RAISED MATERNAL BODY MASS INDEX

AND

CAESAREAN SECTION

Jenan A Shakoor

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Abstract

Introduction

Maternal obesity (defined as a body mass index (BMI) ≥30kg/m^2) and overweight (defined as BMI 25-29.9kg/m^2) have adverse implications for both the mother and the baby, including an increased risk of caesarean section. The prevalence of caesarean section among the UK obstetric population has been increasing in recent years. Evidence suggests that caesarean section in obese women may carry a higher risk of postoperative complications, such as haemorrhage, wound infection and delayed healing. These complications may result in a longer length of stay in hospital after caesarean delivery. To date, UK evidence on the association between maternal BMI and caesarean section has been limited.

Aim

The overall aim of my PhD was to investigate the association between maternal BMI and caesarean section within the North East of England.

Methods and Results

My PhD consists of three phases:

Phase one: a review of the available published literature that investigated the association between maternal BMI and caesarean section rate. The review found that most studies been carried out in the US with only six from the UK. The review highlighted the need for further research in the UK.

Phase two: an investigation of the association between maternal early pregnancy BMI and caesarean section using an existing dataset of 42,362 deliveries in five hospitals in the North East of England. The objectives of this phase were; to identify the caesarean section rate among five hospitals in the North East of England; to describe the caesarean section rate by booking BMI; and to examine the independent impact of BMI on caesarean section, adjusting for potentially confounding variables including maternal age, gestational age, birth weight, ethnicity and socio-economic status in overweight and obese pregnant women compared to pregnant women with recommended BMI.

In phase two, the overall caesarean section rate was 20.6%; 28.4% of obese and 21.9% of overweight women delivered by caesarean section, compared to 17.8% of women with recommended BMI. After adjusting for available confounding factors, the adjusted odds ratio (aOR) for caesarean section among obese women was 1.81 (95%CI: 1.67-1.97; p<0.0005) and 1.29 (95%CI: 1.20-1.39; p<0.0005) among overweight women compared to women with recommended BMI. Thus, there was an almost two-fold increased risk of delivery by caesarean section among women who were obese at the start of pregnancy and an increased risk for women who were overweight.

Phase three: a case note review of 205 women with a singleton pregnancy in 2008, aged ≥16 years and delivered by caesarean section in a district general hospital in the North East of England. The study hypothesis was that overweight and obese pregnant women have more post-caesarean section complications than pregnant women with recommended BMI, resulting in a longer length of stay in hospital.

The results of this study showed that from 205 cases (28% of all caesarean section deliveries in 2008), 86 (42.0%) were to women with recommended BMI, 54 (26.3%) to overweight and 65 (31.7%) to obese women. The median length of maternal stay in hospital was three days, with an inter quartile range (IQR) of 2-3. Twelve (18.5%) obese women stayed in hospital after caesarean section for four days compared to five (9.3%) overweight and eight (9.4%) women with recommended BMI, (p=0.44) but this was not significant.

There were no significant differences in postoperative complications or length of stay in hospital between overweight and obese pregnant women compared to women with recommended BMI.

Conclusion

Overall, my study confirms that obese and overweight women in the North East of England are at increased risk of caesarean section. Among women delivered by caesarean section, however, there was no association between maternal BMI and post-operative complications or length of stay in hospital.

Dedication

This piece of work is dedicated to:

My Father & Mother

Sister & Brothers

Nabil, Esmat & Shan

With all my love

Acknowledgment

I have been interested in having an opportunity to study a PhD in the UK since I finished my masters degree. I was lucky to be one of a thousand students from different specialities who received a scholarship from the Iraqi Ministry of Higher Education and Scientific Research to study at PhD level.

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Statement of contribution

This is to declare that the work contained in this thesis comprises original work conducted by the student under the supervision of Dr Ruth Bell and Professor Judith Rankin. My contributions and those of others were as follows:

For the North East five hospitals cohort study (chapter 4) I used raw data collected for other projects. I carried out all the statistical analysis for this study.

For the Wansbeck General Hospital study, the data was extracted from case notes to my proforma with the help of Dr Tony Chalhoub, a specialist registrar (SpR) at Wansbeck Hospital. I carried out all data entry, coding and statistical analysis.

This thesis has not been submitted for the award of any other degree at any other institution.

Conference publications

1. Maternal body mass index in pregnancy and caesarean section: a cohort study from North East England. Published in Archives of Disease in Childhood, Fetal and Neonatal Edition, Vol.95: No1.2010, British Maternal and Fetal Medicine Society (BMFMS) 13^{th} annual conference, 2010, Newcastle, UK.

2. Maternal body mass index in pregnancy and caesarean section: a cohort study. Published in Obesity Reviews, July 2010, 11^{th} International Conference on Obesity (ICO), 2010, Stockholm, Sweden.

3. Maternal body mass index and caesarean section: a cohort study (presentation), North East Postgraduate Conference (NEPG) 2010, Newcastle, UK.

4. Complications associated with delivery by caesarean section: is there a difference by body mass index? Published in Archives of Disease in Childhood, Fetal and Neonatal Edition, April 2012, Vol. 97, Suppl 1, p 390, British Maternal and Fetal Medicine Society (BMFMS),15th annual conference, 2012, Glasgow, UK.

5. Body mass index in pregnancy and caesarean section: a hospital based study. Published in Obesity Facts, The European Journal of Obesity, Vol.5, Suppl 1, May 2012. 19th European Conference on Obesity (ECO), 2012, Lyon, France.

