essex et al 2013; Lindquist 2013). It is important, then, to consider maternal age when examining the influence of socioeconomic status on operative delivery.

Although studies have yet to reach a consensus on the link between socioeconomic status and caesarean section, the existing literature points to women with low income and minority status being more likely to experience caesareans than their wealthier peers. This may be because women with more education and higher socioeconomic status are able to exercise more control over their childbirth experiences. According to Roth and Henley (2012), “negative maternal outcomes are concentrated among low-income women, [as they] tend to have less prenatal care, more discontinuity of care, and more risk factors” (page 208). In addition to experiencing poorer quality care and having more pregnancy complications, women with low socioeconomic status also tend to have less control over their medical care. Lack of power, control, and agency are emotional barriers to health care for lower-income women, as women with lower status may experience more life stress, less familial support, and greater language barriers (Lazarus 1994; Cook et al 1999). A study by De Jonge et al (2007) determined that women over 36 years old with high levels of education were less likely to use only the supine position when giving birth than were younger women with less educational attainment. This suggests inequalities in choice of birthing position, which could then lead to inequalities in choice of mode of delivery. As De Jonge et al note, there are higher rates of medical interventions such as episiotomies and operative deliveries when women labour only in the supine position. Therefore, in the sample De Jonge et al studied, less educated, younger women were at greater risk of caesarean section than were the older, more educated women.

Differences in health status along socioeconomic gradients have been seen in low-, middle- and high-income countries the world over. These health inequalities can be present even in the face of universal health coverage, as has been documented in Canada, Scandinavia, and the United Kingdom (Adler and Newman 2002; Thompson et al 2006; Currie and Lin 2007). The fact that socioeconomic differences in health still exist when health care is made available for all members of a society implies that there are other, perhaps more indirect socioeconomic forces at work. In order to better understand the contexts in which socioeconomic differences in childbirth intervention may exist, it is worth examining how different types of health care coverage aim to address socioeconomic disparities and in what ways these health care finance systems can contribute to health inequality.

2.7 Socioeconomic Disparities and Childbirth Intervention: The Influence of Health Coverage System

Socioeconomic status has been linked to childbirth interventions in many different countries. Considering the fact that health care is financed differently in many of the countries discussed above, it is worth investigating what influence a country's health system has on a woman's experience of childbirth. This is echoed by Lutomski et al (2014): "assessing the influence of health care coverage status in a variety of health care settings is critical given that rates of obstetric intervention are likely impacted by a country's prevailing model of obstetric care (i.e. midwife-led, obstetrician-led, or shared care models) and health care system (i.e. socialised medicine or fee-for-service)" (page 4). Specifically, what are some expected differences between countries using fee-for-service health care systems and those with organized universal health care?

The question most relevant to this section is: why does a difference in health care across health care systems matter? In the context of the study of labour induction, this difference is critical. Most research into the indicators of labour induction has come out of the United States, a country with a markedly different health care system than the United Kingdom, the country of interest to the present research. One of the motivators for this thesis is how indicators of labour induction may differ in the United Kingdom, and therefore it is important to consider the mechanisms through which this difference could occur.

2.7.1 Insurance or Fee-For-Service Systems

In countries in which health care is available through either public or private health insurance systems, research into existing health inequalities most often highlights unequal access to quality primary medical care as a key determinant of health status. In societies that offer health care finance via insurance plans, people who are uninsured must then to pay out-of-pocket for health expenses, an expectation that can be seen as a direct barrier to health care access. In low- and middle-income countries relying on out-of-pocket health care fees, hospitalizations, maternity care, and acute and long-term illnesses can contribute to families falling into poverty, as in some countries, the costs of unexpected illnesses can rise above 10% of individual household income (McIntyre et al 2005). A study of fee-for-service health care in Iran found that hospital payments put citizens at risk of catastrophic expenditure, most especially for people with low socioeconomic status (Hajizadeh and Nghiem 2011). Patients in high-income countries experience the same direct financial barriers in fee-for-service systems. According to Andrulis (1998) and Adler and Newman (2002), in the United States, low-income families are the most likely to have decreased health care access, with uninsured people more likely to experience both poor medical care and the lack of access to care at all than those who were insured. When people moved from having no insurance to having Medicaid coverage, their health care access increased, although not to the extent of those covered by private health insurance (Andrulis 1998).

These health insurance-based inequalities in health care access have been noted in much research on maternity care. In fact, it may be that these inequalities are more salient in maternal health care, as Adams et al (2003) state that "women are generally more vulnerable than men are to becoming uninsured, because they are less likely to be insured through a job and more likely to be covered as dependents" (page 220). In the United States, Medicaid expansions in the late 1980s meant that by the 1990s, all pregnant women and their infants with incomes below 133% of the poverty line were covered by Medicaid insurance, an increase in total birth coverage from 17% in 1985 to 35% in 1998 (Adams et al 2003; Turcotte et al 2005). However, the prenatal and childbirth coverage provided by Medicaid ends 60 days after birth. Women covered under these Medicaid expansions often have health insurance on a rolling basis (during pregnancy and for just two months after birth), with Adams et al (2003) finding that in some U.S. states, 40% of all women, and two thirds of low-income pregnant women, do not have insurance prior to pregnancy. Women without private health insurance, who rely on Medicaid childbirth insurance for which pregnancy is required to enrol, are more likely to experience unmanaged chronic conditions before pregnancy and to have fewer prenatal visits, as these visits tend to wait until coverage can be secured in the second or third trimester of pregnancy (Turcotte et al 2005; Johnson 2012). Indeed, although women insured through Medi-Cal (California's Medicaid program) fared better than uninsured women, they had higher risks of untimely care and fewer prenatal visits than did those women with private insurance (Braveman et al 1993). Given that Medicaid covers 40% of prenatal visits and births (or more than 12 million low-income women) in the United States, the implications for this short-term health insurance coverage are significant (Johnson 2012).

Interestingly, some research into health insurance type and maternal health care specifically suggests that women in the United States who move from generous private insurance coverage to less generous Medicaid coverage see reductions in the use of childbirth interventions such as ultrasound scans, labour induction, electronic foetal monitoring, and caesarean section, without experiencing any change in the rate of infant mortality (Currie and Gruber 1997). This is important because a reduction in the use of childbirth procedures could reduce overall health expenditure without causing undue harm to mothers and babies, therefore making health coverage less expensive without sacrificing health and safety. It also implies that in some cases, perhaps counterintuitively, less health insurance coverage is not necessarily always detrimental.

Similar results were found in a study of Irish women utilizing either public or private health insurance, in which women with private health insurance were more likely to have an emergency caesarean section, an elective caesarean section, and an operative vaginal delivery, even after controlling for obstetric risk factors (Lutomski et al 2014). In addition, women who laboured using private health insurance were more likely to be induced and undergo epidural anaesthesia. Finally, although induction risk varied by type of induction, overall women with private health coverage were 27% more likely to have their labours induced (Lutomski et al 2014). In this comparison between health care provisions, women with private health insurance experienced more childbirth intervention than those relying on the public health care system.

2.7.2 The Beveridge Model – Tax Payer Funded Government Health Care

According to Exworthy et al (2006), often “health care disparities are generated by the interaction of clinicians’ interpretations of patients’ needs and the interventions they prescribe. [These] interventions are often based on stereotypes and socioeconomic status influences, [meaning that] social determinants influence people’s health status before they even enter the health care system” (page 77). Financial, organisational, and social factors influence affordability and accessibility, such that the mere availability of health services is not enough to completely remove the influence of socioeconomic status. As such, much research into the continued existence of socioeconomic differences in health in countries that benefit from universal health care systems concerns the unequal use of available care. Although universal health care systems tend to have greater proportions of medical care utilization in general, socioeconomic gradients in use are still present (Hanratty et al 2007). As opposed to the direct barrier presented by an inability to pay for services while uninsured in an insurance-based system, people struggling to use care afforded to them by universal health care may find themselves limited by more indirect barriers to health care.

Indirect barriers are the subject of a study by Cook et al (1999), who write that “there is evidence that…a regular source of care does not guarantee that pregnant women will receive adequate prenatal care…Important, yet neglected, barriers include substandard living conditions, limited support from family and friends, stressful life events, language barriers, lack of housing, insufficient transportation, crowded clinics, scheduling difficulties (for example, limited availability of appointments), long waiting times, and interaction with insensitive health care professionals." This is echoed by Alder and Newman (2002), who state that in most cases, social inequalities in health status can be attributed to differences in care utilization in low- and high-income families. While most countries with universal health care have equality in the use of primary care, in many places, people with lower socioeconomic statuses are less likely to utilize speciality care (Palencia et al 2011).

Several studies have underlined this difference in utilization along income gradients. Two studies found that Canadians with low socioeconomic status were more likely to access primary care, but less likely to seek out speciality care than those with higher socioeconomic status (Dunlop et al 2000; Veugelers and Yip 2003), and Wood et al (1999) determined that Canadian men with low income, little education, and low occupational status had higher rates of death from preventable disease. Under the Spanish National Health System from 1993-2006, people in manual occupational classes were more likely to make use of emergency rooms and primary care general practitioners than specialists, who were more likely to be visited by people in the non-manual occupational classes (Palencia et al 2011). A systematic review of countries with universal health care systems including studies conducted in Australia, Canada, Iceland, Ireland, Norway, Spain, and the United Kingdom found a pro-rich bias in the use of specialist services, and either an equal or pro-poor bias in the use of primary care services (Hanratty et al 2007). Some cited reasons for these disparities are the lack of physical access to specialist services in low-income neighbourhoods, the cost or lack of transportation to specialists, and differences in physician referral practices along socioeconomic lines in countries in which specialists can only be seen with referrals from general practitioners (Hanratty et al 2007). In the United Kingdom, people with lower income, education, and employment status have been found to utilize health services less often than expected (Sutton et al 2002). Research from Nova Scotia, where universal health care is also available, indicates that people with lower socioeconomic status utilize primary and hospital care more frequently and specialist care less frequently than those with higher socioeconomic status (Veugelers and Yip 2002). More primary care visits may speak to lower overall health status, and fewer specialist visits may mean less access to quality, focused care (Veugelers and Yip 2002).

Additionally, a study by James et al (2007) highlights the importance of public health measures in reducing the socioeconomic disparities in health status in Canada. From 1971 to 1996, socioeconomic inequality in the incidence of diseases amenable to the medical care made universally available in Canada decreased. Over the same time period, there was very little change in socioeconomic inequality in the incidence of diseases that were amenable to public health measures, such as heart disease and lung cancer. James et al (2007) attribute their findings to educational, social, and behavioural differences between people of varying socioeconomic status. This may suggest that in addition to addressing indirect barriers to health care access, public health initiatives that promote healthy eating, exercise, and quitting smoking can help reduce socioeconomic inequalities in health.

Because socioeconomic gradients in health outcomes continue to exist under universal health care, one might still expect to find differences in maternal health outcomes between women with differing socioeconomic status in a country like the United Kingdom, where the population has access to the health services they require. Indeed, Knight et al (2009) found that in the United Kingdom, non-white women were at significantly higher risk of severe maternal morbidity than white women, and in a study by Redshaw et al (2007), UK women from black and minority groups were more likely to discover pregnancy and access prenatal care later than white women (Redshaw et al 2007). Lifestyle influences and issues with access to quality care (such as referrals to specialists) could mean that women with lower socioeconomic status in the UK face more health problems, and in turn, more interventions, than their counterparts with higher socioeconomic status. Universal health care implies that there are fewer discrete barriers to care and less for-profit medicine, potentially decreasing physician motivation for intervention, meaning that on balance, women with higher socioeconomic status may face less intervention.

Therefore, the relationship between childbirth intervention and socioeconomic status may be different in the United Kingdom than it is in the United States, where women able to afford more intervention through private health insurance are often more likely to experience it. In the United Kingdom, it may be that women with lower socioeconomic status are at greater risk of childbirth intervention than those with higher socioeconomic status, which is the opposite of what some research from the United States has found. As the demographics of women more likely to undergo labour induction in the United States (older, white, highly educated women with private health insurance) may be different from those of women more likely to be induced in the United Kingdom, it is important to be careful about using evidence from one health care setting in another.

Given that this thesis aims to examine the maternal indicators of labour induction in the United Kingdom in part to determine if health care context plays an important role in likelihood of induction, it is worth discussing the mechanisms through which health care provision may influence childbirth intervention in the UK and how this influence may vary by UK country. The following section details the ways in which the funding, structure, and staffing of the NHS across the four countries of the United Kingdom may contribute to different childbirth intervention outcomes.

2.8 Maternal Health Care Provision in the United Kingdom

2.8.1 The National Health Service in the United Kingdom

In 1999, the National Health Service in the United Kingdom was devolved, and each of the four UK countries (England, Wales, Scotland, and Northern Ireland) became responsible for the maintenance of their own health systems. While health care in all four countries remained funded by taxpayers (and to a much lesser degree, by prescription fees), devolution created differences in structure, management, and the allocation of funds between the countries (Nuffield Trust 2011; Nuffield Trust 2014).

In the years 2000 and 2001, the period over which data for the first sweep of the MCS was collected, health care management was organized differently in each of the four UK countries. In England, the Department of Health oversaw eight health regional offices, which were divided into 100 health authorities, which in turn managed over 400 primary care organizations through NHS Trusts (ONS 2016). In Wales, the NHS Wales Department of the National Assembly managed five health authorities, which were split by Welsh unitary authority into 22 local health groups, which then oversaw Trusts (ONS 2016). In Scotland, Trusts were managed by 34 community health partnerships, which were grouped in 14 health boards, with the health boards reporting to the Scottish government (ONS 2016). Finally, in Northern Ireland, four health and social services boards (Northern, Southern, Eastern, and Western) managed Trusts and reported to the Department of Health, Social Services and Public Safety of the Northern Ireland Executive (ONS 2016). In each country, health care was ultimately the purview of the government, but based on population and geographical variation between the nations, there are differences in management structure.

In addition to differences in health care structure after devolution, the four UK countries established differing health care funding policies. After 1999, England was the only UK country for which NHS funding was contingent on Public Service Agreement health care targets created by the UK Treasury to encourage and promote improvement (The Nuffield Trust 2011). England was also the only country that continued to use the “purchaser/provider split,” a policy which provides health boards with government grants that are then used to negotiate the funding of care from providers (the so-called NHS "internal market" created in the early 1990s) (The Nuffield Trust 2011; Maynard and Dixon 2016). In the other devolved countries, this purchaser/provider split was removed and funding policy focused more on geographical and population needs. As evidenced by the varying funding and management structures after devolution, the four UK countries, while still operating under the same health care services in theory, created very different systems in practice.

One comparative study, conducted in 2010 by the Nuffield Trust and focused on 2002-2003, the period just after devolution, sought to understand how the implementation of "different systems of governance and different policies" across the United Kingdom might have impacted health care in the four countries (The Nuffield Trust 2011, page 1). In 2002, of the four UK countries, Scotland had the highest per capita expenditure and the highest rate of GPs and nursing, midwifery and health visiting staff per 1,000 population. England had the lowest per capita expenditure and the lowest rate of GPs and nursing, midwifery and health visiting staff per 1,000 population for the same year. While England and Wales had the same low rate of hospital and dental staff per 1,000 population in 2002, again Scotland had the highest. In the same Nuffield Trust study, the NHS in England was found to be performing better than the health care systems in the three other UK countries across a number of indicators, including life expectancy, amenable mortality rates, and outpatient wait times. As England spent less on health care and had the least amount of health care staffing than the other UK countries, this report implies that England utilized its resources more efficiently. These results were echoed by a more recent Nuffield Trust report published in 2014.

Health care performance varied between Trusts in the same country as well as between UK countries after the devolution of the NHS. In 2000, performance ratings based on clinical outputs (such as patient waiting times and operation cancellations), surveyed patient satisfaction, and independent hospital review reports were issued for NHS Trusts in England in the form of star ratings (Department of Health 2001; Commission for Health Improvement 2003). (It is worth noting that these performance standards were created, tested, and published in England only, as England was the only UK country in which funding was dependent upon performance after devolution.) Hospitals which met all the targets under review were awarded three stars, hospitals meeting most of the targets earned two stars, hospitals with obvious performance issues were given one star, and those hospitals found to be severely underperforming received no stars at all. These star ratings were then used by NHS boards as a way of rewarding high performing hospitals and admonishing those with poor performance. Trusts earning three stars could be awarded up to £1 million in additional funding and the management of highly rated hospitals were given much more autonomy over where the money could be spent. Hospitals with lower ratings were at risk of having their management replaced and of being stigmatized for providing poor quality care or even being dangerous for patients (Snelling 2003). In England, performance and funding were inextricably linked.

These differences in management and funding allocation in hospitals and Trusts both within each UK country and between each UK country may produce different qualities of care in NHS Trusts within each country. In England, for example, where funding allocation is dependent, in part, on the performance of a Trust, differences in Trust priorities could be reflected in the type of care provided by the hospitals under a specific Trust's management. In all four of the UK countries under review, discrepancies in the amount of health care expenditure, the number of beds available in hospitals, the numbers of obstetricians versus midwives on staff, and the number of outpatient and inpatient admissions may influence the care received at an NHS Trust. In these ways, patient experience of health care could vary by Trust as well as between individuals.

Two of the practical ways in which the differences in funding and organization between countries may influence the use of labour induction by NHS Trust is through disparities in the implementation of National Institute for Health and Care Excellence (NICE) guidelines for the use of labour induction, and differences in staffing between Trusts.

2.8.1.1 NICE Guidelines and NHS Trust Implementation

According to their website, The National Institute for Health and Care Excellence (NICE) is an "independent organization responsible for providing national guidance on promoting good health and preventing and treating ill health" (National Institute for Health and Care Excellence 2012). NICE guidelines are referred to often in the literature and are something of a gold standard in UK health care. In 2001, the NICE guidelines concerning the induction of labour stated that pre-term labour induction should be offered to women with diabetes or premature membrane ruptures, and that women with healthy pregnancies should be offered labour induction only if their pregnancies exceed 41 weeks (National Archives Webarchive 2008). Thus, this guidance sets out terms for labour inductions that have medical indications. However, previous published literature indicates that the experience of labour induction in the United Kingdom can be influenced by non-medical indicators, such as the socioeconomic status of the mother or the place in which she gives birth (Diaz 2009; Humphrey and Tucker 2009; Sandall 2014).

A reason for this disparity between the official guidelines and the procedure in practice is that the NICE guidelines, while created for and published by the NHS, are not hard fast rules to which NHS organizations must adhere. According to a 2015 NICE publication discussing the use of NICE guidelines, “there is no single model for effective implementation of NICE guidance; different organizations will implement NICE guidance in different ways…Some organizations may wish to follow our advice in its entirety, but others may wish to just adapt what we suggest or incorporate parts of it into local improvement models” (National Institute for Health and Care Excellence 2015). This guide suggests that while NICE guidance is produced for the NHS, it is not a mandate for the NHS. The voluntary nature of uptake of NICE guidelines is further underscored by a Commissioning Policy report published by the NHS Commissioning Board, which draws a distinction between NHS Directions, instructions from the Secretary of State which place a legal requirements on NHS organizations, and NHS Guidance, which is seen as “non-binding advice which is intended to assist the NHS in the exercise of its statutory duties” (NHS Commissioning Board 2013). The 2013 NHS Commissioning Board publication indicates that NHS bodies can choose not to follow NHS Guidance if they have sufficient justification for this decision, and that “the availability of resources and competing priorities can be a good reason” (NHS Commissioning Board 2013).

Contrasting interpretations of the guidelines governing the use of labour induction in the United Kingdom are one way in which NHS Trusts may have varying labour induction rates. Another potential influence is differences in maternity staffing, the impact of which is detailed below.

2.8.1.2 The Influence of Maternity Staffing

As described in Section 2.6 and 2.7, the type of health care provider a woman utilizes during her labour and birth may influence her risk of labour induction (and childbirth interventions in general). The discussion of maternity staffing in the literature can be divided into two main themes: type of health care worker (midwife or obstetrician/consultant) and the number of staff in comparison to patient caseload (ability to provide one-to-one care). This section considers these two themes in more detail.

In a study conducted by Oakley et al (2006) in the United States, which adjusted for maternal risk factors, the intensiveness of the medical care, and women’s preferences, there were still significant provider differences in 3rd and 4th degree perineal tears and numbers of complications between obstetrician and midwife-led care, with women at greater risk of tears and complications when being treated by obstetricians. Fewer complications in midwifery care is also borne out in the United Kingdom, as evidenced by work by Sandall (2016), who found that women in midwifery care were less likely to have episiotomies and operative deliveries, and were more likely to have spontaneous vaginal births (Sandall 2013). According to Sandall (2014), in the United Kingdom, this difference between midwifery and obstetrician care may be due to “the philosophy behind midwife-led continuity models, [which] includes: an emphasis on the natural ability of women to experience birth with minimum intervention and monitoring the physical, psychological, spiritual and social wellbeing of the woman and family throughout the childbearing cycle" (Sandall 2014, page 5).

The ratio of staff to patients is crucial to the examination of maternity health care because it forms the crux of the argument for continuity of care. Continuity of care refers to the ability of a health care provider to remain with a woman throughout the whole of her labour and birth (Sandall et al 2016). *Changing Childbirth*, a report published by the Expert Maternity Group in 1993, is a frequently-cited government publication underscoring the importance of continuity of care in the provision of maternity services in the United Kingdom, and how it can improve a woman's experience of labour and birth (Sandall 1995). This report also highlighted the need for greater maternal choice in and control over childbirth. However, while *Changing Childbirth* helped move the discourse on improved one-to-one care forward, over the intervening twenty-five years there have been practical challenges – including barriers in the structure of maternal health provision and differences in health provider education – which have made it difficult to fully implement changes recommended in the report in 1993 (Pope et al 2001).

Continuity of care has been cited as an important determining factor in both the physical and emotional experiences of birth (Sandall et al 2016), and a potential explanation for improvement of labour experiences in smaller midwifery practices. One-to-one care for women in labour increases a woman's sense of control over her experience, which increases her satisfaction with her labour and birth (Sandall et al 2016) and may allow women with social disadvantages to have more agency in their childbirth experiences (Finlay and Sandall 2009). Fontein (2010) also stresses the importance of considering the caseload of a practice, as a small number of midwives in a large practice would understandably decrease that practice's ability to provide continuity of care (Fontein 2010). It is for this reason that proportions of number of staff members to number of births have been used in this project.

Additionally, there is evidence that the care a woman receives varies by type of midwifery. Standard midwifery care, the most common practice under the NHS, involves community midwives providing antenatal care at clinics and postnatal care at home, and hospital midwives providing labour and birth care on midwife-led units. Caseload midwifery, a far less common practice, is defined by one midwife being responsible for a set number of women each year, such that pregnant women see the same midwife throughout pregnancy, birth, and the first few weeks postpartum (Finlay and Sandall 2009). In a 2015 UK study of pregnant women with complex social backgrounds, women under caseload midwifery care were more likely to have spontaneous vaginal births and know their midwives, and less likely to have caesarean sections and epidurals, than women receiving standard midwifery care (Rayment-Jones et al 2015).

A reason for this difference in care, Finlay and Sandall (2009) write, is that there is less continuity of care in the standard midwifery model, as it is “more difficult for standard care midwives to utilise their knowledge, skills, and position to advocate for women when they did not known them and had no overall responsibility for their care” (Finlay and Sandall 2009, page 1232). Being an advocate and ensuring continuity requires that a health care worker can exercise personal discretion over health care decisions, which may be impossible in standard maternity health care situations in the UK, considering these situations are often bureaucratic and designed to handle large numbers of people at the same time (Finlay and Sandall 2009). Thus, “the aim of woman-centred care became NHS policy but this aim had to be achieved within structures whose encoded values were very different” (Kirkham 1999, page 733).

Despite the publication of several summary reports comparing the four health systems of the United Kingdom since the devolution of the NHS in 1999 and the assumption that diversity in NICE guideline uptake would lead to differences in maternal health outcomes, there is little information available on how this has impacted maternal care across regions, as midwifery is only assessed along with nursing and health visitors in terms of staffing and hospital admissions. A 2012 report of health care in the UK published by the National Audit Office highlights the differences in infant mortality across the UK, with marked differences reported between regions in England, but there is no specific mention of maternity care.

Considering the potential variation in both implementation of NICE guidelines by NHS Trust and staffing levels and types given the variety in Trust funding and resources within and between countries highlighted in Section 2.8.1, the present thesis aims to determine whether there are differences in labour induction by NHS Trust within countries in the United Kingdom and whether these differences remain once country has been taken into account. The next section considers more specifically how maternal health and labour induction may vary within and between the UK countries.

2.8.2 Maternal Health and NHS Trust

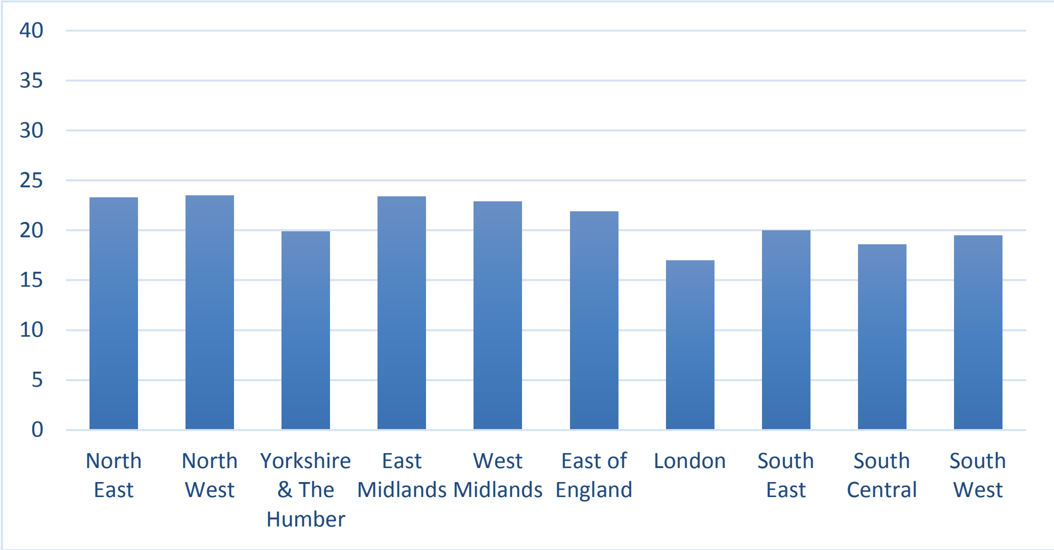
Induction rates have varied across medical units in the United Kingdom since the introduction of intravenous oxytocic drugs in the 1940s and 1950s (Oakley 1983). However, few reports have examined the association between maternal health and health authority or NHS Trust and, in much the same way highlighted in the literature review in Chapter 2, most (if not all) studies investigating the relationship maternal health and specific NHS Trust have used caesarean section as the outcome of interest, making it difficult to determine the association between labour induction and NHS Trust in previous literature. For example, Gurol-Urganci et al (2011) found that there was significant variation in the rates of elective caesarean sections after 39 weeks gestation across NHS Trusts each year from 2000 to 2009, with the rates of elective caesarean after 39 weeks ranging from 28% to 89% in 2008-2009. This speaks to an important variation in maternity care across NHS Trusts, but considering that elective caesarean sections are procedures that by definition bypass labour inductions, these results aren't particularly relevant to the present analysis.

However, some studies that have examined varying caesarean section rates between NHS Trusts are helpful if we consider the well-documented connection between labour induction and caesarean section. A study by Bragg et al (2010) found that in England, rates of caesarean section continued to vary from 14.9% to 32.1% between NHS Trusts after adjusting for maternal health risk factors. When Bragg et al (2010) considered caesarean sections by categorization, they found that most of the variation in the caesarean section rates was in the use of emergency caesarean sections. This is important to the present analysis because the caesarean sections associated with labour inductions are those categorized as emergency sections. Bragg et al end their paper by advising NHS Trusts and clinical commissioners to examine why rates of emergency caesarean section vary considerably between Trusts. One way to do so would be to study whether rates of labour induction vary significantly between Trusts and what factors influence this relationship.

In fact, there does appear to be some evidence that the rate of induction of labour varies between NHS Trusts across the United Kingdom. Figure 2.5 displays the total labour induction rates[3] between Trusts in regions of England for 2012-2013 (a year in which rates were released by Trust rather than by government region or strategic health authority), highlighting that there are in fact differences in the rate of induction by NHS Trust in areas in England. Figures 2.6, 2.7, and 2.8 display the labour induction rates for the year 2014 in NHS health boards in Scotland, hospitals in Northern Ireland, and local health boards in Wales, respectively. These induction rates imply that there are also variations across care providers in Scotland, Northern Ireland, and Wales, with the largest differences being between NHS health boards in Scotland.

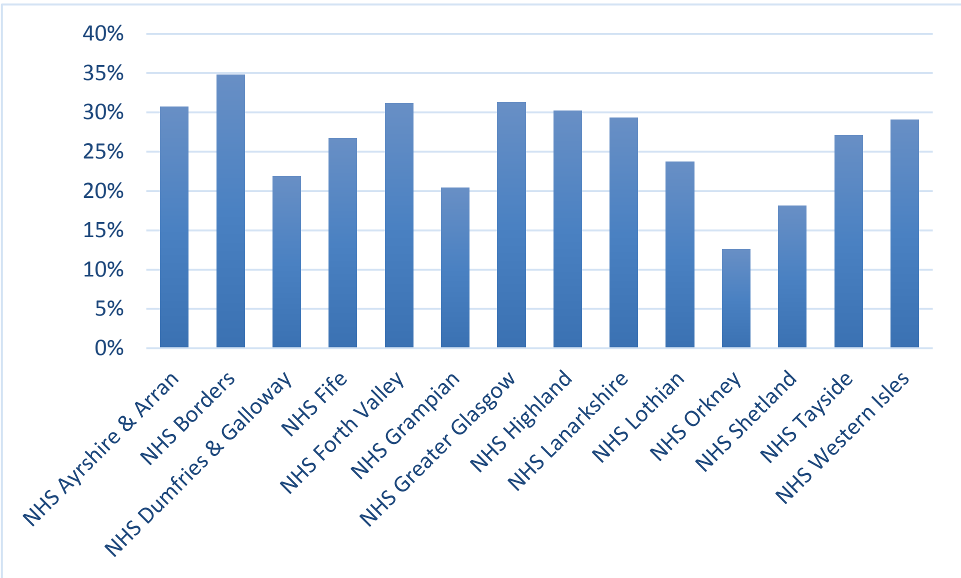
[3] While these figures are technically proportions, both the literature and the data releases refer to them as rates. Therefore, for expediency and consistency, the term rate is used here as well.

Figure 2.5 Labour Induction Rates by NHS Trust in Regions of England, 2012-2013



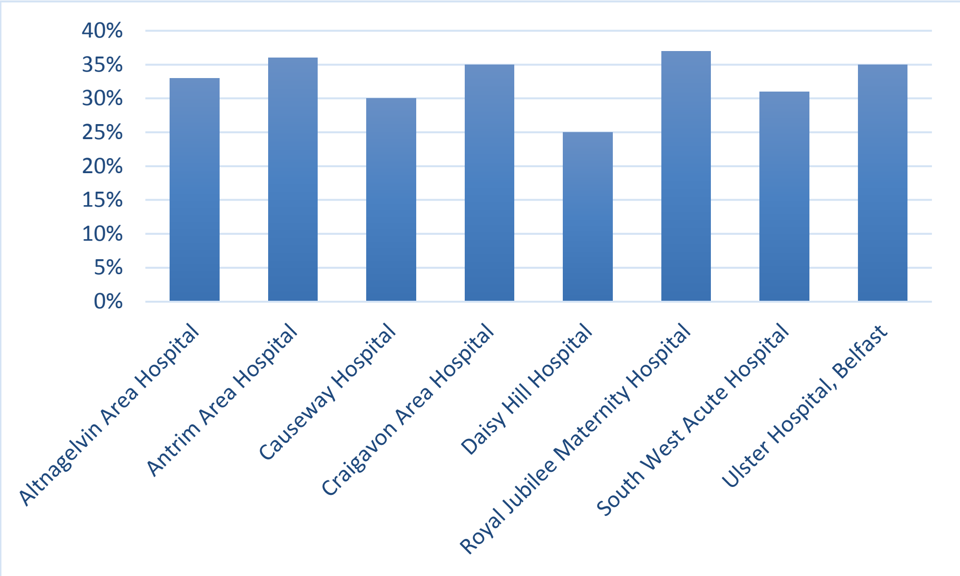
Source: NHS Maternity Statistics 2012-2013

Figure 2.6 Labour Induction Rates by NHS Health Board in Scotland, 2014-2015



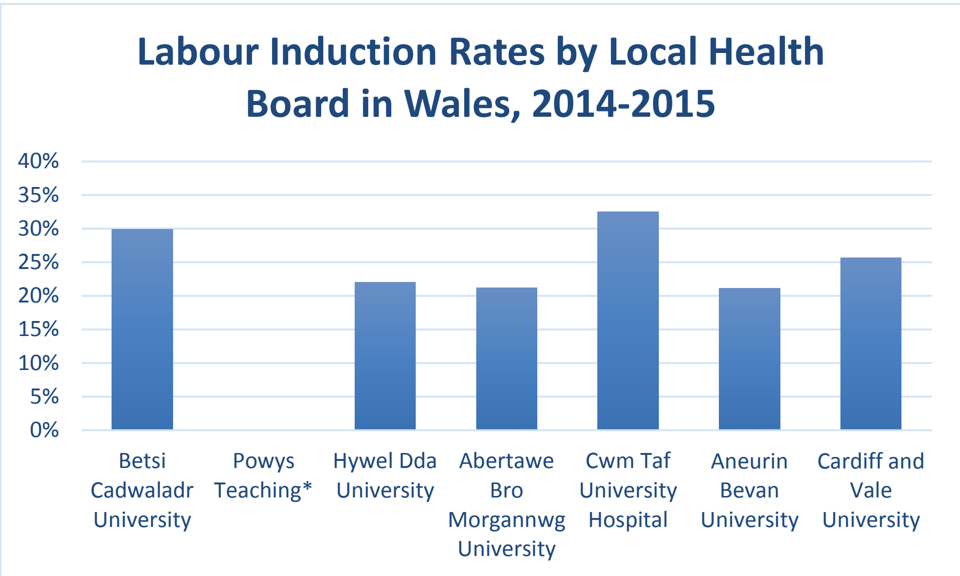
Source: NHS Scotland Maternity Statistics

Figure 2.7 Labour Induction Rates by Hospital in Northern Ireland, 2014



Source: BirthChoiceUK (Department of Health Northern Ireland)

Figure 2.8 Labour Induction Rates by Local Health Board in Wales, 2014-2015



*Powys Teaching Local Health Board has no maternity ward with provisions for childbirth interventions. Thus, no inductions were recorded for 2014-2015 and all births in this local health board were categorized as "unassisted."

Source: Office for National Statistics, Statistics for Wales 2014-2015

A report by the Royal College of Obstetricians and Gynaecologists (RCOG) in 2011 found that there was wide variation in both practice and outcomes in 152 maternity units across England. After adjusting for maternal health and demographic risk factors for labour induction, rates of induction for nulliparous women ranged from 6.1% to 43.4%. For multiparous women, there was a narrower range across hospitals, from 9.7% to 35.7%. According to a recent press release from the RCOG issued in spring 2016, this time focusing on NHS Trusts instead of individual hospitals, there is still considerable variation in maternity care across England. After adjusting for maternal risk factors, there remains a “two-fold difference between NHS Trusts with the lowest and highest rates of emergency caesarean sections,” again the type of caesarean section usually precipitated by a labour induction (RCOG.org 2016). Additionally, induction of labour data from 2013-2014 presented by the RCOG illustrates variation in the rate of labour induction across NHS Trusts by parity in England, with nulliparous women experiencing higher rates of induction as a whole than multiparous women. For example, for the Great Hospitals NHS Foundation Trust located in southwest England, 43.1% of nulliparous women were induced, compared to 25.2% of multiparous women. This trend is apparent for many Trusts across England (RCOG.org 2016).

Variations in the socioeconomic status of women seeking maternity care in the UK is a potential explanation for why there are differences in the rates of labour induction and caesarean section within countries after adjusting for maternal risk factors. The next section details the relationship between socioeconomic status and labour induction posited by this chapter.

2.8.2.1 Maternal Education and Health Care

As discussed in Section 2.6, socioeconomic status is a well-studied determinant of health care access and utilization. However, Adler (2002) writes that “while socioeconomic status is clearly linked to morbidity and mortality, the mechanisms responsible for the association are not well understood [and] identifying these mechanisms provides more options for policy remedies” (Adler 2002, page 61). One objective of this thesis, explored in both Chapter 4 and Chapter 5, is to determine whether maternal education, as a proxy of socioeconomic status, is a mechanism which shapes the risk of labour induction by NHS Trust in the United Kingdom, as this could be important policy information for those areas in which education is a significant predictor of induction of labour.

According to Adler (2002), education is the most salient indicator of socioeconomic status, as it not only influences employment and financial opportunities but also provides the highly educated with more quality information, better life skills, and greater resources with which to choose health behaviours and navigate and exploit health care systems. This echoes a study by Winkleby et al (1990), focusing on examining the risk factors for cardiovascular disease by proxies of socioeconomic status (defined as education, occupation, and income), which found that education was the only indicator of socioeconomic status that had a significant association with risk of disease, even after adjusting for demographic characteristics.

Additionally, while no studies have considered exactly how maternal education operates on birth outcomes between NHS Trusts, some research has explored how sociodemographic factors can affect a patient's satisfaction with their care in the NHS. Turabi et al (2013) and Bone et al (2014) both used the National Cancer Patient Experience Survey to examine patient experience of care, with Turabi et al focusing on the experience of patient involvement in decision making and Bone et al concerned with the rating of care overall. Turabi et al found no significant difference in the reported experience of personal involvement in decision making between hospitals. Conversely, Bone et al found that there was significant difference in the ratings of overall care by NHS Trust; namely, patients who were younger, female, non-white, or suffering from chronic conditions were less likely to rate their care as very good or excellent, after controlling for patient- and Trust-level indicators. While the influence of sociodemographic factors on treatment (or the personal experience of that treatment) is necessarily condition-dependent, making it impossible to generalize these findings from cancer treatment to maternal health care, these two studies provide two important takeaways: 1) health care experience can vary by health care provider, after adjusting for individual and care provider indicators, and 2) this was evident at the NHS Trust level.

Therefore, a study of the association between labour induction and NHS Trust would be best served by the addition of maternal education as a proxy of maternal socioeconomic status. The use of maternal education would provide insight not only into how socioeconomic status shapes the risk of labour induction across NHS Trusts, but also how personal resources associated with educational qualifications (such as higher confidence, broader knowledge, and more informed decision making) influence a woman's childbirth experience.

2.9 Conceptual Framework

The conceptual framework presented in Figure 2.9 below is constructed using core concepts from the literature detailed in the sections above, illustrating how characteristics such as age and ethnicity, those most inherent to a woman and out of her control, can inform her educational, marital, and occupational choices and opportunities, and consequently, how these decisions can impact her health during pregnancy and risk of intervention during childbirth. Drawing on research presented in Section 2.6, the framework also acknowledges that the characteristics of individual women can be influenced by the area in which she lives or the health care she receives, as no experience of health care occurs outside of the influence of the location or the provider.

As discussed above, it has been well documented that a woman's socioeconomic status can have a significant impact on her health as a mother (Hart 1971; Blane 1985; Cook et al 1999; Marmot

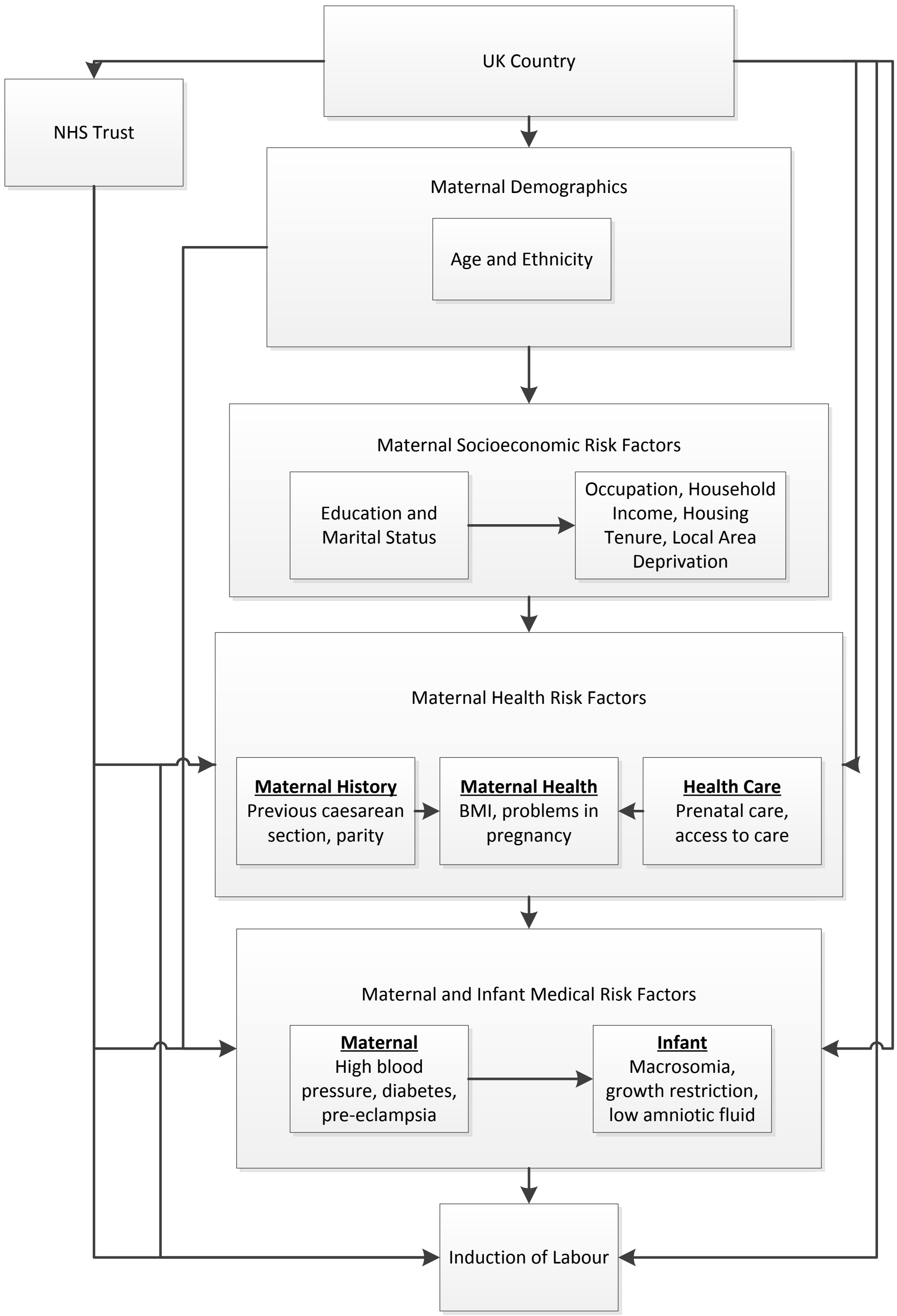
2005, 2007, 2012). The ability of socioeconomic status to both directly and indirectly influence a woman's health and her risk of labour induction is illustrated in Figure 2.9. Socioeconomic disadvantage can have direct effects on a woman's health both before and during pregnancy through poorer quality health clinics, reduced access to quality care, less healthy diets, and increased use of tobacco, alcohol, or substances. The influence that poorer quality health care, a less healthy diet, and the abuse of substances can have on the health of a pregnant woman and her child(ren) can be large, as obesity, smoking in pregnancy, and lack of access to prenatal care are associated with maternal diabetes and high blood pressure, and with infant birth weight complications (Baker and Taylor 1997; Rosenberg et al 2005; Chu et al 2007; Hawkins et al 2008; Chen et al 2009). The evidence of these direct influences on health, and their links to labour induction, are presented as Maternal Health Risk Factors (those more general health issues related to pregnancy) and as Maternal and Infant Medical Risk Factors (health problems expressly related to pregnancy and birth) in Figure 2.9.

The conceptual framework posits that maternal characteristics, such as education, occupation, housing tenure, neighbourhood deprivation, and health care provider, can work from the top of the framework down to labour induction, such that one influence compounds another. For instance, a woman's age and ethnicity can influence her education, occupation, and housing tenure, which in turn impact her risk of the health issues and medical problems leading to labour induction discussed above and illustrated in Figure 2.9 (Hart 1971; Marmot 2005, 2007, 2012). This association between demographics, health risk, and induction can also be influenced by local area deprivation, by the health care providers utilized during pregnancy and birth, and the country in which a woman lives, because, for example, a healthy woman may experience potentially unnecessary childbirth interventions if she gives birth in a place in which interventions are used more liberally than they are somewhere else.