My poster presentations are shown in appendix I

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Glossary of terms used in the thesis

Term	Definition
Apgar score	A number arrived at birth by scoring the heart rate, respiratory effort, muscle tone, skin colour and response to stimuli. Each of these objective signs can receive 0, 1 or 2 points. A perfect Apgar score of 10 means an infant is in the best possible condition. An infant with an Apgar score of 0–7 requires assessment and initiation of resuscitation.
Body mass index (BMI)	The body weight of an individual in kilograms divided by their height in meters squared. A BMI below 18.5 is categorised as underweight, a BMI of 18.5-24.9 as normal/healthy weight, a BMI of 25-29.9 as overweight and a BMI of 30 and above is obese.
Caesarean section	Surgical incision into the abdominal and uterine wall to achieve delivery of the baby.
Deep vein thrombosis	A condition in which a blood clot forms in the muscle of the leg, usually in the calf.
Dystocia	Failure of labour to progress.
External cephalic version	A procedure that externally rotates the fetus from a breech position to vertex presentation.
Fetal distress	Commonly used to describe fetal hypoxia (low oxygen levels in the fetus). The concern with fetal hypoxia is it may result in fetal damage or death if not reversed or if the fetus is not promptly delivered.
Gestational age	Is the age of a fetus or newborn in weeks measured from the first day of the woman's last menstrual cycle to the current date. A term pregnancy can range from 37-42 completed weeks.
Gestational diabetes mellitus	Is a carbohydrate intolerance of varied severity that begins or is first recognised during pregnancy.
Instrumental delivery	An instrument (forceps or ventouse/vacuum) designed as an aid in the vaginal delivery of a baby.

Glossary (continued)

Term	Definition
Intrauterine growth restriction	The growth of the fetus is abnormally slow, or there is no growth. Intrauterine growth restriction is associated with increased risk of medical illness and death in the new-born. Intrauterine growth restriction is also referred to as intrauterine growth retardation.
Late miscarriage	Spontaneous loss of a fetus at 20-23 completed weeks of gestation.
Large for gestational age	Babies weight ≥90^{th} percentile for their gestation.
Live birth	Delivery of an infant regardless of gestational age and shows the signs of life such as respiration, heartbeat, pulsation of the umbilical cord and voluntary movement of the muscle.
Maternal obesity	Obesity, BMI more than or equal to $30kg/m^2$ during pregnancy.
Multipara	A woman who has had two or more pregnancies resulting in a viable baby or stillbirth.
Parity	The classification of women according to the number of times they have given birth to a baby of more than 24 weeks' gestation.
Perinatal death	Death of a fetus or a new-born in the perinatal period that commences at 24 completed weeks' gestation and ends before seven completed days after birth.
Placenta abruption	The premature separation of the placenta from the wall of the uterus.
Placenta previa	Rather than being attached to the upper wall of the uterus, the placenta lies low in the uterus, partly or completely covering the cervix.
Postpartum haemorrhage	Blood loss of 500ml or more from the genital tract up to six weeks after labour.
Pre-eclampsia	A condition in pregnancy characterised by hypertension (elevated blood pressure), albuminuria (leakage of large amounts of the protein albumin into the urine) and oedema (swelling) of the hands, feet and face.
Preterm birth	Delivery of a live born infant before 37 weeks gestation.

Glossary (continued)

Term	Definition
Primipara	A woman who is pregnant and has given birth for the first time and had one or more viable live birth or stillbirth.
Pulmonary embolism	A blockage of one of the arteries in the lung by a blood clot.
Singleton pregnancy	A pregnancy with only one fetus.
Stillbirth	Delivery of a fetus showing no signs of life at 24 or more completed weeks of gestation.
Thromboprophylaxis	Prevention of thromboembolic disease.
Vaginal birth after caesarean	A vaginal birth after a previous caesarean section.
Venous thromboembolism	A blood clot (thrombus) forms in a vein, which in some cases then breaks free and enters the circulation as an embolus, finally lodging in and completely obstructing a blood vessel, for example in lungs causing a pulmonary embolism (PE). The term includes both deep vein thrombosis and pulmonary embolism.

Source: http://www.medterms.com and CMACE[1]

List of abbreviations

- **aOR:** Adjusted Odds Ratio
- **ANOVA:** Analysis of Variance
- **BIA:** Bioelectrical-Impendence Analysis
- **BMI:** Body Mass Index
- **CEMACH:** Confidential Enquiries into Maternal and Child Health
- **CMACE:** Centre for Maternal and Child Enquiries
- **CNSTs:** Clinical Negligence Scheme for Trusts
- **CI:** Confidence Interval
- **CS:** Caesarean Section
- **CTG:** Cardiotocography
- **CT:** Computed Tomography
- **CQUIN:** Commissioning for Quality and Innovation
- **DAG:** Direct Acyclic Graph
- **DVT:** Deep Vein Thrombosis
- **DXA:** Dual energy X-Ray Absorptiometry
- **ECV:** External Cephalic Version
- **FBS:** Fetal Blood Sample
- **GDM:** Gestational Diabetes Mellitus
- **HELLP**: Haemolytic Elevated Liver Enzyme Low Platelet
- **HSE:** Health Survey for England
- **ICU:** Intensive Care Unit
- **IMD:** Index of Multiple Deprivation
- **IUGR:** Intra Uterine Growth Retardation
- **LGA:** Large for gestational Age
- **LLSOA:** Lower Layer Super Output Area
- **MRI:** Magnetic Resonance Imaging
- **NHS:** National Health Service
- **NCEPOD:** National Confidential Enquiry into Patient Outcome and Death
- **NEPHO:** North East Public Health Observatory
- **NHSLA:** NHS Litigation Authority

- **NICE:** National Institute for Health and Clinical Excellence
- **NIGB:** National Information Governance Board
- **NorDIP:** Northern Survey of Diabetes in Pregnancy
- **OR:** Odds Ratio
- **PE:** Pulmonary Embolism
- **PIH:** Pregnancy Induced Hypertension
- **PPH:** Post-Partum Haemorrhage
- **RCOG:** Royal College of Obstetrics and Gynaecology
- **REC:** Research Ethics Committee
- **RR:** Risk Ratio
- **RMSO:** Regional Maternity Survey Office
- **RVI:** Royal Victoria Infirmary
- **SCBU:** Special Care Baby Unit
- **SPR:** Specialist Registrar
- **SPSS:** Statistical Package for the Social Sciences
- **TTN:** Transient Tachypnea of the New-born
- **UK:** United Kingdom
- **UNICEF:** United Nations International Children's Fund
- **USA:** United States Of America
- **UTI:** Urinary Tract Infection
- **UKOSS:** United Kingdom Obstetrics Surveillance System
- **VBAC:** Vaginal Birth After Caesarean Section
- **WHO:** World Health Organisation

CHAPTER ONE

INTRODUCTION

Chapter 1. Introduction

1.1 A brief description of the presentation of the thesis

This thesis comprises six chapters. The **first chapter** is the overall introduction to my PhD and thesis. The **second chapter** outlines the scientific background and consists of three main sections; obesity, which consists of seven subsections, obesity in pregnancy, which consists of three sub-sections and the final, is caesarean section and conclusion.

Chapter three presents the literature search strategy, using key words for searching for articles relating to the association between maternal BMI and caesarean section and the outcome from searching the databases; overall review and conclusion.

Chapter four presents a cohort study involving five maternity units in the North East of England. The chapter presents; an overview of North East England; the aim and objectives of the study; descriptive statistics of the maternal and fetal characteristics of the sample; analysis of the association between BMI and caesarean section and a discussion of the findings.

Chapter five presents a case note review within a district hospital (Wansbeck General Hospital) in Northumberland. I present a brief background on the Wansbeck area, and the characteristics of the population and Wansbeck General Hospital; an overview of descriptive statistics on BMI distribution among the sample; post-partum complications and length of stay in hospital, and the quality of care before and after caesarean section.

Chapter six provides an overall discussion and conclusion of my PhD.

1.2 A brief introduction to the association between maternal obesity and caesarean section

Obesity, defined as a body mass index (BMI) ≥ 30kg/m^2, is a modern day epidemic. It has been identified as an important public health problem throughout the developed world in recent years. [2] The prevalence of overweight (BMI 25-29.9kg/m^2) and obesity has significantly increased in the developed world.[3] Within England, just over a quarter of adults (26% of both men and women) aged 16 or over were classified as obese in 2010, and a greater proportion of men than women (42% compared with 32%) were classified as overweight in 2010.[4]

Maternal obesity generally means obesity that predates the pregnancy. However, measurements are usually only available for early pregnancy. According to nationally representative data from 37 maternity units in England, the prevalence of maternal obesity at the start of pregnancy increased from 7% in 1990 to 16% in 2007.[5] Overweight and obesity in pregnancy have adverse health implications for both the mother and the fetus.[6,7] Research has shown that early pregnancy overweight and obesity increases the risk of gestational diabetes, pre-eclampsia, pregnancy induced hypertension (PIH), postpartum haemorrhage, thromboembolism, low breast feeding and caesarean section.[2,7-10] Infant complications include macrosomia, shoulder dystocia, late fetal loss, stillbirth, intrauterine death, congenital anomaly, preterm birth and head trauma. [7, 8, 9, 11, 12]

Raised BMI also affects the mode of delivery, decreasing vaginal delivery and increasing the risk of caesarean delivery, which can have adverse consequences for both the mother and the baby.[7] A number of studies have consistently described an increased risk of caesarean delivery in obese and overweight women.[10, 13-17] The caesarean delivery rate is increased by around 50% in overweight women and is more than doubled for obese women compared with women with recommended BMI. [14]

The increased risk of caesarean section during labour with raised BMI is thought to be related to a number of factors including prolonged labour due to increased soft tissue thickness in the pelvis resulting in the narrowing of the birth canal, [10] and having a large baby.[16] Moreover, women who have had a previous caesarean section are at risk of requiring subsequent caesarean sections,[18] incomplete dilatation of the cervix,[13] induction failure,[6, 8] differences in labour progression, and difficulties in responses to oxytocin.[19] Fetal distress,[20] pre-eclampsia[21] and gestational diabetes mellitus (GDM),[22] cord accidents and intrauterine death may also be risk factors for early caesarean delivery. [8, 9 23]

The increased rate of caesarean section among overweight and obese pregnant women has adverse implications for the mother and fetus. These include anaesthetic risks during surgery; wound infection following surgery and delayed healing, and increases in the length of hospital stay. This has an impact on the resource requirement for antibiotics, intravenous infusions, blood transfusion, drugs and intensive care treatment.[5] Furthermore, the average cost of pre and postnatal hospital care is higher for overweight/obese mothers than for women with recommended BMI.[8]

To date, there has been limited research in the UK on the relationship between maternal obesity and caesarean section compared with the United States of America (USA) and other countries.

To further understand the health implications of maternal obesity, my PhD was undertaken to provide: an accurate estimate of the effect of maternal overweight/obesity on the rate of caesarean section; review the indications for caesarean section among overweight/obese women, and the extent to which care received by women undergoing caesarean section complies with current guidelines in relation to the use of prophylaxis and thromboprophylaxis before caesarean section.

1.3 Aim

The overall aim of my PhD was to investigate the association between maternal BMI and caesarean section within the North East of England.

1.4 Objectives

My PhD is divided into three phases and the aim of each phase is:

Phase 1: To undertake a review of the currently available international evidence relating to the association between maternal pre-pregnancy BMI in overweight and obese pregnant women and caesarean section.