Finally, socioeconomic status can influence a woman's health through a perceived lack of control over one's choices, both in health specifically and in life in general (Blane 1985; Cook et al 1999; Wood et al 1999; James et al 2007; Braveman et al 2010). When considering pregnancy and childbirth, life events in which mothers must make myriad choices for the health and safety of both themselves and their children, it stands to reason that a woman's perceived control over her health might influence her actual control (Conrad 1992; Lazarus 1994; Lawrence et al 2009). A woman with lower socioeconomic status may be at higher risk of the both the physical problems and the perceived lack of control over choices that can lead to labour induction during childbirth.

This reflected in the conceptual framework by the inclusion of a woman's age and educational qualifications, and the connection between these indicators and her health.

Figure 2.9: Conceptual Framework



Source: Author

If induction of labour can be viewed as the gateway to childbirth intervention (as outlined in Figure 2.2), it is beneficial to further examine the relationship between maternal demographics and risk of labour induction. This conceptual framework illustrates the connections relevant to the goals of this thesis, which are: to determine which of the maternal characteristics highlighted in the conceptual framework are the most critical indicators of labour induction risk for women in the United Kingdom; to explore how the relationship between these maternal indicators and labour induction may vary by the NHS Trust and UK country in which a woman gives birth; and to investigate whether there is a link between induction of labour and operative delivery, as described by Figure 2.2.

2.10 Summary

The purpose of this thesis project is to explore labour induction and its associations with maternal indicators and operative delivery in the context of the United Kingdom. While rates of labour induction have been increasing in the UK over the past several decades, little work has been done on which maternal demographic and socioeconomic indicators make women are more likely to experience this childbirth intervention in the United Kingdom. As most of the literature concerning maternal indicators of induction of labour comes from countries that do not operate under universal health care, it could be that much of what is known about the characteristics of women at risk of induction cannot be easily translated into a UK context. Therefore, given the health care system literature discussed above, the first goal of this thesis is to establish whether the maternal indicators of labour induction in the United Kingdom differ from those highlighted in the literature produced by other countries.

Additionally, although the United Kingdom has higher rated health than many European Union countries and provides care through a universal health care system, there are still notable inequalities between people based on their social class and economic status (Newton et al 2015). These health inequalities are important to the study of maternal health in general and childbirth intervention specifically in the United Kingdom, because as Doran et al (2004) write, "for NHS and social service agencies charged with meeting [health equality] targets, whether social inequalities in health are sharper in some regions of Britain than in others is of scientific and policy relevance." Indeed, researchers have called for better data on and analysis of NHS outcomes, especially those associated with health interventions, as they could help measure NHS success (Lakhani et al 2005). Thus, as inequalities vary substantially by both NHS Trust and country in the United Kingdom, it would be beneficial to also examine the risk of labour induction using measures of NHS Trust indicators, taking both Trust structure and the influence of UK country into account.

The second analysis chapter does this, and contributes to the knowledge about labour induction in the United Kingdom by determining whether the characteristics of individual women are still significant predictors of induction when women are placed within the health care provider and country contexts in which they receive health care.

Finally, while labour induction is an outcome worthy of study in itself, it is also critical because of its relationship to caesarean deliveries, as many previous studies have found a link between undergoing an induction of labour and experiencing an emergency caesarean section. The analyses presented in the third analysis chapter of this project will trace the associations between labour induction and type of delivery in the United Kingdom, in order to determine if there is a risk of entering into and completing the cascade of interventions detailed in the literature and in Figure 2.2, whether this risk is mediated by the use of epidural anaesthesia, and how it is moderated by maternal height.

Chapter 3 The Millennium Cohort Study

3.1 Overview of the Study

The dataset selected for use in this thesis is the Millennium Cohort Study (MCS), as it not only includes variables on all pertinent topics, but also draws its sample from the whole of the UK and is publicly available via the UK Data Service website. The large, UK-wide MCS sample allows for more potential generalizations of findings and helps better illuminate the differences between mothers, and the availability of the data allowed for timely access and analysis

The MCS, managed by the Centre for Longitudinal Studies at the University of London, is a longitudinal survey of over 19,000 cohort children born in 2000-2001 in the United Kingdom. It is the fourth, and most recent, British cohort study. The first sweep of this survey was conducted when cohort members were nine months old and recorded information about the socioeconomic and demographic situations of the families into which they were born, in addition to details about the pregnancies and births experienced by the mothers and cohort babies. Five subsequent sweeps have followed the MCS children when they were three, five, seven, eleven, and fourteen years old. Data for the seventh sweep is currently being collected from cohort members, who are now 17 years old.

Most data from all sweeps of the MCS can be accessed publicly through the UK Data Service website, where the bulk of the survey data and anonymized geographical data can be downloaded by any researcher who builds a UK Data Service account. Datasets with more potentially identifying information, such as specific geographic location or NHS Trust name, require researchers to submit applications for access. Over the course of the research presented in this thesis, both publicly available datasets and those requiring special access applications were utilized.

Ethical approval for the secondary data analysis undertaken in this project was granted by the University of Southampton in 2015.

3.2 Sample Design

The Millennium Cohort Study used electoral wards as the geographical sampling frame. The sample was geographically clustered and stratified to over-represent Wales, Scotland, and Northern Ireland, as well as areas with high poverty and high proportions of ethnic minorities in England. The Index of Deprivation 2000's child poverty measure was used to determine which electoral wards had large numbers of disadvantaged children (Millennium Cohort Study First Survey: Technical Report on Sampling 3rd Edition 2004).

The sample was disproportionally stratified in an attempt to appropriately represent each of the four UK countries, areas of England in which at least 30% of the population was Black or Asian, and more disadvantaged areas (classed as those that did not fall into the minority ethnicity group, but which belonged to the poorest 25% of electoral wards according to the Child Poverty Index of the Index of Deprivation 2000).

For England and Wales, the sample includes babies who were born between September 1, 2000 and August 31, 2001. In an effort to avoid competing with an infant feeding survey being conducted in autumn 2000 in Scotland and Northern Ireland and due to low numbers demanding an extension of the birthdate year, the sample for those two countries was drawn from babies born between November 23, 2000 and January 11, 2002.

The survey relied on Child Benefit records and recruitment via health visitors to find cohort member children.

3.3 Recall Bias in Prospective Studies

The first sweep of the Millennium Cohort Study surveyed parents and guardians of cohort members about nine months after the birth of the cohort member. As the survey information recorded in the MCS is self-reported, there is the very real risk of recall bias in the data, as previous research into health indicates that self-reported health behaviour can be subject to recall error (Gaskell et al 2000; Kjellsson et al 2014). According to Hassan (2005 page 1), recall bias is “intentional or unintentional differential recall (and thus reporting) of information about the exposure or outcome of an association by subjects in one group compared to the other.”

While some research into recall bias indicates that longer recall periods lead to less accurately reported information (Hassan 2005; Stull et al 2009; Kjellsson et al 2014), other studies have determined that recall bias may always be present and that it is simply the type of recall error that changes over time. In a study linking the records of the number of hospitalizations with participant recall of hospitalizations, Kjellsson et al (2014) found that those in the shorter recall period (one month) over reported their number of hospitalizations and those in the longer recall period (one year) under reported hospitalizations. Kjellsson et al (2014) posit that this difference in recall error type may have to do with the frequency and saliency of an experience. Those events that are more frequent call for a shorter recall periods and those that are more salient call for a longer recall period, when researchers can also benefit from the increased amount of information time and exposure grant them.

This is important for the analysis at hand because very few events are more marked in a woman's life than the day (or days) she gives birth to a child. According to Coughlin (1990), the current literature on recall accuracy implies that the extent of incorrect recall can be linked to distinguishing characteristics of the event and its participants, meaning that we might assume there is less recall bias when an event is as profound emotionally or physically as pregnancy and childbirth tends to be.

Studies of maternal recall post-pregnancy have failed to reach a consensus on the trustworthiness of all survey data concerning childbirth. Much of the discord in the literature comes from differences in the recall of various types of medical information. For example, there is some evidence from studies that compared health records with survey data that women have difficulty recalling pregnancy complications such as protein in urine or placental issues accurately in the years after the births in which they were experienced (Olson et al 1997; Buka et al 2004). However, this incorrect recall may be due to failed or partial communication between doctors and mothers during pregnancy, and not to a woman's inability to remember. Most published research agrees that women are able to correctly recall their infant's birth weight, their smoking behaviour, and major medical interventions such as forceps use and caesarean delivery (Delgado-Rodriguez et al 1995; Olsen et al 1997; Yawn et al 1998; Buka et al 2004; Rice et al 2006) up to 20 years or more after the time they occurred, which is important for the present research as these are the variables utilized.

3.4 Use of Data

Before the Millennium Cohort Study data were used in the following analysis chapters, various changes were made to the datasets accessed. To allow for thorough analysis, several downloaded MCS1 datasets were merged, as the research design required information from the full range of available MCS Sweep 1 data. The dataset used for analysis was built by merging the MCS1 Variables, Geographical Data, Longitudinal, and Parent Interview datasets, which had been downloaded without special license or secure access requirements. The information contained in this initial merger of datasets was enough to conduct the analyses presented in Chapter 4, which focuses on the maternal demographic, socioeconomic, and health risk factors for labour induction.

However, as Chapter 5 is concerned with investigating the influence of location of birth (operationalized by NHS Trust) on a mother's risk of labour induction and because the publicly available MCS1 dataset only includes anonymised NHS data, a Special License data application was made to the UK Data Service in order to gain access to the dataset in which the hospitals and NHS Trusts are named. This additional dataset is called the Millennium Cohort Study, 2001-2003: Hospital of Birth: Special License Access, and contains information from the first sweep of the MCS collected in 2001 and the second sweep collected in 2003. The data covered in this dataset include the country in which the cohort birth was recorded, the NHS Trust of birth, and the hospital of birth. This data was collected at the same time as the Millennium Cohort Study data detailed in sections 3.1 and 3.2, using the same sample and survey design. The only difference between this additional dataset and the general MCS dataset outlined above is the sensitivity of the information, such that the hospital of birth and NHS Trust data needed to be protected by Special License status. This Special License dataset was then merged into the dataset detailed above. For the purposes of the analyses in Chapter 5, information on the hospital and NHS Trust of birth, taken from the first sweep, was used.

Once all data were included in the master dataset, stratification, clustering, finite population correction, and design weights obtained from the MCS literature on the University of London's Centre for Longitudinal Studies website were applied to this new dataset. As the MCS data is a sample drawn from the whole population of the UK, the weights utilized help account for the potentially unequal chances of a mother being selected into the MCS sample and make the results of the analyses undertaken here more generalizable to the whole of the United Kingdom.

Finally, as the MCS contains information collected via survey questionnaire nine months after the cohort child's birth, cases in which the natural mother was not the main respondent interviewed were removed in an effort to eliminate as much recall bias as possible. Selecting for natural mother respondents dropped 747 cases, bringing the sample size to 18,497. Additionally, as twin and triplet pregnancies are far less likely to end in labour inductions, cases in which the cohort children were twins (246) or triplets (10) were removed from the dataset, bringing the final sample size to 18,241. The MCS only includes children who were alive at time of first interview nine months post-birth, and thus does not include stillbirths or children who died in the first nine months of life. Therefore, the analyses are conditional upon the child being a singleton birth still alive at nine months old.

3.5 Other Datasets Considered

As this project is concerned with the maternal demographic and socioeconomic risk factors associated with labour induction, it required the use of a detailed maternity dataset, and therefore, for some time, data from the Pregnancy Risk Assessment Monitoring System (PRAMS) in the United States was considered for use in the following analyses. The PRAMS datasets contain state-specific survey data obtained from new mothers in the US, who are selected from a population-based sample using birth certificate details (Kotelchuck 2006). This survey data, collected via questionnaire from 1,000 to 3,000 mothers per participating state, includes information on income, maternal BMI, illnesses in pregnancy, prenatal care, labour and delivery, breastfeeding, and infant health, making it a compelling source of information for a project like this one. However, given the relatively small sample sizes in each state, data from ten to fifteen US states would be necessary to match the number of participants in a nationally representative survey like the Millennium Cohort Study in the UK (which includes nearly 19,000 cohort children), and selecting which of the participating states to include in a broader analysis introduced more potential confounders than felt comfortable. Additionally, as much of the previously published literature concerning the risk of labour induction has been conducted outside the United Kingdom and a motivation for the present thesis is to examine how the associations between risk factors and labour induction differ in the UK health care context, the decision to investigate induction of labour in the United Kingdom was made, and datasets from the United States were no longer considered.

Once the focus was narrowed solely on the United Kingdom, but before the MCS was selected as the final dataset, two alternative UK maternity datasets were considered for the analyses. The first, the Southampton Women's Survey (SWS), contains health information collected from 12,500 women in Southampton, England between 1998 and 2002. Women who conceived children after participating in the first round of interviews were asked to continue their participation through their pregnancies, making the SWS the first survey in Europe to begin collecting information about mothers before they were pregnant. Due to the nature and variety of the data collection (in-person interviews, ultrasound scans, blood work, and umbilical samples), the SWS dataset contains comprehensive information on the women and children included in the sample. Unfortunately, the SWS lacks the information on labour and delivery needed to address the aims of the current project and therefore, it could not be utilized.

The second potential alternate dataset was a HICCS collection of over 80,000 medical records held by Southampton General Hospital, containing detailed medical information for both mothers and babies. While this HICCS dataset would provide a wealth of information on the labour and delivery each woman experienced, it is missing socioeconomic variables such as maternal educational qualifications, which were vital to the project presented here. Additionally, access to the dataset could not be granted in time to make it available for timely use.

Although both the Southampton Women's Survey and the HICCS hospital dataset each contain detailed information about women in the Southampton city and Hampshire council area, ultimately these two datasets lacked key elements necessary for the analyses in this thesis. The Millennium Cohort Study, while less medically detailed and potentially less precise, contains nationally representative data on the pregnancy, labour, and birth experiences of over 18,000 mothers and children, allowing the results of analyses to be better generalized across the United Kingdom. In addition, the MCS provides information on the demographics and socioeconomic statuses of the mothers pre-pregnancy, making it possible to control for these maternal background factors in all the models run in the following analysis chapters. All things considered, the MCS was the most appropriate dataset available for this project.

Chapter 4 Maternal and Infant Risk Factors for Labour Induction in the United Kingdom

4.1 Introduction

As the rate of labour induction increases in the United Kingdom, relatively few studies have focused on why this might be, and while published literature has identified several maternal medical indicators that may increase the likelihood of labour induction, there's little consensus on how these indicators influence risk in the United Kingdom. Therefore, the present analysis seeks to provide a more thorough representation of which women are at greater risk of labour induction in the UK and how this risk is influenced by the medical risk factors identified by previous research.

The focus of this chapter will be on which individual factors specific to women (and the MCS cohort babies they gave birth to) have significant associations with their risk of experiencing labour induction. The purpose of this analysis is to highlight which frequently-cited indicators of childbirth intervention risk are in fact risk factors for women in the United Kingdom, as much of the previous research on labour induction has been conducted in the United States, a country without the universal health care established in the United Kingdom. This contrast in health care funding and provision between the United Kingdom and the United States may lead to differences in the relationship between labour induction and maternal risk indicators.

While one of the explanatory variables used here is a measure of deprivation based on the electoral ward in which a woman lived, there are no additional or more specific location indicators included in the following analysis. The potential mediation of these associations by the location of the NHS Trust a woman used at birth (and by extension, the health care a woman received during labour) will be explored in Chapter 5.

4.2 Research Questions

1) Do maternal demographics and socioeconomic status influence risk of labour induction in the United Kingdom?

2) Do these associations persist after controlling for maternal and infant medical risk factors?

4.3 Methods

This analysis is concerned with which maternal and infant indicators are risk factors for labour induction, and therefore, the outcome variable selected for use in this analysis was whether or not a woman had undergone a labour induction during the birth of the cohort member. This variable included any form of induction, with the text of the survey question reading, "Was the labour induced or attempted to be induced? [Note: Induced labour = any attempt to start labour (including injections, pessaries, breaking the waters)]" (NatCen 2003, page 51). As this induction variable was explicitly concerned with recording whether there was an intervention at the start of labour, this variable does not contain information about labours which had been augmented by drugs after they had already begun. The categorical induction variable is dichotomous (a woman either was induced or was not induced), and therefore, binary logistic regression was selected for the final analysis.

Binary logistic regression is similar to generalized linear regression, a method which models the associations between outcome and explanatory variables by building linear equations based on available data. Both linear and logistic regression allow the description of relationships between variables and the prediction of values of outcome variables. However, as linear regression functions by fitting linear equations to data, outcome variables in linear regression must be continuous. As our outcome variable is dichotomous, we must use logistic regression to model the relationship between labour induction and maternal indicators.

In contrast to linear regression, logistic regression uses a logit function to calculate of the log-odds (the logit transformation of the probability) of a case falling into one of the two categories in a dichotomous outcome variable, as seen in Figure 4.1. This logit transformation of probability allows the binary outcome data to be modelled as a linear function. It also means that in logistic regression, the predictions made are predicted probabilities (transformed into log-odds) instead of predicted discrete events as in linear regression (Shalizi 2013).

In logistic regression, the two categories of a binary outcome variable are coded as Success (1) or Failure (0). In this analysis, a "success" is a woman experiencing labour induction and a "failure" is a woman not experiencing labour induction.

The logit transformation of probability is as follows:

$$Logit(\pi) = log\left[\frac{\pi}{1-\pi}\right] \tag{4.1}$$

Drawing on the conceptualization in Figure 2.9 and previous research detailed in Chapter 2, the analytical framework for this chapter follows a woman's risk of labour induction from her personal demographic information (age and ethnicity) through to each increasingly influential level of risk leading to induction of labour. The analytical framework posits that a woman's age and ethnicity can influence her socioeconomic status, which in turn impacts her general health, which ultimately increases the chances that she'll experience some of the medical risks that can lead to labour induction. Each maternal indicator of risk included in the analytical framework is a risk factor highlighted by the literature as important to either maternal health in general or the risk of childbirth intervention specifically. In this analysis, a woman's socioeconomic status is operationalized through the use of maternal marital status, educational qualifications, household income, housing tenure, last known occupation, and the deprivation of the electoral ward in which she lived, to be detailed below in Section 4.4.2.2.

Given the difference in risk for nulliparous and multiparous women presented in the literature, these two groups are considered separately in these analyses. After the MCS sample was split into nulliparous and multiparous women but before running the logistic regression models, bivariate analysis was performed using Pearson's Chi square tests to illuminate which categorical explanatory variables had significant associations with the labour induction outcome variable. Chi square tests, classic tests of goodness-of-fit, were performed with the labour induction outcome variable and each of the explanatory variables, and were used in an effort to identify those variables that could clarify and improve the fit of the final models. Significance levels were set at $p=0.05$.

After running bivariate analysis, four logistic models were fit for nulliparous women and multiparous women, controlling for various demographic and socioeconomic variables, which are described in further detail in the next section (4.4). The analyses hoped to first capture how ethnicity and age at birth of the cohort member child influenced risk of labour induction. Therefore, the first model was fit using only these maternal demographic variables, in an attempt to build a baseline model for comparison. This model is referred to as Model 1, as shown in Table 4.1 below.

In order to answer research question 1, as defined in Section 4.2, Model 2 added maternal socioeconomic variables to the regression conducted in Model 1. The addition of socioeconomic variables was an attempt to highlight how the influence of maternal demographics alone was affected by indicators of maternal socioeconomic status, such as education and occupation. Models 3 and 4 were efforts to respond to research question 2 and determine how the effects of maternal socioeconomic status on risk of labour induction were controlled by the addition of the maternal and infant health indicators seen as risk factors for childbirth interventions. The structure of Model 4, the final model, is presented in Table 4.1.

Table 4.1: Analytical Framework

Outcome Variable	**Model 1**	**Model 2**	**Model 3**	**Final Model**
Induction	Maternal Demographics	Maternal Demographics	Maternal Demographics	Maternal Demographics
		Maternal Socioeconomic Status	Maternal Socioeconomic Status	Maternal Socioeconomic Status
			Maternal Health	Maternal Health
				Infant Health

The logistic regression model used in this analysis is as follows:

$$Logit(\pi_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \ldots + \beta_k x_{ki} \quad (4.2)$$

where *i* is the individual woman in each case,

$x_{1i}, x_{2i}, x_{3i} \ldots x_{ki}$ are the values of each explanatory variable included in the analysis for woman *i*,

ß is the effect of the explanatory variable on the probability of "success,"

and $Logit(\pi_i)$ is the calculated log-odds of a woman being a "success" (i.e. being induced) given her unique combination of explanatory variables.

All analysis was conducted using STATA version 14, with appropriate sample weighting applied.

4.4 Measures

4.4.1 Outcome Variable

As mentioned above, the outcome variable for this paper was a dichotomous variable containing information about whether or not a labour induction had been performed. This variable included 12,571 women who did not experience labour induction and 5,646 women who did. More detailed information concerning the reason for labour induction (such as medical indications like failure to progress or foetal distress) were not recorded in the MCS dataset and therefore not used in the analysis. Ultimately, as the intention was to measure labour induction as an outcome, the reasons for the use of induction were not necessary. Also missing from the dataset was information about the type of induction performed (for example, whether the induction was the manual rupture of membranes or the administration of intravenous medication). However, as all labour induction implies an intervention into the natural progression of labour, and as this paper is focused on the risk of the intervention itself, the type of induction was not fundamental to the research.

4.4.2 Explanatory Variables

The analysis for the present paper split mothers into two groups, nulliparous and multiparous, in an effort to illuminate any differences between them. Splitting the sample by parity required determining whether or not the cohort member child was a mother's first birth. The Millennium Cohort Study includes children who are the first, second, or higher order births in their families, but does not ask if a cohort member is a mother's first child, meaning that while a cohort member may be the second child born to his mother, this birth order was not explicitly recorded in the dataset. As no derived first birth variable currently exists in the MCS1 dataset, variables outlining relationships in the household were used to ascertain parity. Unfortunately, birthdate information was not available for natural or maternal half-siblings; therefore, it was not possible to determine whether a cohort member was older than a natural or maternal half-sibling living in the household. Therefore, cohort members were determined to be their mother's first births for cases in which cohort members had no natural or maternal half-siblings in the household, no natural siblings living outside the household, and no deceased natural siblings, or who fit the above criteria and were older than their natural siblings not living in the household (true in two cases).

The following explanatory variables concern maternal demographic, socioeconomic, and health indicators of labour induction, as well as infant medical risk factors for induction. These explanatory variables and their categorical organization in the dataset are presented below in Table 4.2.

Table 4.2: Outcome and Explanatory Variable Coding

Variable	Categorical Organization
Labour induction	No labour induction; Labour induction
Maternal age	19 years old and younger; 20-25 years old; 26-30 years old; 31-35 years old; 36 years old and older
Maternal ethnicity	White; Indian; Pakistani & Bangladeshi; Black or Black British; Other including Mixed
Maternal relationship status	Legally married; Cohabiting; Single/Divorce/Widowed
Maternal educational qualifications	Higher and first degrees; Diplomas in Higher Education; A/O Levels (including GCSE grades A-C); Other (including GCSE grades D-G); None
Maternal occupation before pregnancy	Managerial and professional; Intermediate; Self-employed; Lower supervisor; Semi-routine and routine; None
Household income quintiles	Lowest quintile; Second quintile; Third quintile; Fourth quintile; Highest quintile
Housing tenure	Own outright/own with mortgage; Rent from Local/Housing Authority; Rent privately; Other (including living with parents)
Local area deprivation	England – Advantaged; England – Disadvantaged; England – Ethnic; Wales – Advantaged; Wales – Disadvantaged; Scotland – Advantaged; Scotland – Disadvantaged; Northern Ireland – Advantaged; Northern Ireland – Disadvantaged
Maternal smoking	Did not smoke in pregnancy; Smoked in pregnancy
Pregnancy complications	No pregnancy complications; Complications not associated with induction; Complications associated with induction; Other
Maternal BMI before pregnancy	Low (>18.5); Normal (18.5-24.9); High (≥25.0)
Infant birth weight	Low (<2500 grams); Normal (2500-4000 grams); (>4000 grams)
Infant gestational age in days	259 days or less (37 weeks or less); 260-272 days (37 to 39 weeks); 273-286 days (39 to 41 weeks); 287-293 days (41 to 42 weeks); 294 days or more (42 weeks or more)

4.4.2.1 Maternal Demographic Variables

The maternal age variable used in this analysis is maternal age at cohort member's birth, and this variable is measured in completed years. It was computed by linking the date of the mother's birth with the date of the cohort member's birth. (This derived variable was computed for all main respondents, but as we are concerned with natural mothers, only cases in which the natural mother was the main respondent were used in analysis). The variable available in the MCS was continuous, with ages ranging from 14 years old to 48 years old. For the purposes of this analysis and in keeping with previously published studies on childbirth intervention (Heffner 2003; Wilson 2007), the data in this continuous variable was collapsed into five categories: 19 years old and younger; 20-25 years old; 26-30 years old; 31-35 years old; 36 years old and older. In three cases, the respondent's age at birth of the cohort member was recorded as "not known" and these three cases were coded as missing data and dropped from analysis.

Maternal ethnicity was included in the analysis as a maternal demographic variable. Different maternal ethnicity categories were used in the four UK countries (England, Wales, Scotland, and Northern Ireland) that participated in the MCS, as each country has a unique concentration of ethnicities and identities. In the interest of standardizing ethnicities across the whole of the UK, derived ethnicity variables were created for the MCS. Due to sample size constraints, the derived maternal ethnicity variable grouping respondent ethnicity into 6 Census classes was used. For this project, maternal ethnicity was categorized as White, Mixed, Indian, Pakistani or Bangladeshi, Black or Black British, or Other. Cases in which respondents refused to respond (4) or did not know their ethnicity (26) were coded as missing and dropped from analysis.

4.4.2.2 Maternal Socioeconomic Variables

In this analysis, maternal relationship status is a measure of whether a mother is legally married, cohabiting, or single, divorced, or widowed and not cohabiting. Information about maternal respondent cohabitation was derived from variables containing information about respondent legal marital status and relationship to other household members.

Maternal education was measured by highest level of academic qualification held nine months after birth (when data for the first sweep was collected). The eight categories used to record highest academic qualification in the MCS were: Higher Degree, First Degree, Diplomas in Higher Education, A/AS/S Levels, O level/GCSE Grades A-C, GCSE Grades D-G, Other Academic Qualifications (including overseas qualifications), and None of these qualifications. For these analyses, the eight education categories were collapsed into five: Higher and first degrees; Diplomas in Higher Education; A/O Levels (including GCSE grade A-C); Other (including GCSE grades D-G); and None.

Household income would at first glance appear to be the most telling marker of socioeconomic status. However, research suggests that focusing on income alone ignores both household composition, and the emotional, psychological influences of other socioeconomic status proxies such as education and neighbourhood, which can also weigh heavily on a person's health and wellbeing (Duncan 1996). Additionally, household members do not necessarily share household wealth (Eurostat 2013). Therefore, income quintiles were utilized in this research. An income quintile, built using a simple equivalence scale, seeks to take into consideration how differences in household composition influence how well family income measures family wealth (OECD 2013). The income quintiles used in this analysis were measured using the modified OECD equivalence scale income weighted quintiles created for UK-wide analysis (as opposed to those created for single country analysis). As suggested by the name, this variable was split into five categories, ranging from lowest quintile to highest quintile.

Women who own their homes either outright or through a mortgage may be seen as more financially secure than those who live with their parents or those who rent their homes. Considering this, as our analysis hopes to capture indicators of socioeconomic status, housing tenure was selected as an explanatory variable. For the purposes of this analysis, and with adequate sample sizes in mind, the original ten-category MCS housing tenure variable was collapsed into four categories: Own Outright/Own with a Mortgage; Rent from Local/Housing Authority; Rent Privately; and Other (including living with parents). In addition to those respondents living with their parents, the “Other” variable included those who were sharing equity in a rental/mortgage scheme, those who were living rent free, and those who were squatting. Responses that were recorded as refusals, “don’t know,” or not applicable (a total of 39 cases) were coded as missing data and dropped from the analyses.

In this analysis, maternal occupation is defined as the job responsibility expected at a respondent’s last known job, with job responsibility referring to the managerial, supervisory, or routine nature of a woman’s work. In lieu of current employment status, a woman’s last known job was selected as the occupation analysed because there were over 9,600 cases coded as “not applicable” in the variable recording a main respondent currently in work or on leave from a paying job. This may be due to the fact that the data in MCS Sweep 1 was collected just nine months post-birth, when women who left work in order to have their children may not have re-joined the workforce. Thus, in an effort to utilize occupation before pregnancy, a respondent’s last known job was used in the analysis. In addition, only employment information for women was included because the research aims to better understand what maternal characteristics influence childbirth intervention. While women who are married, cohabiting, or in committed relationships may benefit from their partner’s occupation, this information does not pertain to the women themselves, and therefore it was excluded from analysis. Initially in the MCS dataset, employment responsibility for last known job was coded into fifteen NS-SEC major categories, including various levels of managerial and professional responsibility, full time students, and those who had never worked. In an effort to achieve functional sample sizes, a derived variable collapsing the data into five NS-SEC categories (Managerial & Professional, Intermediate, High Supervisory, Lower Supervisory, and Semi-Routine & Routine) and a sixth “not applicable” category was used. The overwhelming majority of data included in the “not applicable” category was that of women who had never worked, but women who were full time students or who refused to state their last known occupation were also represented in this category.

The final socioeconomic variable included in the analysis was a deprivation variable created by the MCS, measuring the relative advantage or disadvantage of the area in which a respondent lived. This local area deprivation variable was derived using indices of multiple deprivation from the electoral ward level linked to the address at interview. Deprivation data for the four UK countries under review was obtained from the ONS, the Welsh Assembly, the NISRA, and the Scottish government, and organized into nine categories: England – Advantaged; England – Disadvantaged; England – Ethnic; Wales – Advantaged; Wales – Disadvantaged; Scotland – Advantaged; Scotland – Disadvantaged; Northern Ireland – Advantaged; and Northern Ireland – Disadvantaged. In England, households were placed into the “Ethnic” category if they were located in electoral wards with populations at least 30% identifying as “Black” or “Asian.” Additionally, English households were deemed “Disadvantaged” if they were not categorized as “Ethnic” and were among the poorest 25% of wards based on the Child Poverty Index for England and Wales. Advantaged English households were those who did not fall into the “Ethnic” or “Disadvantaged” categories. In Wales, Scotland, and Northern Ireland, households were deemed “Disadvantaged” if they were among the poorest 25% of wards based on the Child Poverty Index for England and Wales, and “Advantaged” if they were not among the poorest 25%.

4.4.2.3 Maternal Health Variables

Whether a mother smoked during her pregnancy was derived using MCS1 questions concerning past smoking behaviour, and if and how that smoking behaviour changed during pregnancy. Using main respondent data, a smoking in pregnancy variable was derived, containing two categories: mothers who had never smoked, along with mothers who quit smoking when they discovered they were pregnant; and mothers who continued to smoke tobacco products throughout their pregnancies. This second category included women who changed their smoking behaviour during pregnancy (i.e. reduced the number of cigarettes smoked every day) but did not quit entirely.

An extensive list of various pregnancy complications was collapsed into a variable with four categories: No pregnancy complications; Pregnancy complications not usually associated with induction: bleeding, threatened miscarriage, backache, vomiting, foetal heart rate issues, placental problems, accidents – essentially, problems that did not necessitate induction, or in which an induction would threaten the life of the baby; Pregnancy complications associated with induction: raised blood pressure, eclampsia/preeclampsia, diabetes, gestational diabetes, too much or little fluid around the baby, suspected restricted foetal growth, liver/gall bladder problems, cholestasis, early rupture of the membranes – effectively, any problems that may necessitate labour induction, as detailed in the literature reviewed in Chapter 2; and Other. The data in this variable relied on the mother’s recall of her experience and/or diagnosis of these illnesses during her pregnancy. As the MCS did not include a variable concerning the reason for induction during the birth of the cohort child, organizing this pregnancy complication variable by associations with labour induction allowed it to also act as a proxy variable for reason for induction. While it is not possible to use this proxy to draw any conclusions about the relationship between the potential reason for induction and the likelihood of induction, the inclusion of a variable constructed in this way strengthens the analyses undertaken in this project by controlling for these potential medical indications for labour induction (as described in Section 2.2.1).

Maternal BMI both before and after birth is available in the MCS1 dataset. Maternal BMI before birth was selected, as it is the measurement that would have had bearing on a woman's health in pregnancy. Mothers were asked to provide their height and recall their weight before pregnancy, and from this, maternal BMI before birth was calculated by dividing a mother's height in metres by her weight in kilos and squaring the result. Maternal BMI was then coded into three distinct categories: Low (below 18.5); Normal (18.5-24.9); and High (25 and above).

4.4.2.4 Infant Health Variables

The prediction of infant birth weight via ultrasound technology is controversial and not reliably accurate, so actual infant birth weight is not the best indicator of a predicted infant birth weight that may have motivated a labour induction. However, as predicted infant birth weight was not available in the dataset, actual infant birth weight in kilos was used in the hope of controlling for the influence of predicted birth weights on the induction of labour. Mothers were asked to provide the cohort member's red book, the medical record containing detailed information about an infant's health. The cohort member's birth weight was taken from this document if it was provided. If the red book was not available, interviewers relied on mothers' ability to recall their children's birth weights. Research into recall bias has shown that women are quite good at remembering the birth weights of their babies, with one study finding accurate recall twenty-two years post-birth (Delgado-Rodriguez et al 1995; Olsen et al 1997; Yawn et al 1998; Buka et al 2004; Rice et al 2006). Infant birth weights were collapsed into three categories [Low (<2500 grams), Normal (2500-4000 grams), and High (>4000 grams)], with the birth weight cut off for the High category being the weight at which macrosomia is defined.

In the MCS1, infant gestational age in days was computed in two different ways: if the gestation in weeks was available in linked hospital data and if this gestation measure was between 24 and 43 weeks, it was multiplied by 7 to estimate gestation in days; and if the gestational period in weeks was not available in linked hospital data, gestation was assumed to have been 280 days and days pre-term or post-term were added or subtracted to estimate gestation in days. A continuous derived variable concerning infant gestational age in days was organized into five categories (late preterm, early term, full term, late term, post term) using infant gestational age ranges provided in the WHO 2011 Bulletin.

A risk factor included in the conceptual framework but excluded in the analyses is antenatal care, as in the MCS sample, 96.19% of respondents reported receiving antenatal care, making the sample size of those not receiving care too small to be appropriately analysed.

4.5 Descriptive Results

Descriptive statistics were calculated for the MCS data after the sample was split into two groups, nulliparous and multiparous women, and are presented in Table 4.3 below. These statistics illustrate that nulliparous women and multiparous women have key similarities and differences. For example, a higher percentage of nulliparous women were induced (36.4%) than multiparous women (27.2%). This is in keeping with current literature about labour induction and parity, which has found that nulliparous women tend to experience labour induction more frequently (Seyb et al 1999; Cammu et al 2002; Simpson et al 2005).

While both groups of women seem to have similar proportions of ethnic group membership, with the vast majority of respondents identifying as White in both the nulliparous (86.0%) and multiparous (82.5%) groups, the two types of women differ by age. Eighteen percent of nulliparous women were 19 years old or younger and 6% were 35 years old or older, whereas just 2.2% of multiparous women were 19 years old or younger and 15.5% were 35 years old or more. Multiparous women, then, tend to be older, which might be expected considering multiparous women have had at least one other child.

In the MCS, fewer nulliparous women were married and more were cohabiting or single or divorced than their multiparous counterparts, which may speak to nulliparous women being younger than multiparous women. In addition, a slightly higher percentage of nulliparous women had higher/first degrees (19.0%) than multiparous women (13.4%), with a considerably lower percentage of nulliparous women reporting leaving education before their GCSEs (13.8%) than those women in the multiparous group (23.5%). A higher proportion of nulliparous women were in the highest income quintile and in managerial or professional occupations before having their children. More nulliparous women in the highest income quintile makes sense, considering that the income quintiles used in the MCS were calculated using relative deprivation scales utilizing the relationship between household income and household composition. Households with only one child may have access to more resources, as their incomes have to stretch to fewer people. Following on from this, more nulliparous than multiparous women reported housing tenure other than owning or renting their own properties, implying that perhaps more nulliparous women were living with their parents or in other rent-free situations. Women in both groups were relatively equally represented across local area deprivation categories, with the proportions of respondents in each band nearly identical.

A comparison between the two groups in the maternal and infant health variables highlights a remarkable similarity. Nulliparous and multiparous women had similar percentage distributions across smoking behaviour, pregnancy and labour complications, infant birth weight, and gestational age in days. The groups differed slightly in maternal BMI, with fewer nulliparous women reporting pre-pregnancy BMIs of ≥25.0 (24.3%) than multiparous respondents (31.9%).

Table 4.3: Percentage Distribution of Natural Mother Respondents (Nulliparous versus Multiparous)

		Nulliparous		**Multiparous**	
		%	Number	%	Number
Labour Induction	Not induced	63.6	4,754	72.8	7,817
	Induced	36.4	2,721	27.2	2,925
Maternal Age	19 years and under	18.0	1,350	2.2	232
	20-24 years old	28.9	2,163	20.1	2,165
	25-29 years old	28.7	2,148	30.6	3,291
	30-34 years old	18.4	1,378	31.6	3,397
	35 years and older	6.0	451	15.5	1,663
Maternal Ethnicity	White	86.0	6,432	82.5	8,855
	Indian	2.7	199	2.5	273
	Pakistani/Bangladeshi	5.2	386	8.1	868
	Black/Black British	2.9	216	4.2	449
	Other	3.3	243	2.7	290
Maternal Marital Status	Legally Married	50.7	3,798	64.4	6,925
	Cohabiting	27.9	2,088	20.4	2,195
	Single/Divorced	21.4	1,604	15.2	1,631
Maternal Education	Higher/first degrees	19.0	1,422	13.4	1,436
	Diplomas in higher education	9.4	703	7.6	819
	A/O Levels (GSCE A-C)	43.4	3,244	42.4	4,542
	Other (incl. GCSE D-G)	14.4	1,073	13.2	1,410
	None	13.8	1,032	23.5	2,514
Maternal Occupation	Managerial/professional	30.5	2,283	22.9	2,459
	Intermediate	18.8	1,409	15.2	1,636
	Self-employed	2.6	197	4.1	442
	Lower supervisor	5.2	390	5.6	599
	Semi-routine/Routine	33.0	2,475	39.0	4,197
	None	9.8	736	13.2	1,418
Income Quintile	Lowest Quintile	23.0	1,719	26.6	2,848
	Second Quintile	17.4	1,296	26.1	2,797
	Third Quintile	18.5	1,380	19.3	2,064
	Fourth Quintile	19.1	1,425	16.3	1,744
	Highest Quintile	22.0	1,645	11.8	1,262
Housing Tenure	Own outright/mortgage	57.5	4,295	58.0	6,224
	Rent from LA/HA	21.5	1,610	30.6	3,283
	Rent privately	9.6	720	7.7	821
	Other (incl. with parents)	11.4	850	3.7	399
Local Area Deprivation	England – Advantaged	25.3	1,897	24.6	2,644
	England – Disadvantaged	24.9	1,867	23.9	2,571
	England – Ethnic	11.1	830	14.2	1,531
	Wales – Advantaged	4.5	337	4.5	482
	Wales – Disadvantaged	10.9	813	10.1	1,086
	Scotland – Advantaged	6.5	490	5.9	633
	Scotland – Disadvantaged	7.1	532	6.0	641
	Northern Ireland – Advantaged	3.7	279	4.0	432
	Northern Ireland - Disadvantaged	5.9	445	6.8	731
Smoking Behaviour	Smoked During Pregnancy	15.8	1,182	16.0	1,713
	Did Not Smoke	84.2	6,302	84.0	9,030
Pregnancy Complications	No pregnancy complications	62.1	4,651	62.7	6,737
	Complications not associated with induction	17.7	1,326	19.2	2,066
	Complications associated with induction	15.5	1,160	13.1	1,415
	Other	4.7	353	5.0	533
Maternal BMI	Low (<18.5)	7.5	520	5.0	488
	Normal (18.5-24.9)	68.2	4,737	63.1	6,130
	High (≥25.0)	24.3	1,690	31.9	3,105
Infant Birth Weight	Low (<2500 grams)	7.5	558	5.9	632
	Normal (2500-4000 grams)	84.0	6,287	81.7	8,774
	High (>4000 grams)	8.5	639	12.4	1,333
Infant Gestational Age	259 days or less	10.5	788	10.6	1,135
	260-272 days	14.0	1,052	18.2	1,960
	273-286 days	47.7	3,575	50.1	5,386
	287-293 days	23.4	1,756	17.9	1,926
	294 days or more	4.3	319	3.2	344

4.5.1 Bivariate Results

Following the calculation of descriptive statistics, Pearson's chi square tests were performed on the data in the nulliparous and multiparous groups. These chi square tests analysed the significance of the relationship between each explanatory variable and labour induction in the MCS. The results of these significance tests are presented in Table 4.4. This bivariate analysis presented some expected significant relationships and some unexpectedly insignificant associations.

Across all levels of all variables included in the bivariate analyses, a higher percentage of nulliparous women experienced labour induction than did multiparous women. This is not a surprising result, given the consensus in the literature that women having their first children are more likely to have their labours induced. Additionally, maternal and infant health variables associated with induction (pregnancy complications, maternal BMI, infant birth weight, and gestational age) were all significant for both groups of women.

However, interestingly, maternal age did not have a significant relationship with labour induction. In addition, while the proportions of ethnic group members experiencing induction seems to follow the trend highlighted in the literature, with white women experiencing a higher percentage of inductions than any other ethnicity, maternal ethnicity does not have a significant association with labour induction for nulliparous women (P=0.090) or for multiparous women (P=0.053).

Another unexpected result is that despite being significant for multiparous women, many of the socioeconomic status proxy variables did not have significant associations with labour induction for nulliparous women. Marital status (P=0.031) and local area deprivation (P=0.001) had significant associations for nulliparous women, but educational qualifications, occupation before pregnancy, income quintile, and housing tenure did not. Conversely, each of the socioeconomic variables had significant relationships with labour induction for multiparous women. The lack of significance associated with socioeconomic proxies in the nulliparous group may be due to the cited reasons nulliparous women have labour inductions. In general, women who are expecting their first children tend to have longer pregnancies and slower labours than women who have had at least one other child. The post-date pregnancies and longer labours of nulliparous women often lead them to labour inductions. As later term pregnancies and slow labours are characteristics of first births on the whole and are not associated with specific maternal socioeconomic factors, it may make sense for socioeconomic status to be an insignificant predictor of induction for nulliparous women before models control for maternal and infant health.

Finally, although smoking in pregnancy had a significant association with infant birth weight (P<0.001) in the sample, it does not appear to have an important association with labour induction. While smoking behaviour in pregnancy and induction did not have a significant association in either group of women, each of the other maternal or infant health variables did have a significant relationship with induction in both groups. Pregnancy complications, maternal BMI, infant birth weight, and gestational age in days all had significant associations with labour induction with p values of less than 0.001. It is interesting to note that in nulliparous women who were induced, 72.4% had late post-term pregnancies and 50.3% gave birth to infants with birth weights above 4,000 grams. These proportions were considerably smaller for multiparous women (54.9% and 36.0%, respectively), which again may speak to the tendency for first pregnancies to last longer discussed above, as longer pregnancies can mean larger babies, with post-date foetuses having more time to grow.