Phase 2: To undertake an investigation of the association between maternal BMI in early pregnancy and caesarean section using an existing dataset of deliveries in five hospitals in the North East of England. This analysis will examine the independent impact of BMI on caesarean section adjusting for potentially confounding variables including maternal age at delivery, gestational age at delivery, ethnicity, birth weight, and socio-economic status in overweight and obese pregnant women compared to women with recommended BMI.

Phase 3: To undertake a case note review to test the hypothesis that overweight and obese pregnant women have more post-caesarean section complications than pregnant women with recommended BMI, resulting in a longer length of stay in hospital.

1.5 Research questions

1. Is there an association between maternal BMI and caesarean section among the obstetric population of the North East of England?

2. What are the confounding factors that may affect the association between BMI and caesarean?

3. Does an overweight and obese pregnant woman have more complications after caesarean section and a longer length of stay in hospital compared to women with recommended BMI?

CHAPTER TWO

SCIENTIFIC BACKGROUND

Chapter 2. Scientific Background

2.1 Obesity: General Overview

Overweight and obesity are terms that refer to abnormal or excessive fat accumulation in the body that may impair health. Obesity develops from an accumulation of excess body fat, which occurs when energy intake from food and drink consumption is greater than energy expenditure through the body's metabolism and physical activity.[24] There are different ways to measure obesity, including BMI, waist circumference and waist to hip ratio, skin fold thickness-biceps, and body composition. However, the most frequently used criteria for measuring overweight and obesity is BMI. BMI is calculated by dividing a person's weight measurement (in kg) by the square of their height (in meters). According to the World Health Organisation (WHO) definition, an adult BMI of between 25-29.9kg/m^2 means that a person is considered to be overweight and a BMI of 30kg/m^2 or above means that a person is considered to be obese [24, 25] (Table 2-1).

Table 2-1: Body mass index categories as defined by the World Health Organisation (WHO)

Weight status	BMI kg/m^2
Underweight	<18.5
Normal weight	18.5-24.9
Pre-obese/overweight	25-29.9
Obese class I	30-34.9
Obese class II	35-39.9
Obese class III	≥ 40

Ideally, obesity should be defined by the amount of excess fat that increases health-related risk factors. However, in practice it is not possible to have a single ideal definition of obesity based on excess fat measurement for use as a population–based estimate for three reasons; firstly, an ideal definition needs an exact measurement of excess fat which is difficult to take in practice; secondly, health risks associated with obesity increase on a continuum not at a particular defined cut-off point; and thirdly, the effect of excess fat on health varies among individuals and populations. [26]

2.2 Methods of obesity measurement

2.2.1 Body mass index

The most common method of measuring obesity is by calculating a person's BMI. BMI is the most practical way of measuring the prevalence of obesity at the population level. No particular equipment is needed and therefore it is easy to measure accurately and consistently across large populations. BMI is also widely used around the world, which enables comparisons between countries, regions and population sub-groups.

For most people, their BMI correlates well with their level of body fat. However, certain factors such as fitness, ethnic origin and puberty can sometimes alter the relationship between BMI and body fatness.[27] Estimates of adult obesity by ethnic group to differ according to the measurement used for example, BMI, waist to hip ratio and waist circumference. Black African and Bangladeshi women are more obese when using waist circumference as a measure for example. [28]

In this thesis, BMI is used as the measurement for fatness. This allows comparison with other papers.

2.2.2 Maternal body mass index and gestational weight gain

The important issue in maternal obesity is early pregnancy obesity rather than gestational weight gain during pregnancy. [29] Using BMI in the later stages of pregnancy has limitations, as it is well known that during pregnancy there is naturally acquired weight gain; on average: 4-5 kg of weight at term represents the fetus (3.5kg), the placenta (0.5kg), and amniotic fluid (0.5-1.0) and there is no evidence to determine what is a "healthy" or "unhealthy" BMI when this weight gain is taken into consideration.[29-31]

Current UK guidelines have no recommendations on gestational weight gain, and this lack of guidance has been highlighted by healthcare professionals in the UK as a barrier to consistent practice.[31, 32] Most literature depends on the Institute of Medicine (IOM) recommendations in the US for presenting the weight gain during pregnancy. This guideline stated that women who are obese during pregnancy should gain between 5 and 9kg over the course of their pregnancy, 0.5-2kg in trimester 1 and 0.22kg/week in trimesters 2 and 3.[33, 34] The National Institute for Health and Clinical Excellence (NICE), 2010[30] has called for further research in the UK to asses the appropriateness of these guidelines for the UK population.

Gestational weight gain is associated with adverse outcomes, however obesity existing before pregnancy has a stronger association. Early pregnancy BMI is often used to indicate pre-pregnancy BMI. This thesis considers only existing obesity and not gestational weight gain.[31]

2.2.3 Waist circumference and waist to hip ratio

The circumference of the waist or the waist to hip ratio are sometimes used as a simple measure of body fatness.[35] The cut-off of waist circumference and waist to hip ratio for women is set lower than that for men (88 cm vs 102 cm) because women are at higher risk at the same waist circumference. Waist circumference measurement is good as an indicator of total body fat as BMI or skinfold thickness and is the best anthropometric predictor of visceral fat.[35, 36] Waist circumference has limited use in pre-pregnancy or early pregnancy due to increases in the abdominal circumference during pregnancy.[35, 37] Waist circumference measurements are rarely available in routine data and are less relevant in pregnancy when the waist circumference changes as the fetus grows.

2.2.4 Skin fold thickness-biceps, triceps, subscapular, suprailiac

This method is used to measure subcutaneous fat underneath the skin by grasping a fold of skin and subcutaneous fat using callipers. This method is used mainly to determine relative fatness and the percentage of body fat.[27] Skin fold thickness is an unreliable measure of intra-abdominal fat or central obesity, even with improved prediction equations.[36]

2.2.5 Dual energy x-ray absorptiometry

Dual energy x-ray absorptiometry (DXA) scanning was originally developed to measure bone mineral density and diagnose osteoporosis. This method is not safe during pregnancy as it uses ionising radiation.[35]

2.2.6 Hydrometry

Hydrometry is a dilution method, using isotopes, usually deuterium to measure total body water. This method is used particularly in morbidly obese people ($\geq$35kg/m^2). This technique is not suitable for large-scale pregnancy research.