Table 4.4: Pearson's Chi Square Significance Test Results and Percentage of Those Induced, by Parity

		Nulliparous %	Multiparous %
Maternal Age	19 years and under	36.3	27.2
	20-25 years old	36.1	27.3
	26-30 years old	35.4	27.7
	31-35 years old	37.8	26.5
	36 years and older	38.4	27.6
Sig.		P=0.437	P=0.348
Maternal Ethnicity	White	36.8	28.2
	Indian	34.2	25.8
	Pakistani/Bangladeshi	35.4	23.3
	Black/Black British	33.5	21.2
	Other	31.0	20.7
		P=0.090	P=0.053
Maternal Marital Status	Legally Married	36.0	26.5
	Cohabiting	36.0	28.9
	Single/Divorced	38.0	28.2
		P=0.031	P=0.047
Maternal Education	Higher/first degrees	34.0	20.8
	Diplomas in higher education	36.0	28.1
	A/O Levels (GSCE A-C)	37.5	28.1
	Other (incl. GCSE D-G)	35.7	26.7
	None	37.1	29.4
		P=0.337	P=0.000
Maternal Occupation	Managerial/professional	35.5	25.0
	Intermediate	35.7	26.8
	Self-employed	38.6	26.3
	Lower supervisor	42.6	25.5
	Semi-routine/Routine	37.3	28.9
	None	33.9	27.6
		P=0.054	P=0.020
Income Quintile	Lowest Quintile	36.4	28.9
	Second Quintile	38.1	28.0
	Third Quintile	36.7	27.7
	Fourth Quintile	35.8	25.0
	Highest Quintile	35.3	23.9
		P=0.534	P=0.000
Housing Tenure	Own outright/mortgage	35.9	26.2
	Rent from LA/HA	36.4	29.1
	Rent privately	36.6	27.0
	Other (incl. with parents)	38.6	28.9
		P=0.341	P=0.001
Local Area Deprivation	England – Advantaged	34.0	23.8
	England – Disadvantaged	35.8	26.4
	England – Ethnic	34.3	22.7
	Wales – Advantaged	33.5	24.9
	Wales – Disadvantaged	35.6	28.8
	Scotland – Advantaged	38.9	29.1
	Scotland – Disadvantaged	41.1	32.0
	Northern Ireland – Advantaged	50.5	37.7
	Northern Ireland – Disadvantaged	39.6	39.1
		P=0.001	P=0.000
Smoking Behaviour	Did Not Smoke	36.5	29.6
	Smoked During Pregnancy	36.4	26.8
		P=0.569	P=0.253
Pregnancy Complications	No pregnancy complications	32.6	24.7
	Complications not associated with induction	36.5	30.1
	Complications associated with induction	50.3	34.4
	Other	40.5	29.1
		P=0.000	P=0.000
Maternal BMI	Low (<18.5)	33.7	26.1
	Normal (18.5-24.9)	34.1	26.1
	High (≥25.0)	43.6	30.2
		P=0.0000	P=0.0004

		Nulliparous %	Multiparous %
Infant Birth Weight	Low (<2500 grams)	32.1	29.6
	Normal (2500-4000 grams)	35.4	25.8
	High (>4000 grams)	50.3	36.0
		P=0.0000	P=0.0000
Infant Gestational Age	259 days or less	30.4	25.2
	260-272 days	31.2	25.4
	273-286 days	27.8	21.1
	287-293 days	53.1	42.4
	294 days or more	72.4	54.9
		P=0.0000	P=0.0000

4.6 Logistic Regression Results

Using a series of nested logistic regression models, progressively more specific models were fit following the analytical framework presented in Table 4.1, using data from the MCS Sweep 1 dataset. The first model explored relationships between labour induction and maternal demographic information, with subsequent models adding socioeconomic and maternal and infant health indicators until a final model controlling for various demographic, socioeconomic, and maternal and infant health variables was achieved. The progressive nature of these models allowed the strength of the relationship between labour induction and maternal indicators to be compared across models with varying controls.

The results of the logistic regression models for nulliparous and multiparous women in Tables 4.5 and 4.6 highlight some differences in the relationships between labour induction and maternal and infant demographics in the two groups. These differences are immediately apparent in the odds ratios presented for the two demographic predictors included in the models: maternal age and maternal ethnicity. In all but the first model run in the nulliparous group, women who were 20-25 years old at the birth of the cohort member were less likely to experience labour induction than women 36 years of age and older (OR: 0.757, 0.744, 0.710, $p<0.05$). However, maternal age does not appear to have an important relationship with induction of labour for multiparous women in this sample, as it holds no statistically significant association with induction across any of the four nested models. Additionally, while maternal ethnicity was not a reliable predictor of labour induction for nulliparous women, multiparous Pakistani and Bangladeshi women were less likely than white women to undergo labour induction (OR: 0.635, $p<0.01$). This association maintained its significance after controlling for demographic, socioeconomic, and infant and maternal health variables.

Table 4.5: Odds Ratios for Logistic Regression of Labour Induction: Nulliparous Women

		Model 1	**Model 2**	**Model 3**	**Model 4**
		Odds Ratio	Odds Ratio	Odds Ratio	Odds Ratio
Maternal Age	19 years and under	0.912	0.701*	0.742	0.745
	20-25 years old	0.855	0.757*	0.744*	0.710*
	26-30 years old	0.861	0.836	0.808	0.761*
	31-35 years old	0.950	0.944	0.926	0.889
	36 years and older	Ref	Ref	Ref	Ref
Maternal Ethnicity	White	Ref	Ref	Ref	Ref
	Indian	0.593*	0.492**	0.599	0.686
	Pakistani/Bangladeshi	0.925	0.811	1.001	1.140
	Black/Black British	1.016	0.859	0.763	0.821
	Other	0.867	0.872	0.998	1.103
Maternal Marital Status	Legally Married		Ref	Ref	Ref
	Cohabiting		0.914	0.975	0.966
	Single/Divorced		1.136	1.245	1.293*
Maternal Education	Higher/first degrees		Ref	Ref	Ref
	Diplomas in higher education		1.080	1.080	1.100
	A/O Levels (GSCE A-C)		1.137	1.120	1.185
	Other (incl. GCSE D-G)		1.145	1.155	1.267
	None		1.255	1.294	1.403*
Maternal Occupation	Managerial/professional		Ref	Ref	Ref
	Intermediate		0.928	0.960	0.897
	Self-employed		1.125	1.168	1.138
	Lower supervisor		1.187	1.075	1.022
	Semi-routine/Routine		1.019	1.010	0.960
	None		0.955	1.068	1.046
Housing Tenure	Own outright/mortgage		Ref	Ref	Ref
	Rent from LA/HA		1.157	1.134	1.083
	Rent privately		1.116	1.143	1.110
	Other (incl. with parents)		1.124	1.083	1.071
Income Quintile	Lowest Quintile		0.917	0.910	0.954
	Second Quintile		0.998	0.924	0.960
	Third Quintile		1.023	0.983	1.033
	Fourth Quintile		0.945	0.880	0.887
	Highest Quintile		Ref	Ref	Ref
Local Area Deprivation	England – Advantaged		Ref	Ref	Ref
	England – Disadvantaged		1.086	1.091	1.080
	England – Ethnic		1.317	1.322	1.380
	Wales – Advantaged		0.903	0.834	0.846
	Wales – Disadvantaged		1.108	1.110	1.100
	Scotland – Advantaged		1.192	1.257	1.321
	Scotland – Disadvantaged		1.310**	1.409**	1.415**
	Northern Ireland – Advantaged		2.020***	2.212***	2.552***
	Northern Ireland – Disadvantaged		1.189	1.251*	1.350*
Smoking Behaviour	Smoked during pregnancy			0.875	0.923
	Did not smoke during pregnancy			Ref	Ref
Pregnancy Complications	No pregnancy complications			Ref	Ref
	Complications not associated with induction			1.170*	1.209*
	Complications associated with induction			2.152***	2.645***
	Other			1.398**	1.380*
Maternal BMI	Low (<18.5)			Ref	Ref
	Normal (18.5-24.9)			1.128	1.091
	High (≥25.0)			1.651***	1.052***
Infant Birth Weight	Low (<2500 grams)				1.117
	Normal (2500-4000 grams)				Ref
	High (>4000 grams)				1.400***
Infant Gestational Age	259 days or less				0.933
	260-272 days				1.114
	273-286 days				Ref
	287-293 days				2.890***
	294 days or more				7.916***

*P<0.05 **P<0.01 ***P<0.001

Table 4.6: Odds Ratios for Logistic Regression of Labour Induction: Multiparous Women

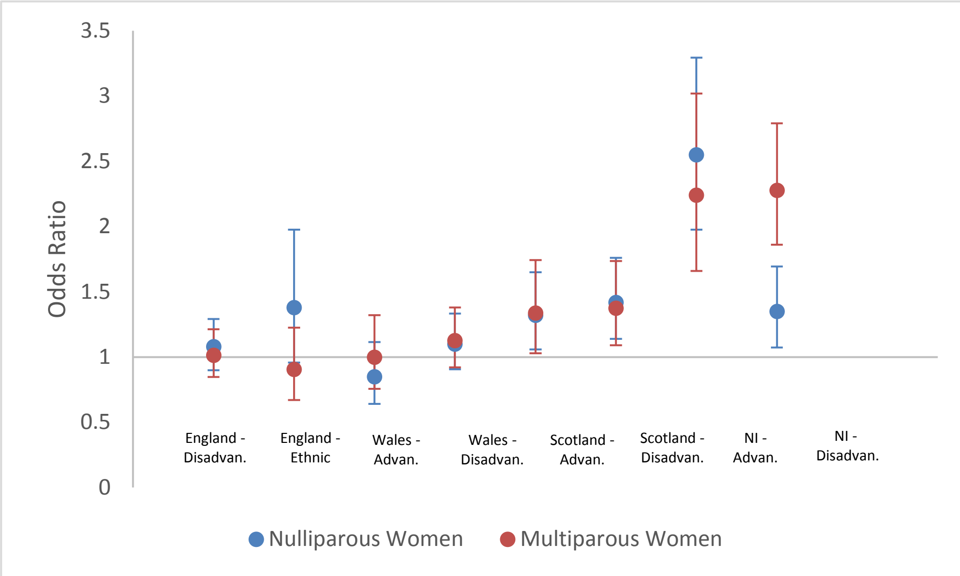
		Model 1	Model 2	Model 3	Final
		Odds Ratio	Odds Ratio	Odds Ratio	Odds Ratio
Maternal Age	19 years and under	1.147	0.935	0.961	1.060
	20-25 years old	1.121	0.937	0.934	0.928
	26-30 years old	1.020	0.914	0.938	0.914
	31-35 years old	0.959	0.957	0.994	0.974
	36 years and older	Ref	Ref	Ref	
Maternal Ethnicity	White	Ref	Ref	Ref	Ref
	Indian	1.043	1.100	1.085	1.210
	Pakistani/Bangladeshi	0.757***	0.615***	0.614***	0.635**
	Black/Black British	0.765	0.842	0.802	0.902
	Other	0.865	0.825	0.820	0.855
Maternal Marital Status	Legally Married		Ref	Ref	Ref
	Cohabiting		1.042	1.083	1.054
	Single/Divorced		0.937	0.989	0.944
Maternal Education	Higher/first degrees		Ref	Ref	Ref
	Diplomas in higher education		1.551***	1.596***	1.592***
	A/O Levels (GSCE A-C)		1.539***	1.580***	1.673***
	Other (incl. GCSE D-G)		1.374**	1.491***	1.550***
	None		1.552***	1.693***	1.882***
Maternal Occupation	Managerial/professional		Ref	Ref	Ref
	Intermediate		0.909	0.882	0.893
	Self-employed		0.972	0.991	0.999
	Lower supervisor		0.819	0.758*	0.793
	Semi-routine/Routine		1.030	1.004	1.020
	None		1.206	1.225	1.249
Housing Tenure	Own outright/mortgage		Ref	Ref	Ref
	Rent from LA/HA		1.013	1.006	1.011
	Rent privately		0.923	0.972	0.981
	Other (incl. with parents)		1.110	1.085	1.030
Income Quintile	Lowest Quintile		1.233	1.136	1.116
	Second Quintile		1.233	1.159	1.134
	Third Quintile		1.092	1.050	1.030
	Fourth Quintile		0.972	0.916	0.944
	Highest Quintile		Ref	Ref	Ref
Local Area Deprivation	England – Advantaged		Ref	Ref	Ref
	England – Disadvantaged		1.001	1.107	1.015
	England – Ethnic		0.931	0.931	0.906
	Wales – Advantaged		1.043	1.044	1.000
	Wales – Disadvantaged		1.128	1.140	1.130
	Scotland – Advantaged		1.307*	1.360**	1.340*
	Scotland – Disadvantaged		1.340***	1.355***	1.375***
	Northern Ireland – Advantaged		1.935***	2.083***	2.240***
	Northern Ireland – Disadvantaged		1.925***	2.160***	2.277***
Smoking Behaviour	Smoked during pregnancy			0.928	0.972
	Did not smoke during pregnancy			Ref	Ref
Pregnancy Complications	No pregnancy complications			Ref	Ref
	Complications not associated with induction			1.334***	1.393***
	Complications associated with induction			1.866***	2.114***
	Other			1.235	1.310
Maternal BMI	Low (<18.5)			Ref	Ref
	Normal (18.5-24.9)			0.914	0.878
	High (≥25.0)			1.093	1.066
Infant Birth Weight	Low (<2500 grams)				1.322
	Normal (2500-4000 grams)				Ref
	High (>4000 grams)				1.190
Infant Gestational Age	259 days or less				1.175
	260-272 days				1.380***
	273-286 days				Ref
	287-293 days				3.046***
	294 days or more				6.048***

*P<0.05 **P<0.01 ***P<0.001

Of the six socioeconomic predictor variables used in this analysis, three had no substantively significant relationship with labour induction in either the nulliparous or multiparous groups. Maternal occupation, housing tenure, and income quintile, three standard economic indicators, had no association with induction of labour in any of the nested models run for both groups. Maternal marital status, used as a proxy of socioeconomic status, had no significant relationship with labour induction for multiparous women. For nulliparous women, however, those who were single or divorced had greater odds of being induced than those who were legally married (OR: 1.293, $p<0.05$).

Local area deprivation had a comparable association with labour induction in both groups of women. In the multiparous group, living in both advantaged and disadvantaged areas of Scotland and Northern Ireland placed mothers at greater risk of labour induction than living in advantaged areas of England (Advantaged Scotland OR: 1.340, $p<0.05$; Disadvantaged Scotland OR: 1.375, $p<0.001$; Advantaged Northern Ireland OR: 2.240, $p<0.001$; Disadvantaged Northern Ireland OR: 2.277, $p<0.001$). These relationships, and their levels of association, were consistent across each nested model. A similar trend was apparent for nulliparous women: mothers living in disadvantaged areas of Scotland and anywhere in Northern Ireland had an increased risk of labour induction compared to mothers living in advantaged areas of England (Disadvantaged Scotland OR: 1.415, $p<0.01$; Advantaged Northern Ireland OR: 2.552, $p<0.001$; Disadvantaged Northern Ireland OR: 1.350, $p<0.05$). As was the case for multiparous women, these associations were stable across all models that included the local area deprivation variable. Overall, living in Northern Ireland placed women at greater risk of labour induction than living in any other country in the UK. The results for local area deprivation for both nulliparous and multiparous women in Model 4 are displayed in Figure 4.3 below.

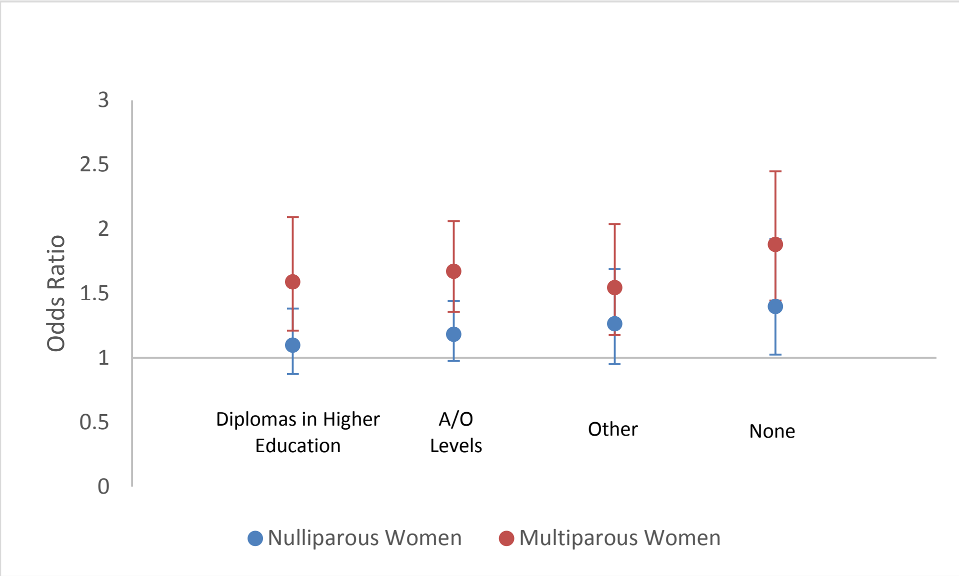
Figure 4.3: Risk of Labour Indication by Local Area Deprivation, Model 4 Odds Ratios



Additionally, for women living in areas of England categorized as “Ethnic” in the MCS data, parity influenced the risk of labour induction. After controlling for maternal and infant indicators in the final model, nulliparous women living in ethnic areas in England were nearly 1.5 times more likely to be induced than women living in advantaged areas of England, whereas multiparous women living in ethnic areas in England were about 10% less likely to be induced than women in advantaged areas of England.

A difference between the two groups is seen in the association between labour induction and maternal educational qualifications (as displayed in Figure 4.4). For nulliparous women, maternal education does not appear to be a particularly compelling predictor of labour induction. The only significant relationship across the nested models appears in the final model, with women with no educational qualifications being at higher risk of induction than those with higher and first degrees (OR: 1.403, $p<0.05$). Conversely, maternal education is one of the most important predictors of labour induction for multiparous women. It is a consistently significant predictor in each nested model and is significant at $p<0.001$ for each variable category. Multiparous women with higher and first degrees were less likely to experience labour inductions than women with any other educational qualification (Diplomas in higher education OR: 1.592, $p<0.001$; A/O Levels and GCSE A-C OR: 1.673, $p<0.001$; Other qualifications including overseas and GCSE D-G OR: 1.550, $p<0.001$; None OR: 1.882, $p<0.001$).

Figure 4.4: Risk of Labour Induction by Maternal Education, Model 4 Odds Ratios



While maternal smoking behaviour was not a significant predictor of induction of labour in either group of women, pregnancy complications and maternal BMI, two other indicators of maternal health which have been found to influence the incidence of labour induction, did have some significant associations with induction. Nulliparous and multiparous women who experienced complications during pregnancy were more likely to undergo induction of labour than were women who had no pregnancy complications, although for nulliparous women, the association was stronger in women with complications associated with induction (OR: 2.645, p<0.001) than in those with complications not usually associated with induction (OR: 1.209, p<0.05). Interestingly, while maternal BMI was a significant predictor of labour induction for nulliparous women, as women with BMIs over 25.0 were more likely to be induced than those with BMIs lower than 18.5 (OR: 1.052, p<0.001), maternal BMI did not have an important relationship with labour induction for multiparous women after controlling for demographic, socioeconomic, and health predictors.

Similarly, for multiparous women, infant birth weight did not have a significant association with induction of labour in either model in which it was included. Infant birth weight did have an important relationship with labour induction for nulliparous women, with women birthing infants with birth weights over 4,000 grams more likely to be induced than mothers who had infants weighing 2,500-4,000 grams (OR: 1.400, p<0.001). Infant gestational age, however, was a significant predictor in both groups. For both nulliparous (Late Term OR: 2.890, p<0.001; Post Term OR: 7.916, p>0.001) and multiparous women (Late Term OR: 3.046, p<0.001; Post Term OR: 6.048, p>0.001), a late or post term gestational age put women at higher risk of labour induction than being at term. For multiparous women, an early term gestational age was also a risk factor for labour induction, with pregnancies ranging from 260-272 days (early term) being at greater risk of induction than those at term (OR: 1.380, p<0.001).

4.7 Discussion

In this study of the maternal and infant predictors of labour induction in the United Kingdom, several demographic, socioeconomic, and health variables were seen to have significant associations with induction of labour. Some of these relationships followed from previous research on childbirth interventions and others were unexpected.

Perhaps the most unsurprising finding is that in the Millennium Cohort Study, more nulliparous women were induced (36.4%) than multiparous women (27.2%). This is in keeping with the literature on labour induction, which finds that fewer multiparous women experience inductions than do nulliparous women (Seyb et al 1999; Cammu et al 2002; Simpson et al 2005). A common explanation for this difference in labour induction rates is that a woman's first pregnancy often goes past term and her first birth can be longer and slower than subsequent births, both of which are risk factors associated with labour induction. In the sample used for this analysis, nulliparous women did in fact have a larger proportion of late and post term pregnancies (27.7%) than did multiparous women (21.1%).

Additionally, in both groups of women, the categories most often associated with labour induction in the literature were shown to have the greatest percentages of induced women in the MCS sample. The largest proportions of nulliparous and multiparous women induced were in the older, white, lowest income quintile, disadvantaged electoral ward, low educational qualification, less work responsibility, BMI over 25.0, pregnancy complications associated with labour induction, and macrosomic baby or late or post term pregnancy categories. These raw proportions follow findings in presented previous literature (Gulmezoglu et al 2012; Moore and Low 2012; Bonsack et al 2014).

Based on results and discussion presented in previous research, maternal age was considered an important risk factor for labour induction in the present analysis. On one hand, a younger woman may be at greater risk of induction, as her pregnancy is more likely to go post term and her labour is more likely to be lengthy and slow (Thomas and Paranjothy 2001). On the other, younger women tend to be less at risk for some of the health indicators of induction, such as gestational diabetes, hypertension, and pre-eclampsia (Heffner et al 2003; Buescher and Mittal 2006; Wilson 2007). In this respect, as it could have presented itself in a number of ways, the relationship between maternal age and labour induction was one of the most anticipated results in this analysis. In chi square analyses performed on the MCS sample as a whole, maternal age appeared to exert an influence over labour induction (with a p value of 0.001).

However, in the logistic regression models fit for nulliparous and multiparous women specifically, maternal age was only a significant predictor of labour induction in the nulliparous parity group. In nulliparous women, those who had their cohort baby at 20-25 years old were less likely to be induced than those who were 36 years old or older when their baby was born. This result follows from the literature mentioned above which reports that younger women may experience fewer pregnancy-related health problems that lead to labour induction. Conversely, maternal age was not significant in any model run in the multiparous group. This is curious because women in the multiparous group were older on average than those in the nulliparous group (6% of nulliparous women were 36+ compared to 15.5% of multiparous women), and one might expect to find that advanced maternal age, and its association with pregnancy-related illness, was a risk factor for induction of labour (Heffner et al 2003). While an explanation for this could have been that splitting the analyses by parity, an indicator linked to age, removed the influence of age, exploratory analyses conducted on the sample as a whole (with nulliparous and multiparous samples merged) also found that maternal age was not a significant predictor of labour induction. The results of this analysis indicate that maternal age is not a compelling predictor of labour induction in the MCS, after controlling for demographic, socioeconomic, and health variables.

Interestingly, income quintile and maternal occupation also were not significant predictors of labour induction for either group of women. This is at odds with some previously published studies on childbirth intervention and labour induction, which have found that income-based measures of socioeconomic status have significant associations with induction of labour (Kozhimannil et al 2014). Much of the research into predictors of intervention has been conducted in the United States, where differences in health care payment and provision may make the results difficult or even impossible to generalize to the UK. In the United Kingdom, where universal health care is established, it makes sense that some socioeconomic variables aren't as profound an influence on health care practices as they are in the US. The significance of the socioeconomic proxy variable containing information on a woman's local area deprivation (via her neighbourhood deprivation as measured by the Child Poverty Index) may shed light on the importance of access to quality services, access to the transportation to these services, the quality/interest of providers, and the types of social support in place in a woman's life to allow her to make decisions about her health throughout pregnancy and care during childbirth.

As expected, maternal and infant health risk factors for induction had significant associations with labour induction in the logistic regression models run in this analysis. For both groups of mothers, women with no pregnancy complications were less likely to undergo labour induction than women with pregnancy complications. Among nulliparous and multiparous women who experienced pregnancy complications, those with illnesses which have been associated with induction of labour, such as hypertension, diabetes, and pre-eclampsia, were at greater risk of induction (Nulliparous OR: 2.645; Multiparous OR: 2.114) than those with complications not regularly associated with labour induction (Nulliparous OR: 1.209; Multiparous OR: 1.393). The results for infant gestational age in this analysis also echo trends presented in the literature. In both groups of women, having pregnancies that ran into late or post term put women at substantially greater risk of induction (Nulliparous late term OR: 2.890, post term OR: 7.916; Multiparous late term OR: 3.046, post term OR: 6.048). As one of the most common indications for induction of labour is a post-date pregnancy, the significance of infant gestational age is not a surprising result. However, considering the literature on labour induction and macrosomia, which is linked to post-date pregnancy, it is curious that infant birth weight and maternal BMI (a risk factor for both maternal health complications and macrosomia) were not significant predictors in multiparous women. One explanation is that in the MCS sample, multiparous women who had high BMI readings or who were carrying potentially macrosomic babies may have had previous birth experiences that influenced whether or not they were induced during the labour and birth of the MCS cohort child. These previous pregnancy or birth complications associated the BMI or infant birth weight may have precluded women from labour induction in the MCS sample.

The presence of influences other than those categorized as socioeconomic or health related is evidenced by the finding that maternal education has a significant relationship with labour induction for both nulliparous and multiparous women. The importance of maternal education is perhaps due to the influence education can have on a women's perceived control over her health care and her ability to navigate the health care system available to her. Indeed, higher education has been linked to lower risk of labour induction and higher confidence in medical decision making in previous research (Braveman et al 2010; Cammu et al 2011).

In the present research, the influence of education on risk of labour induction is most salient in multiparous women, as having a higher degree made women at least 1.5 times less likely to be induced than women in any other education category. This is interesting because in the MCS sample, more nulliparous women (19.0%) had higher degrees than multiparous women (13.4%) and a larger percentage of multiparous women fell into the "No education" category (13.8% of nulliparous women were categorized as having no education qualifications compared with 23.5% of multiparous women). Despite a lower proportion of multiparous women being highly educated in this sample, educational attainment may be more significant in this group overall because women who had given birth at least once before the birth of the cohort baby benefited from their previous childbirth experience in addition to their education. Armed with lessons from their previous labours, highly educated multiparous women may be more inclined to vocalize their preferences.

Previous research posits that an increase in educational attainment can lead to an increase in self-efficacy, which is “the belief that one can successfully accomplish a task and one’s estimation that if the task is accomplished, it will lead to specific outcomes” (Tilden et al 2016, page 2), meaning that women who are more educated may be able to more confidently advocate for themselves both before and during their labours. Women with greater feelings of self-efficacy have been found to be more positive about pregnancy and birth, and to feel less pain and use fewer interventions (such as epidural pain management) during labour (Carlsson et al 2015; Tilden et al 2016). The maternal education results presented in this chapter speak to a potential link between educational qualifications and feelings of self-efficacy during childbirth. However, to better illuminate the relationship between maternal self-efficacy and labour induction, further research could use qualitative methods to investigate how education and parity influence feelings of maternal control and choice during labour and birth in women utilizing the NHS. Qualitative interviews or focus groups would highlight how well the experiences of women lined up with their preferences, and whether the association between preference and experience varied by maternal educational qualifications.

The importance of the deprivation of a woman’s local area speaks to the continued existence of less discrete barriers to health care for women in less advantaged areas of a country with universal health care. Even in countries where health care is made universally available, women in disadvantaged places may have to contend with busier clinics, longer wait times, lower quality interactions with medical professionals, trouble securing transportation to clinics, and a lack of social support, all of which makes accessing available care more difficult (Cook et al 1999; Alder and Newman 2002; Hanratty et al 2007). This may be particularly true in Northern Ireland. According to a study by Abel et al (2016), which adjusted Indices of Multiple Deprivation from each UK country in an effort to allow for the comparison of deprivation between countries, 37% of the population of Northern Ireland lived in places falling in most deprived fifth of the United Kingdom, making it the most deprived country in the UK (Abel et al 2016). Additionally, a Population Trends bulletin produced by the Office for National Statistics in 2010 reported that differences in health and mortality by socioeconomic status were more pronounced in Northern Ireland than for each of the other countries in the United Kingdom (Young et al 2010), which indicates that people with lower socioeconomic status in Northern Ireland are at greater risk of health problems than people in other countries in the UK. Northern Ireland also consistently has the highest rates of labour induction and caesarean section in the UK, and rates higher than those in the Republic of Ireland (Northern Ireland Audit Office 2014). The greater deprivation, more pronounced health differences by socioeconomic status, and higher rates of childbirth intervention documented in Northern Ireland are reflected in the greater risk of induction for women living in both disadvantaged and advantaged electoral wards in Northern Ireland found in this analysis. It may be that in Northern Ireland, women living in advantaged electoral wards are still disadvantaged when compared to women living in advantaged electoral wards in England, and that this relative disadvantage is evidenced by their greater risk of labour induction.

The significance of education and local area deprivation, and the lack of significant economic associations, even after controlling for medical indications for labour induction, implies that income, wealth, and status alone cannot account for differences in labour induction between women in the United Kingdom. Instead, the results of the present research highlight the importance of studying the influence of a woman's environment and education on how she engages with health care practitioners and how she participates in medical decision-making.

4.7.1 Limitations

The present analyses were strengthened by the inclusion of many maternal demographic, socioeconomic, and health variables, and by the large, UK-wide sample offered in the Millennium Cohort Study. This broad sample, taken from each of the four UK countries, allowed for the analysis of induction risk factors for each country and for a comparison of the results to be made between countries. The division of the sample by parity helped to highlight differences between women who were experiencing their first births and women who had had other children, and potential reasons for these differences.

However, despite containing a large UK-wide sample size and making many important variables available, the MCS data is nearly twenty years old, which may introduce questions of relevance to today's policy making (see Chapter 3 for more detail on the decision to use the MCS for this project and Section 7.3 for discussion of data relevance). This study was also limited by missing variables that could have bolstered the strength of the analyses. The MCS contains no information about why a labour was induced, how the labour was induced (for example, either intravenously or manually), or whether the labour induction was perhaps in fact a labour augmentation, with induction techniques utilized to speed up a slow labour. More detailed information about the labour inductions experienced by women in this sample would have helped underline the associations between induction and various maternal indicators. Also, these analyses did not include variables concerning the duration of labour, which the literature reports could be linked to the risk of labour induction, or whether a woman had previously given birth by caesarean section. Previous operative delivery could influence a multiparous women's risk of induction, as past caesarean sections can complicate future labour inductions. Further research could benefit from addition of these maternal health variables into the models.

Additionally, given the significance of the association between induction of labour and the relative advantage or disadvantage of the location in which a woman lived, future analyses would be best served by examining labour induction in the context of the characteristics of health care providers, such hospitals or Trusts, which would allow more thorough spatial analyses to be performed. A thorough examination of the mediators inherent to health care providers would allow future research to more fully understand what about a woman's location made her more or less likely to undergo labour induction in the present analyses.

4.8 Conclusion

The results presented above indicate that the risk of labour induction does indeed differ between women in the United Kingdom. This difference is evident not only between nulliparous and multiparous women, but also within those groups. Nulliparous women were more likely than multiparous women to have their labours induced, but there are more significant associations with labour induction and maternal indicators for multiparous women than for nulliparous women. Although health characteristics such as pregnancy complications and infant gestational age in days are significant predictors of labour induction in both groups, maternal education and local area deprivation, while still associated with induction for nulliparous women, had more important relationships with induction in multiparous women.

The relationship between maternal education and labour induction risk in multiparous women indicates that there is something about educated women who have given birth to at least one other child that makes them less likely to experience labour inductions. Drawing from previous research into the association between education and health care decision-making, this thesis suggests that in addition to their past personal experiences with childbirth, multiparous women may possess greater feelings of self-efficacy, the belief that they can manifest certain outcomes, which in turn makes them more secure in their labour and birth preferences (Tilden et al 2016). When considered on the individual level, this appears to be a potential explanation. However, a woman's belief in herself and her ability to advocate for herself during labour and birth may come into conflict with the services available to her or the preferences of her health care provider. Additionally, as discussed in the last section, the significant associations between labour induction and local area deprivation highlighted by the present analysis suggest that the relative advantage or disadvantage of the area in which a woman lives can influence her risk of labour induction. The determination that in the MCS, women in advantaged areas in England were less likely to experience labour induction than those in advantaged or disadvantaged areas of Scotland and Northern Ireland also introduces questions about the characteristics of care in those countries that might influence a woman's risk.

In Chapter 5, the maternal indicators of labour induction risk utilized in this chapter will be analysed as individual level variables in multilevel models containing characteristics of the NHS Trust in which a woman gave birth. These analyses will serve to further define which maternal characteristics are associated with the risk of labour induction in the United Kingdom and how these are influenced by the health care providers women use during labour and birth.

Chapter 5 Examining Labour Induction in the Context of NHS Trust in the United Kingdom

5.1 Introduction

In the previous chapter, analyses examined which maternal and infant socioeconomic and health indicators were risk factors for labour induction in United Kingdom. The results of that analysis were that a woman's educational qualifications and the deprivation of the electoral ward in which she lived had significant relationships with her risk of labour induction, associations which remained significant after adjusting for maternal and infant health indicators.

In this next chapter, the research aims to take the examination of labour induction risk in the context of location a step further, and determine whether induction risk is affected by the NHS Trust in which a woman gives birth, as posited by the conceptual framework in Figure 2.9 in Section 2.9. It would serve this study to investigate how the influence of woman's individual indicators on her risk of labour induction is dependent on the characteristics of the health care provider she utilizes during birth, considering the difference in risk presented in Chapter 4. This paper posits that the variations in labour induction risk outlined in the previous chapter may be due to differences amongst NHS Trusts both within and between countries in the United Kingdom.

Understanding the effects of NHS Trust is important to the study of maternal health and childbirth intervention in the United Kingdom as NHS Trusts are the bodies through which NHS funding is dispersed to hospitals and through which health care quality is assessed. Additionally, from 2000-2001, the year the MCS cohort children were born, 97.2% of the births in England and Wales were recorded in NHS hospitals, further underlining the importance of studying the relationship between NHS Trusts and childbirth in the UK (ONS Birth statistics, England & Wales 2000). While the organization of the NHS has changed slightly over the last two decades, the funding of NHS Trusts by larger commissioning bodies governed by each of the four UK countries has remained a constant, making the present study of the influence of NHS Trust in the MCS still relevant today.

The link between a woman's risk of labour induction and the NHS Trust in which she gave birth will be analysed in the following chapter using multilevel modelling, with individual women set as the first level and NHS Trust at birth as the second level. In addition to exploring if risk of labour induction varies by NHS Trust, the influence of maternal education on the risk of labour induction will be considered in the context of NHS Trust, given its significance in Chapter 4. Indicators of

NHS Trust practice, such as differences in staffing and numbers of births in from 2000-2001, will be added to models at the Trust level to see which, if any, of these indicators influence the relationships between maternal indicators and labour induction. Finally, the country of the NHS Trust will be added to the model to help further specify the effect of context on labour induction risk.

5.2 Research Questions

1) Does the likelihood of labour induction vary significantly across NHS Trusts in the United Kingdom?
2) Does the effect of maternal education on the likelihood of labour induction vary across NHS Trusts in the UK?
3) Adjusting for the effect of maternal education, can the variation in labour induction by NHS Trust in the UK be explained by the number of births at and the staffing characteristics of the Trusts?
4) Does variation in labour induction by NHS Trust remain when models control for the effect of maternal education and adjust for UK country?

5.3 Methods

In order to examine the interplay between a woman's individual indicators for labour induction and the NHS Trust in which she delivered her cohort child, this paper employs a multilevel modelling strategy. As outcome variable in this analysis is dichotomous (whether or not a woman had her labour induced), the analyses presented here were undertaken using multilevel logistic regression (see explanation of log-odds probability transformation in Section 4.3).

Multilevel models take into account the variation between individuals and also between the higher-level clusters in which they are nested. Students nested within schools, patients nested within hospitals, and individuals nested within families can all have their individual responses influenced by the schools, hospitals, or families in which they are placed (Twisk 2006). Multilevel modelling considers that those individuals nested within the same higher level unit will be more alike than those in different higher level units. Previous studies have posited that in order to fully illuminate the contextual influences of locations, it is necessary to use analyses which account for the nested structure of the information being tested (Humphreys and Carr-Hill 1991; Shouls et al 1995).

According to Snijders and Bosker (2012), comparing regression results from separate logistic regression models across locations of interest may ignore the correlation between those locations and could blur the details of relationships between areas and outcomes, both of which could be detrimental to a study of these relationships. Additionally, ignoring the influence of a macro-level indicator on micro-level outcomes could lead to misleading or false results. Indeed, Dibben et al (2006) suggest that analysing both the effects of area-level and individual-level indicators in studies of maternal and infant health provides “a more refined picture of the relationship between socioeconomic inequalities” and birth outcomes. In Chapter 4, individual level data were considered on their own, both in an effort to highlight indicators related to the woman themselves and also due to data restrictions, as NHS Trust data are anonymized in the Millennium Cohort Study (MCS). In the present chapter, analysis utilizes NHS Trust names, obtained through researcher completion of Secure Access data training from the UK Data Service, to link MCS individual data to Trust level indicators, which could not have been accomplished with anonymous Trust level data.

The present analysis uses the labour induction outcome variable and most explanatory variables from the MCS dataset discussed in Chapter 4. In addition to the data already outlined, this chapter introduces a NHS Trust variable taken from the Millennium Cohort Study, 2001-2003: Hospital of Birth: Special License Access dataset obtained via Special License from the UK Data Service (see Section 3.4 for more detailed discussion of this dataset). Additional data about the number of births and the number of maternity care staff available at each NHS Trust was collected from each of the four UK countries under review (discussed in greater detail in Section 5.4.3.1).

Figure 5.1: Associations between Level 1 and Level 2

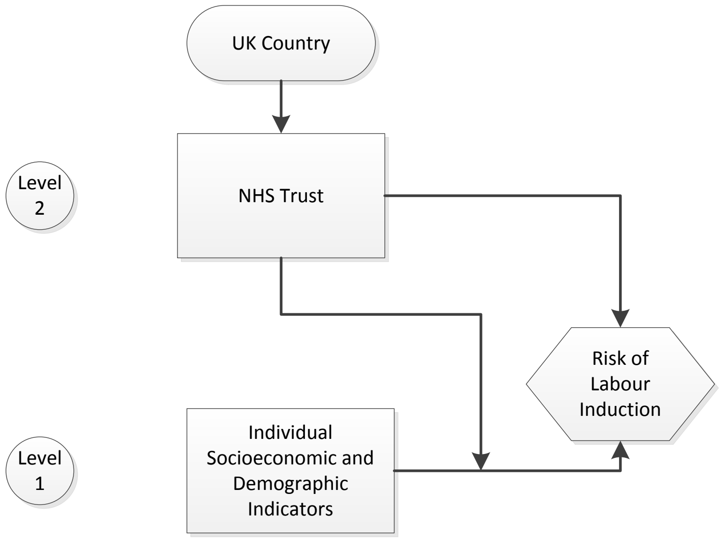


Figure 5.1 above illustrates the relationship between the two levels proposed by the present research. Drawing from previous research into the associations between health outcomes, hospitals, and NHS Trusts, the goal of this analysis is to examine the relationship between labour induction and maternal indicators such as education, socioeconomic predictors, and country of cohort member birth, by NHS Trust. This chapter posits relationships between and within levels; namely, that there will be a difference between induction rates between NHS Trusts by maternal demographics and also that there will be a cross-level interactions between NHS Trusts and labour induction, whereby the relationship between a woman's demographic, socioeconomic, and health indicators and her risk of labour induction is dependent on the NHS Trust in which she gives birth. Additionally, this chapter seeks to understand how the country in which a NHS Trust exists may hold sway over the influence the Trust has on the risk of labour induction.

In the two-level modelling strategy employed in this investigation, Level 1 is defined as the individual women who gave birth to the cohort member child between 2000 and 2001. Level 2 is defined as the NHS Trust in which a woman gave birth to the cohort member. Two-level multilevel models were run for nulliparous and multiparous women, with individual women nested within NHS Trusts. The Level 1 individual data is identical to that described in Chapter 4, and included demographic, socioeconomic, and health controls for women and health information about their cohort children. The Level 2 NHS Trust data are Trust level variables described in the following Section 5.4.

The two-level model structure was selected after initial three-level models, including both hospital and Trust levels, were run using different permutations of the individual level maternal and infant explanatory variables from Chapter 4. In every multilevel model that included individual-level explanatory variables and hospital and Trust level structures, the 95% confidence intervals for the random effects of the hospital level were 0. This indicated that there was no variation at the hospital level in these models, and that all variation was being explained by other factors, such as the individual-level explanatory variables and the Trust level structure. A possible explanation for the Trust level capturing all the variation is that NHS Trusts manage the guidelines that hospitals then employ, meaning that one might expect variation in practice to overlap between hospitals and Trusts. As there were no hospital-level explanatory variables available for use in the later models for research question 3 (see Section 5.4.3.1), and in an effort to remove unnecessary complications from the final models, the hospital level was ultimately removed from the analyses.

Finally, UK country of the NHS Trust was considered as a potential third level in the models, but was ultimately entered as a Trust-level variable. This decision was made because there are only four countries in the United Kingdom, making the clustering into countries potentially meaningless in a multilevel model. This country variable is entered into models as a Trust-level variable because the Trust-level indicators of labour induction (staffing and resources) are influenced by the organization and interpretation of the UK country in which they exist. Considering all the above, the final multilevel models in this chapter included just individual and Trust levels, with country of NHS Trust entered at the Trust level.

As was the case in Chapter 4, the MCS sample was split by parity, allowing the following analyses to consider the women in each group separately. To investigate the first research question, whether or not there is a statistically significant difference between rates of labour induction between NHS Trusts, first a random intercept model was run without accounting for any Level 1 variation. A random intercept multilevel model holds the effect of Level 1 explanatory variables as the same across individuals, and is concerned mostly with understanding the relationships inherent in hierarchical (or multilevel) data. Due to the dichotomous nature of the labour induction outcome variable, this model was a logistic random intercept model.

The logistic random intercept model used in this analysis is presented below:

$$Logit(P_{ij}) = \beta_0 x_{0ij} + \beta_1 x_{nij} + u_j x_{0ij} + e_{ij} \tag{5.2}$$

$$u_j \sim N(0, \sigma_u^2)$$

$$e_{ij} \sim N(0, \sigma_e^2)$$

where:

$Logit(P_{ij})$ is the log-odds for individual *i* in group *j*,

$\beta_1 x_{nij}$ refers to the fixed effect of each of the Level 1 explanatory variables,

u_j is the random group level residual,

e_{ij} is the random individual level residual,

σ_u^2 is the variance between groups, and

σ_e^2 is the variance within groups

In this random intercept model, both β_0 and β_n are considered fixed effects, such that each individual in Level 1 is under the same fixed effect of the Level 1 explanatory variables and only the effects of NHS Trust are allowed to be random.

Also included in the output for these random intercept models is the median odds ratio (MOR). The MOR is a logistic regression substitution for the intraclass correlation (ICC) variance measure used in linear regression. ICC is a measure of the variability between individuals within Trusts compared with the variability of between Trusts themselves, which highlights the level with the most unexplained variability, or clustering. Intraclass correlation is a straightforward calculation in linear regression, in which the individual level and area level variance can be directly compared, but it is a more complex measure for logistic regression. This is because in logistic regression, the area level variance is calculated on a logistic scale and individual variance is calculated as probability. The MOR method for measuring variability between levels, as described by Merlo et al (2006), "translate[s] the area level variance in the widely used odds ratio (OR) scale…, shows the extent to which the individual probability of [having a labour induction] is determined by [NHS Trust], and is therefore appropriate for quantifying contextual phenomena" (Merlo et al 2006, page 292)." According to Merlo et al 2006, if the MOR output was 1, this would mean there were no differences between NHS Trusts in the probability of labour induction. Conversely, a large MOR figure would imply that there were Trust level differences in risk of induction of labour.

The formula for MOR used in this analysis is:

$$MOR = \exp(0.95\sqrt{\sigma_u^2}) \tag{5.3}$$

In addition to the risk of induction varying between NHS Trusts, this chapter proposes that the relationship between labour induction and maternal education will be different between NHS Trusts, which means a model needs to consider the variation between Level 1 variables. Considering that in research question 2, there is a proposed effect of the Level 2 NHS Trust variable on the Level 1 outcome variable and assuming that there is variation in maternal education between women at Level 1, random slope models were chosen for exploring research question 2. Random slope models take into account the variation in both levels and would illuminate an interaction between NHS Trust and maternal education. A random slope model allows both the intercept and the slope of a regression model to vary, meaning that there is variation assumed both between individuals at Level 1 and between groups at Level 2 (Snijders and Bosker 2012).

The logistic random slope model is as follows:

$$Logit(P_{ij}) = \beta_0 x_{0ij} + \beta_1 x_{nij} + u_{0j} + u_{1j}x_{1ij} + e_{0ij} \quad (5.4)$$

$$\begin{matrix} u_{0j} \\ u_{1j} \end{matrix} \sim N(0, \Omega_u) \quad \Omega_u = \begin{matrix} \sigma^2_{u0} & \\ \sigma^2_{u01} & \sigma^2_{u1} \end{matrix}$$

$$e_{0ij} \sim N(0, \sigma^2_{e0})$$

where:

$\beta_1 x_{nij}$ is the slope of the average change across all groups,

σ^2_{u1} is the slope variance between groups

σ^2_{u0} is the intercept variance between groups, and

σ^2_{u01} is the covariance between slopes and intercepts

This model captures variation for both the individual women and the NHS Trusts in which they gave birth to their cohort children.

The calculation of intraclass correlation is only appropriate for random intercept models, as in a random slope model, ICCs are calculated for each value of the variable for which random slopes are generated (for example, an ICC for each category in a categorical variable or infinite numbers of ICCs for a continuous variable), making interpretation difficult. Therefore, MOR, the logistic regression substitute for ICC, will not be calculated for the random slope models in this chapter.

Additionally, z tests will be used to determine whether or not there is significant clustering of labour inductions at the NHS Trust level. For the purposes of this chapter, a z score greater than 1.645 indicates that there is significant variation in risk of labour induction by NHS Trust. The formula for calculating the z score is:

$$z = \frac{\bar{x} - \mu}{\sigma_{\bar{x}}} \quad (5.5)$$

Where:

$\bar{x} - \mu$ is the estimate of labour induction risk in the sample, and

$\sigma_{\bar{x}}$ is the standard error between NHS Trusts

To explore the effect of maternal education across NHS Trusts after the addition of Level 2 staffing and resource variables as hypothesized by research question 3, a third set of multilevel models were fit. Whether these models were random intercept or slope depended on the results of the analyses performed for research questions 1 and 2, as if the random slope model attempting to answer research question 2 determined that there is in fact no significant variation in the relationship between maternal education and labour induction risk in Level 1, it would not be necessary to continue using random slope models to investigate research question 3. If a random slope model was unnecessary, a random intercept model would be selected for the final part of the analysis in this chapter. Based on the results of research question 2 analyses, random slope models were used for both nulliparous and multiparous women in the investigation of research question 3.

As was the case in the previous chapter, the sample was split by parity before the data was analysed, as in addition to evidence presented in the literature referenced above about the importance of parity to labour induction, the results obtained in Chapter 4 point to there being important differences in labour induction risk between nulliparous and multiparous women in this dataset specifically. Prior to running multilevel models, descriptive statistics were undertaken on the sample as a whole and after it had been split by parity, in an effort to see if there were any preliminary associations between labour induction and NHS Trust.

For each research question, the first multilevel models run included just the two level variables: individual women (by parity), and the NHS Trust in which they gave birth to their cohort child. These first models did not include any further information about the women or areas in which the NHS Trusts were located. These initial models were run to use as baseline comparison models to assess the influence of Level 1 and Level 2 explanatory variables added in subsequent models. For research questions 1 and 2, after the initial models were run, individual level variables (concerning maternal demographic, maternal socioeconomic, and maternal and infant health indicators) were added to the models. For research question 3, models included both the same individual level variables used for research questions 1 and 2 as well as Level 2 explanatory variables: the number of births per Trust in 2000-2001, the staffing ratios (number of obstetricians versus number of midwives) at each Trust in 2000-2001, and the ratio of midwives to births at each Trust in 2000-2001. Finally, to examine the influence of UK country, the model fit to answer research question 4 was the same as that used for research question 3, with the addition of the UK country of NHS Trust at the Trust level.

Much data exploration determined that the local area deprivation variable utilized in Chapter 4 was more a measure of country than it was a measure of deprivation when added to models with both individual and Trust level structure. Due to the nature of the variable, it could not be clearly defined as at the individual level. This variable assigned individuals to Advantaged, Disadvantaged, or, in England, Ethic groups based on the Child Poverty Index for England and Wales measure for the electoral ward in which a woman lived (see Section 4.4.2.2 for more detailed information). As deprivation was measured at the electoral ward level and not at the individual level, there were concerns that this deprivation variable may be a community level measure of deprivation, not an individual level measure. As a community level variable, this variable presented complications in a two-level model with individual and Trust level explanatory levels. Additionally, in each of the nearly one hundred exploratory models run for these analyses, when compared to the Advantaged England category, only Advantaged and Disadvantaged areas in Scotland and Northern Ireland had significant relationships with labour induction, potentially indicating a country effect and not a deprivation effect. When sensitivity analyses were performed[4], relative advantage was not a significant indicator of labour induction, and country was. Thus, ultimately, a decision was made to remove this deprivation variable from analyses and instead use a measure of country of NHS Trust.

Once this deprivation variable was removed from analyses, the multilevel models outlined above were run using a variable containing information solely on the country in which a cohort birth occurred, without considering the relative deprivation of the electoral ward in which a woman lived. In order to test the influence of the country in which a woman gave birth, the models discussed above were run both with and without the country of cohort member birth variable. The results obtained from these two models will be presented and compared in section 5.6.

Additionally, although all existing 2000-2001 NHS Trusts were represented in the MCS data, there were ten Trusts in which there was only one cohort member birth recorded. These Trusts with only one case were not be collapsed into other Trust groupings. A robustness check of the multilevel model results was run with and without these ten Trusts, and as a result of these checks, these ten cases were retained in the models. These robustness checks are essential because if there is only one case in a Trust, those Trusts technically do not have two-level data for

[4] Multilevel logistic regressions were run using data in this electoral ward deprivation variable recoded into an advantage/disadvantage variable (which collapsed country categories by advantage) and into a country variable (which collapsed deprivation categories by country). In these multilevel regressions, the recoded relative advantage variable was not a significant indicator of labour induction, and the recoded country variable was a significant predictor of induction. Results of these sensitivity analyses can be found in Appendix A.

comparison in the models. Trusts with only one cohort member birth either had only one labour induction or one birth that was not induced, making them a difficult group for comparison. However, the inclusion of these Trusts into models did not alter results of the multilevel models run as checks, and therefore they were not removed from the final analyses.

5.4 Measures

Many of the measures used in this chapter have been outlined in detail in the Chapter 4 and remain the same, unless stated otherwise. Important additions to the list of measures from Chapter 4 are those variables concerning the second level of the multilevel models, the NHS Trusts within which a woman delivered her child. These Level 2 mediators are discussed below.

5.4.1 Outcome Variable

The outcome variable in this analysis is a dichotomous variable containing information on whether or not a woman experienced a labour induction during the birth of the cohort member child. This variable concerns 12,571 women whose labours were not induced and 5,646 women whose labours were induced.

5.4.2 Individual Level Explanatory Variables

Nearly all individual level explanatory variables initially utilized in this chapter are identical those used in Chapter 4. As detailed in Table 5.1 below, these variables included maternal demographic, socioeconomic, and health indicators, as well as infant health indicators. Maternal demographic and socioeconomic indicators included in the analyses were maternal age, maternal ethnicity, maternal education, relationship status, income quintile, housing tenure, and maternal occupation before pregnancy. Given that smoking in pregnancy did not have a significant association with labour induction in chi square tests or in any of the logistic regressions presented in Chapter 4, it was excluded from the analyses undertaken in the present paper. Therefore, maternal health variables included in this chapter were maternal BMI before pregnancy and pregnancy complications (both those associated with labour induction risk and those not associated with labour induction risk). Infant health variables were infant birth weight and infant gestational age at birth, measured in days.

The sample was again divided into nulliparous and multiparous women, in order to examine any differences between women who were experiencing their first births and women who had had other children before the cohort member. Therefore, the parity variable built using half-sibling, sibling, and household member data described in Section 4.4.2 was also used here. Measures of maternal socioeconomic status, such as relationship status, income quintile, housing tenure, and occupation, were not significant predictors of labour induction in Chapter 4, but were retained in the models run in the present chapter as socioeconomic controls.

Table 5.1: Individual Level Explanatory Variable Coding

Individual Level Explanatory Variables	**Categorical Organization**
Maternal age	19 years old and younger; 20-25 years old; 26-30 years old; 31-35 years old; 36 years old and older
Maternal ethnicity	White; Indian; Pakistani & Bangladeshi; Black or Black British; Other including Mixed
Maternal relationship status	Legally married; Cohabiting; Single/Divorced/Widowed
Maternal educational qualifications	Higher and first degrees; Diplomas in Higher Education; A/O Levels (including GCSE grades A-C); Other (including GCSE grades D-G); None
Maternal occupation before pregnancy	Managerial and professional; Intermediate; Self-employed; Lower supervisor; Semi-routine and routine
Household income quintiles	Lowest quintile; Second quintile; Third quintile; Fourth quintile; Highest quintile
Housing tenure	Own outright/own with mortgage; Rent from Local/Housing Authority; Rent privately; Other (including living with parents)
Illness in pregnancy	No pregnancy complications; Complications not associated with induction; Complications associated with induction; Other
Maternal BMI before pregnancy	Low (>18.5); Normal (18.5-24.9); High (≥25.0)
Infant birth weight	Low (<2500 grams); Normal (2500-4000 grams); (>4000 grams)
Infant gestational age in days	259 days or less (37 weeks or less); 260-272 days (37 to 39 weeks); 273-286 days (39 to 41 weeks); 287-293 days (41 to 42 weeks); 294 days or more (42 weeks or more)

5.4.3 NHS Trust Level Variables

As discussed above, the Level 2 variables included in this analysis are NHS Trust identifiers concerning the NHS Trust in which each woman gave birth to the cohort member child. The Level 2 NHS Trust variable contains information on which of the 173 NHS Trusts in England, Wales, Scotland, and Northern Ireland a woman utilized during the birth of the cohort child. Depending on the size or location of the Trust, the number of individual cases varies considerably (from 1 case to 650 cases). The number of NHS Trusts for which data exists in the MCS are presented in Table 5.2 below. Due to data protection restrictions, the NHS Trusts included in the following analyses cannot be listed by name.

Table 5.2: NHS Trusts in the MCS, by UK Country

UK Country	NHS Trusts
England	137
Wales	14
Scotland	11
Northern Ireland	10

5.4.3.1 NHS Trust Level Explanatory Variables

The inclusion of higher level explanatory variables into the adjusted models in this chapter is an effort to explain the variation of labour induction risk by NHS Trust reported in the results of the unadjusted multilevel model in Section 5.6. Table 5.3 details the several explanatory variables created for utilization in the adjusted models. In an effort to use consistent data measured in similar ways across each country in the UK, these variables concern what the Nuffield Trust (2011) calls health care "inputs," namely issues of staffing and population, rather than health outcomes or patient satisfaction.

Table 5.3: NHS Trust Explanatory Variables and Their Coding

Level 2 Explanatory Variables	Coding Description
Number of births per NHS Trust	Continuous numerical data
Number of midwives per NHS Trust	Continuous numerical data
Number of obstetricians per NHS Trust	Continuous numerical data
Ratio of obstetricians to midwives per NHS Trust	Continuous numerical data
Ratio of midwives to births per NHS Trust	Continuous numerical data
Ratio of obstetricians to births per NHS Trust	Continuous numerical data

In order to utilize explanatory variables at Trust level, attempts were made to collate NHS staffing and birth information for 2000-2001 in all four UK countries. The explanatory variables gathered for this Trust level analysis were: the number of births in per NHS Trust in each country; the number of midwives per NHS Trust in each country; the number of obstetricians per NHS Trust in each country; the ratio of the number of FTE obstetricians and the number of midwives per NHS Trust in each country; the ratio of the number of obstetricians and births per NHS Trust in each country; the ratio of the number of midwives and births per NHS Trust in each country; total number of midwives in each country; and the total number of obstetricians in each country. The midwife and obstetrician counts utilized in this project included only the number of full time equivalent (FTE) positions filled at each NHS Trust.

The NHS Trust explanatory variables concerning the number of midwives or obstetricians per Trust were requested from the four UK countries because this chapter is interested in determining how a woman's risk of labour induction may be influenced by the type of Trust staffing available to her. For example, a woman delivering her baby at a hospital in which more obstetricians are available than midwives may be more likely to experience intervention (Luthy et al 2004). In an attempt to measure this, the variables concerning how many obstetricians were practicing in each Trust, how many midwives were employed by each Trust, and how many births occurred at each Trust were used to create variables containing the ratios of obstetricians to births and midwives to births in each Trust, and another variable includes the ratio of obstetricians to midwives per Trust in each country. These midwife/birth and OBGYN/birth proportions were intended to be measures of the type of staffing available to women (midwife or obstetrician).

While the proportions of midwives and obstetricians per Trust are measures of the influence of different types of staffing, the number of births at each NHS Trust is included as a Trust level explanatory variable in the models as a measure of Trust size. In addition, the ratio of the number of OBGYNs to midwives is used in lieu of the raw numbers of midwives and OBGYNs employed by each Trust in an effort to better understand how different proportions of medical professionals affect risk of intervention. As one goal of this chapter is to illuminate whether staffing characteristics influence care, this ratio of midwives to obstetricians could help determine if NHS Trusts with larger proportions of midwives to obstetricians or midwives to births are associated differently with labour induction than those with smaller proportions.

The initial research plan called for using both the ratio of midwives to births and the ratio of obstetricians to births in the multilevel models for research question 3. However, when analysing the relationship between these two variables in preparation for fitting the models, it became clear that it would be inappropriate to use them both. For nulliparous women, the correlation between these two variables was 0.9754, and for multiparous women, the correlation between these two ratios was 0.9680, indicating that they are too closely related to be included in the same models. Given the correlation between the two variables, the decision to exclude the ratio of obstetricians to births was made[5]. In the models presented here, the ratio of midwives to births is used as the Trust staffing measure.

Unfortunately, despite the interest in controlling for type of care and delivery location in this project, it was not possible to determine from the MCS data whether births occurred in freestanding midwife-led birth centres, in midwife-led birth centres in hospitals, or in obstetrician-led labour wards in hospitals, or whether Trusts utilized standard or caseload

[5] Excluding obstetricians in favour of midwives was a decision informed by the literature, which indicates that women under midwifery care are less likely to experience childbirth interventions (Sandall 2013).

midwifery. Therefore, the present research relied on the staffing ratios described above to attempt to control for the type of care experienced during labour and delivery.

For England, staffing information and the number of births per NHS hospital were obtained from NHS Digital. Staffing and birth information for Wales was collected from StatsWales. Scottish NHS staffing and birth data was accessed via the Information Services Division of NHS National Services Scotland. Staffing information for each Trust in Northern Ireland was collected from the Northern Ireland Department of Health and Social Care Key Facts Workforce Bulletin (March 2009), published in May 2009. The number of births per Health and Social Care Trust board in Northern Ireland in 2006 were obtained from the Northern Ireland Statistics and Research Agency (NISRA).

All staffing and birth information from England, Scotland, and Wales used in this chapter is from the year 2000-2001. Northern Ireland is an exception, as the earliest staffing and birth data available was from 2006-2007. Therefore, all staffing and birth data from Northern Ireland is from the year 2006-2007. Once access to the Special License data had been granted, the list of NHS Trusts for which staffing information was obtained was compared to the list of 120 NHS Trusts provided by the Special License MCS data, and the staffing and population information for those Trusts not present in the MCS data was removed.

While individual Trust information was available for England, Scotland, and Northern Ireland, all of the Trust name data for Wales had been coded as Not Applicable and collapsed together in the Special License MCS dataset. Fortunately, all data pertaining to Trust Code remained separate and individual for all four countries, and the Trust codes provided by a 9 March 2001 Health Statistics and Analysis Welsh Health Circular allowed for the naming of Welsh Trusts in the MCS by matching the Trust codes on the Circular with the unmerged codes contained within the dataset.

Seven of the English NHS Trusts included in the MCS data (Addenbrookes NHS Trust, East Somerset NHS Trust, Essex Rivers Healthcare NHS Trust, Kings Lynn and Wisbech Hospitals, Northwick Park/Central Middlesex, Swindon and Marlborough NHS Trust, and Walsgrave Hospitals NHS Trust) were not present in the list of Trusts with available staffing data. As key Trust level data was missing for these cases, the 406 respondents who gave birth at these Trusts were excluded from the models. These omitted English NHS trusts comprised 3.5% of the English sample and 2.2% of the MCS sample overall. Four of the NHS Trusts present in the MCS dataset and the staffing dataset (Morecambe Bay Health Authority, Sheffield Children's NHS Foundation Trust, South Manchester PCG, and Walton Centre NHS Foundation Trust) did not actually have accompanying staffing information linked to their row in the staffing dataset. These Trusts were excluded from the final UK Trust data. One Wales Trust could not be identified by its code. This Trust, and the one case it represented, was excluded from the UK Trust name variable.

5.5 Descriptive Results

There are 173 NHS Trusts across the whole of the United Kingdom represented in the MCS sample analysed. The number of MCS births in each Trust in the MCS dataset ranges from 1 to 650, with a mean of 107.2 births per Trust. There is similar variation in the number of labour inductions at each Trust, as this number ranges from 0 to 227 across the NHS Trusts included in this analysis.

When the rates of labour inductions are considered by NHS Trust in each UK country, a clear difference between countries emerges. Table 5.4 displays the percentages of labour inductions in Trusts by country, before the sample was split by parity. England has the lowest proportion of inductions (29.4%) and Northern Ireland has the highest proportion (40.8%), which is in keeping with results presented in Chapter 4, in which women in Northern Ireland had the highest risk of labour inductions.

Table 5.4: Proportion of Labours Induced in NHS Trusts in the MCS, by UK Country

UK Country of NHS Trust	**Labour Induction Rate in MCS Sample**
England	29.4%
Scotland	35.1%
Wales	31.3%
Northern Ireland	40.8%

In Chapter 4, when the MCS sample as a whole was split by parity, nulliparous women experienced labour induction in larger proportions than multiparous women. Table 5.5 shows the differences in the proportions of labour inductions in NHS Trusts in each UK country when the sample is examined by parity. In each country, a larger proportion of nulliparous women were induced than were multiparous women. In both groups, England continues to have the lowest percentage of inductions and Northern Ireland has the highest, with Scotland's proportions similar to those in Wales. Additionally, there are greater differences in proportions between countries for multiparous women, with the difference between England (lowest proportion) and Northern Ireland (highest proportion) being 8.7% for nulliparous and 13.5% for multiparous women.

Table 5.5: Proportion of Nulliparous and Multiparous Labours Induced in NHS Trusts in the MCS, by UK Country

UK Country	**Labour Induction Rate in MCS Sample**	
	Nulliparous	**Multiparous**
England	35.0%	25.4%
Scotland	40.0%	31.1%
Wales	35.1%	28.4%
Northern Ireland	43.7%	38.9%

5.6 Multilevel Modelling Results

5.6.1 Multilevel Modelling Results: Research Question 1

To answer the first research question – namely, does the likelihood of labour induction vary significantly across health care providers in the United Kingdom? – random intercept multilevel logistic models were run separately for nulliparous women and multiparous women. As reported in Section 5.4.2 above, several of the individual-level maternal variables (marital status, occupation, housing tenure, and income quintile) remained insignificant in every model in which they were included. These proxies of socioeconomic status were retained in the models as controls, but in an effort to present the final model results as clearly as possible, the parameter outputs for these variables have been excluded from this chapter and are instead available in Appendix B.

Odds ratios and standard errors for the two-level random intercept model for nulliparous women (Model 1) are presented in Table 5.6 below. While maternal ethnicity is not a significant predictor of labour induction for nulliparous women in this model, some categories of maternal age and maternal education are significant predictors. Being between 20-25 and 26-30 years old makes nulliparous women significantly less likely to have their labours induced (OR: 0.735 and OR: 0.762, respectively), and having no reported education makes nulliparous women significantly more likely to have their labours induced (OR: 1.310). Nulliparous women with any type of illness or complication in pregnancy are significantly more likely to have their labours induced than those without any illness or complication in pregnancy, and women with high BMIs (OR: 1.293), giving birth to large babies (OR: 1.358), and those going post-term (8.076) were significantly more likely to undergo labour inductions than those nulliparous women with low BMIs, average weight babies, and pregnancies at or before term.

Several measures of variance at the individual and Trust level imply that there is a difference in risk of labour induction between NHS Trusts. The likelihood ratio test, which tests the null hypothesis that there will be no significant variation in labour induction between NHS Trusts, produced a test statistic of 13.06 and a p-value of <0.001, indicating that there is significant variation in labour induction between NHS Trusts. Additionally, the estimate (0.050) and standard error (0.021) of the random parameter (NHS Trust) indicate that there is significant variation in labour induction between NHS Trusts in this model ($z=2.380$; $z > 1.645$).

Similarly, the median odds ratio (MOR), a measure of variance in the model, is 1.236. According to Merlo et al (2006), a MOR greater than 1 would imply Trust level differences. Additionally, if greater than 1, this measure can be interpreted as illustrating an increase in the probability of labour induction (in comparison to the median). In the case of nulliparous women in this model, giving birth in a NHS Trust with a higher probability of labour induction increases the risk of labour induction by 1.236 times. Both the likelihood ratio test and MOR results indicate that for nulliparous women, the likelihood of labour induction does vary by NHS Trust.

Table 5.6: Odds Ratios for Random Intercept Multilevel Model 1: Nulliparous Women

		Odds Ratio	**Standard Error**
Maternal Age	19 years and under	0.760	0.115
	20-25 years old	0.735*	0.762
	26-30 years old	0.762*	0.092
	31-35 years old	0.903	0.113
	36 years and older	Ref	Ref
Maternal Ethnicity	White	Ref	Ref
	Indian	1.334	0.273
	Pakistani/Bangladeshi	1.269	0.230
	Black/Black British	0.855	0.174
	Other	1.039	0.188
Maternal Education	Higher/first degrees	Ref	Ref
	Diploma in higher ed	1.090	0.122
	A/O Levels (GSCE A-C)	1.167	0.103
	Other (incl. GCSE D-G)	1.159	0.135
	None	1.131*	0.168
Pregnancy Complications	No pregnancy complications	Ref	Ref
	Complications not associated with induction	1.257**	0.095
	Complications associated with induction	2.597***	0.201
	Other	1.393**	0.179
Maternal BMI	Low (<18.5)	Ref	Ref
	Normal (18.5-24.9)	0.974	0.115
	High (≥25.0)	1.293*	0.164
Infant Birth Weight	Low (<2500 grams)	0.983	0.127
	Normal (2500-4000 grams)	Ref	Ref
	High (>4000 grams)	1.360**	0.133
Infant Gestational Age	259 days or less	0.954	0.109
	260-272 days	1.050	0.093
	273-286 days	Ref	Ref
	287-293 days	3.091***	0.212
	294 days or more	8.076***	1.210
Random Effects Parameters		Estimate 0.050 SE 0.022 Likelihood Ratio Test x_2^2= 13.06 P<0.001	
Median Odds Ratio		1.236	

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

The results of the two-level model for multiparous women (Model 1) are presented in Table 5.7 below. For multiparous women, maternal education and measures of maternal and infant health status during pregnancy and birth are significant predictors of labour induction in this model of variation by NHS Trust. A multiparous woman with no education has a risk of labour induction nearly 80% higher than a multiparous woman with a higher or first degree (OR: 1.787). Being Pakistani or Bangladeshi is also a significant predictor, with Pakistani/Bangladeshi women less likely to be induced than white women in this sample (OR: 0.633). Surprisingly, maternal BMI, linked to labour induction in the literature, the results in Chapter 4, and for nulliparous women in the Table 5.6 in this chapter, is not a significant predictor of labour induction for multiparous women in this model.

The p-value of <0.001 obtained from the likelihood ratio test indicates that a model which assumes no random intercepts (i.e. no variation by NHS Trust) is rejected. In other words, this model demonstrates that the risk of labour induction for multiparous women does vary by Trust in the United Kingdom. Additionally, the estimate (0.135) and standard error (0.035) of the random parameter (NHS Trust) indicate that there is significant variation in the induction of labour between NHS Trusts at z > 1.645 (z=3.860). The MOR obtained from the model outputs is 1.418, meaning that for multiparous women, a NHS Trust with a higher probability of labour induction increases the risk of labour induction by 1.418 times. These measures of variance across levels indicate that in these models, there is variation in risk of labour induction by the NHS Trust in which a multiparous woman gave birth.

Table 5.7: Odds Ratios for Random Intercept Multilevel Model 1: Multiparous Women

		Odds Ratio	**Standard Error**
Maternal Age	19 years and under	0.896	0.203
	20-25 years old	0.908	0.867
	26-30 years old	0.930	0.075
	31-35 years old	0.908	0.070
	36 years and older	Ref	Ref
Maternal Ethnicity	White	Ref	Ref
	Indian	1.074	0.199
	Pakistani/Bangladeshi	0.633*	0.113
	Black/Black British	0.773	0.141
	Other	0.828	0.167
Maternal Education	Higher/first degrees	Ref	Ref
	Diploma in higher ed	1.505***	0.175
	A/O Levels (GSCE A-C)	1.566***	0.146
	Other (incl. GCSE D-G)	1.483***	0.176
	None	1.787***	0.207
Pregnancy Complications	No pregnancy complications	Ref	Ref
	Complications not associated with induction	1.405***	0.093
	Complications associated with induction	1.869***	0.139
	Other	1.328*	0.156
Maternal BMI	Low (<18.5)	Ref	Ref
	Normal (18.5-24.9)	0.920	0.118
	High (≥25.0)	1.090	0.144
Infant Birth Weight	Low (<2500 grams)	1.355*	0.170
	Normal (2500-4000 grams)	Ref	Ref
	High (>4000 grams)	1.272***	0.095
Infant Gestational Age	259 days or less	1.050	0.107
	260-272 days	1.225**	0.0872
	273-286 days	Ref	Ref
	287-293 days	2.794***	0.186
	294 days or more	5.774***	0.787
Random Effects Parameters		Estimate 0.135 SE 0.035 Likelihood Ratio Test x_2^2= 71.37 P<0.001	
Median Odds Ratio		1.418	

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

5.6.2 Multilevel Modelling Results: Research Question 2

The second research question posed in this paper concerns whether the effect of maternal education on the likelihood of labour induction varies significantly across NHS Trusts in the United Kingdom. Exploring answers to this question required the use of two-level random slope logistic regression models, which allowed the influence of maternal education on labour induction to vary by the Trust in which the birth took place. These models controlled for maternal age and ethnicity, and proxies of maternal socioeconomic status, and included maternal and infant health variables, while accounting for Trust level hierarchical structure. In order to best capture maternal education at the Trust level in these models and in an effort to provide clarity in the results, a binary education variable categorizing a woman's education as "higher degree" or "no higher degree" was used as the random slope variable. Therefore, only one "higher degree" random slope was calculated for each of the random slope models.

As evidenced by the results for nulliparous women presented in Table 5.8 below, odds ratios, standard errors, and statistical significance in the random slope model presented here (Model 2) remain similar across parameters to those in the random intercept model presented in Table 5.6. Nulliparous women in their twenties are around 75% less likely to be induced than women 36 years and older, women with high maternal BMIs are more likely to be induced than women with low BMIs (OR: 1.296), women with pregnancy complications associated with labour induction are more likely to be induced than those without pregnancy complications (OR: 2.60), and women giving birth to infants with high birth weights and older gestational ages are more likely to be induced than women having smaller babies and those with shorter pregnancies. Another result consistent across the two models is that women who have no educational qualifications are at greater risk of being induced than those with higher or first degrees.

When considering the influence of the random slope, set in these models as maternal higher degree, it is clear that the effect of maternal education on labour induction risk does not vary by NHS Trust. The estimated variation associated with the random slope (maternal higher degree) is 0.091 and the standard error, the variation in the sample itself, is 0.065. These numbers provide a z score of 1.40, which indicates that there is not a significant amount of variation in the random slope ($z < 1.645$). This z test shows that there is not a statistically significant difference in labour inductions by maternal educational qualifications in nulliparous women across NHS Trusts. In nulliparous women, the risk of labour induction is not significantly associated with variation in maternal education.

Table 5.8: Odds Ratios for Random Slope Multilevel Model 2: Nulliparous Women

		Odds Ratio	**Standard Error**
Maternal Age	19 years and under	0.756	0.114
	20-25 years old	0.731*	0.095
	26-30 years old	0.759*	0.092
	31-35 years old	0.900	0.113
	36 years and older	Ref	Ref
Maternal Ethnicity	White	Ref	Ref
	Indian	1.339	0.275
	Pakistani/Bangladeshi	1.273	0.229
	Black/Black British	0.854	0.173
	Other	1.042	0.188
Maternal Education	Higher/first degrees	Ref	Ref
	Diploma in higher ed	1.086	0.121
	A/O Levels (GSCE A-C)	1.169	0.105
	Other (incl. GCSE D-G)	1.162	0.136
	None	1.131*	0.170
Pregnancy Complications	No pregnancy complications	Ref	Ref
	Complications not associated with induction	1.256**	0.095
	Complications associated with induction	2.599***	0.201
	Other	1.390**	0.178
Maternal BMI	Low (<18.5)	Ref	Ref
	Normal (18.5-24.9)	0.975	0.127
	High (≥25.0)	1.296*	0.133
Infant Birth Weight	Low (<2500 grams)	0.986	0.128
	Normal (2500-4000 grams)	Ref	Ref
	High (>4000 grams)	1.357**	0.133
Infant Gestational Age	259 days or less	0.951	0.108
	260-272 days	1.050	0.093
	273-286 days	Ref	Ref
	287-293 days	3.093***	0.212
	294 days or more	8.065***	1.210
Random Effects Parameters: Higher Degree		Estimate 0.091 SE 0.065 Likelihood Ratio Test x_2^2= 13.67 P=0.0034	

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

Results of the random slope model (Model 2) run for multiparous women, illustrated in Table 5.9 below, report that the effect of maternal education on labour induction risk varies by NHS Trust for multiparous women. In Model 2, the random slope parameters are significant (Random slope estimate: 0.139; Random slope standard error: 0.058; z score: 2.400; $z > 1.645$), indicating that for multiparous women, the risk of induction of labour is influenced by maternal education across NHS Trusts. This is supported by the likelihood ratio test results provided by this random slope model for multiparous women (Likelihood Ratio Test: $p = 0.0000$).

In addition, much like those discussed above for nulliparous women, the size, direction, and significance of the parameters for the explanatory variables do not change much (or, in some cases, at all) when compared between the random intercept model results presented in Table 5.7 and the random slope model results in Table 5.9 below. This multiparous random slope model displays some key differences from the nulliparous random slope model. Unlike in the nulliparous sample, maternal age and maternal BMI are not a significant predictors of labour induction. Maternal education, however, is. For multiparous women, women in every category of maternal education are significantly more likely to have their labours induced than women with higher or first degrees (at $p = 0.000$). Women with no educational qualifications maintain the greatest risk of labour induction when compared to women with higher or first degrees (OR: 1.878).

Along most maternal and infant health variables, however, the multiparous results are in line with those obtained from the nulliparous sample. Multiparous women with pregnancy complications associated with labour induction are at greater risk of induction than those without pregnancy complications (OR: 1.870), and high infant birth weights (OR: 1.272) and pregnancies of 294 days or longer (OR: 5.776) are associated with greater risk of labour induction than normal infant birth weights and shorter gestational ages.

Table 5.9: Odds Ratios for Random Slope Multilevel Model 2: Multiparous Women

		Odds Ratio	**Standard Error**
Maternal Age	19 years and under	0.892	0.201
	20-25 years old	0.907	0.087
	26-30 years old	0.929	0.075
	31-35 years old	0.908	0.070
	36 years and older	Ref	Ref
Maternal Ethnicity	White	Ref	Ref
	Indian	1.072	0.199
	Pakistani/Bangladeshi	0.616**	0.110
	Black/Black British	0.764	0.139
	Other	0.825	0.167
Maternal Education	Higher/first degrees	Ref	Ref
	Diploma in higher ed	1.519***	0.178
	A/O Levels (GSCE A-C)	1.642***	0.160
	Other (incl. GCSE D-G)	1.552***	0.189
	None	1.878***	0.223
Pregnancy Complications	No pregnancy complications	Ref	Ref
	Complications not associated with induction	1.403**	0.092
	Complications associated with induction	1.870***	0.139
	Other	1.327*	0.156
Maternal BMI	Low (<18.5)	Ref	Ref
	Normal (18.5-24.9)	0.917	0.118
	High (≥25.0)	1.085	0.144
Infant Birth Weight	Low (<2500 grams)	1.355*	0.170
	Normal (2500-4000 grams)	Ref	Ref
	High (>4000 grams)	1.272***	0.095
Infant Gestational Age	259 days or less	1.047	0.108
	260-272 days	1.227***	0.087
	273-286 days	Ref	Ref
	287-293 days	2.804***	0.187
	294 days or more	5.777***	0.788
Random Effects Parameters: Higher Degree		Estimate 0.139 SE 0.058 Likelihood Ratio Test x_2^2= 73.64 P=0.0000	

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

5.6.3 Multilevel Modelling Results: Research Questions 3 and 4

Answering the third and fourth research questions explored in this paper – whether variation in labour induction risk by NHS Trust can be explained by characteristics of the Trust and if this variation remains after controlling for the country of NHS Trust – required some examination of the models used for nulliparous and multiparous women. Considering that the random slope model presented in Section 5.6.2 was a significant fit for multiparous women, a random slope model allowing for variation in maternal education by NHS Trust was used again in an attempt to answer research questions 3 and 4. As the random slope model was not significant in the model for nulliparous women in the previous section, a random intercept model was initially considered for the investigation of these final research questions for the nulliparous sample. However, in the interest of comparing the research question 3 and 4 nulliparous models both to each other and to those run for multiparous women, ultimately random slope models were also run for models both adjusting for and not adjusting for country in the nulliparous sample.

Table 5.10 below displays the results of the random slope models examining research questions 3 and 4 for nulliparous women, one adjusting just for NHS Trust characteristics (Model 3) and the other adjusting for both NHS Trust characteristics and country of NHS Trust (Model 4). In the Model 3, adjusting solely for NHS Trust characteristics, the random slope parameters are not significant (Random slope estimate: 0.064; Random slope standard error: 0.186; z score: 0.344; $z < 1.645$), indicating that there is no significant variation in maternal education between Trusts when the characteristics of NHS Trust are considered. The addition of country of NHS Trust in Model 4 affects no change in the significance of the variation in maternal education between Trusts, as the random slope parameters are also insignificant in the model including these variables (Random slope estimate: 0.081; Random slope standard error: 0.169; z score: 0.479; $z < 1.645$). The likelihood ratio tests for these two models both indicate no significant variation in maternal education (Model 3 Likelihood Ratio Test: $p = 0.9720$; Model 4 Likelihood Ratio Test: $p = 0.9497$).

Some of the parameters in Models 3 and 4 remain very much the same as they were in the models run in Section 5.6.2. For example, nulliparous women in their early twenties are still less likely to be induced than women 36 years or older (Model 3 OR: 0.696; Model 4: 0.701), women with complications associated with labour induction are more likely to be induced than women without pregnancy complications (Model 3 OR: 2.543; Model 4 2.566), and women giving birth to infants with large birth weights are more likely to be induced than those giving birth to babies with normal weights. However, the addition of Trust level variables and country of NHS Trust into these nulliparous random slope models has changed the relationship of some of the other indicators in the models. High maternal BMI, which was significant in Model 2 in the previous section, is no longer significant in Models 3 and 4. Similarly, maternal education is no longer significant in the fully adjusted Model 4. While maternal ethnicity is not significant in any previous models in this chapter, after adjusting for both country and Trust level variables, Indian women are significantly more likely to be induced than white women (OR: 1.636). In Model 4, the final model adjusting for both country of NHS Trust and Trust level explanatory variables, a gestational age of 287 days and over remains a significant predictor of labour induction, with the risk of induction continuing to increase as pregnancies go post-term (287-293 days OR: 3.152; 294 days and over OR: 8.903).

As for the Trust level variables themselves, in Model 3, the ratio of midwives to births is a significant predictor of induction of labour for nulliparous women (OR: 2.613). When country is not controlled for in the model, as the ratio of midwives to births increases, so does a woman's risk of labour induction. However, in the Model 4, the model controlling for Trust characteristics as well as country of Trust, this association is no longer significant. Furthermore, while the addition of country of Trust in Model 4 changed some of the parameters and removed the significance of the Trust level variables, country of Trust itself did not prove to be a significant predictor of labour induction for nulliparous women in this sample.

Table 5.10: Odds Ratios for Random Slope Multilevel Models 3 and 4: Nulliparous Women

		Model 3		Model 4	
		Odds Ratio	Standard Error	Odds Ratio	Standard Error
Maternal Age	19 years and under	0.700	0.132	0.703	0.133
	20-25 years old	0.696*	0.113	0.701*	0.114
	26-30 years old	0.746*	0.112	0.748	0.113
	31-35 years old	0.850	0.133	0.850	0.133
	36 years and older	Ref	Ref	Ref	Ref
Maternal Ethnicity	White	Ref	Ref	Ref	Ref
	Indian	1.588*	0.376	1.636*	0.393
	Pakistani/Bangladeshi	1.343	0.311	1.395	0.329
	Black/Black British	0.727	0.175	0.737	0.180
	Other	1.061	0.238	1.075	0.242
Maternal Education	Higher/first degrees	Ref	Ref	Ref	Ref
	Diploma in higher ed	0.990	0.140	0.993	0.141
	A/O Levels (GSCE A-C)	1.164	0.133	1.163	0.134
	Other (incl. GCSE D-G)	1.160	0.174	1.172	0.177
	None	1.330	0.217	1.334	0.219
Pregnancy Complications	No pregnancy complications	Ref	Ref	Ref	Ref
	Complications not associated with induction	1.211*	0.117	1.221*	0.118
	Complications associated with induction	2.543***	0.250	2.566***	0.253
	Other	1.370	0.224	1.363	0.223
Maternal BMI	Low (<18.5)	Ref	Ref	Ref	Ref
	Normal (18.5-24.9)	0.951	0.147	0.953	0.148
	High (≥25.0)	1.210	0.200	1.208	0.201
Infant Birth Weight	Low (<2500 grams)	0.798	0.131	0.806	0.133
	Normal (2500-4000 grams)	Ref	Ref	Ref	Ref
	High (>4000 grams)	1.324*	0.161	1.322*	0.161
Infant Gestational Age	259 days or less	1.005	0.143	1.004	0.143
	260-272 days	1.080	0.120	1.085	0.120
	273-286 days	Ref	Ref	Ref	Ref
	287-293 days	3.154***	0.276	3.152***	0.276
	294 days or more	8.860***	1.713	8.903***	1.720
Number of births per Trust		1.004	0.021	0.985	0.225
Ratio of obstetricians to midwives per Trust		0.408	0.251	0.720	0.523
Ratio of midwives to births per Trust		2.613**	0.924	1.306	0.820
Country of NHS Trust	England			Ref	Ref
	Wales			0.904	0.111
	Scotland			1.195	0.142
	Northern Ireland			1.310	0.277
Random Effects Parameters: Higher degree		Estimate 0.064 SE 0.186 Likelihood Ratio Test x_2^2= 0.23 P=0.9720		Estimate 0.081 SE 0.169 Likelihood Ratio Test x_2^2= 0.35 P=0.9497	

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

The results of Models 3 and 4 for multiparous women are presented in Table 5.11 below. Again, results of models adjusting for NHS Trust level variables and adjusting for both NHS Trust level variables and country of NHS Trust are provided. Adjusting for Trust level explanatory variables in these models removes any significant variation in labour induction by maternal education between Trusts. The parameters of the random slope (maternal higher degree) are insignificant in in Model 3 (Random slope estimate: 0.071; Random slope standard error: 0.481; z score: 0.148; z < 1.645), and in Model 4 (Random slope estimate: 0.155; Random slope standard error: 0.143; z score: 1.084; z < 1.645). However, despite maternal education being an insignificant predictor of labour induction across NHS Trusts in Model 4, the likelihood ratio tests for both models indicate that the relationship between labour induction and NHS Trust remains significant, with labour induction risk varying significantly by Trust (Model 3 Likelihood Ratio Test: p = 0.005; Model 4 Likelihood Ratio Test: p = 0.022). As both the results discussed in Section 5.6.2 indicated that risk of labour induction did vary significantly by maternal education between Trusts, the addition of Trust level variables in Models 3 and 4 has had a large influence on the effect of maternal education on induction risk.

Most of the parameters provided in Section 5.6.2 have not changed substantially with the introduction of NHS Trust level variables in Model 3 and the further adjustment of country of Trust in Model 4. Maternal age and BMI are still not significant predictors of labour induction for multiparous women, and complications in pregnancy, high infant birth weight (Model 3 OR: 1.208; Model 4 OR: 1.208), and pregnancies lasting more than 287 days are. Additionally, Pakistani and Bangladeshi women are still significantly less likely to be induced than white women in both Model 3 and 4 (Model 3 OR: 0.550; Model 4 OR: 0.568). In the model adjusting for both Trust level variables and country of Trust, country of Trust is a significant predictor of labour induction. Multiparous women giving birth in NHS Trusts in Northern Ireland are at a significantly increased risk of induction when compared to multiparous women in England (OR: 2.056).

The number of births per Trust and the ratio of midwives to births are significant Trust level predictors of labour induction in Model 3, before the adjustment for country. As the number of births (OR: 1.049) and the ratio of midwives to births (OR: 9.430) increased, the risk of labour induction did as well. Similar to the nulliparous Model 4, when the country of NHS Trust is included in Model 4, none of the three Trust level explanatory variables remain significant predictors of induction of labour. However, unlike for nulliparous women discussed above, the country of NHS Trust is a significant predictor of labour induction for multiparous women in this fully adjusted model.

Table 5.11: Odds Ratios for Random Slope Multilevel Models 3 and 4: Multiparous Women

		Model 3		Model 4	
		Odds Ratio	Standard Error	Odds Ratio	Standard Error
Maternal Age	19 years and under	0.746	0.220	0.746	0.219
	20-25 years old	0.987	0.118	0.990	0.119
	26-30 years old	0.957	0.097	0.957	0.097
	31-35 years old	0.866	0.085	0.864	0.085
	36 years and older	Ref	Ref	Ref	Ref
Maternal Ethnicity	White	Ref	Ref	Ref	Ref
	Indian	1.066	0.245	1.134	0.259
	Pakistani/Bangladeshi	0.550*	0.130	0.567*	0.131
	Black/Black British	0.830	0.230	0.845	0.183
	Other	0.1.11	0.267	1.140	0.275
Maternal Education	Higher/first degrees	Ref	Ref	Ref	Ref
	Diploma in higher ed	1.648***	0.241	1.661***	0.244
	A/O Levels (GSCE A-C)	1.688***	0.208	1.728***	0.214
	Other (incl. GCSE D-G)	1.470*	0.230	1.509***	0.237
	None	1.978***	0.296	2.008***	0.300
Pregnancy Complications	No pregnancy complications	Ref	Ref	Ref	Ref
	Complications not associated with induction	1.600***	0.133	1.607***	0.134
	Complications associated with induction	1.842***	0.174	1.853***	0.174
	Other	1.417*	0.212	1.428*	0.214
Maternal BMI	Low (<18.5)	Ref	Ref	Ref	Ref
	Normal (18.5-24.9)	0.950	0.159	0.932	0.156
	High (≥25.0)	1.162	0.200	1.140	0.196
Infant Birth Weight	Low (<2500 grams)	1.067	0.171	1.069	0.171
	Normal (2500-4000 grams)	Ref	Ref	Ref	Ref
	High (>4000 grams)	1.209*	0.113	1.208*	0.113
Infant Gestational Age	259 days or less	1.076	0.140	1.085	0.141
	260-272 days	1.236*	0.112	1.236*	0.112
	273-286 days	Ref	Ref	Ref	Ref
	287-293 days	2.794***	0.235	2.788***	0.234
	294 days or more	5.902***	1.075	5.910***	1.072
Number of births per Trust		1.049*	0.021	1.035	0.025
Ratio of obstetricians to midwives per Trust		0.646	0.251	1.065	0.799
Ratio of midwives to births per Trust		9.430***	0.924	1.288	0.963
Country of NHS Trust	England			Ref	Ref
	Wales			1.054	0.143
	Scotland			1.233	0.169
	Northern Ireland			2.056***	0.436
Random Effects Parameters: Higher degree		Estimate 0.071 SE 0.481 Likelihood Ratio Test x_2^2= 17.65 P=0.0005		Estimate 0.155 SE 0.143 Likelihood Ratio Test x_2^2= 9.62 P=0.0221	

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

5.7 Discussion

The most salient results from the explorations of the four research questions posed by this chapter are that labour induction does vary between NHS Trusts in the United Kingdom and that risk of induction is influenced by the educational qualifications a woman has obtained, and the NHS Trust and country in which she gives birth. While maternal education influenced induction for both nulliparous and multiparous women, country of NHS Trust was only a significant predictor of labour induction for multiparous women, indicating that parity is also still an important consideration for differences in labour induction even when accounting for health care provider structure.

The models run for research question 3, adjusting for Trust level variables, provide some insight into what NHS Trust characteristics could be driving differences in labour induction between Trusts. When models do not control for country, the ratio of midwives to births per NHS Trust is a significant predictor of labour induction for nulliparous women, and both the ratio of midwives to births per NHS Trust and the number of births per NHS Trust are significant predictors of labour induction for multiparous women. At first glance, the midwife ratio results would not be surprising given the ample literature referring to the association between midwifery care and (a decrease in) labour induction (Hundley et al 1994; Fontein 2010). However, in the nulliparous and multiparous models presented in this chapter, the odds ratios associated with the significant ratio of midwives to births variable suggests that as the midwife-to-birth ratio increases, the risk of labour induction also increases.