2.2.7 Imaging

Both computed tomography (CT) and magnetic resonance imaging (MRI) provide high resolution cross-sectional scans of selected tissue or organs. Both techniques can measure regional fat distribution but MRI has the advantages of avoiding radiation exposure, which is an important consideration in pregnancy.[36]

2.2.8 Bioelectrical impedance analysis

Bioelectrical impedance analysis (BIA) measures the impedance or opposition to the flow of an electric current through the body fluids contained mainly in the lean and fat tissue. [38,27] The main advantage of using this measurement is that it can measure both maternal adiposity and the distribution of fat.[35] BIA can be measured within 1-2 minutes from the legs only, although the opportunity for inaccurate measurement is high. [27]

2.3 Prevalence of obesity

Obesity prevalence is increasing worldwide. Current estimates from the WHO report published in 2012 [39] stated that more than 1.4 billion adults, 20 and older, were overweight (BMI≥25kg/m^2). Of these, over 200 million men and nearly 300 million women were obese. Overweight and obesity are the fifth leading risk for global deaths; at least 2.8 million adults die each year as a result of being overweight or obese.[39]

In the UK, the Health Survey for England (HSE) reported that 8% of adult women and 6% of adult men were classified as obese in 1980.[3] By 1993 this had increased to 16% of women and 13% of men. In 2010, 26% of both women and men were obese and a further 33% of women and 44% of men were overweight. [4,3, 40-42]

The Foresight report, Tackling Obesities: Future Choices project, published in 2007, predicted that in England 28% of women and 36% of men aged between 21 and 60 will be obese in 2015, and by 2025 these figures are estimated to rise to 36% for women and 47% for men.[43] Moreover, the report predicted that if no action was taken, the prevalence of obesity is predicted to affect 50% of adult women and 60% of adult men by 2050. [43]

The North East Public Health Observatory (NEPHO), 2009[44] reported that 61% of adult women and 68% of adult men (16 years or over) in the North East were overweight, and 25% of women and 30% of men were obese.

More women than men tend to be obese whereas the reverse is true for overweight (BMI>25 or above). In England a greater proportion of men than women (42% compared with 32%) were classified as overweight in 2010.[4]

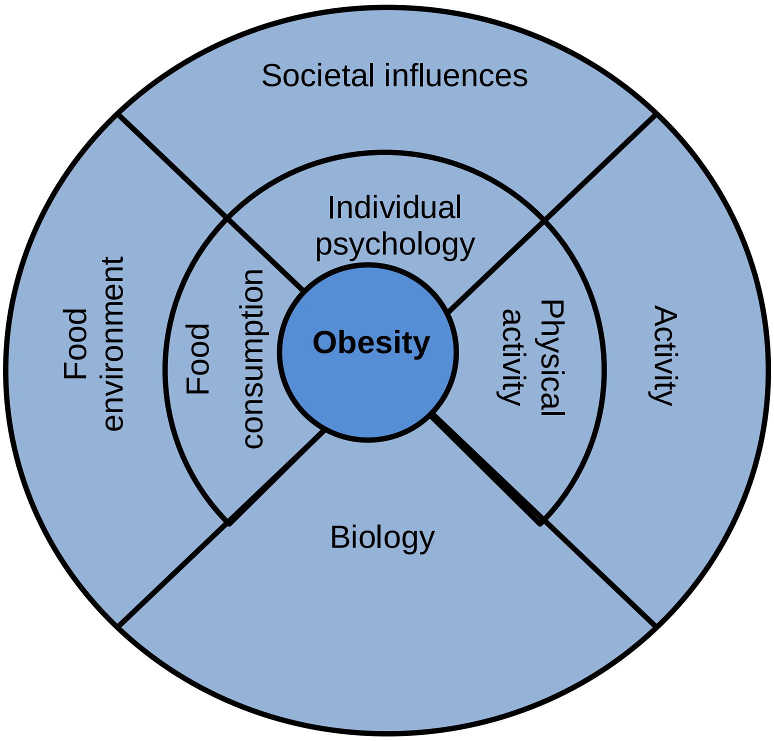
There are many social influences that differentially influence male and female food intake and energy expenditure patterns. However, it is obvious that biological and evolutionary components are also important factors underlying the differences in the rate of obesity between the sexes.[45]

2.4 Determinants of obesity

Overweight and obesity result from an energy imbalance between calorie intake from food and drink and calorie expenditure through the body's metabolism and physical activity, over a prolonged period resulting in the accumulation of excess body fat.[27, 46 47] The global increase in overweight and obesity may be due to many complex genetic, behavioural and societal factors which have ultimately resulted in positive energy balance and increasing weight reflecting accumulation of body fat.

The Foresight report (2007)[43] referred to a "*complex web of societal and biological factors that have, in recent decades, exposed our inherent human vulnerability to weight gain*". The report presented an obesity system map with energy balance at its centre. It was found that 100 variables directly or indirectly influence energy balance. To make the Foresight map simpler, it has been divided into seven cross-cutting major themes (Figure 2-1). [27, 43]

Figure 2-1: Obesity system map after dividing into seven predominant themes



Source: Foresight system map, 2007

http://www.bis.gov.uk/foresight

The seven cross- cutting themes are:

- Biology: this is related to individual genetics and ill health;
- Activity environment: the effect of the environment on an individual's activity behaviour, such as deciding to cycle to work, may be influenced by road safety, air pollution or provision of a cycle shelter and showers;
- Physical activity: the type, frequency and intensity of activities an individual carries out, such as cycling dynamically to work every day;
- Societal influences: the impact of society, for example the effect of media, education, peer pressure or culture;
- Individual psychology: such as, a person's individual psychological drive for specific foods and consumption patterns, or physical activity patterns or preferences;

- Food environment: the effect of the food environment on an individual's food choices, for example deciding to eat more fruit and vegetables due to availability and quality of fruit and vegetables close to home;
- Food consumption: the quality, quantity (portion size) and frequency (snacking patterns) of an individual's diet.