An initial reading of these results appears to be at odds with the established literature, but upon further review, it seems that this is in line with previous research into risk of childbirth intervention and health care provider size. Fontein’s study of midwifery practices in the Netherlands found that women in practices with a maximum of two midwives had significantly lower rates of referral to consultant care, pain relief during labour, foetal monitoring, unplanned caesarean sections, and childbirth interventions in general (Fontein 2010). This decrease in childbirth intervention in smaller midwife-led units is often met with increased patient satisfaction, a link explained by continuity of care, a practice which ensures that a woman is cared for by the same midwife throughout her labour and delivery (de Jonge et al 2014). It is possible that in the present research, the variable concerning the number of midwives per NHS Trust speaks more to the size of the NHS Trust and less to the precise practice of the staff employed by the Trust. However, although *Changing Childbirth* was published in 1993, continuity of care policy had not yet been implemented at the time MCS data was collected (Sandall et al 2011). Therefore, while it may be that women at larger Trusts had less individualized care than women in smaller

Trusts, it is impossible to say whether the increase in labour induction risk as the number of midwives increases is tied to a disruption in the continuity of care, a difference in practice between obstetricians and midwives, or simply the size of the NHS Trust in which the birth took place.

The interpretation of midwife-to-birth ratio as being more a measure of Trust size than Trust practice is bolstered by the tests of correlation presented in Section 5.6.2, which led to the ratio of obstetricians to births being excluded from the models in this chapter because it was too highly correlated with the ratio of midwives to births variable. Given the results provided by the midwives-to-birth ratio in the multilevel models, it may be that the obstetricians- and midwives-to-births ratios are so closely correlated because they are measures of the same thing: NHS Trust size. A larger NHS Trust would necessarily have greater numbers of obstetricians and midwives than a smaller NHS Trust, meaning that these ratios could be measures of Trust size and not of the different care styles posited between obstetricians and midwives in the literature (Hundley et al 1994).

As described above, the significance of Trust level characteristics to risk of labour induction disappears when the models adjust for the country of the NHS Trust in which a woman gave birth to the MCS cohort child. Therefore, the country of NHS Trust influenced a woman's risk of labour induction, both as a significant predictor of induction itself multiparous women and as a control for the influence of Trust level characteristics for nulliparous and multiparous women. While there is no significant association between labour induction and country of NHS Trust for nulliparous women in Model 4, it is evidenced for multiparous women, such that in the fully adjusted models, multiparous women in Northern Ireland were at greater risk of having their labours induced than multiparous women in England. The results presented here indicate that in the year 2000-2001, there were differences in labour induction risk by country in the United Kingdom, with women in England being less likely to experience an induction than women in Northern Ireland.

There are a few explanations for these differences by country. Considering that England was the only country to retain the internal market and performance-based incentives in health care provision after devolution of the NHS in 1999, it is possible that the variation between Trusts by country could be due to differences in both management and expenditure. It may be that NHS Trusts in England, concerned at the time with meeting funding targets and certain performance benchmarks (some of which measured patient experience), were less inclined to over-utilize a costly intervention. In addition, differences in interpretation or implementation of guidelines pertaining to labour induction may exist between the four countries of the United Kingdom. The

National Institute for Health and Care Excellence (NICE) labour induction guidelines, which call for woman-centred care based on informed consent and individualized treatment, and dictate appropriate use of labour induction, provide this guidance for England only (National Institute for Health and Care Excellence 2017). While the three devolved countries can be consulted during the development of NICE guidelines, the NICE website states that “decisions on how our guidance applies in [Scotland, Wales, and Northern Ireland] are made by the devolved administrations” (National Institute for Health and Care Excellence 2017). Therefore, there is room for differences in interpretation in the use of labour induction between UK countries, despite the existence of official guidelines.

This discussion of country differences between Trusts highlights the relationship between labour induction and maternal education as another key result described by the models in this chapter. As was the case in Chapter 4, maternal education is a significant predictor of labour induction in every model fit for multiparous women, with women with no educational qualifications being at the greatest risk of induction when compared to women with higher or first degrees. In nulliparous women, having no educational qualifications is a significant predictor in the Models 1 and 2, before the addition of Trust level characteristics to the model. Thus, the results of the multilevel models presented here echo those from Chapter 4: maternal education is a significant predictor of and influence on induction of labour for multiparous women, and the women at greatest risk of induction are those with the least education.

While variation in maternal education did not have significant influence on labour induction by NHS Trust in nulliparous women, in multiparous women, the effect of maternal education on labour induction did vary between Trusts in Model 2, before the addition of Trust level variables into models removed any significant variation in labour induction by maternal education between Trusts for multiparous women. However, the association between labour induction and NHS Trust remained significant in these models even after the addition of Trust level variables removed the significant variation in induction of labour by maternal education between Trusts. Additionally, maternal education remained a significant predictor of labour induction for multiparous women; the risk of induction by educational qualifications just no longer varied by NHS Trust. This implies that these Trust level variables help explain some of the variation in risk of labour induction by maternal education in NHS Trusts. The Trust level variables – the number of births, the ratio of midwives to births, and the ratio of midwives to obstetricians – help standardise the risk of labour induction, such that within the NHS, Trust characteristics, serving as proxies for Trust structure and organization, may impact the experiences of multiparous women with certain educational qualifications, regardless of which NHS Trust they utilize. For both groups of women, these Trust level variables were only significant predictors of labour induction in models that did not adjust for country. These results serve to underscore that there are differences at the Trust level between countries that influence the risk of labour induction for women within those countries.

It appears that risk of induction of labour does vary NHS Trust for both nulliparous and multiparous women, when country is not considered in models. Unfortunately, it remains unclear precisely why this might be. As the Trust level variables presented here are the only Trust indicators made available by the four UK countries, it was not possible to get a clearer picture of why there is variation by Trust. It was only possible to say that there is.

5.7.1 Limitations

A major limitation to research undertaken in this chapter is the lack of comprehensive, detailed data at the Trust level. This study would have benefitted greatly from the addition of Trust level variables such as the number of maternal inpatient admissions, the type of birth environment (labour ward, midwife unit, or birthing centre) on offer at each Trust, maternity unit expenditure, and whether the Trust utilized standard or caseload midwifery. These variables might have helped further highlight which differences amongst NHS Trusts are those responsible for differences in labour inductions between Trusts. Unfortunately, the combination of NHS restructuring throughout the 2000s and lack of standardized data collection between the four countries in the United Kingdom prevented the use of any Trust level variables other than those utilized here.

In addition, as described in Section 3.3, another data limitation to this study is at the individual level, in that the data was collected by survey nine months after the birth of the cohort member, making the information susceptible to recall bias. A way of avoiding this would have been to use hospital record data. However, hospital data is not without its own complications; namely, that there would have been fewer socioeconomic controls available for use and it would have been impossible to control for maternal education in such a dataset.

Finally, as described in Section 4.7.1 and 7.3, the age of the data in the MCS may be considered a limitation in using the results of this chapter in current policy making decisions. Chapter 3 and Section 7.3 outline why the MCS was the best dataset currently available for use.

5.8 Conclusion

Much like those presented in the previous chapter, the results discussed above highlight key differences in the risk of labour induction between nulliparous and multiparous women. Although the risk of labour induction by NHS Trust increases for both groups of women in Scotland and Northern Ireland, this risk disappears for nulliparous women when models adjust for Trust level variables. When maternal education is considered, these results again serve to further underscore the results presented in Chapter 4: educational qualifications have the most significant associations with labour induction in multiparous women. Despite the fact that greater proportions of nulliparous women experience labour inductions (both in the literature and in the MCS data examined here), the analyses performed thus far have turned up few significant associations between maternal demographic and socioeconomic variables and risk of labour induction for nulliparous women. A potential explanation for this is that there are influences on nulliparous women (such as longer pregnancies and labours or less confidence or self-efficacy) that contribute to their greater risk of labour induction but which are unobserved in the data at hand. This difference between nulliparous and multiparous women is an area that is should be explored by future research.

In addition, the results of this chapter's analyses contribute to discussions of woman-centred care. Since *Changing Childbirth* was published in 1993, UK health care guidelines have been focused on individualized pregnancy and labour care and much has been made of the importance of continuity of the care to women during childbirth (Flint et al 1989; Fontein 2010; de Jonge et al 2014; Sandall et al 2016). The findings presented here suggest that in 2000-2001, larger health care providers were still struggling to provide woman-centred care in ways that impacted the use of childbirth interventions, as evidenced by the increased risk of labour induction in NHS Trusts with higher midwife-to-birth ratios. It would be interesting to repeat these analyses on a more recent cohort study (and with more detailed to Trust level data) to see if the size of the NHS Trust and its staffing ratios still influence the risk of labour induction in the United Kingdom.

Thus far, this thesis has investigated the influence of maternal education, parity, NHS Trust and country of cohort member birth on the risk of labour induction in the United Kingdom. In Chapter 6, maternal and infant indicators will be used in tests of the association between labour induction and operative delivery. The relationship between labour induction and type of delivery will be outlined, and the mediating influence of epidural anaesthesia on the risk of operative delivery will be examined. In addition, maternal height will be considered as a potential moderator of the associations between labour induction, epidural anaesthesia, and operative delivery. Chapter 6 will explore how women move through the cascade of interventions and how the risk of entering and completing the cascade is influenced by maternal demographic factors.

Chapter 6 The Cascade of Intervention: Epidural Pain Management and the Association between Labour Induction and Operative Delivery in the United Kingdom

6.1 Introduction

The first two analysis chapters of this thesis focus on how the risk of labour induction is associated with maternal demographic, socioeconomic, and health indicators in the United Kingdom, as examined by the data available in the first sweep of the Millennium Cohort Study. Having explored which indicators increase the risk of labour induction in the United Kingdom in Chapter 4 and how this risk is influenced by the NHS Trust in which a woman gives birth in Chapter 5, Chapter 6 seeks to determine whether labour induction is linked to the risk of caesarean section in the MCS and how this association is mediated by epidural anaesthesia, a key childbirth intervention, and moderated by maternal height, a biological indicator of operative delivery. In this final analysis chapter, the factors influencing labour induction and caesarean section in the MCS will be investigated, while adjusting for maternal demographic, socioeconomic status, and health indicators.

By investigating the relationship between labour induction and operative delivery, this final analysis chapter aims to draw together all the exploration of labour induction in this thesis, which was initially conceived as a way to better understand a woman's experience of and movement through childbirth. The existing literature's focus on caesarean section as an outcome is justifiable, considering the rising rates of this procedure the world over. However, in order to address rising rates of caesarean sections and better understand birth intervention, researchers must also study which women are at risk of the interventions that come before operative delivery, as the majority of caesarean sections occur after induction of labour.

Given its relationship to most childbirth interventions and its position at the start of labour, labour induction can be seen as the entry into the cascade of intervention, the first intervention of many that can lead a woman to an emergency caesarean section, as illustrated in Figure 2.2 in Chapter 2. The present chapter seeks to determine how labour induction is related to caesarean section through an intervention that comes between them, and to highlight which women are at risk of completing the cascade of intervention (defined here as experiencing both labour induction and caesarean section). In effect, Chapter 6 aims to link the individual indicators of induction outlined in the conceptual framework in Figure 2.9 with the pathways to operative delivery detailed in the cascade of interventions diagram illustrated in Figure 2.2.

Literature concerning the association between labour induction and caesarean section has pointed to a "central question," as outlined by Lieberman et al (1996): if increased rates of caesarean section over time are in part "related to the effects of epidural [anaesthesia] itself or to the characteristics of women who elect to receive epidural [anaesthesia]" (Lieberman et al 1996). Therefore, in addition to examining the relationship between labour induction and type of delivery, this paper also investigates the link between the characteristics of women who receive epidural anaesthesia and their risk of caesarean section, most especially after induction of labour. Finally, as previous research points to maternal stature as an indicator for operative delivery, this paper will explore how maternal height may moderate the associations between labour induction, epidural, and delivery type.

The following sections detail how the relationship between induction of labour and delivery type is defined in the cascade of intervention and how common operative delivery is in the United Kingdom, both currently and when data was collected in 2000-2001. In addition, the connection between labour induction, epidural anaesthesia, and type of delivery is explored, and maternal height is discussed as a potential moderating force in this triad.

6.1.1 Induction of Labour and Operative Delivery: The Cascade of Intervention

The cascade of intervention, a term referring to the tendency for one childbirth intervention to follow another, is a pathway through which labour induction and operative delivery are linked in maternal health literature. In this chapter, operative delivery is defined as a birth in which vaginal birth is assisted by mechanical or surgical techniques, such that the use of forceps, ventouse, episiotomy, and caesarean section are all classed as operative deliveries. While several different types of delivery are considered operative, not all types of operative delivery are associated with the cascade of intervention. A large number of studies dedicated to caesarean section have established a difference between emergency caesarean sections, classed as those caesareans that occur after labour begins, and "elective" caesareans, which are planned procedures that occur before the onset of labour. An "elective" caesarean is a bit of a misnomer, as in the majority of the cases, this is not a decision a woman makes to avoid labour, but rather a medical necessity given a set of risk factors that make labour too dangerous. Emergency caesarean sections, on the other hand, are generally those performed after labour begins, when problems arise during labour, and it is these caesarean sections which are linked to labour inductions, for both nulliparous and multiparous women (Thorsell et al 2011).

This link between labour induction and emergency caesareans exists because attempting to begin a labour artificially introduces a host of external interventions that can cause complications in childbirth. Women who have their labours induced can be attached to electronic foetal monitors to track the heartbeats of their babies through the medically-enhanced contractions, leaving them laying supine in bed, a position which slows labour. Additionally, women who are induced can have more painful labours and they make more use of epidural anaesthesia, which again leads to women labouring on their backs (Bassett 1996; Johanson 2002; Spong et al 2012). These slower, supine labours increase the risk of foetal distress or failure to progress in labour, both of which are indications for emergency caesarean section.

Foetal distress and failure to progress are also indicators for assisted vaginal delivery, which is defined as the use of forceps, ventouse, or episiotomy. The baby is delivered vaginally, but the delivery is assisted (and sometimes surgical, if a vaginal incision must be made). The use of forceps, ventouse, or episiotomy is associated with a sense of urgency; often, these delivery methods are used in situations in which a baby must be delivered quickly, much like in emergency caesarean sections. According to the literature, assisted vaginal delivery is associated with labour induction in much the same way as emergency section is; namely, that labour induction increases the likelihood of assisted vaginal delivery. In a study by Cammu et al (2002), nulliparous women who were induced were at greater risk of both assisted vaginal delivery and caesarean section than those who were not induced, and induction of labour was significantly associated with use of forceps and ventouse for both nulliparous and multiparous women in a study by Gardella et al (2001). There is evidence in the literature, then, that labour induction can increase the risk of operative delivery (both assisted vaginal deliveries and emergency caesarean sections) for both nulliparous and multiparous women. (See Sections 2.2 and 2.3, and Figure 2.2 for more detailed discussion of the link between labour induction and delivery type.)

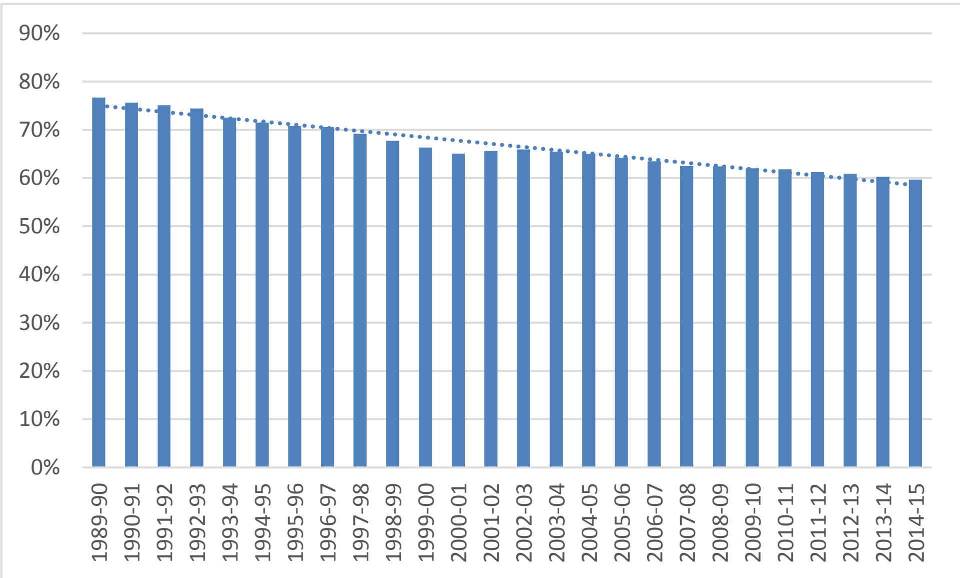
The next section provides an overview of the rates of labour induction and caesarean section in the United Kingdom, and how they have changed over the last thirty years. It also details the how these rising rates are relevant to the present study and the ways in which this paper hopes to contribute to the literature concerning these trends.

6.1.2 Operative Delivery in the United Kingdom

According to the NHS Maternity Statistics produced for England in 2013-2014, the rate of caesarean section has risen in the last three decades. In 1984, 10.1% of births in England were caesarean sections; by 2014, this figure had risen to 26.2%. This rise in caesarean section is evident for both elective and emergency caesarean sections when these forms of delivery are considered separately. An increase in the rate of emergency caesarean sections is of interest to the present study because it is these caesareans which are often linked to labour induction, considering a woman is only induced if she is expected to experience labour. A woman who has undergone a planned caesarean delivery generally would not have been induced.[6] Additionally, in a summary of the RCOG's *Patterns of Maternity Care in English NHS Trusts 2013/14*, by published by BMJ in 2016, Wise reports that the rates of unassisted vaginal delivery vary from 33% to 62% within NHS Trusts, and that emergency caesarean sections rates range from 8% to 15% (Wise 2016).

Figure 6.1 illustrates the decreasing number of spontaneous vaginal deliveries in England over the last three decades. In 1989, over 76% of births in England were spontaneous, unassisted vaginal deliveries, and by 2006, this number had dropped to 64% of births. This decrease in unassisted vaginal birth in England coincides with a rising number of emergency caesarean section, as outlined in Figure 6.2.

Figure 6.1: Percentage of Spontaneous Vertex Vaginal Deliveries in England, 1989-2015



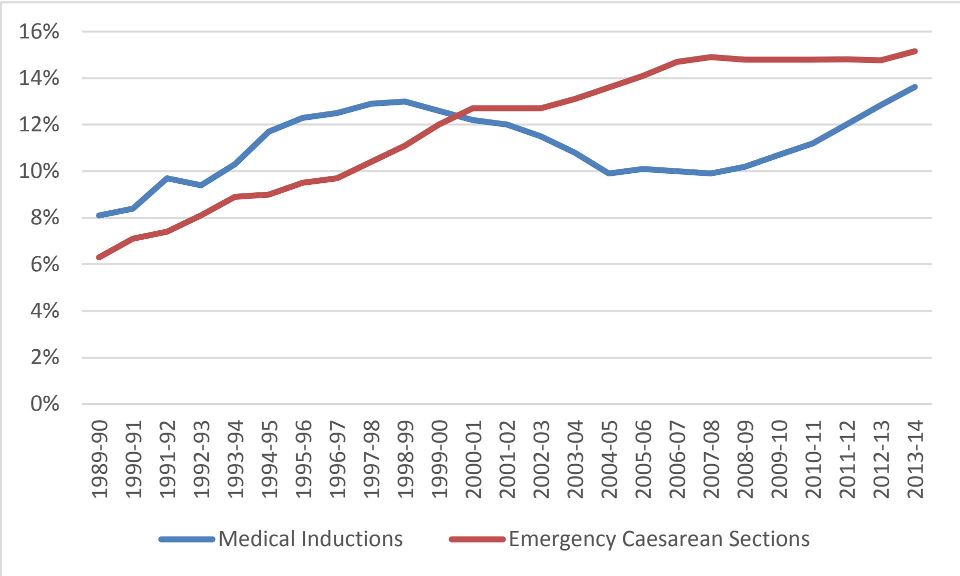
Source: NHS Digital, NHS Maternity Statistics, 2013-2014

In Figure 6.2 below, the steady increase in the number of emergency caesarean sections in England over the twenty-five year period from 1989-2014 is clearly illustrated. The proportions of

[6] Here, planned caesarean section refers to the type of "elective" caesarean section that occurs before the onset of labour. See Section 6.1.1 for a more detailed discussion of "elective" versus "emergency" caesarean sections.

births in England occurring via emergency caesarean section more than doubled during this time period. The trend in labour induction is less straightforward. For several years, between 2003 and 2009, the rates of labour induction dipped from their highest point in 1998-1999, before beginning to rise again by 2010. However, although the proportions of labours beginning by medical inductions decreased during the 2000s, they did not drop to or below levels documented in (or before) 1990, they nearly doubled between 1990 and 2014, and they are currently still on the rise (17.3% of labours in England were augmented by medical induction in 2016-2017).

Figure 6.2: Percentages of Medical Inductions and Emergency Caesarean Deliveries in England, 1989-2014[7]



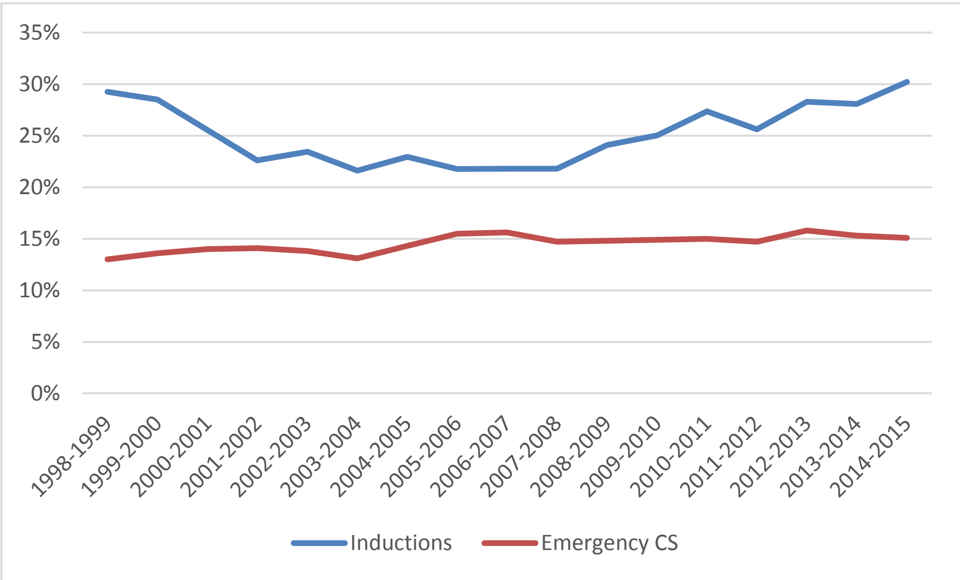
Source: NHS Digital, NHS Maternity Statistics, 2013-2014; Health and Social Care Information Centre 2015

The proportions of emergency caesarean sections have also increased in the last two to three decades in Wales and Scotland, as evidenced by Figures 6.3 and 6.4. While the proportions in Wales have not increased by very much, the proportions in Scotland echo those in England: births by emergency caesarean section nearly doubled from 1989 (9.0%) to 2016 (16.9%). Similarly, while 20.4% of labours experienced some form of induction in Scotland in 1989, by 2016, 30.9% of births utilized induction.

[7] This figure presents information on the proportions of medical inductions in England. A medical induction is one which is performed via intravenous or pessary medication. A surgical induction refers to the efforts to start labour by artificial membrane rupture, or ART, which is defined as the breaking of the amniotic sac. Figures 6.3 and 6.4 below display proportions for the total number of (medical and surgical) inductions in Wales and Scotland.

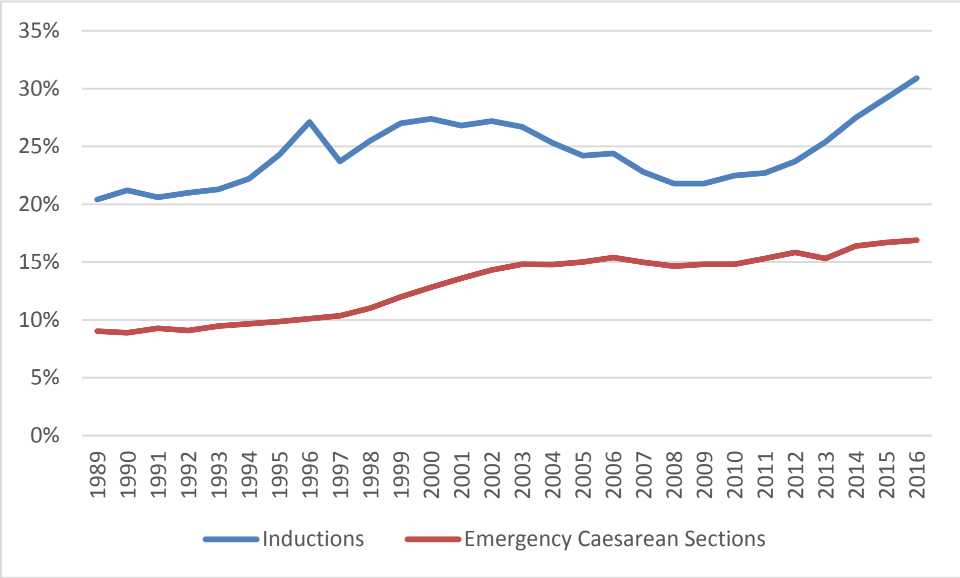
England, Wales, and Scotland all appear to have the same trends in labour induction in the decade from 2000-2010, with the rates of labour induction decreasing for a period of time over those ten years. Most interestingly, in Scotland, the proportions of emergency caesarean section seem to mirror those of labour induction: when labour inductions increase, so do emergency caesarean sections, and when Scotland experiences its decrease in labour inductions, the proportions of emergency caesarean sections stabilize before starting to rise again when labour inductions increase again. This indicates that there may be a relationship between induction of labour and emergency caesarean section, at least in Scotland.

Figure 6.3: Percentages of Inductions and Emergency Caesarean Sections in Wales, 1998-2015



Source: Maternity Statistics, Wales, National Assembly for Wales; NHS Wales Informatic Services, PEDW Statistics

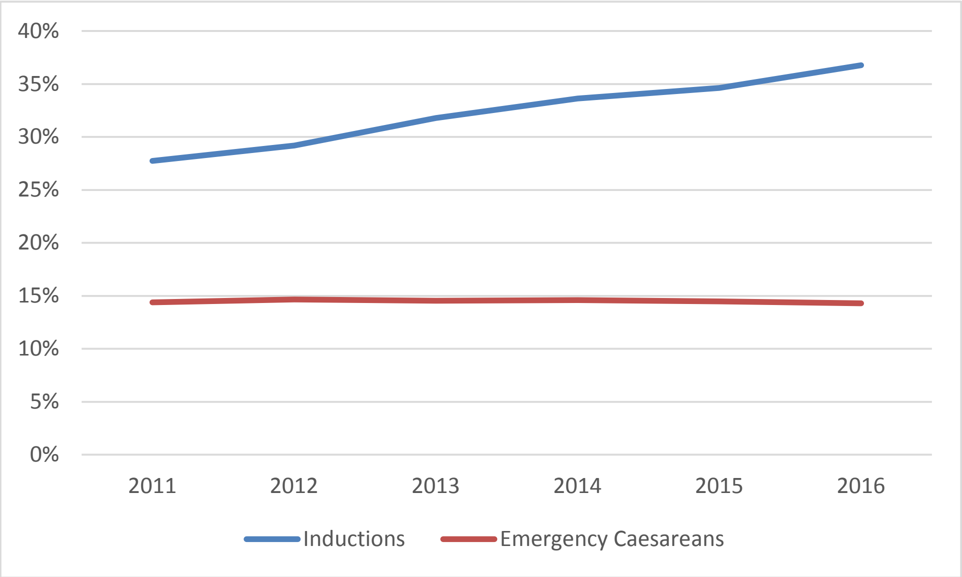
Figure 6.4: Percentages of Inductions and Emergency Caesarean Sections in Scotland, 1989-2016



Source: SMR02 ISD Scotland

Although available data on labour inductions and emergency caesarean sections in Northern Ireland was limited to 2011 to 2016, making it impossible to determine the trends in these two interventions over time in the country, it is interesting to note that over just six years, the percentage of labour inductions increased from 27.8% to 36.8%, as evidenced by Figure 6.5. This is further evidence that examining indicators of labour induction in the United Kingdom remains relevant today, especially for Northern Ireland

Figure 6.5: Percentages of Inductions and Emergency Caesarean Sections in Northern Ireland, 2011-2016



Source: Northern Ireland Health Statistics

In addition, it's important to note that while there has not been a one-to-one, permanently steady increase in labour inductions and caesarean sections in the United Kingdom, the use of these interventions is currently rising. Despite fluctuating through the years, proportions of both induction of labour and emergency caesarean section remain higher by 2014 and 2015 then they were in the early 1990s.

The childbirth data from the MCS, collected in 2000 and 2001, comes from a time in which the proportions of labour induction and caesarean section were relatively high in each of the countries. Although the proportions are unique and the trends have fluctuated, Great Britain has seen an increase in induction of labour and operative delivery over the last twenty years. The concurrent rising rates beg a few questions: Which women are at greater risk of undergoing assisted vaginal deliveries and emergency caesarean sections instead of unassisted vaginal births in the United Kingdom? How is labour induction involved in a woman's risk of operative delivery? Does the use of epidural anaesthesia, an intervention that comes between labour induction and caesarean, influence the relationship between the two? And lastly, does maternal height moderate the labour induction, epidural, and delivery type triad? This paper aims to find answers to these questions.

As rates of caesarean section are rising in the United Kingdom, and more and more women are experiencing operative delivery, examining how commonly cited indicators of delivery type, such as epidural anaesthesia and maternal height, influence childbirth is vital to understanding which women are at greater risk of assisted vaginal deliveries or emergency caesarean sections. The following sections explore the connections between these childbirth interventions in more detail. First, Section 6.1.3 examines the association between labour induction, epidural anaesthesia, and caesarean section, including a discussion of labour induction and epidural use and common complications associated with emergency caesarean sections: foetal distress and failure to progress. Next, Section 6.1.4 describes the influence of maternal height on the likelihood of caesarean section.

6.1.3 Labour Induction, Epidural, and Type of Delivery

In the studies outlining the cascade of intervention, after labour induction initiates the cascade, the one of the next interventions is the use of epidural anaesthesia (Simpson and Atterbury 2003; Amis 2007). While not every woman who is induced undergoes an epidural and many women who are not induced choose epidural pain relief, there remains an important connection between labour induction and epidural. The reason for this is that an induction of labour often increases the intensity of contractions, and this increase in labour pain can encourage women to utilize epidural anaesthesia (Wilson 2007; Zanconato 2011). This is borne out in qualitative studies as well, as the questionnaire study of women's perceptions and experiences of labour induction by Shetty et al (2005) found that more women who were induced reported that labour induction was more painful than they expected and that significantly more women who were not induced found labour less painful than they expected (Shetty et al 2005).

In addition to being associated with labour induction, epidural anaesthesia has been linked to changes in labour after its administration. In a study of nulliparous women with spontaneous labours, those who had epidural anaesthesia were 3.7 times more likely to experience caesarean section than women who did not have an epidural, with the greatest risk being to those women who were given epidurals during the first stages of their labours (Lieberman et al 1996). The importance of the timing of the epidural administration is echoed by Nagoette et al (1997). While Nageotte et al (1997) found no difference in the rates of caesarean section between groups of women who were given epidurals and those who were given combination spinal-epidurals[8], there was a significant association between both types of analgesia and caesarean section when the epidurals or spinal-epidurals were administered while the foetus was at a negative station or

[8] Epidural anaesthesia is defined by the insertion of a catheter into the epidural space in the spine, through which local anaesthetics are injected, numbing the lower body and preventing labouring women from walking. Spinal anaesthesia is a one-time injection into the spinal column. Spinal-epidurals, as defined by Nagoette et al 1997, are a combination of spinal and epidural anaesthesia that allow women both pain relief and continued movement in their lower limbs.

before a mother was dilated to at least 4 centimetres (Nagoette et al 1997). This suggests that being given too early in a labour may be another avenue through which an epidural may influence the speed or effectiveness of labour.

Changes in the speed of labour caused by premature administration of epidural anaesthesia may be responsible for common complications that arise during labour inductions; namely, that labours slow down or fail to progress, or that electronic foetal monitors pick up signs of foetal distress (Bassett 1996; Johanson 2002; Simpson and Thorman 2005; Spong et al 2012). Both of those complications, failure to progress and foetal distress, are indicators for ventouse or forceps delivery, episiotomy, and emergency caesarean sections; all efforts to deliver a baby quickly (Yudkin et al 1979; Dublin 2000; Liu and Sia 2004). Additionally, in a systematic review of articles concerning the side effects of epidural use, Mayberry, Clemmens, and De (2002) found that "another unintended effect of epidurals is the diminished sensation associated with the reflex urge triggered by distention of the birth canal and coinciding with the decreased ability to actively 'push' during the second stage of labour. The diminished bearing-down sensation associated with epidurals has resulted in the conventional practice among physicians and nurses of encouraging directed, strong, and sustained pushing efforts while using prolonged breath holding…[This can lead to] increased maternal fatigue, [which] is also a common indication for caesarean section" (Mayberry, Clemmens, and De 2002, page S89). It is possible that epidural is linked to operative delivery through its ability to alter the efficacy of labour.

While some previous studies have highlighted a relationship between epidural and caesarean section, others have reported the opposite. Impey, MacQuillan, and Robson (2000) found no increase in caesarean section or operative vaginal delivery in a retrospective analysis of nulliparous women in Dublin. Leighton and Halpern (2002) performed a meta-analysis of both randomized and retrospective studies concerning the link between epidural and caesarean section and found that while a significant association was reported in the retrospective studies, no significant association was reported in randomized trials. A reason for this discrepancy is that the randomized trials reviewed by Leighton and Halpern only randomized women into epidural versus opioid anaesthesia groups and did not control for women who did not receive anaesthesia. Women consenting to one or the other form of pain medication may also be more likely to consent to a caesarean section.

Still other studies are more equivocal. In their review of retrospective papers and randomized trials, Liberman and O'Donoghue (2002) report there is insufficient evidence to conclude whether or not epidural leads to increased likelihood of caesarean section. An important consideration is that many of the studies, both randomized and retrospective, focus their attention on nulliparous women. It may be that the relationship between epidural and caesarean section is different for multiparous women.

The contradictory results of studies of epidural use highlight a few themes important to the potential mediating influence of epidural anaesthesia on labour induction and delivery type: timing of epidural administration; differences in maternal demographics; parity; and the impact of maternal preference. While the MCS does not contain information about cervical dilation (in association with epidural or not), it does provide information on maternal demographic and health history, and on parity. Leighton and Halpern (2002) caution that the significant link between epidural and caesarean section in retrospective studies may be due to demographic differences between mothers, as shorter, heavier women giving birth to larger babies at greater gestational ages tended to choose epidural anaesthesia more frequently in the studies reviewed. The present study hopes to address some of these concerns by controlling for maternal height, BMI before pregnancy, and the gestational age and weight of the foetus at birth, in addition to parity and maternal ethnicity. As discussed in Chapter 5, it may be possible to use maternal educational qualifications as a proxy for a woman's ability to advocate for her personal preferences, and as such, analyses in the present chapter also adjust for maternal educational qualifications.

6.1.4 Maternal Height and Caesarean Section

While many previous studies have investigated the relationship between maternal socioeconomic and operative delivery (see Section 2.2 for more detailed discussion), much of the literature concerning the association between maternal indicators and type of delivery has focused on biological predictors of caesarean section, as it is important to know what inherent traits may make one woman more likely to undergo a caesarean section than another. Frequently cited inherent maternal traits associated with caesarean section are maternal age and obesity, because as discussed in Section 2.5.1, there are well-documented relationships between maternal obesity and advancing maternal age and risk of operative delivery, for both nulliparous and multiparous women (Peipert and Bracken 1993; Ecker et al 2001; Heffner et al 2003; Cleary-Goldman et al 2005; Bayrampour and Heaman 2010). Another common biological predictor of caesarean section cited in this literature is maternal height. In fact, a WHO collaborative study published in 1995 determined that height was the best maternal indicator of assisted and operative delivery (World Health Organization 1995).

There has been discussion in the literature about whether a mother's stature, coupled with the size of her infant, influences her ability to give birth vaginally. Drawing on studies of hip size in biological anthropology, some investigations in caesarean section have found that shorter women birthing larger babies are more likely to undergo caesarean sections than taller women having smaller babies (Mahmood 1989; Lieberman et al 1996; Thorp et al 1989). Kirchengast and Hartmann (2007) found that as maternal height decreased, the likelihood of caesarean section increased significantly, which echoed work by Prasad and Al-Taher (2002), in which short maternal stature was associated with caesarean section (Prasad and Al-Taher 2002; Kirchengast and Hartmann 2007). In addition to outlining the existence of an association, work has been done to try to identify at which point a woman's height becomes a risk factor. In a paper by Mahmood et al (1989), those women delivering by caesarean section were significantly shorter (with a mean height of 159.03cm) than those having unassisted vaginal deliveries (with a mean height of 162.02cm); Kappel et al (1987) reported that women shorter than 155cm were three times more likely to experience an emergency caesarean section than women between 166 and 175cm tall; Read et al (1994) found that women shorter than 160cm were at greater risk of caesarean section than those taller than 160cm; and a study by Van Bogaert (1998) states that women experiencing unassisted vaginal births were taller, with longer limbs, feet, and vertebral columns than women who had caesarean sections or vaginal births after caesarean section (VBAC).

One reason maternal height holds such influence over type of delivery is summarized by Kara et al (2003): "maternal height has been reported as an obstetric risk factor [because] short stature may be associated with an increased incidence of obstructed labour due to cephalopelvic disproportion" (Kara et al 2003). Cephalopelvic disproportion (or CPD) refers to a labour complication in which the foetal head is too large to pass through the maternal pelvis. CPD is a serious complication that can delay progress in labour, and cause traumatic foetal brain injury and shoulder dystocia, which occurs when foetal shoulders become trapped under the maternal public bone (Penn and Ghaem-Maghami 2001; Mander 2007). Previous studies have found that shorter women were at greater risk of caesarean section for CPD specifically. Shorter maternal height was associated with greater likelihood of caesarean section due to labour arrest in a paper by McGuinness and Trivedi (1999), and data analysed by Mahmood et al (1989) suggests that women shorter than 160cm were at greater risk of caesarean section for CPD. Taking the study of maternal stature of CPD a step further, Brabin et al (2002) found that nulliparous women under 154cm were at greater risk of CPD. Shorter women having their first babies might be at greatest risk of caesarean section.

According to Mahmood et al (1989), while there is a connection between maternal height and caesarean section, there is no association between labour induction and maternal height. Therefore, a woman's height might be expected to influence her likelihood of caesarean section in the MCS despite not being considered to influence her likelihood of labour induction.

The following sections will specify the research questions and conceptual framework driving this paper, with the aim of drawing together the various factors posited to influence a woman's experience of labour induction, epidural anaesthesia, and operative delivery in the United Kingdom.

6.2 Research Questions

1) Is labour induction associated with type of delivery in the Millennium Cohort Study?
2) Does the association between labour induction and delivery type vary by UK country?
3) Is the relationship between labour induction and delivery type mediated by epidural anaesthesia?
4) Does maternal height moderate the relationship between labour induction, epidural, and delivery type?

6.3 Conceptual Framework

The literature concerning the cascade of intervention discusses how interventions at the beginning of the cascade increase the likelihood of interventions further along the cascade (Yudkin et al 1979; Bassett 1996; Dublin 2000; Johanson 2002; Thorsell et al 2011; Spong et al 2012). Drawing from this previous research, this paper hopes to underline how childbirth interventions are related to one another in the MCS dataset. It also focuses on how the associations between interventions may be influenced by characteristics of mothers shown to be significant in Chapters 4 and 5. Given the results presented in those chapters, maternal demographic indicators, maternal socioeconomic status (measured in part by educational attainment), and the country of cohort member birth are considered carefully in the present analysis.

Figure 6.6 below details both the relationships between labour induction, epidural, and type of delivery in the cascade of intervention and the potential for these relationships to be influenced by maternal height and country of cohort member birth, as posited by this chapter. In this diagram, and in the analyses that follow, epidural use is considered a mediator of the association between labour induction and type of delivery, meaning that its appearance in the cascade may change the association between induction and the use of assisted vaginal delivery (i.e. episiotomy, forceps, or ventouse extraction) and emergency caesarean section.

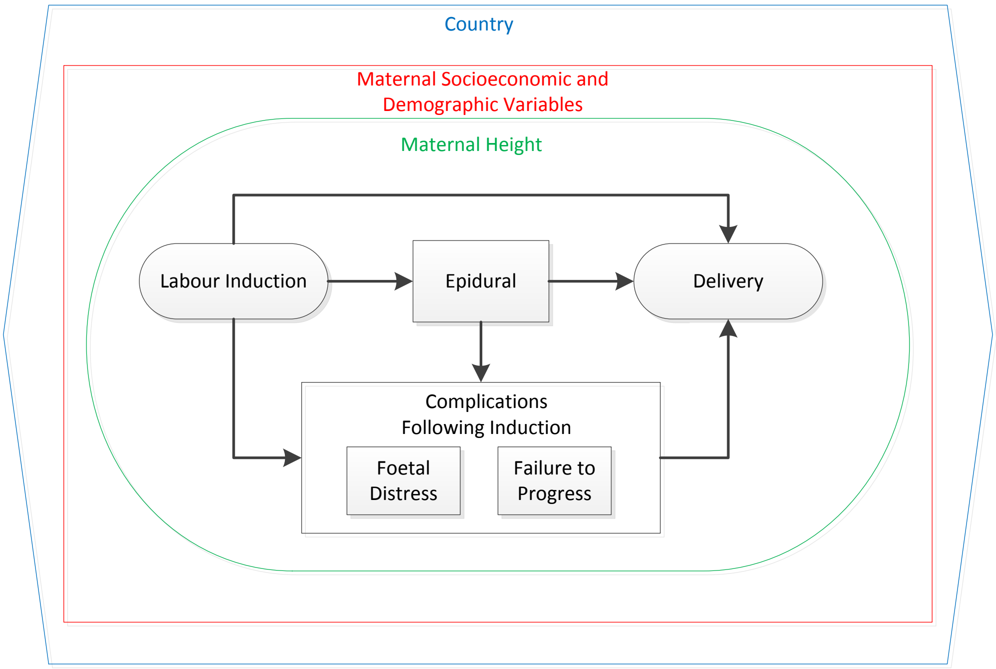
In addition, the figure considers maternal height as a potential moderator of the relationship between labour induction, epidural, and delivery type because, as outlined in Section 6.1.4, maternal height influences labour and delivery in much the same way as induction of labour and epidural influence childbirth; namely, by affecting the speed at which a labour progresses. Therefore, one aim of this paper is to determine whether women of certain heights are at greater risk of operative delivery after labour induction and epidural than those of other heights.

The incidence of foetal distress and the diagnosis of failure to progress are featured in this conceptualization because they are medical factors that weight heavily on the association between labour induction and type of delivery. As discussed in Section 6.1.3, they are generally considered to be the links between labour induction and operative delivery, and the reason for this link may be their relationship with epidural use. Therefore, although they are treated as control variables in the models run for this chapter, they are key features of this conceptual framework.

Finally, Figure 6.6 also includes maternal socioeconomic and demographic variables, as much like foetal distress and failure to progress above, while they are not considered mediators or moderators in this project, they are crucial moving parts in this conceptualization. Although they are not highlighted in any particular way in the present chapter, they are vital controls in the analyses.

As this chapter aims to examine the influence of maternal height on the likelihood of operative delivery, Figure 6.6 includes maternal height as a moderating influence on the association between labour induction, epidural, and delivery type. Additionally, this figure highlights the influence that UK country may have on the pathways through which interventions are related. Interventions in the cascade are coloured black, the moderating influence of maternal height is coloured green, maternal demographic and socioeconomic controls are coloured red, and UK country is coloured blue. The arrows represent the pathways through which maternal socioeconomic status and demographic variables, UK country, and maternal height may work on the associations between the interventions, in attempt to illustrate the combined effects of the mediating, moderating, and control variable influences.

Figure 6.6: Mediators and Moderators of the Cascade of Intervention



As outlined in Section 6.2 above, the analyses in this chapter aim to answer questions relating to different pieces of Figure 6.6. Research questions 1 and 2 will determine whether there is a significant association between labour induction and type of delivery, and whether this association varies by UK country. The answers to these first two research questions will serve as both a contribution to previous literature concerning the relationship between labour induction and delivery type, and a justification for the importance of investigating this relationship in more detail.

Research questions 3 and 4 will examine how the relationship between induction and delivery is mediated by epidural use, and how the mediating power of this intervention is further moderated by maternal height, after controlling for demographic variables and socioeconomic status (operationalized, in part, by the educational qualifications of the mother of the cohort child).

The section that follows details the ways in which the different research questions will be addressed. This next section includes a discussion concerning the selection of the most effective statistical analyses, descriptions of the models, and the statistical notations themselves.

6.4 Methods

A categorical outcome variable concerning the type of delivery necessitated a multinomial logit model, and thus, multinomial logistic regression (MLR) was selected as the part of the research strategy. Multinomial logistic regression is an extension of logistic regression and is a way of modelling the relationships between independent variables and a nominal (unordered categorical) outcome variable. Like binary logistic regression, MLR allows for regression on categorical outcome variables by transforming probabilities into log-odds through the logit function[9] and uses maximum likelihood estimation to calculate the probability of belonging to one category of an outcome variable over another, while providing the ability to control for the influence of independent variables. Another important feature of MLR is that both continuous and categorical predictors can be entered into the models as independent variables (Petrucci 2009). This is an advantage for this paper, as while most of the independent variables are categorical, a maternal height variable is entered into the multinomial models as continuous (see description of independent variables in Section 6.5.4).

Multinomial logistic regression does not assume a normal distribution in the data, but it does make an assumption relevant to the present paper: independence among the categories of the outcome variable, which requires that falling into one category of the outcome variable is not dependent on another category of the outcome variable. As the outcome variable for this study is discrete mode of birth for the cohort child, there is independence between the categories in the outcome variable.

As the nominal outcome variable used in this chapter has three categories (see Section 6.5.1 for more details), the models run by the following analyses will require multiple formulae, one for each of the two outcome categories being compared to the baseline category. The formulae for multinomial logistic regression used in this paper are as follows:

$$g_j(x) = \beta_{j0} + \beta_{j1}x_1 + \beta_{j2}x_2 + \cdots + \beta_{jp}x_p \tag{6.7}$$

$$g_1(x) = \beta_{10} + \beta_{11}x_1 + \beta_{12}x_2 + \cdots + \beta_{1p}x_p$$

$$g_2(x) = \beta_{20} + \beta_{21}x_1 + \beta_{22}x_2 + \cdots + \beta_{2p}x_p$$

Where:

j is the category of outcome variable

$g_j(x)$ is the logit function of the outcome variable category

β_{j0} is the constant value for outcome category *j*, and

[9] See Section 4.3 for discussion of the logit transformation.

$\beta_{jp}x_p$ is the effect of each explanatory variable on the probability of membership in outcome category *j*

In addition to the direct effects of labour induction on risk of caesarean section, this paper also aims to outline the indirect effects of epidural use on caesarean section after controlling for labour induction, as well as how this intervention mediates the association between induction and delivery. For this reason, KHB mediation analysis was also performed.

KHB meditation analysis concerns the parsing out of direct and indirect effects of mediating variables in logit models. Breen, Karlson, and Holm (2013), the creators of the KHB method, report that it is not possible to decompose the total effects in nonlinear binary models in the same way as is done for linear models. According to Breen, Karlson, and Holm, "this is because, in nonlinear binary probability models, the regression coefficients and the error variance are not separately identified; rather, the model returns coefficient estimates equal to the ratio of the true regression coefficient divided by a scale parameter, which is a function of the error standard deviation. Because the error variance may differ across models, the total effect does not decompose into direct and indirect effects in the desired way" (Breen, Karlson, and Holm 2013, page 165). To combat this issue in logistic mediation analysis, the KHB method holds both the scale and the standard error to an assumed standard distribution. This method of decomposition of total effects into direct and indirect effects is referred to as the "difference in coefficients" method.

The formulae for deriving direct, indirect, and total effects for logit models using the KHB method are as follows:

$$\text{Direct Effects:}\quad b_{yx.z} = \frac{\beta_{yx\cdot z}}{\sigma_e} \tag{6.8a}$$

$$\text{Indirect:}\quad \theta_{zx} b_{yz.x} = \frac{\theta_{zx} \times \beta_{yz\cdot x}}{\sigma_e} \tag{6.8b}$$

$$\text{Total:}\quad \frac{\beta_{yx}}{\sigma_e} = \frac{\beta_{yx\cdot z} + \theta_{zx} \times \beta_{yz\cdot x}}{\sigma_e} \tag{6.8c}$$

Where:

$\beta_{yx\cdot z}$ is the direct mediating effect of the mediating variable (*z*) on the relationship between labour induction (*x*) on caesarean section (*y*)

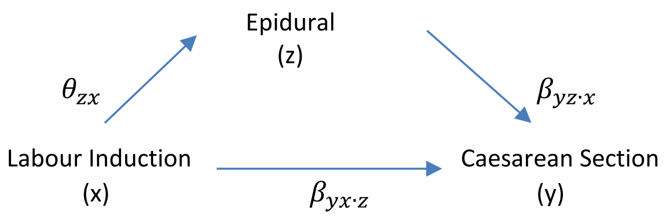
σ_e is the scale parameter

θ_{zx} is the effect of labour induction (*x*) on the mediating variable (*z*), and

$\beta_{yz \cdot x}$ is the effect of labour induction (*x*) on the relationship between caesarean section (*y*) and the mediating variable (*z*)

Breen, Karlson, and Holm (2013) illustrate the decomposition of total effects into indirect and direct effects using the figure below:

Figure 6.9: Decomposition of Total Effects in KHB Mediation Analysis



In the same way as in Chapters 4 and 5, the MCS sample was separated into nulliparous and multiparous mothers before the multinomial logistic regression and KHB analyses undertaken. While this separation was partially motivated by further investigating the associations reported in the previous two analysis chapters, this paper was also interested in examining the relationship between labour induction and caesarean section in multiparous women, as much of the previously published literature on induction and operative delivery has focused its attention on samples of nulliparous women. For example, of 21 trials of epidural use examined as part of a Cochrane review, thirteen included just nulliparous women and only one reported results for just multiparous women (Anim-Somuah et al 2010).

The above multinomial logistic regression models were used to answer the first and second research questions posited by this paper. In order to investigate whether labour induction increases the likelihood of operative delivery or caesarean section, one MLR model was run for both nulliparous and multiparous women, using the categorical mode of delivery variable as the outcome variable and adjusting for maternal demographic and socioeconomic information (age, ethnicity, educational qualifications, housing tenure, employment, relationship status, and income quintile), maternal and infant health variables listed above (maternal health problems in pregnancy, smoking behaviour, maternal BMI at booking, blood pressure in pregnancy, gestational age in days, and infant birth weight), the use of epidural anaesthesia, the presence of foetal distress or failure to progress diagnoses, and the UK country in which the birth took place. To examine whether the association between labour induction and type of delivery varied by UK country, another MLR model was run for each group of women. These regression models controlled for all variables present in the MLR model constructed for research question 1, but made the additional adjustment for an interaction between UK country and labour induction.

The third and fourth research questions posited that the use of epidural anaesthesia has a mediating effect on the association between labour induction and mode of delivery, and were therefore investigated utilizing KHB mediation analyses. For both research questions 3 and 4, KHB models included the categorical delivery type outcome variable, the labour induction variable, and the epidural anaesthesia variable, as well as control variables. As both of these research questions were also interested in how maternal height moderates the association between labour induction and caesarean section, models fit for both questions adjusted for maternal height.

To answer research question 3, which is concerned with whether the risk of operative delivery after labour induction is mediated by the use of epidural, one KHB model was run for nulliparous and multiparous women. This model adjusted for all explanatory variables significant for women in the multinomial logistic regression models for research question 2, including maternal height.

As research question 4 seeks to better understand how maternal height moderates the mediation effect of epidural on the association between labour induction and delivery type, the analyses for this research question divide the samples of nulliparous and multiparous women by height categories. First, analyses were run on two different height categories (women 1.59m or shorter and women 1.60m or taller) and then the height categories were further specified into three different categories (women 1.59m or shorter, women between 1.60m and 1.69m tall, and women 1.70m or taller). All of the KHB mediation analyses run for research question 4 adjust for explanatory variables found to be significant for nulliparous and multiparous women respectively in the MLR models run for research question 2 in Section 6.7.2.

6.5 Measures

6.5.1 Outcome Variable

The outcome variable for the present analysis is a categorical variable containing information on the type of delivery a mother experienced during the birth of the cohort member. The four categories were initially defined as spontaneous vaginal delivery (no instruments), assisted vaginal delivery (forceps or ventouse), planned caesarean section, and emergency caesarean section.

Women who had planned caesarean sections were initially retained in the type of delivery variable because planned caesarean is a relevant delivery method for those who were not induced, despite the fact that a planned caesarean is an irrelevant delivery type for those who may have entered the cascade of intervention (as experiencing the cascade implies an attempt at vaginal birth) and the fact that those undergoing planned caesareans by definition would not have been induced. However, “planned caesarean,” much like “elective caesarean,” is a problematic term. It is difficult to know, while analysing secondary data from a retrospective study, how a woman may have understood the meaning of a planned caesarean section. For some, a planned caesarean section is one in which a surgery date is chosen by the mother and her doctor and delivery occurs without the onset of labour. This is the interpretation of planned caesarean section that initially kept this delivery type in the models. For others, however, a planned caesarean section is simply one that is not an emergency, meaning that it would be possible for a woman who laboured to eventually have a planned caesarean section. In fact, in the MCS sample, a considerable number of nulliparous and multiparous women reported having a planned caesarean section and being induced, which should have been mutually exclusive experiences. After considering what a planned caesarean might have meant to the women in the MCS - Were women having planned caesareans given pessaries? Had their waters broken? Is this why they thought they'd been induced? Or did they answer this question as if they had always personally planned/expected to have a caesarean? - it was ultimately decided that this category was too problematic to be used in the analyses, as there is no way to know how individual women interpreted their experience of planned caesarean section.

Thus, the delivery type outcome variable used in these analyses in this chapter contained three categories: spontaneous vaginal delivery (no instruments), assisted vaginal delivery (forceps or ventouse), and emergency caesarean section.

6.5.2 Explanatory Variables

An important explanatory variable in this chapter is the binary indicator concerning whether or not a woman underwent a labour induction (first discussed in Section 4.4.1). Women who were induced by pessaries, by intravenous injection, or by membrane rupture were all labelled as "induced" and women who did not report any of these procedures were categorized as "not induced."

In addition to the induction of labour variable above, the models run in this paper will be adjusted for several maternal and infant health variables shown to have important relationships with labour induction in the literature and previous chapters of this thesis, or to have had significant associations with caesarean section in the literature. Nearly all of these explanatory variables have been described in previous sections of this thesis (Sections 4.4.2 and 5.4.2) and are presented in Table 6.1 below.

Table 6.1: Explanatory Variable Coding

Individual Level Explanatory Variables	**Organization**
Maternal age	19 years old and younger; 20-25 years old; 26-30 years old; 31-35 years old; 36 years old and older
Maternal ethnicity	White; Indian; Pakistani & Bangladeshi; Black or Black British; Other including Mixed
Maternal relationship status	Legally married; Cohabiting; Single/Divorced/Widowed
Maternal educational qualifications	Higher and first degrees; Diplomas in Higher Education; A/O Levels (including GCSE grades A-C); Other (including GCSE grades D-G); None
Maternal occupation before pregnancy	Managerial and professional; Intermediate; Self-employed; Lower supervisor; Semi-routine and routine
Household income quintiles	Lowest quintile; Second quintile; Third quintile; Fourth quintile; Highest quintile
Housing tenure	Own outright/own with mortgage; Rent from Local/Housing Authority; Rent privately; Other (including living with parents)
Illness in pregnancy	No pregnancy complications; Complications not associated with induction; Complications associated with induction; Other
Maternal BMI before pregnancy	Low (<18.5); Normal (18.5-24.9); High (≥25.0)
Maternal height in metres	Continuous numerical data
Infant birth weight	Low (<2500 grams); Normal (2500-4000 grams); High (>4000 grams)
Infant gestational age in days	259 days or less; 260-272 days; 273-286 days; 287-293 days; 294 days or more
Foetal distress	Binary: Yes or No
Failure to progress	Binary: Yes or No

6.5.3 Mediating Variable

This paper posits that the pain relief a woman utilizes during labour could have a mediating influence on the relationship between labour induction and delivery type. Therefore, a binary pain relief variable, separating women into "epidural" or "no epidural" categories, will be utilized in the models in this chapter. The "no epidural" category includes women who used gas and air, TENS machines, Pethidine or Demerol injections, no pain relief, or other forms of relief (such as water births, local anaesthetics, or minor pain killers). This category excludes women who reported that they "did not have labour," as this indicates that they experienced planned caesarean sections, which, as discussed in Section 6.5.1 above, is a delivery type excluded from the following analyses.

6.5.4 Moderating Variable

A new addition to the variable list in this chapter is maternal height. Maternal height was entered into multinomial models for research questions 1 and 2 as a continuous variable. This is an attempt to illuminate how one-unit differences in height measurement (in this case, millimetres) are associated with a woman's risk of caesarean section.

Research questions 3 and 4 are concerned with whether a woman's height has a moderating influence on the relationship between labour induction and caesarean section after the use of epidural anaesthesia. If a woman with shorter stature is at greater biological risk of operative delivery, it may follow that the mediating influence of epidural is different in her case than in the case of a taller woman, who does not carry the same biological risk.

Therefore, KHB mediation analyses were run to examine whether maternal height moderates the effect of epidural on delivery outcome, and in these mediation analyses, the samples of nulliparous and multiparous women were split by height - initially into 1.59m or shorter and 1.60m or taller groups, and then into 1.59m or shorter, 1.60-1.69m, and 1.70m or taller groups. The decision to categorize maternal height in this way for the KHB analyses was taken after a review of the literature detailed in Section 6.1.4. In previously published research, 1.60m is the tallest height identified at which women are no longer at greater risk of caesarean section. Therefore, the KHB analyses use this as a cut-off point between "short" women potentially at higher risk and "tall" women who may not be at risk.

6.6 Descriptive Results

Of the total sample size of 18,241 mothers in the MCS, 5,646 had their labours induced and 2,200 gave birth via emergency caesarean section. Of those who had their labours induced, 16.8% underwent emergency caesarean sections, as compared with 9.9% of those who were not induced; 5.6% of those induced had their births assisted with forceps, as compared with 3.2% of those who were not induced; and 6.8% of those induced gave birth via ventouse extraction, as compared with 4.5% of those who were not. Women who had labour inductions experienced more labour complications than those not induced ("very long labour": 8.9% vs. 5.0%; "foetal distress - heart rate sign": 12.3% vs. 6.2%) and utilized pain medication during labour in greater proportions than women who did not have inductions (Gas and air: 74.0% vs. 67.0%; Pethidine or Demerol: 4.4% vs. 3.5%; Epidural: 13.0% vs. 11.6%), with the exceptions of general anaesthesia and the use of TENS machines.

Chi square tests comparing labour induction with type of delivery and labour induction with type of pain relief used during delivery both had a significance of $p < 0.001$, indicating that in this sample, labour induction is associated with delivery type and type of pain relief used during delivery. In unadjusted logistic regression models run for the total sample before splitting by parity, including just labour induction and type of delivery as the outcome, women who had labour inductions were more likely to have vaginal births assisted with forceps or ventouse extraction and emergency caesarean sections than they were to have normal vaginal deliveries.

As discussed above in Section 6.5.1, this paper required special consideration of the use of a planned caesarean delivery outcome category. While planned caesarean section was eventually removed from the delivery type outcome variable used here, it is worth briefly examining the proportions of those nulliparous and multiparous women who experienced planned caesarean section. The delivery outcomes by labour induction and epidural use for nulliparous and multiparous women are presented below in Figures 6.10 and 6.11, respectively.

For both groups of women, those who had epidurals but were not induced had the highest percentages of planned caesarean sections. This makes sense, given that a planned caesarean necessitates pain medication but no induction of labour, as there is no attempt at vaginal birth in a planned caesarean section (as it is defined here). However, as described above, there are also high proportions of women who were induced and who had epidurals having planned caesarean sections, especially for multiparous women (Figure 6.11).

Figure 6.10: Delivery Outcomes for Nulliparous Women, by Labour Induction and Epidural Use

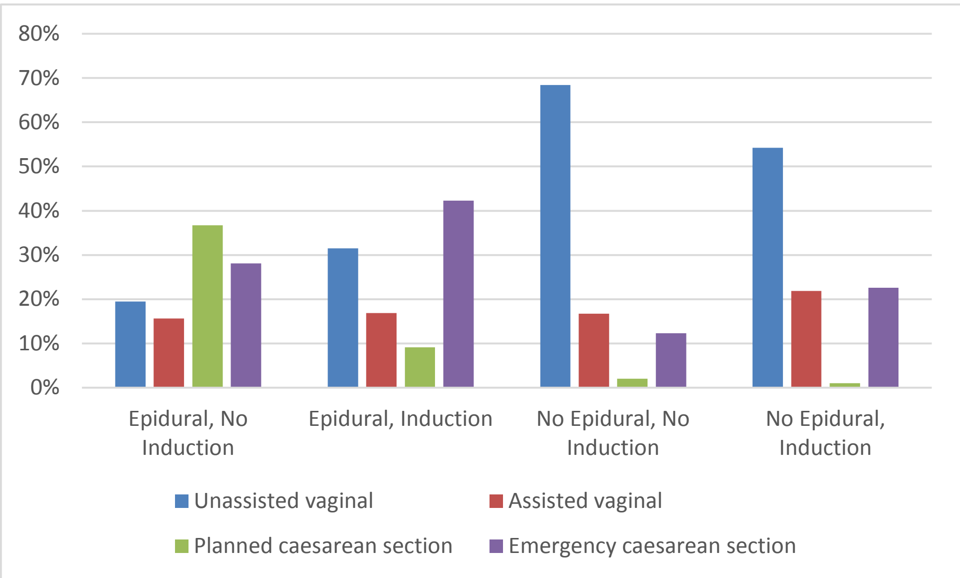
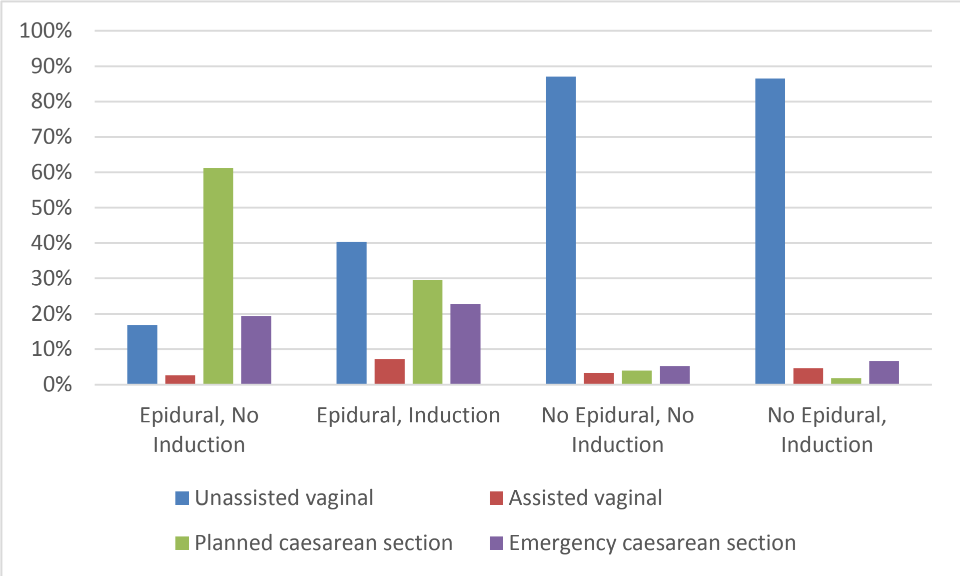


Figure 6.11: Delivery Outcomes for Multiparous Women, by Labour Induction and Epidural Use



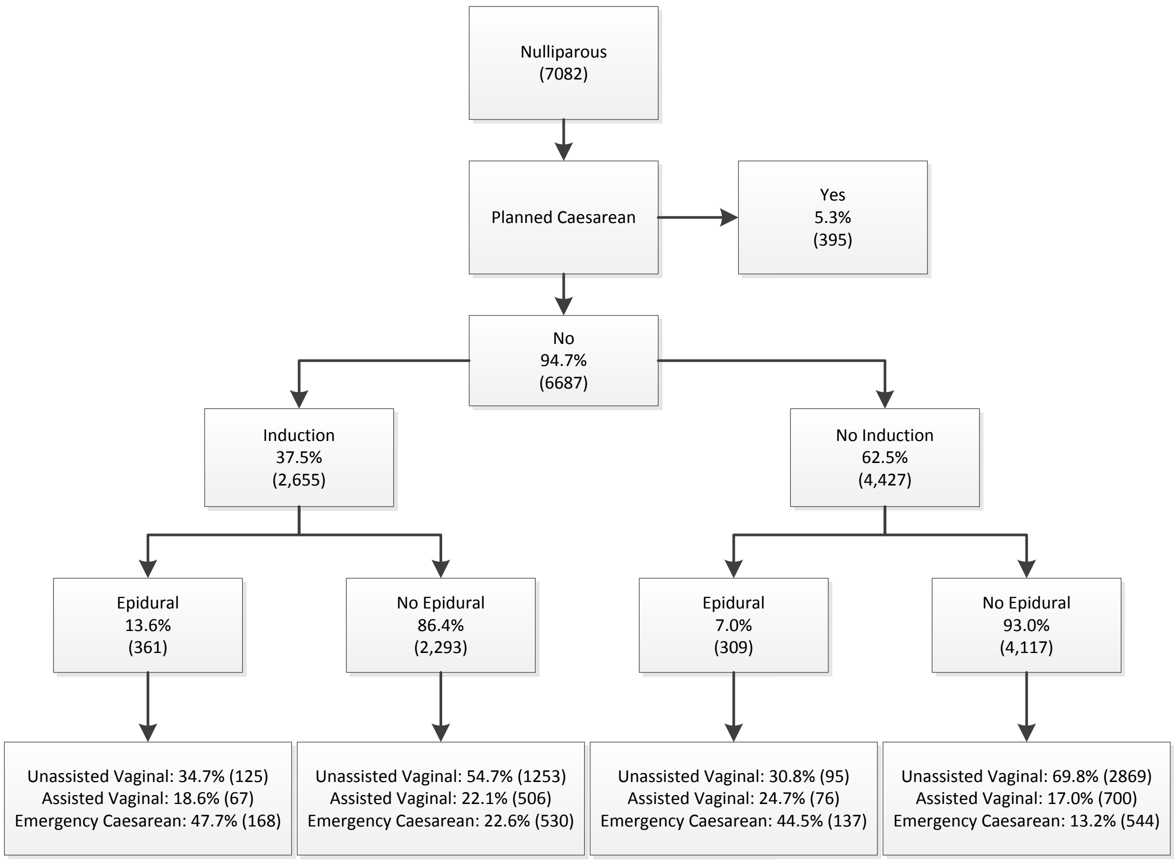
Larger proportions of multiparous women had planned caesareans (across all categories). This is probably due to the fact that many multiparous women had had previous caesarean sections and were encouraged to have repeat caesareans. Unfortunately, any previous operative deliveries cannot be accounted for these analyses because information on past births is not available in the MCS data. However, these descriptive statistics provide evidence that multiparous women in this sample were undergoing more planned caesarean sections than nulliparous women despite having lower proportions of induction-related complications than nulliparous women, and one explanation for this finding is previous caesarean delivery.

In addition to illustrating both expected and unexpected planned caesarean section results, which serve to underscore why this delivery category will not be included in any multivariate analysis, Figures 6.7 and 6.8 demonstrate that for both parity groups, the use of epidural anaesthesia seems to have an association with delivery outcome. In both nulliparous and multiparous women, regardless of whether or not they were induced, there are many more unassisted deliveries in women who did not utilize epidural anaesthesia than in women who had epidurals.

To further parse out the relationship between labour induction, epidural, and delivery outcome, Figures 6.12 and 6.13 below illustrate the proportions of nulliparous and multiparous women (respectively) according to whether they experienced each intervention. In keeping with the discussion above concerning the difficulty associated with using planned caesarean section in these analyses, this delivery type was excluded from the descriptive statistics pathways illustrated below.

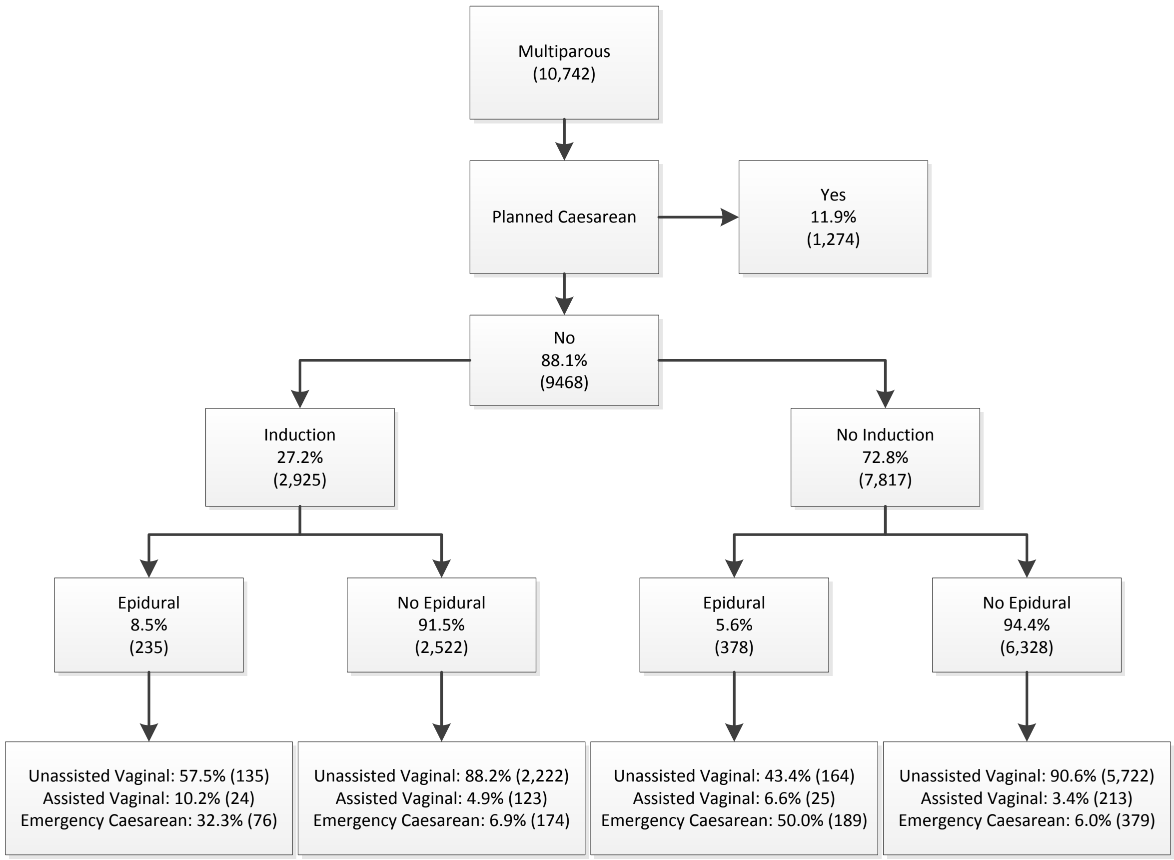
A higher percentage of nulliparous women experienced induction (37.5%) than multiparous (27.2%), which follows the literature concerning which women are at greater risk of labour induction. Larger proportions of nulliparous women used epidurals, regardless of induction, but more multiparous women who were not induced used epidurals than nulliparous women who were not induced. In addition, a higher percentage of multiparous women who were not induced had emergency caesarean sections after epidural (50.0%) than multiparous women who experienced both induction and epidural (32.3%). This also follows previous research into the association between labour induction and delivery type, in that birth history has important influence on which women are induced in subsequent pregnancies. Although the MCS does not hold information concerning birth history, these descriptive results indicate that multiparous women who are not induced may be at greater risk of emergency caesarean sections, perhaps due to complications from their previous labours and births that prevent them from being induced in subsequent births.

Figure 6.12: Nulliparous Descriptive Statistics



Additionally, there are more nulliparous emergency caesarean sections at the end of each induction/epidural pathway than there are multiparous emergency caesarean sections. While planned caesarean section outcomes are not presented at the end of the pathways in these figures, it is clear from the total number of planned caesareans included in the diagrams that a greater proportion of multiparous women experienced planned caesarean sections (11.9%) than did nulliparous women (5.3%). The percentage of emergency caesarean deliveries in nulliparous and multiparous women who were induced and received epidurals is 47.7% to 32.3%, respectively, meaning that about a third more nulliparous women who utilized epidurals after inductions underwent emergency caesarean sections than multiparous women who used epidural anaesthesia after induction. The relationship between parity and emergency caesarean sections may be due to the fact that more nulliparous women are induced and therefore more nulliparous women experience the cascade of intervention.

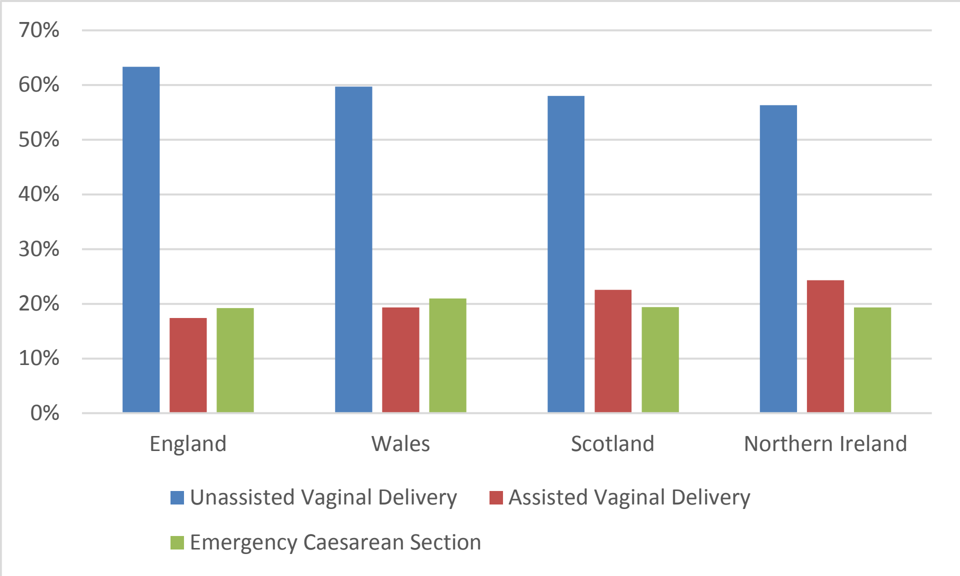
Figure 6.13: Multiparous Descriptive Statistics



Further, research question 2 posits that the association between labour induction and type of delivery may differ between UK countries. This draws on existing literature and national data that indicates a difference in rates of induction of labour and operative delivery between the four countries of the United Kingdom. Additionally, bivariate chi square analysis of UK country and delivery type in the MCS indicate that there is a significant relationship between country of cohort member birth and type of delivery (Nulliparous: $p < 0.001$; Multiparous: $p = 0.036$). Figures 6.14

and 6.15 illustrate the proportions of delivery types by UK country in the MCS for nulliparous and multiparous women.[10]

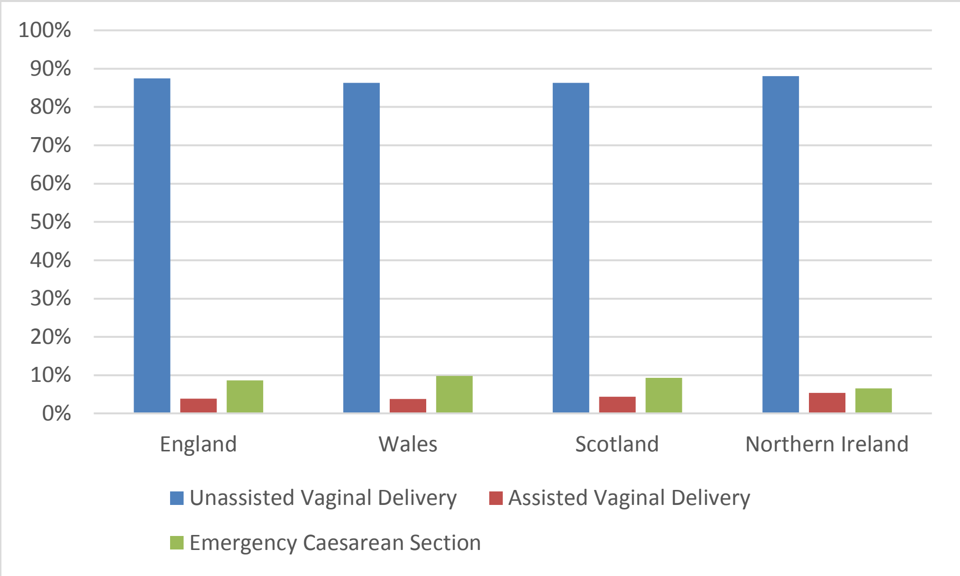
Figure 6.14: Nulliparous Delivery Type by UK Country



These two figures demonstrate that there is a proportional similarity in delivery type between countries in the United Kingdom. The analyses that follow in Section 6.7 will examine whether, despite the similarities in proportions, the relationships between these delivery types and the maternal and infant indicators included in the models vary between these four countries.

[10] The proportions displayed in these figures are taken from the outcome variable that excludes "planned caesarean section" as a delivery type, detailed in Section 6.4.1. While the proportions in each category are necessarily lower when a fourth "planned caesarean section" category is added to the figure, the general pattern of similarity between countries does not change.

Figure 6.15: Multiparous Delivery Type by UK Country



While the above descriptive statistics underscore the importance of exploring the differences between UK countries, Tables 6.2 and 6.3 demonstrate that this may be difficult to do in the MCS dataset, as sample sizes get quite small for some delivery type categories in Scotland, Wales, and Northern Ireland, most especially in multiparous women. For example, there were only 54 nulliparous women in Northern Ireland who experienced emergency caesarean section without being induced.

Table 6.2 Number of Nulliparous Women Experiencing Delivery Types, by Induction

Induction by UK Country	Unassisted Vaginal Delivery	Assisted Vaginal Delivery	Emergency Caesarean Section
England			
No	1,934	461	414
Yes	831	300	424
Wales			
No	443	119	124
Yes	200	89	102
Scotland			
No	366	115	90
Yes	196	104	98
Northern Ireland			
No	221	81	54
Yes	152	80	74

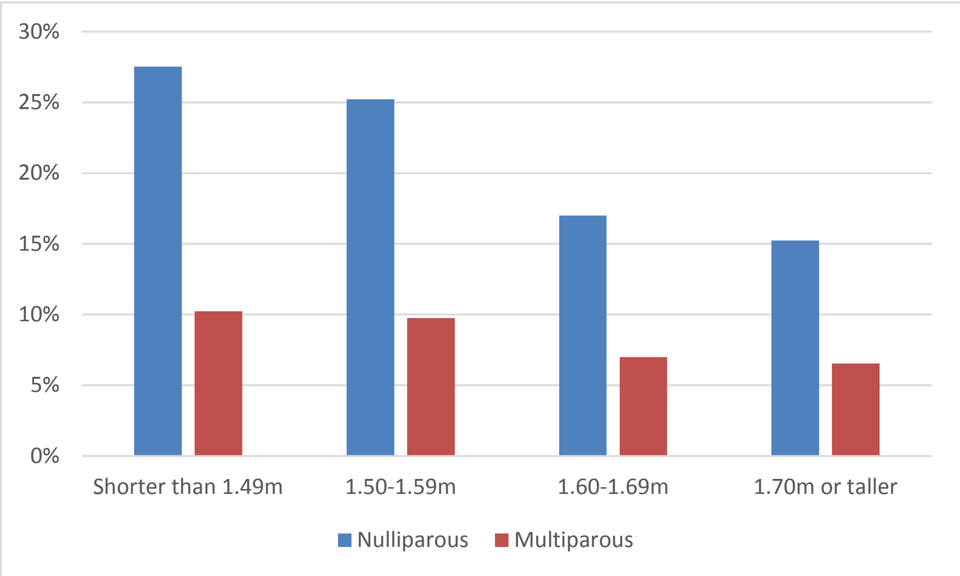
For multiparous women, the average number of women in the MCS who experienced assisted vaginal delivery after induction in Scotland (21), Wales (19), and Northern Ireland (22) is just under 21. These small sample sizes may make it difficult to report significant relationships between these categories.

Table 6.3 Number of Multiparous Women Experiencing Delivery Types, by Induction

Induction by UK Country	Unassisted Vaginal Delivery	Assisted Vaginal Delivery	Emergency Caesarean Section
England			
No	3,387	145	383
Yes	1,334	85	132
Wales			
No	838	33	88
Yes	336	19	46
Scotland			
No	658	28	64
Yes	312	21	41
Northern Ireland			
No	506	32	33
Yes	376	22	33

Finally, as maternal height has been highlighted as an important explanatory variable and as a potential moderating influence in the relationship between epidural and operative delivery, it's worth detailing trends in the association between maternal height and delivery type. Below, Figure 6.16 illustrates that for both nulliparous and multiparous women, shorter women experienced nearly twice as many emergency caesarean sections than taller women. It also appears that there are greater differences between proportions of emergency caesarean sections by height for nulliparous women than for multiparous women.

Figure 6.16: Proportion of Emergency Caesarean Section by Maternal Height



Given the above descriptive results, there do appear to be associations between labour induction, epidural, UK country, maternal height, and delivery type, but it is possible that they might be tempered in the results due to sample size restrictions. The next section presents the multinomial logistic regressions and KHB mediation analyses conducted to examine the trends described here and answer the research questions posed by this chapter.

6.7 Multivariate Results

6.7.1 The Association Labour Induction and Type of Delivery

Full output tables, including relative risk ratios for every explanatory variable included in the MLR models for nulliparous and multiparous women in this section and the next, can be found in Appendix C. In this section and Section 6.7.2 below, relative risk ratios for labour induction, foetal distress, failure to progress, maternal height, epidural use, UK country, maternal educational qualifications, and maternal age will be displayed in results tables. Maternal education and maternal age are the only demographic and socioeconomic control variable reported in the body of the chapter because these variables are of special interest to the present analyses. Advanced maternal age is often cited as an important indicator of delivery type, as reported in Section 2.4. Maternal educational qualifications were significant predictors of induction of labour in Chapters 4 and 5; the relative risk ratios are reported here to highlight whether maternal education is a significant predictor of delivery type in this sample as well. Table 6.4 below displays the relative risk ratios from MLR models of the association between labour induction and type of delivery for nulliparous women.

Table 6.4: Relative Risk Ratios from Multinomial Analyses of Association between Labour Induction and Delivery Type, Nulliparous Women[ab]

	Type of Delivery	
	Assisted Vaginal Delivery	**Emergency Caesarean Section**
Maternal age		
19 years and younger	0.267***	0.123***
20-25 years	0.333***	0.224***
26-30 years	0.542***	0.407***
31-35 years	0.634**	0.667*
36 years and older (Ref)		
Maternal education		
Higher & first degrees (Ref)		
Diploma in higher education	1.228	1.121
A/O Levels	1.100	0.873
Other	1.088	1.036
None	0.822	1.005
Induction		
No	0.746***	0.548***
Yes (Ref)		
Foetal Distress		
No	0.250***	0.199***
Yes (Ref)		
Failure to progress		
No	0.222***	0.173***
Yes (Ref)		
Maternal Height	0.438	0.018***
Epidural		
No	0.418***	0.201***
Yes (Ref)		
UK Country		
England (Ref)		
Wales	1.217	1.525***
Scotland	1.376**	1.290
Northern Ireland	1.354*	1.181

[a]Reference category: Unassisted vaginal delivery
[b]Model adjusted for maternal ethnicity, relationship status, employment, housing tenure, income quintile, problems in pregnancy, maternal BMI, infant birth weight, and infant gestational age in days

The two sociodemographic variables included in Table 6.4 display two very different associations with delivery type for nulliparous women. Younger women are significantly less likely than those 36 years and older to experience both assisted vaginal delivery and emergency caesarean section in this sample. Conversely, no level of maternal education is a significant predictor of delivery type. Echoing the results for maternal education and labour induction presented in the first two papers of this thesis, maternal education is not a significant predictor of operative delivery for nulliparous women in this sample.

Not surprisingly, foetal distress and failure to progress, common diagnoses of labour complications, have significant associations with type of delivery. Women experiencing no foetal distress were significantly less likely to have assisted vaginal births (RRR: 0.250) and emergency caesarean sections (RRR: 0.213) than women who did experience foetal distress. Similarly, women who were not diagnosed as failing to progress were significantly less likely to undergo assisted vaginal deliveries (RRR: 0.222) or emergency caesarean sections (RRR: 0.105) than those women who did fail to progress.

In addition, labour induction is associated with delivery type in nulliparous women. Nulliparous women who were not induced were significantly less likely to have assisted vaginal deliveries (RRR: 0.746) and emergency caesarean sections (RRR: 0.548). Additionally, although it is not a significant predictor of assisted vaginal birth, maternal height is significantly associated with emergency caesarean sections, such that each centimetre increase in height reduces the likelihood of emergency caesarean section (RRR: 0.018). Epidural is a significant predictor of both assisted vaginal delivery (RRR: 0.418) and emergency caesarean section (0.201), with women who did not have epidurals being less at risk of operative delivery than those who did have epidural anaesthesia.

Finally, the UK country in which the birth occurred was a significant predictor for both types of operative delivery. Nulliparous women in Scotland and Northern Ireland had significantly greater likelihood of having an assisted vaginal delivery than women in England, and nulliparous women in Wales had greater risk of experiencing emergency caesarean sections than women in England.

The results for multiparous women are included in Table 6.5 below. (See Appendix C for output for every explanatory variable included in these models.)

Table 6.5: Relative Risk Ratios from Multinomial Analyses of Association between Labour Induction and Delivery Type, Multiparous Women[ab]

	Type of Delivery	
	Assisted Vaginal Delivery	**Emergency Caesarean Section**
Maternal age		
19 years and younger	0.513	0.139**
20-25 years	0.521**	0.524**
26-30 years	0.626**	0.637**
31-35 years	0.840	0.751
36 years and older (Ref)		
Maternal education		
Higher & first degrees (Ref)		
Diploma in higher education	0.726	0.697
A/O Levels	1.029	0.687*
Other	0.691	0.682
None	0.923	0.530**
Induction		
No	0.811	1.375*
Yes (Ref)		
Foetal Distress		
No	0.182***	0.213***
Yes (Ref)		
Failure to progress		
No	0.107***	0.105***
Yes (Ref)		
Maternal Height	0.125	0.018***
Epidural		
No	0.263***	0.089***
Yes (Ref)		
UK Country		
England (Ref)		
Wales	1.074	1.457**
Scotland	0.965	1.510**
Northern Ireland	1.153	0.970

[a]Reference category: Unassisted vaginal delivery
[b]Model adjusted for maternal ethnicity, relationship status, employment, housing tenure, income quintile, problems in pregnancy, maternal BMI, infant birth weight, and infant gestational age in days

For multiparous women, the relationships between delivery type and socioeconomic indicators differ from those presented for nulliparous women above. While maternal age is also a significant predictor of both assisted vaginal delivery and emergency caesarean section for multiparous women, this association is only evident for certain age categories. Multiparous women between the ages of 20 and 30 years old are significantly less likely to experience assisted vaginal deliveries than those women 36 years old and older, and multiparous women between the ages of 14 and 30 years old are less likely to undergo an emergency caesarean section than those women 36 years old and older. It appears that in multiparous women, those aged 31-35 years do not differ significantly from those 36 years old and older in their likelihood of operative delivery. Additionally, multiparous women with A/O levels and no maternal educational qualifications are significantly less likely to undergo emergency caesarean sections than women with higher and first degrees. Much like for multiparous woman and labour induction, maternal education has a significant relationship with delivery type for multiparous women. However, whereas fewer educational qualifications made multiparous significantly more likely to be induced (see Chapter 4), fewer educational qualifications makes multiparous women less likely to undergo emergency caesarean sections.

Much like for nulliparous women above, failure to progress and foetal distress diagnoses have significant associations with type of delivery. Multiparous women who were not classed as failing to progress were significantly less likely to undergo assisted vaginal deliveries (RRR: 0.107) or emergency caesarean sections (RRR: 0.105) than those women who were. Women without foetal distress diagnoses were significantly less likely to have assisted vaginal births (RRR: 0.182) and emergency caesarean sections (RRR: 0.213) than women experiencing foetal distress.

In models both excluding and including epidural use, labour induction is associated with emergency caesarean section in multiparous women. Interestingly, those women who are induced are significantly less likely to have an emergency caesarean section, which is the opposite of the association between labour induction and emergency caesarean section presented for nulliparous women. A possible explanation for this that a multiparous woman may not be induced if she’d previously had a caesarean section, meaning that a multiparous woman who is induced is someone who has a history of “positive” birth outcomes.

Finally, UK country, maternal height, and epidural anaesthesia are significantly associated with type of delivery for multiparous women. Women who did not utilize epidural anaesthesia were significantly less likely to experience both assisted vaginal deliveries (RRR: 0.263) and emergency caesarean sections (RRR: 0.089), and for multiparous women, the likelihood of emergency caesarean section decreases as women increase in height. Multiparous women in Wales (RRR: 1.457) and Scotland (RRR: 1.510) were significantly more likely to experience emergency caesarean sections than women in England.

6.7.2 The Association of Labour Induction and Type of Delivery by UK Country

Having outlined in Section 6.7.1 that there is an association between labour induction and type of delivery for both nulliparous and multiparous women, the second research question examined by this paper hopes to determine whether this association varies by UK country. This question was addressed by including an interaction between UK country and induction of labour into the multinomial logistic regression models fit in the previous section. The results of these models adjusting for the interaction between UK country and labour induction for nulliparous women are presented in Table 6.6 below.