2.4.1 Genetic factors

Research has shown that there is a role for genetics in obesity. Some people are genetically predisposed to developing obesity, but that genotype can be expressed in certain adverse environmental conditions, such as a high fat diet and sedentary life style.[47]

2.4.2 Diet

There has been a global shift in diet towards choosing unhealthy foods that are high in fats and sugars but low in vitamins and minerals and this has contributed to the increase in body weight. [46] In addition, patterns of food consumption may also be contributing to the obesity epidemic. Fast food consumption has been associated with more energy dense food, higher fat intake and more consumption of drinks containing sugar. [48] Moreover, a higher proportion of energy provided by fat is associated with weight gain [49] and diets high in complex carbohydrates give way to more varied diets with a higher rate of fats and sugars. [50,24]

In the UK, current government recommendations are that everyone should eat plenty of fruit and vegetables (at least five of a variety each day), plenty of potatoes, bread, rice and other starchy foods, some milk and dairy foods, meat, fish, eggs, beans and other non-dairy sources of protein. Foods and drinks high in salt, fat and sugar should be consumed infrequently and in small amounts. [4]

2.4.3 Socio-economic / environmental factors

Socio-economic and environmental factors are also important drivers of the obesity epidemic. In developing countries, obesity is associated with higher socio-economic status (SES) but the epidemic spread to those in lower socio-economic groups when high fat diets become more affordable.[51] People in managerial or professional employment (a proxy for high SES) have lower overweight and obesity levels than people with semi-routine and routine positions.[52] Data from the HSE 2010, showed that the proportion of women who were obese was higher in the lower income quintiles (34%) and lower in the highest quintiles ranging from (17%).[4] Furthermore, urbanisation in developing countries is associated with higher proportions of obesity. This could relate to access to cheap energy dense food as well as reductions in physical activity due to changes in the physical demands of work. Furthermore, the built environment might also influence the development of excess weight, probably through influences on both diets and physical activity for example, areas with few recreational facilities, safety concerns, rough and hilly land, or insufficient lighting can hinder physical activity. [53,54] Furthermore, an increase in high density of fast-food restaurants, convenience stores, bars, food distribution programs with high-fat foods, and concentrated media marketing, all promoting un healthful food choices, hinder good nutrition. [53]

2.4.4 Ethnicity

Overweight and obesity rates are higher in some ethnic groups than others. In 2004, in England, black Caribbean and Irish men had the highest prevalence of obesity; 25% for each group compared to 23% in the general population.[55] For black African women, the prevalence was 38%, black Caribbean 32%, Pakistani ethnic groups 28% and 8% for Chinese women. [55]

There is limited data on the incidence of obesity in different ethnic groups, because national surveys tend to sample only small numbers from minority groups. For many ethnic groups, the sample size is too small to allow for reliable comparisons or predictions. [43]

2.4.5 *Physical activity*

One of the reasons for increasing body weight is a less active lifestyle with less physical activity due to the increased sedentary nature of many forms of work, changing modes of transportation, and increasing urbanisation.[24, 49, 56] In 2010, 41% of respondents aged more than two said they walked for 20 minutes or more at least three times a week and an additional 23% said they did so at least once or twice a week. However, 20% of respondents reported that they took walks of at least 20 minutes “less than once a year or never”. [4]

2.4.6 *Age*

Overweight and obesity rate vary with age. The HSE data in 2007 indicated that the peak level of overweight and obesity in individuals is between 55-64 years of age, while the lowest is in the 16-24 age group among both men and women.[55]

2.5 Health effects of obesity

Overweight and obesity lead to serious health concerns. Raised BMI is a major risk factor for chronic diseases such as, cardiovascular diseases, diabetes, musculoskeletal disorders and some cancers.[24] The risk to health increases progressively as BMI increases.[24]

Overweight and obesity are preventable. At the individual level, achieving balanced energy and a healthy weight should be aimed for, as well as an increase in physical activity as part of daily life. The NICE guidelines on the prevention, identification, assessment and management of overweight and obesity (2006) [42] highlight that overweight and obesity are important risk factors for developing long term health problems. The guidelines stated that the risk of these health problems can be identified using both BMI and waist circumference for those with a BMI of 35kg/m^2 or more. [42]

Overweight and obesity are important risks for more than one million deaths and 12 million episodes of ill health in Europe every year.[57] Overweight and obesity can be considered a risk factors for different complications, such as developing type 2 diabetes, the prevalence of which has increased by 50% in the last 10 years,[58] as well as hypertensive disorders, ischemic stroke, cardiovascular diseases, osteoarthritis and some types of cancers (breast, endometrial and colon). [58]

Overweight and obesity can also affect a country's socio-economic development through increasing health care costs and loss of productivity and income.[57] Obesity and overweight account for 2-6% of the total health care cost in developed countries.[57] Furthermore, adult obesity is responsible for up to 6% of the health care expenditure in Europe.[58]

2.6 Prevention and management of obesity

Preventing the increase in obesity rates is not without considerable challenges. However, there are some interventions that can be introduced which may reduce overweight and obesity. For example, providing free or lower price healthy food in school meals might increase the awareness of both the child and the family about the quality of the food they choose to eat. Furthermore, schools can encourage children to maintain healthy weight by running, swimming programs based on reducing hours of playing video games, using computer and TV viewing, and encouraging healthy eating at school.[59] Providing space and time for the children to play sports and other physical activities may encourage them to adopt a healthy lifestyle. In addition, taking regular physical activity, such as walking for 30 minutes every day, or cycling to work rather than using car or public transportation, may be encouraged by providing facilities, such as safe walking routes, parks and places for parking bicycles for users. In addition to providing the population with accurate and balanced information on healthy diet, regulatory and policy interventions such as reducing marketing and advertising for unhealthy food; increasing taxes on unhealthy ingredients such as fat and refined sugar and increasing availability of affordable vegetables and fruits through planning regulations, may also contribute to tackling the obesity epidemic. [57, 46,39]

The NICE have published guidance on the prevention, identification, assessment and management of overweight and obesity in adults and children.[41] The guidance has recommendations in two main areas; public health recommendations which include; the public, the NHS, local authorities and partners in the community, early years settings, schools, workplaces and self-help, commercial and community programmes, and clinical recommendations. I have summarised some important recommendations in (Appendix II).

2.7 Obesity in pregnancy

2.7.1 Prevalence of obesity in women of reproductive age

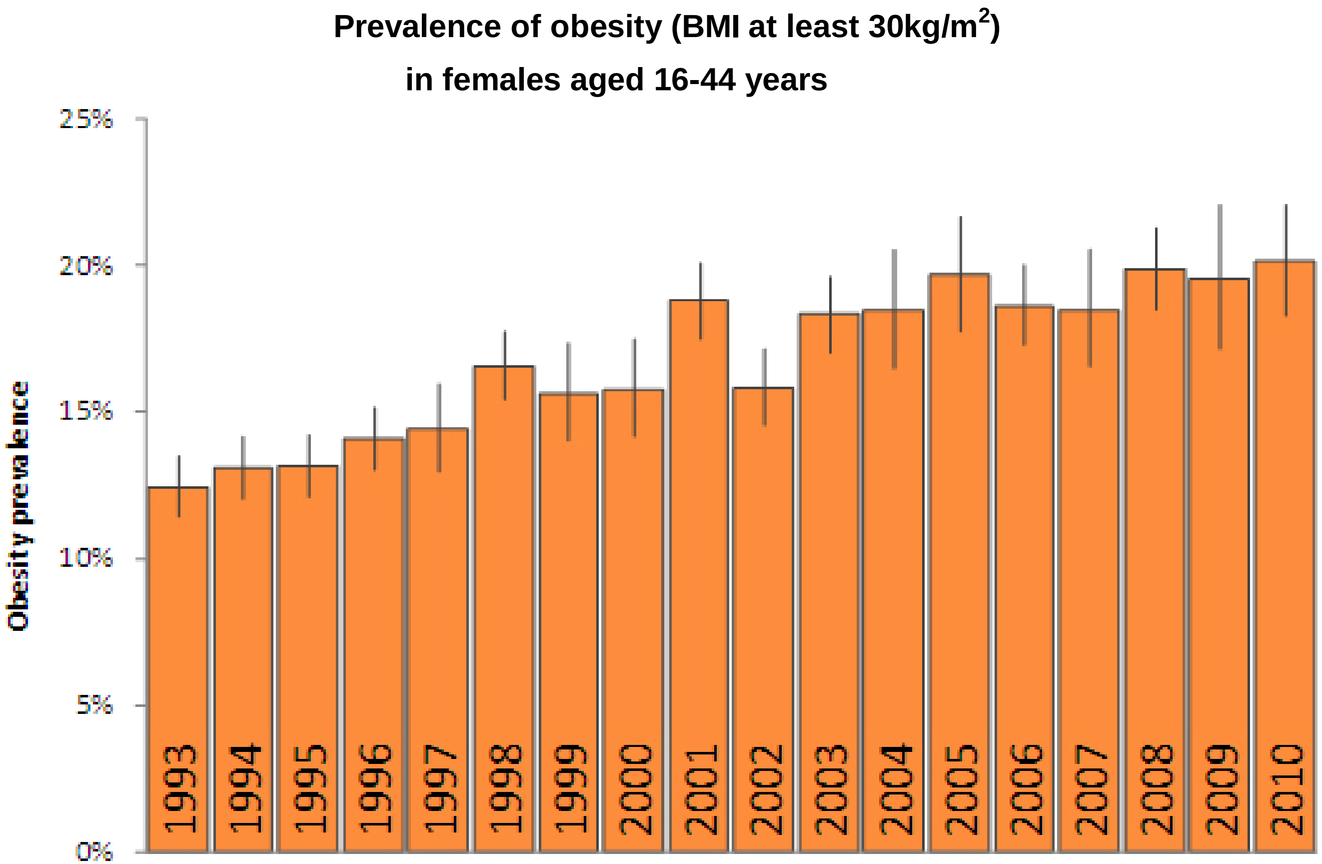
Obesity and overweight are increasing among individuals of different ages, including women of reproductive age, making it a common condition during pregnancy.[50, 56, 60-62]

The data from the HSE (2007) shows that the prevalence of obesity (BMI at least $30kg/m^2$) among women of reproductive age (16-44 years), increased from 14.4% in 1997 to 20.2% in 2008 (Figure 2-2).

Within this age group the prevalence of obesity increases with age; in 2008, the prevalence of obesity was 14% in the age group 16-24 and 25% in those aged 35-44. [63,27] While a recent HSE report (2012) revealed a gradual rise in the prevalence of obesity in women from 16.4% in 1993 to 26.1% in 2010.[4]

Obtaining accurate data on maternal obesity is difficult as most recorded BMI utilises self-reported height and weight, and most of the BMI information routinely collected is at the first antenatal booking visit.