The addition of UK country and the interaction between country and induction doesn't change the significance, magnitude, or direction of any of the indicators that were included in the model for nulliparous women in the previous section. In the model presented in Table 6.6 below, it appears that UK country itself remains a significant predictor of delivery type, with nulliparous women in Scotland (RRR: 1.693) more likely to undergo an assisted vaginal delivery than those women in England, and nulliparous women in Wales (RRR: 1.534) more likely to experience an emergency caesarean section than women in England. However, adjusting for a potential interaction between UK country and labour induction indicates that in the nulliparous sample, there is no variation in the association between delivery type and labour induction by country in the United Kingdom. None of the results for this interaction are significant for either assisted vaginal delivery or emergency caesarean section.

Table 6.6: Relative Risk Ratios from Multinomial Analyses of Association between Labour Induction and Delivery Type by UK Country, Nulliparous Women[ab]

	Type of Delivery	
	Assisted Vaginal Delivery	**Emergency Caesarean Section**
Maternal age		
19 years and younger	0.267***	0.123***
20-25 years	0.331***	0.224***
26-30 years	0.543***	0.407***
31-35 years	0.633**	0.667*
36 years and older (Ref)		
Maternal education		
Higher & first degrees (Ref)		
Diploma in higher education	1.230	1.120
A/O Levels	1.104	0.873
Other	1.091	1.036
None	0.825	1.006
Induction		
No	0.779*	0.554***
Yes (Ref)		
Foetal Distress		
No	0.249***	0.199***
Yes (Ref)		
Failure to progress		
No	0.221***	0.173***
Yes (Ref)		
Maternal Height	0.436	0.005***
Epidural		
No	0.417***	0.201***
Yes (Ref)		
UK Country		
England (Ref)		
Wales	1.230	1.534**
Scotland	1.693**	1.360
Northern Ireland	1.389	1.241
UK Country#Induction		
England#Induced (Ref)		
Wales#Induced	0.985	0.991
Scotland#Induced	0.704	0.932
Northern Ireland#Induced	0.967	0.902

[a]Reference category: Unassisted vaginal delivery
[b]Model adjusted for maternal ethnicity, relationship status, employment, housing tenure, income quintile, problems in pregnancy, maternal BMI, infant birth weight, and infant gestational age in days

Table 6.7 below includes the results of the models adjusting for the interaction between UK country and labour induction for multiparous women. In the same way as for nulliparous women, adjusting the models used in Section 6.6.1 for UK country and a potential interaction between country and labour induction does not substantially change any of the parameters presented for multiparous women in the previous section.

The results obtained for multiparous women mirror those presented for nulliparous women above. While UK country continues to be a significant predictor of emergency caesarean section in the model, with multiparous women in Wales (RRR: 1.744) and Scotland (RRR: 2.048) at greater risk than women in England, there does not appear to be significant variation in the association between labour induction and delivery type by country in the United Kingdom, as evidenced by the fact that none of the RRRs for this interaction are significant.

Table 6.7: Relative Risk Ratios from Multinomial Analyses of Association between Labour Induction and Delivery Type by UK Country, Multiparous Women[ab]

	Type of Delivery	
	Assisted Vaginal Delivery	**Emergency Caesarean Section**
Maternal age		
19 years and younger	0.512	0.140***
20-25 years	0.519**	0.527**
26-30 years	0.627*	0.636**
31-35 years	0.838	0.755
36 years and older (Ref)		
Maternal education		
Higher & first degrees (Ref)		
Diploma in higher education	0.727	0.693
A/O Levels	1.028	0.686
Other	0.690	0.680
None	0.922	0.533
Induction		
No	0.801	1.521**
Yes (Ref)		
Foetal Distress		
No	0.183***	0.211***
Yes (Ref)		
Failure to progress		
No	0.107***	0.105***
Yes (Ref)		
Maternal Height	0.124	0.006***
Epidural		
No	0.264***	0.018***
Yes (Ref)		
UK Country		
England (Ref)		
Wales	1.217	1.744*
Scotland	0.972	2.048**
Northern Ireland	0.901	1.327
UK Country#Induction		
England#Induced (Ref)		
Wales#Induced	0.822	0.779
Scotland#Induced	0.999	0.629
Northern Ireland#Induced	1.566	0.584

[a]Reference category: Unassisted vaginal delivery
[b]Model adjusted for maternal ethnicity, relationship status, employment, housing tenure, income quintile, problems in pregnancy, maternal BMI, infant birth weight, and infant gestational age in days

The following Figures 6.17 and 6.18 display the predicted probabilities of delivery type by UK country of delivery, calculated from this section's MLR models run including the UK country/induction interaction, for nulliparous and multiparous women respectively. It is clear from these figures that unassisted vaginal delivery is the most likely delivery type for both groups of women, and that women in England are less likely to have operative births, regardless of parity. There is also more obvious variability in delivery type for nulliparous women in the MCS, as the predicted probabilities of assisted vaginal delivery and emergency caesarean section in each of the four countries are more than twice those reported for multiparous women in Figure 6.18. This may be partially due to the fact that the multiparous sample used in these analyses may have been women who were more likely to have unassisted vaginal deliveries (as women who had had a previous caesarean section may have had a planned caesarean section during the birth of the MCS cohort member, and those having planned caesarean sections were excluded from the sample).

Figure 6.17: Predicted Probabilities of Delivery Type by UK Country for Nulliparous Women

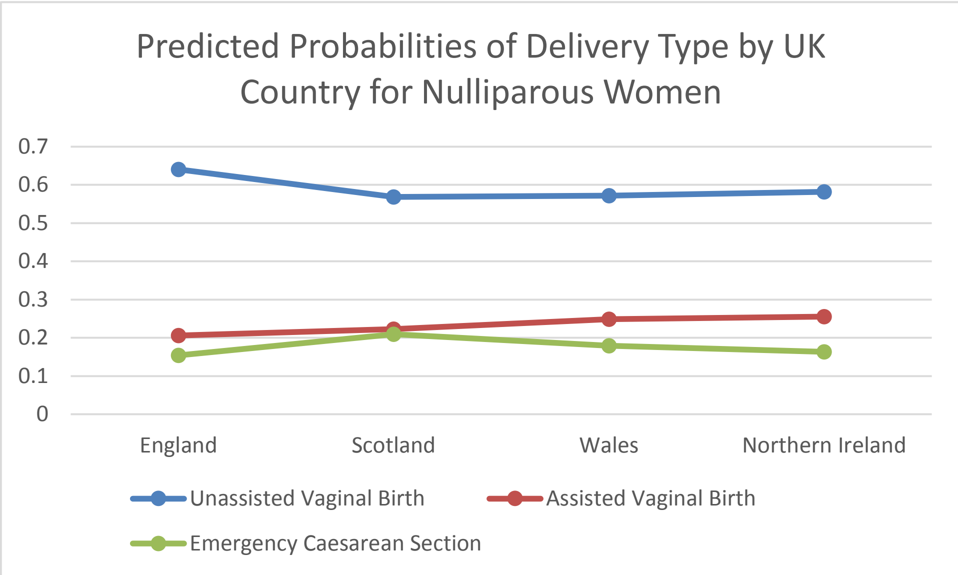
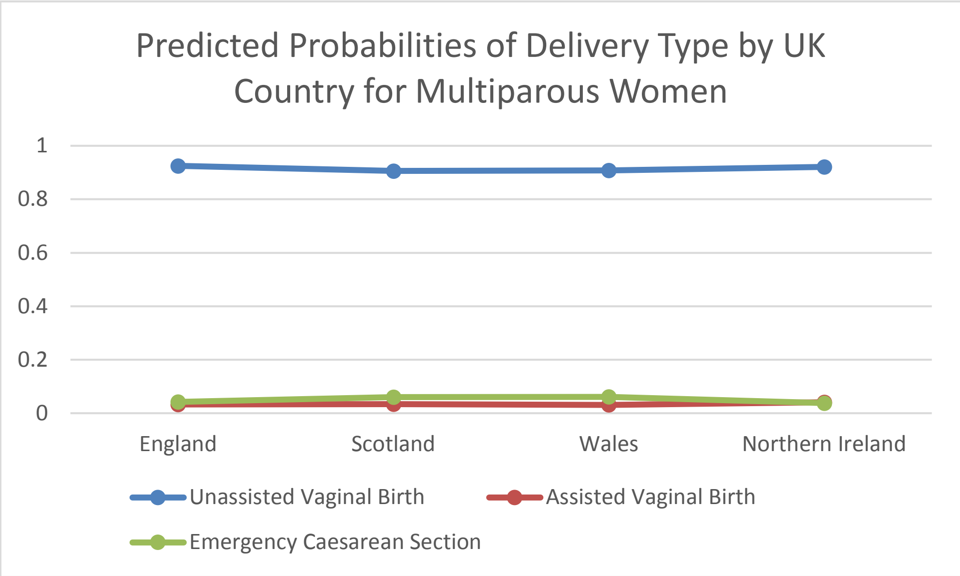


Figure 6.18: Predicted Probabilities of Delivery Type by UK Country for Multiparous Women



In both this section and Section 6.7.1, results of MLR analyses has shown that there is a relationship between labour induction and both assisted vaginal delivery and emergency caesarean section for nulliparous and multiparous women, and that this relationship remains significant even after adjusting for maternal and infant indicators. The following two sections will explore this association in detail, by examining the mediating influence of epidural anaesthesia on the labour induction and operative delivery pathway.

6.7.3 KHB Mediation Analysis: Epidural Anaesthesia

This paper's third research question explores if and how the use of epidural anaesthesia mediates the relationship between labour induction at the beginning of the cascade of interventions and type of delivery at the end of the cascade. The investigation of this mediation effect required the use of KHB mediation analysis, a technique created specifically for logistic regression mediation analysis and discussed in detail in Section 6.4. The KHB models run for this paper were adjusted for every explanatory variable that was significant in the multinomial logistic regressions conducted for nulliparous and multiparous women in Section 6.7.2. Unassisted vaginal birth is used as the reference delivery category, such that the delivery type results are for assisted vaginal delivery and emergency caesarean section as compared to unassisted vaginal delivery.

Previous literature points to the importance of epidural anaesthesia to the type of delivery a woman experiences after being induced. Therefore, it was of interest to see if epidural appeared to be a mediating effect of delivery type in the MCS sample being studied here. Tables 6.8 and 6.9 below show the relative risk ratios of operative delivery after induction for both nulliparous women and multiparous women (respectively) in MLR models. Model 1 controls for all variables included in the MLR models in Section 6.7.2, with the exception of epidural anaesthesia. Model 2 controls for variables in Model 1, and further adjusts for epidural. After adjusting for epidural use, the relative risk ratios for each delivery type increased for both groups of women, such that the addition of epidural to the models controls for some variation in the models. This indicates that epidural does indeed have a mediating role in the relationship between labour induction and type of delivery.

Table 6.8: Association Between Labour Induction and Delivery Type, Nulliparous Women[ab]

	Assisted Vaginal Delivery		Emergency Caesarean Section	
	Model 1	**Model 2**	**Model 1**	**Model 2**
Induction				
No	0.748**	0.779*	0.497***	0.554***
Yes (Ref)				
Epidural				
No		0.417***		0.201***
Yes (Ref)				

[a]Reference category: Unassisted vaginal delivery
[b]Model adjusted for maternal age, maternal education, maternal ethnicity, relationship status, employment, housing tenure, income quintile, problems in pregnancy, foetal distress, failure to progress, maternal height, maternal BMI, infant birth weight, infant gestational age in days, UK country, and an interaction between UK country and labour induction

Table 6.9: Association Between Labour Induction and Delivery Type, Multiparous Women[ab]

	Assisted Vaginal Delivery		Emergency Caesarean Section	
	Model 1	**Model 2**	**Model 1**	**Model 2**
Induction				
No	0.752	0.801	1.285	1.521**
Yes (Ref)				
Epidural				
No		0.264***		0.018***
Yes (Ref)				

[a]Reference category: Unassisted vaginal delivery
[b]Model adjusted for maternal age, maternal education, maternal ethnicity, relationship status, employment, housing tenure, income quintile, problems in pregnancy, foetal distress, failure to progress, maternal height, maternal BMI, infant birth weight, infant gestational age in days, UK country, and an interaction between UK country and labour induction

Having determined that there does appear to be a mediation effect of epidural on delivery type after labour induction, KHB models were run in order to determine the direction, magnitude, and significance of this mediation effect. The KHB models for nulliparous women and multiparous women are below in Table 6.10.

Table 6.10: KHB Coefficients for both Nulliparous and Multiparous Women

	Nulliparous KHB		Multiparous KHB	
	KHB Coefficients	% of effect	KHB Coefficients	% of effect
Total Effects	0.385***	100%	0.268*	100%
Direct Effect	0.322***	83.6%	0.222	82.8%
Indirect effect	0.063	16.4%	0.046	17.2%

The mediation effect of epidural anaesthesia is displayed in Table 6.10 above as the indirect effect. The indirect output for nulliparous women indicates that 16.4% of the association between labour induction and delivery type can be attributed to epidural anaesthesia. For multiparous women, the indirect effect result in this table indicates that 17.2% of this association is due to the use of epidural anaesthesia, but this result is not significant. These KHB models imply that epidural use is not a significant mediator of the relationship between induction of labour and delivery type for either nulliparous or multiparous women. Given that multiparous women may have experienced previous birth outcomes that influence their likelihood of being induced in the first place and are less likely to undergo emergency caesarean sections, this finding also follows from the literature. However, given the evidence presented in Section 6.1.3, it is surprising that epidural use would not mediate the relationship between labour induction and delivery type for nulliparous women, who are generally seen as more at risk of operative delivery after epidural anaesthesia.

As the above KHB analyses have controlled for all explanatory variables found to be significant in the MLR models in Sections 6.7.1 and 6.7.2, they adjusted for maternal height. The next section is an effort to illuminate how maternal height may influence the labour induction, epidural, operative delivery triad.

6.7.4 KHB Mediation Analysis: Maternal Height Moderation

In order to further examine what relationship maternal height has with the relationship between labour induction, epidural, and delivery type, maternal height was conceptualized as a moderator for the final research question in this paper. Drawing on previous research on maternal stature and operative delivery (Kappel et al 1987; Mahmood 1989; Read et al 1994; Brabin et al 2002), the samples of nulliparous women and multiparous women were divided by height, with 1.60 meters being the cut off height. Separate KHB models were run for women 1.59 meters or shorter and women 1.60 meters or taller, for both nulliparous and multiparous women. As discussed above, a measurement of 1.60 meters was selected as the point at which women were considered “not at risk” of operative delivery because it was the tallest height cited in the literature as still being an indicator for caesarean section.

Results from the two KHB models for nulliparous women are presented in Table 6.11 below. It is clear from this output table that there is no significant effect of induction or epidural anaesthesia on delivery type for nulliparous women 1.59 meters are shorter, as neither the direct effect of induction on delivery type (Coefficient: 0.139) or the indirect effect of epidural after induction on delivery type (Coefficient: 0.064) are significant. Conversely, there is a significant relationship between labour induction and delivery type for nulliparous women over 1.60 meters or taller (Coefficient: 0.375), and epidural does significantly mediate this relationship (Coefficient: 0.064). For women 1.60 meters tall or taller, 14.6% of the effect of labour induction on type of delivery is due to the use of epidural anaesthesia.

Table 6.11: KHB Coefficients for Nulliparous Women 1.59m or Shorter and 1.60m or Taller

	Women 1.59m or shorter	**Women 1.60m or taller**
Total Effects	0.234	0.438***
Direct Effect	0.139	0.375***
Indirect Effect	0.064	0.064**

Table 6.12 below details the results of the KHB models run for multiparous women with maternal height as a moderator. Much like for nulliparous women, there is no significant effect of epidural use on the type of delivery a multiparous woman 1.59 meters or shorter experiences. And, in keeping with the results presented for multiparous women in Table 6.10, while there is now a significant direct effect of labour induction on delivery type for multiparous women (Coefficient: 0.475), there is no significant effect of epidural anaesthesia on delivery type for multiparous women 1.60 meters or taller. Maternal height does not appear to be an important mediator of the association between labour induction and delivery type for multiparous women.

Table 6.12: KHB Coefficients for Multiparous Women 1.59m or Shorter and 1.60m or Taller

	Women 1.59m or shorter	**Women 1.60m or taller**
Total Effects	-0.360	0.520***
Direct Effect	-0.410	0.475***
Indirect Effect	0.048	0.045

Seeing as epidural is a significant mediator of the relationship between labour induction and delivery type for nulliparous women who are 1.60 meters or taller, three further KHB models were run for nulliparous women: one for women 1.59 meters tall or shorter; one for women between 1.60 and 1.69 meters tall; and one for women 1.70 meters or taller. The results of these three KHB models can be seen in Table 6.13 below.

After separating maternal height into three categories (Short, Average, and Tall, perhaps), it appears that epidural anaesthesia is a significant mediator of the association between induction and delivery only for women between 1.60 meters and 1.69 meters tall. For these women, 16.6%

of the effect of induction on type of delivery can be associated with the use of epidural anaesthesia. Epidural, then, is an important mediator of the relationship between beginning of the cascade of intervention and the end of the cascade for nulliparous women, but does not account for a very high proportion of the effect of induction on delivery.

Table 6.13: KHB Coefficients for Nulliparous Women 1.59m or Shorter, 1.60cm to 1.69 cm, and 1.70 cm or Taller

	Women below 1.59m	**Women 1.60-1.69m**	**Women above 1.70m**
Total Effects	0.203	0.397***	0.527***
Direct Effects	0.139	0.331***	0.468**
Indirect Effects	0.064	0.066**	0.059

Despite the lack of significant effects of epidural for multiparous women in Tables 6.10 and 6.12, KHB models for the three different height groups were run for multiparous women, in an effort to examine all potential influences. As evidenced by Table 6.14 below, epidural remains an insignificant mediator of the association between labour induction and type of delivery for multiparous women in each height category.

Table 6.14: KHB Coefficients for Multiparous Women 1.59m or Shorter, 1.60cm to 1.69 cm, and 1.70 cm or Taller

	Women below 1.59m	**Women 1.60-1.69m**	**Women above 1.70m**
Total Effects	-0.360	0.443***	0.742**
Direct Effects	-0.410	0.401***	0.691**
Indirect Effects	0.048	0.043	0.051

The MLR and KHB mediation analyses presented here outline the associations between labour induction, epidural anaesthesia, and operative delivery for both groups of women analysed. The next section will describe these results in more detail and help place them in context.

6.8 Discussion

The purpose of this paper was to determine whether labour induction is associated with operative delivery in the United Kingdom, if this association varies by UK country, how this association is mediated by the use of epidural anaesthesia, and whether the relationship between labour induction, epidural, and delivery type is moderated by maternal height. The results presented above provide important answers to those questions.

Labour induction is a significant predictor of assisted vaginal and emergency caesarean section delivery for nulliparous women, both in models that controlled for epidural anaesthesia and those that did not, meaning that nulliparous women who are induced are more likely to experience operative deliveries than women who are not induced. For multiparous women, labour induction is only a significant predictor of emergency caesarean section for multiparous women after controlling for epidural use, and for this group of women, having a labour induction makes a woman significantly less likely to have an emergency caesarean section. These differences between the two groups of women support the findings of previous literature concerning the relationship between labour induction and operative delivery.

Nulliparous women are widely recognized as being at greater risk of caesarean section than multiparous women, both after induction and after epidural (Seyb et al 1999; Cammu et al 2002; Leighton and Halpern; Simpson et al 2005). The reason cited most often for this is that women experiencing their first births can have longer pregnancies and longer, slower labours than women having subsequent children, meaning that nulliparous women are more likely to be induced (due to extended pregnancy), and more likely to have epidurals (due in part to more intense contractions experiences after labour induction), leading to higher likelihood of emergency caesarean sections (Yeast et al 1999; Maslow and Sweeney 2000; Heffner et al 2003; Luthy et al 2004; Wilson 2007). These trends were borne out in the descriptive statistics presented in Section 6.5, in which nulliparous women had higher proportions of induction, epidural after induction, and emergency caesarean section after induction and epidural than multiparous women.

For both nulliparous and multiparous women, epidural is a significant predictor of operative delivery, such that women who do not have epidurals are less likely to have assisted vaginal deliveries and emergency caesarean sections. As with the relationship between induction of labour and delivery type above, the multivariate results that indicate epidural is a significant predictor of operative delivery once other indicators are controlled. These results follow from previous studies that have outlined the relationship between epidural anaesthesia and operative delivery (Lieberman et al 1996; Nagoette et al 1997), which have reported that epidural use increases the likelihood of having assisted vaginal deliveries and emergency caesarean sections.

The UK country in which a birth occurred was a significant predictor of delivery type for both groups of women. Nulliparous women in Wales were at greater risk of emergency caesarean section than women in England, and for multiparous women, living in Wales and Scotland increased the risk of emergency caesarean section, even after other observed characteristics were controlled. A potential reason for this is that, as discussed in Section 2.8.1, after the devolution of the NHS in 1999, each UK country became responsible for the management of their own health care system. While NICE guidelines on the use of labour induction and caesarean section have been written with the whole of the UK in mind, interpretation and implementation of these guidelines is up to the discretion of each of the four countries individually (National Institute for

Health and Care Excellence 2017). In Wales and Scotland, medical professionals may be less likely to practice expectant management as pregnancies go past due dates or more likely to take women to theatre for caesarean sections than those practicing in England, due to their competing interpretations of guidelines.

Additionally, it may be that despite being members of Great Britain, the cultures of the different countries hold independent opinions on the use of childbirth interventions, which are then filtered through to the women who are giving birth in each country. Research into the influence of attitudes on labour experience and birth outcomes has shown that these attitudes can hold some sway on the actual experience of labour and birth. After comparing responses about the willingness to accept obstetric interventions from women in 1987 to those from women in 2000, Green and Baston (2007) found not only that attitudes had changed (with women in 2000 being more willing to accept interventions than those in 1987), but that women in 2000 who were rated as more willing to accept interventions had nearly two times the odds of experiencing an operative delivery than women who reported being less willing to accept interventions. In another study of birth attitudes influencing actual experiences, women who reported higher levels of fear about labour and birth experienced more pain, intervention, and negative feelings during and after birth than those who did report as much fear of childbirth (Haines et al 2012). Therefore, it could be that cultural attitudes concerning the physical experience of birth and the acceptance of labour induction and operative delivery vary between UK countries, influencing the association between induction and delivery type in each nation.

Despite the significance of UK country itself on induction of labour and delivery type, the relationship between labour induction and type of delivery does not vary significantly between UK countries. An explanation for this is that while health care practice may vary between countries, making women in one country more susceptible to operative delivery than others, the relationship between two interventions themselves may be stable. Thus, although woman's country may increase her likelihood of labour induction (as seen in Chapter 4) or emergency caesarean section, once a woman is induced, the likelihood that she will experience an emergency caesarean section may remain the same, regardless of which UK country she lives in, even after adjusting for other indicators for emergency caesarean section. This is in line with previously published literature concerning the cascade of intervention cited in Section 6.1.1, which indicates that employing one intervention (labour induction) is associated with the use of other interventions (emergency caesarean section). However, it is important to note that the coefficients for UK country in the MLR models were large, which is an indication that the sample sizes of women who had experienced various pathways (for example, women who had undergone labour induction, epidural, and emergency caesarean section) may have been too small to illuminate any significant differences. This may have been particularly true for Wales and Northern Ireland (see Section 6.7). Although not possible with data currently available, the study of the cascade of intervention in the United Kingdom would benefit from the examination of the association between labour induction and delivery type in each UK country using a dataset with sample sizes larger than those available to the present study in the MCS.

Another interesting output from the multinomial logistic regressions performed for research questions 1 and 2 is that the maternal education patterns described for nulliparous and multiparous women in relation to labour induction as an outcome variable in Chapter 4 and Chapter 5 are present again in these analyses of delivery type as an outcome. Maternal education is not a significant predictor of delivery type for nulliparous women, but is a significant predictor of emergency caesarean section for multiparous women with A/O level education or no educational qualifications. Interestingly, however, multiparous women with A/O level education or no educational qualifications are less likely to experience emergency caesarean sections than multiparous women with higher degrees, whereas multiparous women with no educational qualifications were more likely to experience labour inductions than multiparous women with higher degrees. As discussed in Chapter 5, as these models controlled for socioeconomic and health indicators of labour induction and operative delivery, this may reflect differences in health care decision making between multiparous women with higher degree educational qualifications and those without, perhaps via the confidence afforded to educated multiparous women by their experiences in higher education. It is possible that there is an educational gradient in the way women engage with their health care providers, or in the way health care providers respond to women with varying educational backgrounds. Untangling how maternal education is associated with health care decision making in childbirth is an avenue for future research.

The KHB mediation analysis provide quantitative estimates as to how epidural anaesthesia mediates the relationship between induction and delivery type. In models run for research question 3 and research question 4, it is clear that epidural use only mediates the relationship between labour induction and caesarean section for nulliparous women, and only then when the moderating influence of maternal height is taken into consideration. It makes sense for a nulliparous woman’s labour and birth to be more influenced by a biological characteristic such as height, as it is during a woman’s first birth that her birth history is written. Nulliparous women who experience difficult first births often become multiparous women who do not undergo labour inductions or emergency caesarean sections, instead having repeat caesarean sections after facing similar pregnancy complications in subsequent pregnancies or due to fears about the safety of vaginal birth after caesarean section, thereby bypassing the cascade of intervention in their subsequent births (Rageth et al 1999; Kayani and Alfirevic 2004; Al-Zirqi et al 2010).

In KHB models run for nulliparous women, while the direct effect of induction on type of delivery is significant in all models, the indirect effect of epidural after induction on delivery type is not significant when maternal height is categorized as 1.59m or shorter and 1.60m or taller. However, when further KHB models split the sample of nulliparous women by height categories, the significant direct of effect of induction on delivery type is only present for women 1.60m or taller, and a significant indirect effect of epidural on delivery type is present only for women between 1.60 and 1.69 metres tall. Therefore, epidural is an important mediator of the relationship between induction of labour and type of delivery for nulliparous women of “average” height, which is an association that follows from previous research on maternal height and childbirth. A nulliparous woman shorter than 1.59m tall may be at such increased risk of operative delivery due to her height that an epidural cannot have any significant influence on her likelihood of assisted vaginal delivery or emergency caesarean section. Conversely, an induced woman between 1.60m and 1.69m, who is not at such increased risk due to her height, may more likely to experience emergency caesarean section after epidural anaesthesia due to complications associated with epidural use, such as failure to progress or foetal distress, than a woman of the same height who is induced but doesn’t utilize epidural anaesthesia. Further, it is possible that being over 1.70m tall is protective against operative delivery for women, and indeed, other studies have found that likelihood of caesarean section decreases significantly as women get taller (Kappel et al 1987; Prasad and Al-Taher 2002; Kirechengast and Hartmann 2007) and that women with longer limbs and vertebral columns are more likely to have unassisted vaginal births (Van Bogaert 1998).

Although the relationship between labour induction and delivery type was significant for multiparous women in multinomial logistic regressions, and the direct effect of labour induction on delivery type was significant for multiparous women 1.60m or taller in KHB mediation models, epidural is not a significant mediator of this relationship in any of the models run for research questions 3 and 4. The explanation for this may lie in the sample of women in this study who had already had at least one child. A multiparous woman who was at an increased biological risk of operative delivery (due to her shorter stature, for example) may be a woman who had already experienced a caesarean section (planned or emergency) with her first birth, and according to the literature, a woman who had already undergone a caesarean section might be less likely to induced, especially if she had had more than one previous caesarean section, due to increased risk of birth complications such as uterine rupture (Rageth et al 1999; Kayani and Alfirevic 2004; Al-Zirqi et al 2010). As the KHB analyses in this paper analysed the pathway between labour induction and delivery type, it could be that the multiparous women available for study in this pathway were women who had already had successful vaginal deliveries, as being a multiparous woman who was induced may indicate that she did not have a caesarean with her first (or any other previous) birth. A history of successful vaginal birth would indicate that a woman was not at high risk of operative delivery due to her stature, meaning that maternal height should not be expected to be a significant predictor for this group of women. While a gap in data prevented the analyses in this paper from controlling for birth history, this KHB mediation result appears to point to the importance of birth history for multiparous women. Further research into this relationship is needed.

Even though epidural does not mediate the relationship between labour induction and type of delivery for multiparous women, potentially for the reason outlined above, it is worth reiterating that the direct effect of labour induction on delivery type was significant for women 1.60m or taller in this group in the MCS. As discussed above, this indicates that labour induction increases a multiparous woman's likelihood of operative delivery, if she is 1.60 metres tall or taller.

6.8.1 Limitations

A major limitation to this study is that the data did not include a variable containing information on birth history and therefore this could not be controlled for in the models. As birth history is important to the complete understanding of the experience of a multiparous woman, future research investigating the link between labour induction and delivery type, the mediating effect of epidural, or the moderating influence of maternal height on operative delivery should take this into consideration. If birth history had been available, it might have been possible to determine how many multiparous women who were not induced during the cohort member's birth had a history of caesarean section. However, despite the absence of a variable outlining previous birth experiences, the results presented here do indicate that birth history can be influential in a woman's experience of childbirth interventions.

Another limitation is that there was no clear definition for what a planned caesarean section meant to women in this dataset, meaning that planned caesarean sections were excluded from the analyses. In addition, the small sample sizes for some childbirth intervention pathways in Wales, Scotland, and Northern Ireland might have made it difficult (or impossible) to fully explore the relationship between labour induction and delivery type in each of these countries. Future research would benefit from more robust sample sizes in each UK country and from more explicit definitions of variables.

A final limitation, also detailed in Sections 4.7.1, 5.7.1, and 7.3, is the age of the MCS data, which at nearly twenty years old, may introduce questions of relevance to modern policy makers. Chapter 3 and Section 7.3 discuss why the MCS was the best fit for this analysis.

6.9 Conclusion

Results presented in this chapter underline the association between labour induction and delivery type that has been reported in published literature investigating the cascade of intervention. Namely, that a significant relationship between the two exists in the United Kingdom, such that women who are induced may be at greater risk of experiencing operative deliveries than women who are not induced. By linking labour induction to delivery type, while controlling for the maternal and infant variables found to be significant in the previous two analysis chapters, this chapter not only corroborates the findings presented in the literature, but also bolsters the argument that analysing the maternal indicators of labour induction helps fill an important gap in knowledge, as if labour induction increases the likelihood of operative delivery, it follows to determine what leads to labour induction in the first place.

This paper also contributes to maternal health literature by presenting evidence that the use of epidural can mediate the relationship between induction and delivery type for nulliparous women, and that this mediating influence can be moderated by maternal height. This result for nulliparous women is important because they are often cited as being at higher risk of operative delivery, and the results of this chapter highlight the use of epidural after labour induction as a mechanism through which this occurs. Knowing that nulliparous women who are between 1.60 and 1.69 metres tall have a greater likelihood of operative delivery after induction and epidural further defines an at-risk population that could be prioritized in maternal health provision.

In addition to reporting a significant association between induction of labour and delivery type, this paper has taken the exploration of the relationship between labour induction and operative delivery a step further than previous research by determining that the association between labour induction and delivery type is mediated by the use of epidural anaesthesia and that this influence works differently on women of different heights. More broadly, this chapter has served as the bookend for this thesis, synthesizing the concepts introduced in Chapter 2 and analysed in part in Chapters 4 and 5.

Chapter 7 Conclusion

7.1 Thesis Contributions

This project examines the cascade of intervention in the United Kingdom in three analyses chapters which investigate labour induction and operative delivery through different, but related, socioeconomic, demographic, and contextual lenses. Chapter 4 explores associations between maternal indicators and labour induction; Chapter 5 investigates whether these associations persist across and within NHS Trusts, in an effort to analyse variation in labour induction at the NHS Trust level and to better understand individual maternal indicators in broader health care contexts; and Chapter 6 determines that the maternal indicators associated with labour induction are also associated with operative delivery, that epidural mediates the relationship between induction and delivery, and that this relationship is further moderated by maternal height. Through these analyses, this thesis has explored pathways through which women experience childbirth interventions in the United Kingdom, and has highlighted relationships between maternal characteristics and childbirth interventions which help underline which women are at greater risk of labour induction and emergency caesarean section.

The most pressing motivation for this project was to critically consider the cascade of intervention in the United Kingdom, and to determine whether or not there were significant associations between labour induction and the childbirth interventions that may follow it, including operative delivery at the end of the cascade. Using the literature reviewed in Chapter 2 as a guide, this thesis conceptualized labour induction as the beginning of the cascade of interventions (as illustrated in Figure 2.2) and endeavoured to outline how the maternal indicators of labour induction in the UK were related to other childbirth interventions (as posited by Figure 2.9). The results of the three analysis chapters presented here indicate that there are indeed associations between labour induction and many maternal demographic, socioeconomic, and health variables, and that many of these associations remain significant for operative delivery as well. Most of the maternal (and infant) characteristics significantly associated with labour induction in Chapters 4 and 5 of this thesis (maternal BMI, maternal age, and pregnancy complications) were also significantly associated with type of delivery in Chapter 6. This indicates that there is some consistency amongst risk factors for childbirth intervention and that the established link between labour induction and caesarean section in the literature may be due in part to the same women being at risk for both labour induction and caesarean section.

Results produced in Chapter 6 indicate that there is a significant relationship between labour induction and operative delivery (as described by Figure 6.6), even after adjusting for maternal and infant characteristics, thus defining the cascade of intervention in the MCS, and that this association differs by parity. Nulliparous women who were not induced were significantly less likely to experience assisted vaginal delivery and emergency caesarean sections than nulliparous women who were induced. This is a relationship that might be expected, as the literature reports an increased risk of operative delivery after labour induction for women delivering their first babies (Luthy et al 2004; Patterson et al 2011). Multiparous women who were not induced were more likely to have emergency caesarean sections than multiparous women who were induced, which also follows from the literature. Multiparous women with complicated birth histories may not undergo inductions of labour (Silver et al 2006; Dodd et al 2013); thus, it is possible that in this sample, being induced was an indicator of a better birth history for multiparous women, as those multiparous women who were induced may have had more positive birth histories and were therefore less likely to experience emergency caesarean sections.

Additionally, although this unfortunately cannot be tested with the available data, the determination that labour induction is related to caesarean section in this project, even after adjusting for health issues leading to operative delivery, supports other evidence that rising rates of caesarean section are linked to rising rates of labour induction (Wilson 2007; Wilson et al 2010; Moore 2012). Despite the difference in the direction of the relationship for nulliparous and multiparous women presented here, the significant associations between labour induction and type of delivery underscore the importance of considering the cascade of interventions when implementing childbirth interventions. This is bolstered by the fact that epidural anaesthesia was found to be a significant mediator of the relationship between induction and delivery for women between 1.60m and 1.69m tall. Women in that height group who had epidurals were more likely to give birth via operative delivery after labour inductions than women who had had not used epidural anaesthesia. The mediating influence of epidural anaesthesia, a commonly used childbirth pain relief technique that is often associated with the cascade of intervention, is further evidence that there are associations between childbirth interventions and that one intervention may beget another through the cascade.

This finding is also important from a policy perspective, as it highlights a very specific group of women who are at increased risk of operative delivery following labour induction and epidural use, information that could be used in efforts to make women fitting this profile more aware of potential complications they may face during pregnancy and birth, thus contributing to making maternal health care more woman-centred under the NHS in the United Kingdom. However, it is important to note that while this result is in line with previously published literature concerning both the influence of epidural on delivery type and the varying risk of operative delivery by maternal height, it is also a determination made on a select sample of women using survey data. While the significant influence of NHS Trust reported in Chapter 5 indicates it may be impossible to generalize results of hospital episode data analyses across the whole of the NHS, future research into the risk of childbirth intervention by maternal height using a large hospital episode dataset could help further underscore the likelihood of operative delivery for women of different statures, and provide more comprehensive background to aid in the creation of clinical guidance on how to inform patients about their risks during birth.

Another motivation for this thesis was to study the links between socioeconomic status and childbirth intervention, as these are associations which are reported as significant in previous literature conducted outside the United Kingdom (Leeb et al 2005; Wilson 2007; Wilson et al 2010; Roth and Henley 2012; Essex et al 2013; Raisanen et al 2014). Income quintile, housing tenure, and maternal occupation were not significant indicators of labour induction or caesarean section in the analyses presented here, indicating that socioeconomic status is not a particularly significant influence on childbirth intervention in the UK, at least not as operationalized by this project. This puts the results of this thesis at odds with some literature on induction. However, considering that much of the previously published work concerning the indicators of childbirth intervention comes out of the United States, this is perhaps not surprising. In research conducted in the United States, women who are white, more highly educated, and utilizing private health insurance (proxies of higher socioeconomic status, as described in Section 2.6.1) have an increased likelihood of experiencing labour induction and operative delivery than women of lower socioeconomic status (Coonrod et al 2000; MacDorman et al 2002; Wilson 2007; Wilson et al 2010). It follows that women with higher socioeconomic status make more use of health care procedures in a system in which the availability of health care services is tied to the level of insurance coverage a person is able to afford.

It is telling that in this project, maternal education is the socioeconomic proxy found to be a significant predictor of both labour induction (in Chapters 4 and 5) and emergency caesarean section (for multiparous women in Table 6.3 in Chapter 6) in the United Kingdom, as it is a marker of socioeconomic standing that may influence the way a woman utilizes health care once she has gained access to health care. The literature concerning the interactions between socioeconomic status and health care systems draws a clear distinction between the availability of services and the ability to use them (Blane 1985; Braveman et al 2010). Much of this debate centres on the meaning of "access," in that the existence of a service does not eradicate the direct and indirect barriers one might face in attempts to use it (Marmot 2007). It may be that in the United Kingdom, universal health care provision allows women physical access to maternity services, but maternal educational qualifications help women navigate the use of them. In a study of the determinants of participating in cervical screening in the United Kingdom, Sabates and Feinstein (2006) found that women with higher educational qualifications were more likely to take advantage of the free cervical screening program offered by the NHS than women with lower qualifications. According to Sabates and Feinstein (2006), this may be because women with more education are also more aware of the importance of health screenings, more able to understand the purpose of such screenings, and more confident in their communications with health care providers. As cervical screenings on the NHS are provided to women free of charge at the point of service, a difference in utilization by maternal educational qualifications provides evidence that access to care and ability to navigate care present different challenges.

Therefore, although the results of Chapter 6 show no clear link between socioeconomic variables and the induction and operative delivery relationship, this serves to strengthen the argument presented in the review of the literature in Chapter 2 and the discussion section of Chapters 4 and 5; namely, that the associations between maternal indicators and childbirth interventions are in part products of the health care system in which they exist. Socioeconomic status is a significant indicator of childbirth intervention in countries in which socioeconomic status is related to the access of health care provision, like in United States. Results from this thesis suggest that socioeconomic status is not as important an indicator of childbirth intervention in the United Kingdom, where health care is free at the point of service.

Chapter 6 also makes it clear that even after adjusting for many socioeconomic and demographic factors, significant relationships between childbirth interventions in the United Kingdom remain. Undergoing a labour induction can increase the likelihood of experiencing an operative delivery, having an epidural mediates this relationship between induction and delivery (such that women having epidurals after labour induction are more likely to experience operative delivery), and finally, this relationship is further moderated by maternal height, with women between 1.60 and 1.69m tall at greater risk of operative delivery after labour induction and epidural than women of other heights. Knowing that maternal height is a significant risk factor for operative delivery after induction and epidural for nulliparous women, regardless of demographic background and socioeconomic status, may help inform health care provision and decision making for all first time mothers. Thus, although socioeconomic indicators were not significant predictors themselves, models adjusting for them help underscore the importance of taking socioeconomic status into consideration in studies of childbirth and intervention. This project, then, contributes to the existing literature by determining that certain women in Great Britain are at greater risk of labour induction and operative delivery than others, and that the population at risk in the United

Kingdom differs from that in other places in which research has been conducted on the indicators of childbirth intervention.

The notion of context also features heavily in this project, as location of birth has been shown to influence a woman's childbirth experience (Bragg et al 2010; Fontein 2010; Gurol-Urgani et al 2011; Sandall 2016). Context is considered in all three of the analysis chapters, albeit a bit differently in each. Chapter 4 determined that for women in Scotland and Northern Ireland, local area deprivation was a significant predictor of labour induction, such that even after models adjusted for maternal and infant health indicators, women in disadvantaged areas of those countries were more likely to experience induction of labour than women in advantaged areas of England. This finding follows from the research concerning socioeconomic status and childbirth intervention reported in Section 2.6, most notably a study by Fairley et al (2011), which determined that women in the most deprived areas of Scotland were more likely to undergo emergency caesarean sections than women from the least deprived areas of the country. For the women surveyed by the MCS, the deprivation of the area in which a woman lived did significantly influence her risk of labour induction.

Additionally, the results of Chapter 4 highlighted Northern Ireland as a country in which both nulliparous and multiparous women in disadvantaged and advantaged places were at greater risk of labour induction than advantaged women in England. Studies have found Northern Ireland to be the most deprived country in the United Kingdom, with the highest levels of childbirth intervention and most pronounced differences in health by socioeconomic status, and often point to the social, political, and economic unrest experienced by the country as reasons for this (Young et al 2010; Northern Ireland Audit Office 2014; Abel et al 2016). According to the results presented in this project, with all women in Northern Ireland at increased risk of labour induction than women in advantaged electoral wards in England, there are discrepancies in childbirth intervention risk associated with differences in deprivation between countries as well as within them.

Context and location were explored in Chapter 5 by analysing variability in labour induction risk by NHS Trust. The likelihood of labour induction did vary by NHS Trust, for both nulliparous and multiparous women, after adjusting for individual maternal (and infant) variables and NHS Trust level variables, such as births per Trust and differences in maternity staffing ratios, and controlling for UK country. Additionally, Chapter 5 presented evidence that a woman's risk of induction by her educational qualifications varied by NHS Trusts, implying that the way women engage with their health care varies by health care provider. Variance in risk of intervention across Trusts, even after adjusting for health risk factors, indicates that in the UK, a woman's health care provider influences her childbirth experience, perhaps due to varying interpretations of intervention guidelines published by NICE, discussed in detail in Section 7.2 below.

When Chapter 6 considered the risk of operative delivery across the four countries of the UK, multinomial models found that there were differences in risk for women in different countries. Nulliparous women in Scotland and Northern Ireland were at significantly greater risk of assisted vaginal delivery than women in England, and nulliparous women in Wales more likely to undergo emergency caesarean section than women in England. For multiparous women, living in Wales and Scotland significantly increased the likelihood of emergency caesarean sections. For both groups of women, then, there is a country effect on the risk of operative delivery. As this effect remains after adjusting for maternal and infant health indicators of intervention, these results serve to underline discrepancies in guidance interpretation as an explanation for differences in risk of intervention between countries in the United Kingdom.

Context was a critical consideration in this project because every women gives birth within the confines of the social and policy contexts of the place in which she lives, and in order to create policy best suited to the women of a country, it is crucial to understand how certain associations operate in that specific context. For example, in the United States, there are large differences in the experience of childbirth and its associated interventions based on maternal ethnicity and insurance coverage (Conrood 1997; Wilson 2007; Nepomnyaschy 2009). While these are key results for policymakers in the United States, these relationships are rendered relatively meaningless in the United Kingdom, where a large majority of women give birth in NHS hospitals and where inequalities based on ethnicity and race do not function in the same way as they do in the United States. This contrast in the contextual importance of results exists between every country in which research on childbirth has been conducted, due to discrepancies in social and political structures and differences in health care provision. Furthermore, the United Kingdom makes an interesting case for studying context, as while it is one nation, it is also four countries, each independently responsible for the structuring and organization their own tax-payer funded health care. This project posited that in such a unique environment, the relationships between childbirth intervention and the context in which a woman lives and receives care (the deprivation of her electoral ward, the NHS Trust in which she gives birth, the country in which she lives) may differ from those relationships reported from other contexts, and for socioeconomic, educational, and health care system indicators, this does indeed seem to be the case.

7.2 Policy Implications

Despite the fact that data analysed for this project were collected in 2000-2001, the results presented here remain relevant today. As of this writing in 2018, despite fluctuations over the years, the rates of labour induction and caesarean section in the United Kingdom remain similar to those in 2000, and are currently on the rise (see Figure 2.1), labour induction NICE guidance has not substantively changed, and the NHS is still working to provide individualized, woman-centred care to all women who utilize the service (Finlay and Sandall 2009; Sandall 2014; Sandall et al 2016). One of the most important tenets of woman-centred care is meeting women where they are, providing information about their options and listening to their preferences (Finlay and Sandall 2009; Sandall 2014; Sandall et al 2016). According to Johnson et al (2003), "woman-centred care refers to women making informed choices, being involved in and having control over their care, and their relationships with their primary caregiver" (Johnson et al 2003, page 30). However, a statistical release published by the Care Quality Commission in 2017 reports that 61% of women included in the NHS maternity care experience survey did not have the same midwife for each of their antenatal appointments (Care Quality Commission, 2017). Therefore, despite how the publication of *Changing Childbirth* in 1993 changed the discourse about woman-centred care, the NHS in the United Kingdom is still learning how to put this into practice.

The continued significance of maternal educational qualifications in the models run throughout this project, after adjusting for other demographic, socioeconomic, and health indicators, may suggest that education allows women with more qualifications to better navigate health care decisions and exercise control their birth experiences. Future research should focus on how educational qualifications influence a woman's ability to advocate for herself during childbirth in the United Kingdom. However, the information provided by this thesis about which women are at greater risk of childbirth intervention in the UK could help shape the continuing efforts to provide appropriate care to women who are the most vulnerable to complications and potentially the least able to advocate for themselves and their preferences in the health care system.

Indeed, a paper by Coulter and Ellins (2007) analysing the effectiveness of patient focused heath care programs reported that "because health literacy is central to enhancing involvement of patients in their care, all strategies to strengthen patient engagement should aim to improve health literacy" (Coulter and Ellins 2007, page 27). Without a basic understanding of how to find and process information about their health care, people not only be unable to manage their health – they will not feel empowered to try. In their review of the best practices for engaging patients in their health care, Coulter and Ellins suggest that the combination of written (leaflet and online resources) and oral support from health care providers, in addition to targeted mass media campaigns and educational programs supported by health care practitioners, has been shown to be effective at increasing health literacy amongst patients in the United Kingdom. In order to make supplemental educational health materials available to those that need them, it is crucial to know who makes up the target population. In the case of improving health literacy concerning who is at increased risk of labour induction and operative delivery, this thesis contributes valuable information about who is in the population at risk in the United Kingdom; namely, women with lower educational qualifications. Current NICE guidelines instruct health care professionals to "encourage the woman to look at a variety of sources of information" before offering a labour induction (National Institute for Health and Care Excellence 2008) and a NICE labour induction quality standard publication from April 2014 states that women should be given personalized information about the risks and benefits of labour induction before being induced (National Institute for Health and Care Excellence 2014). Understanding which women may be at greater risk of labour induction, after controlling for demographic, socioeconomic, and health indicators, can help health care practitioners best tailor the personalized presentation of risk factors for labour induction to those who need it most.

Furthermore, the significant variation of labour induction by NHS Trust presented in Chapter 5 indicates that the type of maternity staffing available at a given health care provider may be an important consideration in the move toward more woman-centred care. This result points to the relationship between type of staffing and continuity of care. Although there was no information about the type of midwifery care on offer at each NHS Trust under review, the significance of maternity staffing on the risk of labour induction highlights the importance of considering the organization of maternity health care workers at NHS Trusts, and whether this organization allows for the provision of one-to-one maternity care. As detailed in Section 2.8.1.2, the ability to provide woman-centred varies even within midwifery care provided in the United Kingdom. The differences in labour induction risk between women across NHS Trusts detailed in Chapter 5 serve to strengthen the argument that while standard midwifery may allow for a more equitable distribution of resources to many patients, it cannot allow for the advocacy for individual differences and preferences in the way that caseload midwifery can. The implementation of more caseload midwifery units may be a way for the United Kingdom to take woman-centred health care forward in the future.

Finally, the significant variation of the use of labour induction by NHS Trust detailed in this project, even after adjusting for socioeconomic and health indications for the intervention, suggests that NHS Trusts may have differed in their interpretation and implementation of NICE guidelines on labour induction specifically (and perhaps childbirth interventions more broadly) when women surveyed by the MCS gave birth. While NICE guidelines are the "crème de la crème" of clinical guidelines, NICE was founded in February 1999, meaning it had only just begun influencing policy by the time the MCS data was collected 2000-2001 (Samanta et al 2003). This indicates that differences in policy may be an explanation for the significant differences in labour induction by NHS Trust. While it has been some time since the founding of NICE and the beginning of its influence on health care provision in the United Kingdom, the variation in labour induction by NHS Trust remains relevant in 2018, as NICE guidelines are not mandatory, the interpretations of this guidance can still vary, and the uptake of the guidance can be determined by “anyone who has a responsibility for commissioning or delivering high quality health care and health improvement based on the best available evidence” (National Institute for Health and Care Excellence 2015).

The decision to implement certain guidelines may be made by individuals, such as medical or clinical directors, or by groups, like NHS clinical commissioning groups, the local clinician-led bodies that plan and commission NHS health care for NHS Trusts (National Institute for Health and Care Excellence 2015), and the ways in which the guidance is put into practice can vary. In a study of the variation in the implementation of NICE guidance between organizations, conducted by England’s North East Quality Observatory System in 2014, representatives from twelve NHS Trusts and eleven Clinical Commissioning Groups reported that “the vast scope of [clinical] guidance, lack of resources or differences in commissioning budgets, shortages of specialist staff, and competing commissioning priorities” were all reasons why the uptake and implementation of NICE guidelines could vary by organization (NEQOS 2014, page 6). The differences in who can decide to implement NICE guidelines and how this decision is made could allow for much variation in the use of the guidelines both between and within UK countries even today, twenty years after the establishment of NICE and the births of the MCS babies.

In addition to highlighting the characteristics of women who may need more support during labour and birth, the results presented in this thesis suggest that risk of labour induction varies by health care provider. This may serve to underscore literature advocating for a more individualized model of maternity care provision in the United Kingdom, such as caseload midwifery, where each woman is assigned a midwife who is her health care provider all throughout pregnancy and during her entire labour and birth. While it was not possible to know what type of midwifery model was operating at each NHS Trust under review, it may be that variations in the risk of labour induction were associated with different types of midwifery or labour ward care. This thesis contributes to the policy discourse by indicating which women are at risk of labour induction and operative delivery, and how these interventions are related in the United Kingdom. An avenue for future research would be taking this information about which women are at greater risk of labour induction in the UK and exploring how different types of midwifery care support the women at greater risk of labour induction in the United Kingdom.

7.3 Limitations

The biggest limitations encountered in writing this thesis were in the availability or accessibility of data. Perhaps the most critical data limitation was the age of the information in the MCS, as the data were collected in 2000-2001, but analysed for this project from 2015-2018. As discussed in Chapter 3, the MCS was the dataset best fit for the research undertaken here, in that it included most of the maternal demographic, socioeconomic, and health variables of interest and allowed for the generalization of results to each of the four countries of the United Kingdom. The age of the data may encourage questions about its relevance, but given that there are no other comparable datasets in the United Kingdom, and that the core structure of NHS maternal health provision and NICE labour induction guidelines have remained similar since 2000, the MCS is the best (and currently only) option for conducting research into the risk of childbirth intervention across the whole of the United Kingdom.

A similar structural data limitation is that the MCS information was collected via questionnaire nine months after the birth of the cohort baby, which could have introduced recall bias into the answers provided by the mothers surveyed. However, research into women's ability to recall details of the births of their children indicates that mothers are actually quite good at correctly remembering things like their infant's birth weight or any potential interventions they experienced (Delgado-Rodriguez et al 1995; Olsen et al 1997; Yawn et al 1998; Buka et al 2004; Rice et al 2006). A clear way of avoiding recall bias in this study would have been to utilize hospital episode data instead of survey data, but in addition to hospital data being more difficult to generalize and often lacking in specific demographic and socioeconomic information, collating medical data from hospitals across the United Kingdom was beyond the scope of this project.

This work would have also been improved by the addition of several variables that were, unfortunately, not available for use, including information on a woman's previous birth history, NHS Trust funding and staffing, and the use of electronic foetal monitoring (discussed in Section 7.4). The inclusion of a birth history variable would have allowed for a more nuanced investigation of the relationship between labour induction and delivery type for multiparous women. Women who had had caesarean sections or adverse labour or birth outcomes in the past may have been more likely to have scheduled planned caesarean sections for the MCS cohort births. As planned caesarean sections were ultimately excluded from the analyses, multiparous women who had a history of pregnancy complications or difficult childbirth may have been excluded as well. This is an explanation for why the predicted probabilities presented for multiparous women in Section 6.7.2 showed such a clear preference for unassisted vaginal delivery. If these analyses had been run including a birth history variable, it would have been possible to further parse out the relationship between labour induction and delivery type for multiparous women.

Additionally, this thesis would have benefitted from more detailed, complete, and standardized information at the NHS Trust level, which would have improved the fit of the models and helped account for more variability at this health care provider level. There were Trusts in which the sample sizes were small, and Trusts in which there were no available data at all. More specifically, a variable concerning whether or not a Trust was utilizing a caseload midwifery model of care would have allowed this thesis to determine whether there was an influence of the type of midwifery care offered to women.

Finally, the analyses conducted in Chapter 6 would have been strengthened by increased sample sizes in Wales, Scotland, and Northern Ireland in the childbirth intervention pathways under review. As there were a small number of cases for some childbirth pathways (for example, just 19 women in Wales had an assisted vaginal delivery after labour induction), it may have been impossible to reach a full understanding of how the cascade of interventions functions in those countries in the United Kingdom. However, while there were limitations encountered in the completion of this project, given the information currently available, the project could not have utilized better data to address the research questions considered here. The next section discusses some ways in which future researchers can take the results presented in this thesis forward.

7.4 Future Research

One avenue for future research is to replicate the analyses presented here with more medical information for mothers, taken either from hospital episode data or specific hospital datasets. While results from Chapter 5 suggest that data from specific hospitals would make the results more difficult to generalize, it would provide greater control over medical and health indicators that may have been influenced by recall bias in the MCS participants or simply not addressed in the survey questionnaire used to collect the MCS data.

Future study of the cascade of interventions in the United Kingdom would also benefit from the inclusion of more variables concerning childbirth interventions, especially information on whether or not electronic foetal monitoring (EFM) was used during labour. The use of EFM is cited in the literature as having a similar effect on labour as epidural anaesthesia, as accurate measurement via EFM requires labouring women to lay still on their backs (Penn and Ghaem-Maghami 2001). This has the potential to slow labours, and a slower, longer labour increases the likelihood that a labour may fail to progress or that there may be a diagnosis of foetal distress. In addition, varying interpretations of irregular heart tracings picked up by monitors may contribute to increases in the use of caesarean section (Thacker et al 1995; Schifrin 2017). Given its reported importance in previous studies of the cascade of intervention, including this variable in further research into childbirth intervention is crucial. Although information concerning EFM was not available for use in this project, the significance of epidural anaesthesia as a mediator of the relationship between labour induction and operative delivery serves as motivation for looking into EFM as another potential mediator in future analyses.

Another focus of future research could be the significant contextual considerations reported in this thesis. Due to the lack of available data, this project could not include the type of midwifery model used at each of the NHS Trusts. However, considering variation in the risk of labour induction between NHS Trusts remained after adjusting for a broad range of maternal (and infant) indicators of risk, the type of midwifery on offer at an NHS Trust could be an important variable to consider in future work, perhaps in a study of birth outcomes under different models within the same Trust. In addition, the work presented here highlights women in Northern Ireland as being at the greatest risk of childbirth intervention in the United Kingdom. Further work could explore the mechanisms driving childbirth intervention in the Northern Irish context, perhaps with hospital data from several Trusts in the country, in an effort to determine more precisely which maternal risk factors for labour induction and operative delivery exist there, and how these are related to measures of socioeconomic status specific to Northern Ireland.

Additionally, future research could focus on the distinct pathways through the cascade of intervention, using path analysis or structural equation modelling. This type of research could help identify which women were more likely to experience each distinct pathway through the cascade (for example, which women move from labour induction to emergency caesarean section with no other intervention, and which women experience labour induction, electronic foetal monitoring, epidural anaesthesia, and then operative delivery). Understanding which women follow which pathway could provide critical information about where to best focus policies aimed at parental education and health care provider training.

Finally, the use of qualitative data collection and analysis is crucial for future work. Given the results presented in this thesis highlighting the differences in labour induction risk between women by maternal education, there is a need to understand how a woman's preferences about labour and delivery match up with her experience of labour and delivery, and how this preference/experience relationship is associated with maternal educational qualifications. Are multiparous women with fewer educational qualifications more likely to have labour inductions because their health care providers aren't listening to their preferences or are they more likely to have labour inductions because inductions are part of their expectations about childbirth? While qualitative research was outside the remit of the present project, conducting focus group or case study work into the lived experience of labour induction in the United Kingdom is vital to a full understanding of who is at greatest risk of entering and completing the cascade of intervention.

7.5 Conclusion

Most of the research into the maternal indicators of labour induction and how they are related to delivery type – and, in essence, whether there is a cascade of intervention – has been conducted in countries with health care systems that differ from that established in the United Kingdom. The aim of this thesis was to contribute to the current literature on which women were at greater risk of labour induction in the United Kingdom, how the risk of labour induction was associated with type of delivery, and whether risk of intervention varied by NHS Trust. This project was motivated by improving the understanding of which women are at risk of labour induction and operative delivery across different contexts in the United Kingdom, in an effort to provide both health care practitioners and women themselves with more information with which to make decisions about the management of labour and birth in the UK.

The results presented here have identified significant maternal demographic, socioeconomic, and health indicators of labour induction in the United Kingdom, such as maternal age, educational qualifications, and pregnancy complications, and have outlined how their relationships with labour induction differ by parity, NHS Trust, and UK country. Additionally, this thesis has succeeded in determining that there is a significant relationship between labour induction and type of delivery (significantly mediated by epidural, and moderated by maternal height in nulliparous women). Thus, it appears that the cascade of intervention was borne out in the childbirth experiences of the some of the mothers surveyed by the Millennium Cohort Study.

Appendix A Local area deprivation sensitivity analyses: Chapter 5

Sensitivity analyses performed to determine whether Local Area Deprivation was an appropriate measure to include in multilevel models presented in Chapter 5

	Nulliparous (Model including Country)	Nulliparous (Model including Advantage)	Multiparous (Model including Country)	Multiparous (Model including Advantage)
Maternal Age				
19 years and younger	0.887	0.885	0.951	0.937
20-25 years	0.766*	0.765*	0.925	0.912
26-30 years	0.780*	0.780*	0.956	0.947
31-35 years	0.918	0.919	0.928	0.926
36 years and older (Ref)				
Maternal Ethnicity				
White (Ref)				
Indian	1.433*	1.434	1.102	1.172
Pakistani & Bangladeshi	1.456**	1.458*	0.821	0.875
Black or Black British	0.898	0.897	0.777	0.805
Other (including Mixed)	1.004	1.004	0.813	0.837
Maternal Education				
Higher & first degrees (Ref)				
Diploma in higher education	1.090	1.090	1.500***	1.493***
A/O Levels	1.202*	1.202*	1.543***	1.525***
Other	1.223*	1.222	1.521***	1.491***
None	1.388***	1.385***	1.896***	1.858***
UK Country				
England (Ref)				
Wales	**0.954**		**1.030**	
Scotland	**1.353*** **		**1.283*** **	
Northern Ireland	**1.688*** **		**2.071*** **	
Local Area Advantage/Disadvantage				
Advantaged (Ref)				
Disadvantaged		**1.017**		**1.090**
Ethnic		**1.004**		**0.926**
Maternal BMI				
Low (<18.5) (Ref)				
Normal (18.5-24.9)	0.973	0.973	0.954	0.954
High (≥25.0)	1.322*	1.321*	1.134	1.131
Illness in Pregnancy				
No pregnancy complications (Ref)				
Complications not associated with induction	1.260***	1.260***	1.371***	1.366***
Complications associated with induction	2.560***	2.556***	1.783***	1.777***
Other	1.379**	1.380**	1.380***	1.371**
Infant Birth Weight				
Low (<2500 grams)	1.045	1.044	1.382***	1.386**
Normal (2500-4000 grams) (Ref)				
High (>4000 grams)	1.372***	1.372***	1.275***	1.281***
Gestational Age in Days				
259 days or less	0.976	0.976	1.040	1.036
260-272 days	1.10	1.110	1.200**	1.198**
273-286 days (Ref)				
287-293 days	3.110***	3.104***	2.779***	2.778***
294 days or more	7.844***	7.843***	5.716***	5.727***

Appendix B Fully adjusted models: Chapter 5

Full Chapter 5 models, including all socioeconomic status and health variables

Table 5.6: Odds Ratios for Random Intercept Model 1: Nulliparous Women

		Odds Ratio	Standard Error
Maternal Age	19 years and under	0.760	0.115
	20-25 years old	0.735*	0.762
	26-30 years old	0.762*	0.092
	31-35 years old	0.903	0.113
	36 years and older	Ref	Ref
Maternal Ethnicity	White	Ref	Ref
	Indian	1.334	0.273
	Pakistani/Bangladeshi	1.269	0.230
	Black/Black British	0.855	0.174
	Other	1.039	0.188
Maternal Education	Higher/first degrees	Ref	Ref
	Diploma in higher ed	1.090	0.122
	A/O Levels (GSCE A-C)	1.167	0.103
	Other (incl. GCSE D-G)	1.159	0.135
	None	1.131*	0.168
Maternal Marital Status	Legally Married	Ref	Ref
	Cohabiting	1.168	0.115
	Single/Divorced	0.996	0.072
Maternal Occupation	Managerial/Professional	Ref	Ref
	Intermediate	0.943	0.081
	Self-employed	1.099	0.187
	Lower supervisor	1.099	0.145
	Semi-routine/Routine	0.971	0.086
	None	0.966	0.126
Income Quintile	Lowest Quintile	1.058	0.133
	Second Quintile	1.097	0.122
	Third Quintile	1.053	0.101
	Fourth Quintile	0.999	0.087
	Highest Quintile	Ref	Ref
Housing Tenure	Own outright/Mortgage	Ref	Ref
	Rent from LA/HA	1.003	0.944
	Rent privately	1.030	0.107
	Other (including with parents)	1.115	0.116
Pregnancy Complications	No pregnancy complications	Ref	Ref
	Complications not associated with induction	1.257**	0.095
	Complications associated with induction	2.597***	0.201
	Other	1.393**	0.179
Maternal BMI	Low (<18.5)	Ref	Ref
	Normal (18.5-24.9)	0.974	0.115
	High (≥25.0)	1.293*	0.164
Infant Birth Weight	Low (<2500 grams)	0.983	0.127
	Normal (2500-4000 grams)	Ref	Ref
	High (>4000 grams)	1.360**	0.133
Infant Gestational Age	259 days or less	0.954	0.109
	260-272 days	1.050	0.093
	273-286 days	Ref	Ref
	287-293 days	3.091***	0.212
	294 days or more	8.076***	1.210
Random Effects Parameters		Estimate 0.050 SE 0.022 Likelihood Ratio Test x_2^2= 13.06 P=0.000	

Median Odds Ratio	1.236

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

Table 5.7: Odds Ratios for Random Intercept Model 1: Multiparous Women

		Odds Ratio	Standard Error
Maternal Age	19 years and under	0.896	0.203
	20-25 years old	0.908	0.867
	26-30 years old	0.930	0.075
	31-35 years old	0.908	0.070
	36 years and older	Ref	Ref
Maternal Ethnicity	White	Ref	Ref
	Indian	1.074	0.199
	Pakistani/Bangladeshi	0.633*	0.113
	Black/Black British	0.773	0.141
	Other	0.828	0.167
Maternal Education	Higher/first degrees	Ref	Ref
	Diploma in higher ed	1.505***	0.175
	A/O Levels (GSCE A-C)	1.566***	0.146
	Other (incl. GCSE D-G)	1.483***	0.176
	None	1.787***	0.207
Maternal Marital Status	Legally Married	Ref	Ref
	Cohabiting	0.969	0.084
	Single/Divorced	1.066	0.071
Maternal Occupation	Managerial/Professional	Ref	Ref
	Intermediate	0.949	0.803
	Self-employed	1.051	0.138
	Lower supervisor	0.864	0.104
	Semi-routine/Routine	0.987	0.079
	None	1.175	0.132
Income Quintile	Lowest Quintile	1.032	0.121
	Second Quintile	0.998	0.103
	Third Quintile	0.985	0.096
	Fourth Quintile	0.940	0.893
	Highest Quintile	Ref	Ref
Housing Tenure	Own outright/Mortgage	Ref	Ref
	Rent from LA/HA	1.072	0.793
	Rent privately	1.068	0.108
	Other (including with parents)	1.095	0.150
Pregnancy Complications	No pregnancy complications	Ref	Ref
	Complications not associated with induction	1.405***	0.093
	Complications associated with induction	1.869***	0.139
	Other	1.328*	0.156
Maternal BMI	Low (<18.5)	Ref	Ref
	Normal (18.5-24.9)	0.920	0.118
	High (≥25.0)	1.090	0.144
Infant Birth Weight	Low (<2500 grams)	1.355*	0.170
	Normal (2500-4000 grams)	Ref	Ref
	High (>4000 grams)	1.272***	0.095
Infant Gestational Age	259 days or less	1.050	0.107
	260-272 days	1.225**	0.0872
	273-286 days	Ref	Ref
	287-293 days	2.794***	0.186
	294 days or more	5.774***	0.787
Random Effects Parameters		Estimate 0.135 SE 0.035 Likelihood Ratio Test x_2^2= 71.37 P=0.000	
Median Odds Ratio		1.418	

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

Appendix B

Table 5.8: Odds Ratios for Random Slope Model 2: Nulliparous Women

		Odds Ratio	Standard Error
Maternal Age	19 years and under	0.756	0.114
	20-25 years old	0.731*	0.095
	26-30 years old	0.759*	0.092
	31-35 years old	0.900	0.113
	36 years and older	Ref	Ref
Maternal Ethnicity	White	Ref	Ref
	Indian	1.339	0.275
	Pakistani/Bangladeshi	1.273	0.229
	Black/Black British	0.854	0.173
	Other	1.042	0.188
Maternal Education	Higher/first degrees	Ref	Ref
	Diploma in higher ed	1.086	0.121
	A/O Levels (GSCE A-C)	1.169	0.105
	Other (incl. GCSE D-G)	1.162	0.136
	None	1.131*	0.170
Maternal Marital Status	Legally Married	Ref	Ref
	Cohabiting	1.168	0.115
	Single/Divorced	0.996	0.072
Maternal Occupation	Managerial/Professional	Ref	Ref
	Intermediate	0.942	0.081
	Self-employed	1.100	0.187
	Lower supervisor	1.100	0.145
	Semi-routine/Routine	1.150	0.086
	None	1.300	0.126
Income Quintile	Lowest Quintile	1.059	0.133
	Second Quintile	1.097	0.122
	Third Quintile	1.054	0.101
	Fourth Quintile	0.999	0.088
	Highest Quintile	Ref	Ref
Housing Tenure	Own outright/Mortgage	Ref	Ref
	Rent from LA/HA	1.002	0.094
	Rent privately	1.028	0.107
	Other (including with parents)	1.114	0.116
Pregnancy Complications	No pregnancy complications	Ref	Ref
	Complications not associated with induction	1.256**	0.095
	Complications associated with induction	2.599***	0.201
	Other	1.390**	0.178
Maternal BMI	Low (<18.5)	Ref	Ref
	Normal (18.5-24.9)	0.975	0.127
	High (≥25.0)	1.296*	0.133
Infant Birth Weight	Low (<2500 grams)	0.986	0.128
	Normal (2500-4000 grams)	Ref	Ref
	High (>4000 grams)	1.357**	0.133
Infant Gestational Age	259 days or less	0.951	0.108
	260-272 days	1.050	0.093
	273-286 days	Ref	Ref
	287-293 days	3.093***	0.212
	294 days or more	8.065***	1.210
Random Effects Parameters: Higher Degree		Estimate 0.091 SE 0.065 Likelihood Ratio Test x_2^2= 13.67 P=0.0034	

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

Table 5.9: Odds Ratios for Random Slope Model 2: Multiparous Women

		Odds Ratio	Standard Error
Maternal Age	19 years and under	0.892	0.201
	20-25 years old	0.907	0.087
	26-30 years old	0.929	0.075
	31-35 years old	0.908	0.070
	36 years and older	Ref	Ref
Maternal Ethnicity	White	Ref	Ref
	Indian	1.072	0.199
	Pakistani/Bangladeshi	0.616**	0.110
	Black/Black British	0.764	0.139
	Other	0.825	0.167
Maternal Education	Higher/first degrees	Ref	Ref
	Diploma in higher ed	1.519***	0.178
	A/O Levels (GSCE A-C)	1.642***	0.160
	Other (incl. GCSE D-G)	1.552***	0.189
	None	1.878***	0.223
Maternal Marital Status	Legally Married	Ref	Ref
	Cohabiting	0.969	0.084
	Single/Divorced	1.063	0.070
Maternal Occupation	Managerial/Professional	Ref	Ref
	Intermediate	0.953	0.081
	Self-employed	1.053	0.138
	Lower supervisor	0.865	0.104
	Semi-routine/Routine	0.990	0.794
	None	1.173	0.132
Income Quintile	Lowest Quintile	1.032	0.121
	Second Quintile	0.999	0.103
	Third Quintile	0.984	0.096
	Fourth Quintile	0.937	0.089
	Highest Quintile	Ref	Ref
Housing Tenure	Own outright/Mortgage	Ref	Ref
	Rent from LA/HA	1.067	0.079
	Rent privately	1.068	0.108
	Other (including with parents)	1.093	0.150
Pregnancy Complications	No pregnancy complications	Ref	Ref
	Complications not associated with induction	1.403**	0.092
	Complications associated with induction	1.870***	0.139
	Other	1.327*	0.156
Maternal BMI	Low (<18.5)	Ref	Ref
	Normal (18.5-24.9)	0.917	0.118
	High (≥25.0)	1.085	0.144
Infant Birth Weight	Low (<2500 grams)	1.355*	0.170
	Normal (2500-4000 grams)	Ref	Ref
	High (>4000 grams)	1.272***	0.095
Infant Gestational Age	259 days or less	1.047	0.108
	260-272 days	1.227***	0.087
	273-286 days	Ref	Ref
	287-293 days	2.804***	0.187
	294 days or more	5.777***	0.788
Random Effects Parameters: Higher Degree		Estimate 0.139 SE 0.058 Likelihood Ratio Test x_2^2= 73.64 P=0.0000	

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

Appendix B

Table 5.10: Odds Ratios for Random Slope Models 3 and 4: Nulliparous Women

		Model 3		Model 4	
		Odds Ratio	Standard Error	Odds Ratio	Standard Error
Maternal Age	19 years and under	0.700	0.132	0.703	0.133
	20-25 years old	0.696*	0.113	0.701*	0.114
	26-30 years old	0.746*	0.112	0.748	0.113
	31-35 years old	0.850	0.133	0.850	0.133
	36 years and older	Ref	Ref	Ref	Ref
Maternal Ethnicity	White	Ref	Ref	Ref	Ref
	Indian	1.588*	0.376	1.636*	0.393
	Pakistani/Bangladeshi	1.343	0.311	1.395	0.329
	Black/Black British	0.727	0.175	0.737	0.180
	Other	1.061	0.238	1.075	0.242
Maternal Education	Higher/first degrees	Ref	Ref	Ref	Ref
	Diploma in higher ed	0.990	0.140	0.993	0.141
	A/O Levels (GSCE A-C)	1.164	0.133	1.163	0.134
	Other (incl. GCSE D-G)	1.160	0.174	1.172	0.177
	None	1.330	0.217	1.334	0.219
Maternal Marital Status	Legally Married	Ref	Ref	Ref	Ref
	Cohabiting	1.055	0.100	1.062	0.133
	Single/Divorced	1.083	1.083	1.093	0.102
Maternal Occupation	Managerial/Professional	Ref	Ref	Ref	Ref
	Intermediate	0.950	0.105	0.946	0.104
	Self-employed	1.118	0.233	1.131	0.236
	Lower supervisor	1.169	0.196	1.165	0.195
	Semi-routine/Routine	1.034	0.118	1.032	0.118
	None	1.162	0.192	1.164	0.193
Income Quintile	Lowest Quintile	1.062	0.171	1.073	0.173
	Second Quintile	1.138	0.161	1.142	0.163
	Third Quintile	1.084	0.131	1.076	0.131
	Fourth Quintile	0.962	0.109	0.961	0.109
	Highest Quintile	Ref	Ref	Ref	Ref
Housing Tenure	Own outright/Mortgage	Ref	Ref	Ref	
	Rent from LA/HA	1.042	0.124	1.023	0.122
	Rent privately	1.068	0.142	1.063	0.141
	Other (including with	1.152	0.148	1.134	0.146
parents)					
Pregnancy Complications	No pregnancy complications	Ref	Ref	Ref	Ref
	Complications not associated with induction	1.211*	0.117	1.221*	0.118
	Complications associated with induction	2.543***	0.250	2.566***	0.253
	Other	1.370	0.224	1.363	0.223
Maternal BMI	Low (<18.5)	Ref	Ref	Ref	Ref
	Normal (18.5-24.9)	0.951	0.147	0.953	0.148
	High (≥25.0)	1.210	0.200	1.208	0.201
Infant Birth Weight	Low (<2500 grams)	0.798	0.131	0.806	0.133
	Normal (2500-4000 grams)	Ref	Ref	Ref	Ref
	High (>4000 grams)	1.324*	0.161	1.322*	0.161
Infant Gestational Age	259 days or less	1.005	0.143	1.004	0.143
	260-272 days	1.080	0.120	1.085	0.120
	273-286 days	Ref	Ref	Ref	Ref
	287-293 days	3.154***	0.276	3.152***	0.276
	294 days or more	8.860***	1.713	8.903***	1.720
Number of births per Trust		1.004	0.021	0.985	0.225
Ratio of obstetricians to midwives per Trust		0.408	0.251	0.720	0.523
Ratio of midwives to births per Trust		2.613**	0.924	1.306	0.820
Country of NHS Trust	England			Ref	Ref
	Wales			0.904	0.111
	Scotland			1.195	0.142
	Northern Ireland			1.310	0.277
Random Effects Parameters: Higher degree		Estimate		Estimate	
		0.064		0.081	
		SE		SE	

	0.186	0.169
	Likelihood Ratio Test x_2^2= 0.23 P=0.9720	Likelihood Ratio Test x_2^2= 0.35 P=0.9497

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

Appendix B

Table 5.11: Odds Ratios for Random Slope Models 3 and 4: Multiparous Women

		Model 3		Model 4	
		Odds Ratio	Standard Error	Odds Ratio	Standard Error
Maternal Age	19 years and under	0.746	0.220	0.746	0.219
	20-25 years old	0.987	0.118	0.990	0.119
	26-30 years old	0.957	0.097	0.957	0.097
	31-35 years old	0.866	0.085	0.864	0.085
	36 years and older	Ref	Ref	Ref	Ref
Maternal Ethnicity	White	Ref	Ref	Ref	Ref
	Indian	1.066	0.245	1.134	0.259
	Pakistani/Bangladeshi	0.550*	0.130	0.567*	0.131
	Black/Black British	0.830	0.230	0.845	0.183
	Other	0.1.11	0.267	1.140	0.275
Maternal Education	Higher/first degrees	Ref	Ref	Ref	Ref
	Diploma in higher ed	1.648***	0.241	1.661***	0.244
	A/O Levels (GSCE A-C)	1.688***	0.208	1.728***	0.214
	Other (incl. GCSE D-G)	1.470*	0.230	1.509***	0.237
	None	1.978***	0.296	2.008***	0.300
Maternal Marital Status	Legally Married	Ref	Ref	Ref	Ref
	Cohabiting	0.905	0.098	0.913	0.099
	Single/Divorced	1.023	0.088	1.034	0.089
Maternal Occupation	Managerial/Professional	Ref	Ref	Ref	Ref
	Intermediate	0.917	0.099	0.926	0.100
	Self-employed	1.090	0.182	1.105	0.184
	Lower supervisor	0.791	0.120	0.781	0.118
	Semi-routine/Routine	0.936	0.096	0.941	0.096
	None	1.264	0.181	1.270	0.182
Income Quintile	Lowest Quintile	1.011	0.150	0.975	0.145
	Second Quintile	0.907	0.119	0.880	0.116
	Third Quintile	0.931	0.115	0.914	0.113
	Fourth Quintile	0.876	0.107	0.914	0.106
	Highest Quintile	Ref	Ref	Ref	Ref
Housing Tenure	Own outright/Mortgage	Ref	Ref	Ref	Ref
	Rent from LA/HA	1.045	0.099	1.050	0.099
	Rent privately	1.079	0.139	1.083	0.140
	Other (including with parents)	0.997	0.175	1.011	0.178
Infant Gestational Age	259 days or less	1.076	0.140	1.085	0.141
	260-272 days	1.236*	0.112	1.236*	0.112
	273-286 days	Ref	Ref	Ref	Ref
	287-293 days	2.794***	0.235	2.788***	0.234
	294 days or more	5.902***	1.075	5.910***	1.072
Number of births per Trust		1.049*	0.021	1.035	0.025
Ratio of obstetricians to midwives per Trust		0.646	0.251	1.065	0.799
Ratio of midwives to births per Trust		9.430***	0.924	1.288	0.963
Country of NHS Trust	England			Ref	Ref
	Wales			1.054	0.143
	Scotland			1.233	0.169
	Northern Ireland			2.056***	0.436
Random Effects Parameters: Higher degree		Estimate 0.071		Estimate 0.155	
		SE 0.481		SE 0.143	
		Likelihood Ratio Test x_2^2= 17.65 P=0.0005		Likelihood Ratio Test x_2^2= 9.62 P=0.0221	

[1]Model controls for maternal relationship status, maternal job, housing tenure, and income quintile

*P<0.05 **P<0.01 ***P<0.001

Appendix C Fully adjusted models: Chapter 6

Full Chapter 6 models, including all socioeconomic status and health variables.

Table 6.2: Relative Risk Ratios from Multinomial Analyses of Association between Labour Induction and Delivery Type, Nulliparous Women[a]

	Type of Delivery	
	Assisted Vaginal Delivery	Emergency Caesarean Section
Maternal age		
19 years and younger	0.267***	0.123***
20-25 years	0.333***	0.224***
26-30 years	0.542***	0.407***
31-35 years	0.634**	0.667*
36 years and older (Ref)		
Maternal ethnicity		
White (Ref)		
Indian	0.775	1.045
Pakistani & Bangladeshi	0.682	0.749
Black or Black British	0.338**	1.609
Other (including Mixed)	0.755	0.826
Maternal education		
Higher & first degrees (Ref)		
Diploma in higher education	1.228	1.121
A/O Levels	1.100	0.873
Other	1.088	1.036
None	0.822	1.005
Maternal relationship status		
Legally married (Ref)		
Cohabiting	0.786	0.994
Single/Divorced/Widowed	0.905	0.957
Maternal occupation before pregnancy		
Managerial and professional (Ref)		
Intermediate	1.087	1.320
Self-employed	1.286	1.037
Lower supervisor	0.965	0.969
Semi-routine and routine	1.164	1.144
Housing tenure		
Own outright/own with mortgage (Ref)		
Rent from Local/Housing Authority	0.909	1.137
Rent privately	0.974	1.070
Other (including living with parents)	0.806	2.475**
Income quintile		
Lowest quintile	1.125	0.696
Second quintile	0.904	0.966
Third quintile	1.090	0.890
Fourth quintile	0.990	0.959
Highest quintile (Ref)		

Illness in pregnancy		
No pregnancy complications (Ref)		
Complications not associated with induction	1.222*	0.993
Complications associated with induction	0.917	1.415*
Other	1.009	0.789
Maternal BMI before pregnancy		
Low (<18.5) (Ref)		
Normal (18.5-24.9)	0.989	1.332
High (≥25.0)	0.936	1.873*
Infant birth weight		
Low (<2500 grams)	0.585*	4.033***
Normal (2500-4000 grams) (Ref)		
High (>4000 grams)	1.259	1.697**
Infant gestational age in days		
259 days or less	1.171	4.086***
260-272 days	0.753*	1.617**
273-286 days (Ref)		
287-293 days	0.946	1.229
294 days or more	1.225	1.703
Induction		
No	0.746***	0.548***
Yes (Ref)		
Foetal Distress		
No	0.250***	0.199***
Yes (Ref)		
Failure to progress		
No	0.222***	0.173***
Yes (Ref)		
Maternal Height	0.438	0.018***
Epidural		
No	0.418***	0.201***
Yes (Ref)		
UK Country		
England (Ref)		
Wales	1.217	1.525***
Scotland	1.376**	1.290
Northern Ireland	1.354*	1.181

[a]Reference category: Unassisted vaginal delivery

Table 6.3: Relative Risk Ratios from Multinomial Analyses of Association between Labour Induction and Delivery Type, Multiparous Women[a]

	Type of Delivery	
	Assisted Vaginal Delivery	**Emergency Caesarean Section**
Maternal age		
19 years and younger	0.513	0.139**
20-25 years	0.521**	0.524**
26-30 years	0.626**	0.637**
31-35 years	0.840	0.751
36 years and older (Ref)		
Maternal ethnicity		
White (Ref)		
Indian	1.393	0.670
Pakistani & Bangladeshi	0.552	0.524*
Black or Black British	0.436	1.889*
Other (including Mixed)	1.451	0.959
Maternal education		
Higher & first degrees (Ref)		
Diploma in higher education	0.726	0.697
A/O Levels	1.029	0.687*
Other	0.691	0.682
None	0.923	0.530**
Maternal relationship status		
Legally married (Ref)		
Cohabiting	0.830	0.516*
Single/Divorced/Widowed	1.017	0.875
Maternal occupation before pregnancy		
Managerial and professional (Ref)		
Intermediate	0.770	0.892
Self-employed	1.027	1.554
Lower supervisor	1.232	1.142
Semi-routine and routine	0.955	1.304
Housing tenure		
Own outright/own with mortgage (Ref)		
Rent from Local/Housing Authority	0.580**	1.137
Rent privately	1.848*	1.070
Other (including living with parents)	1.362	2.475**
Income quintile		
Lowest quintile	1.473	0.696
Second quintile	1.398	0.966
Third quintile	1.021	0.890
Fourth quintile	1.362	0.959
Highest quintile (Ref)		
Illness in pregnancy		
No pregnancy complications (Ref)		
Complications not associated with induction	1.029	0.993
Complications associated with induction	0.849	1.415*
Other	0.563	0.789
Maternal BMI before pregnancy		

Low (<18.5) (Ref)		
Normal (18.5-24.9)	1.392	1.332
High (≥25.0)	1.149	1.873*
Infant birth weight		
Low (<2500 grams)	0.449	4.033***
Normal (2500-4000 grams) (Ref)		
High (>4000 grams)	1.510	1.697**
Infant gestational age in days		
259 days or less	1.223	4.086***
260-272 days	0.601*	1.617*
273-286 days (Ref)		
287-293 days	1.136	1.229
294 days or more	1.191	1.703
Induction		
No	0.811	1.375*
Yes (Ref)		
Foetal Distress		
No	0.182***	0.213***
Yes (Ref)		
Failure to progress		
No	0.107***	0.105***
Yes (Ref)		
Maternal Height	0.125	0.018***
Epidural		
No	0.263***	0.089***
Yes (Ref)		
UK Country		
England (Ref)		
Wales	1.074	1.457**
Scotland	0.965	1.510**
Northern Ireland	1.153	0.970

[a]Reference category: Unassisted vaginal delivery

Table 6.4: Relative Risk Ratios from Multinomial Analyses of Association between Labour Induction and Delivery Type by UK Country, Nulliparous Women[a]

	Type of Delivery	
	Assisted Vaginal Delivery	**Emergency Caesarean Section**
Maternal age		
19 years and younger	0.267***	0.123***
20-25 years	0.331***	0.224***
26-30 years	0.543***	0.407***
31-35 years	0.633**	0.667*
36 years and older (Ref)		
Maternal ethnicity		
White (Ref)		
Indian	0.771	1.044
Pakistani & Bangladeshi	0.685	0.750
Black or Black British	0.336**	1.606
Other (including Mixed)	0.756	0.827
Maternal education		
Higher & first degrees (Ref)		
Diploma in higher education	1.230	1.120
A/O Levels	1.104	0.873
Other	1.091	1.036
None	0.825	1.006
Maternal relationship status		
Legally married (Ref)		
Cohabiting	0.785	0.994
Single/Divorced/Widowed	0.902	0.957
Maternal occupation before pregnancy		
Managerial and professional (Ref)		
Intermediate	1.088	1.320
Self-employed	1.287	1.037
Lower supervisor	0.964	0.968
Semi-routine and routine	1.164	1.145
Housing tenure		
Own outright/own with mortgage (Ref)		
Rent from Local/Housing Authority	0.914	0.917
Rent privately	0.975	1.077
Other (including living with parents)	0.803	1.049
Income quintile		
Lowest quintile	1.124	1.030
Second quintile	0.899	1.049
Third quintile	1.087	1.017
Fourth quintile	0.989	1.105
Highest quintile (Ref)		
Illness in pregnancy		
No pregnancy complications (Ref)		
Complications not associated with induction	1.223*	0.983
Complications associated with induction	0.916	1.230
Other	1.008	0.705
Maternal BMI before pregnancy		
Low (<18.5) (Ref)		

Normal (18.5-24.9)	0.994	0.821
High (≥25.0)	0.939	1.235
Infant birth weight		
Low (<2500 grams)	0.587*	1.718**
Normal (2500-4000 grams) (Ref)		
High (>4000 grams)	1.261	3.225***
Infant gestational age in days		
259 days or less	1.174	1.907***
260-272 days	0.753*	0.957
273-286 days (Ref)		
287-293 days	0.942	0.953
294 days or more	1.235	1.512
Induction		
No	0.779*	0.554***
Yes (Ref)		
Foetal Distress		
No	0.249***	0.199***
Yes (Ref)		
Failure to progress		
No	0.221***	0.173***
Yes (Ref)		
Maternal Height	0.436	0.005***
Epidural		
No	0.417***	0.201***
Yes (Ref)		
UK Country		
England (Ref)		
Wales	1.230	1.534**
Scotland	1.693**	1.360
Northern Ireland	1.389	1.241
UK Country#Induction		
England#Induced (Ref)		
Wales#Induced	0.985	0.991
Scotland#Induced	0.704	0.932
Northern Ireland#Induced	0.967	0.902

[a]Reference category: Unassisted vaginal delivery

Table 6.5: Relative Risk Ratios from Multinomial Analyses of Association between Labour Induction and Delivery Type by UK Country, Multiparous Women[a]

	Type of Delivery	
	Assisted Vaginal Delivery	**Emergency Caesarean Section**
Maternal age		
19 years and younger	0.512	0.140***
20-25 years	0.519**	0.527**
26-30 years	0.627*	0.636**
31-35 years	0.838	0.755
36 years and older (Ref)		
Maternal ethnicity		
White (Ref)		
Indian	1.394	0.669
Pakistani & Bangladeshi	0.553	0.517*
Black or Black British	0.436	1.882*
Other (including Mixed)	1.450	0.957
Maternal education		
Higher & first degrees (Ref)		
Diploma in higher education	0.727	0.693
A/O Levels	1.028	0.686
Other	0.690	0.680
None	0.922	0.533
Maternal relationship status		
Legally married (Ref)		
Cohabiting	0.832	0.512*
Single/Divorced/Widowed	1.016	0.871
Maternal occupation before pregnancy		
Managerial and professional (Ref)		
Intermediate	0.772	0.892
Self-employed	1.030	1.543
Lower supervisor	1.236	1.134
Semi-routine and routine	0.955	1.310
Housing tenure		
Own outright/own with mortgage (Ref)		
Rent from Local/Housing Authority	0.582*	1.135
Rent privately	1.848*	1.072
Other (including living with parents)	0.799	2.464**
Income quintile		
Lowest quintile	1.471	0.696
Second quintile	1.396	0.968
Third quintile	1.020	0.894
Fourth quintile	1.362	0.957
Highest quintile (Ref)		
Illness in pregnancy		
No pregnancy complications (Ref)		
Complications not associated with induction	1.026	0.993
Complications associated with induction	0.846	1.430*
Other	0.565	0.788
Maternal BMI before pregnancy		
Low (<18.5) (Ref)		

Normal (18.5-24.9)	1.388	1.331
High (≥25.0)	1.143	1.873*
Infant birth weight		
Low (<2500 grams)	0.450	4.044***
Normal (2500-4000 grams) (Ref)		
High (>4000 grams)	1.510	1.687**
Infant gestational age in days		
259 days or less	1.216	4.089***
260-272 days	0.601*	1.621*
273-286 days (Ref)		
287-293 days	1.136	1.232
294 days or more	1.183	1.729
Induction		
No	0.801	1.521**
Yes (Ref)		
Foetal Distress		
No	0.183***	0.211***
Yes (Ref)		
Failure to progress		
No	0.107***	0.105***
Yes (Ref)		
Maternal Height	0.124	0.006***
Epidural		
No	0.264***	0.018***
Yes (Ref)		
UK Country		
England (Ref)		
Wales	1.217	1.744*
Scotland	0.972	2.048**
Northern Ireland	0.901	1.327
UK Country#Induction		
England#Induced (Ref)		
Wales#Induced	0.822	0.779
Scotland#Induced	0.999	0.629
Northern Ireland#Induced	1.566	0.584

[a]Reference category: Unassisted vaginal delivery

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