Figure 2-2: Obesity prevalence among women aged 16-44 years during the period 1997-2008



Source: National Obesity Observatory (NOO) report, 2012

http://www.noo.org.uk/publications/719/Body_Mass_Index_as_a_measure_of_obesity

2.8 Prevalence of obesity in early pregnancy

International studies show a prevalence of maternal obesity ranging from 1.8% to 25.3% across countries using the WHO classification of obese (BMI 30kg/m^2).[50] However, comparing international rates using data from published studies is difficult due to differences in the BMI classification used to define obesity and the time that the study was conducted, as well as the different health systems involved.

For many years, healthcare professionals working in maternity services in the UK have reported an increasing trend towards obesity in early pregnancy. However, there has been an absence of national data to support this issue. Three UK studies from single maternity units have shown an increasing prevalence of maternal obesity in recent years in Middlesbrough (England),[64] Glasgow (Scotland),[65]and Cardiff (Wales)[66] (Table 2-2).

2.8.1 Single centre studies

Glasgow study

The Glasgow study [65] aimed to identify the trend in obesity among the maternity population at a maternity unit in Glasgow. The data was from maternity records and included women who booked up to or including 14 weeks of gestation. Two study periods were included, 1990 and 2002/2004. The WHO definition was used to calculate the proportion of BMI. Nearly one in five women were obese at booking. The proportion of women who were obese at booking more than doubled over time in unadjusted analyses. In addition, the likelihood of obesity in 2002/ 2004 relative to 1990 was increased following adjustment for potential confounders such that the likelihood of obesity was 3.07-fold higher (95% CI, 1.60– 5.89, P= 0.001) in 2002/2004 in analyses adjusted for age, parity, booking gestation, smoking and deprivation category. Similarly, women were 60% more likely to be obese or overweight (BMI ≥25 kg/m^2) in 2002/2004 relative to 1990 adjusted odds ratio of 1.62 (95% CI 1.04– 2.53, P= 0.033).

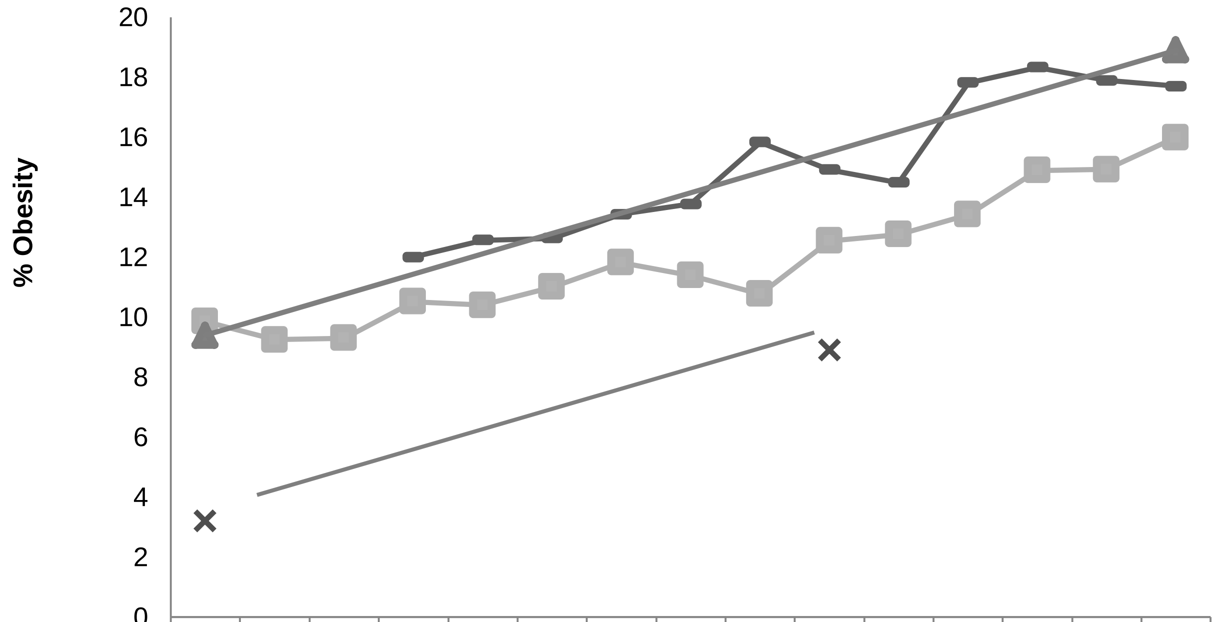
Middlesbrough study

The second study from Middlesbrough[64] was a longitudinal database study, which aimed to identify trends in maternal obesity incidence among 36,821 women over 15 years. Maternal height and weight were recorded at the initial booking appointment from a direct measurement by midwives at GP practice bookings, with only a small proportion of self-reported measurements from home booking appointments, approximately 5%. The data included all booking appointments between 1 January 1990 and 31 December 2004 for women of at least 16 weeks gestation. The result showed that the proportion of obese women at the start of pregnancy increased significantly over time from 9.9 to 16.0% ($P < 0.01$).

Cardiff study

The Cardiff population-based observational study[66] aimed to show the increased risk of adverse outcomes in labour and fetomaternal morbidity in obese women. This study included 8,350 primigravid, singleton, uncomplicated, term pregnancy (≥37 weeks) with accurate BMI measurement (measured by the midwife at the booking visit) from the period 1990 and 1999. This study found that the prevalence of obese pregnancies more than doubled (3.2-8.9%) between 1990 and 1999. The proportion of pregnancies with a booking BMI>30 kg/m^2 was 8.1% and with BMI>40 was 0.4% during the study period.

Figure 2-3: A comparison of published local maternal obesity data and HSE data



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HSE (% Obesity in Women of Childbearing Age)				12.0	12.6	12.6	13.4	13.8	15.8	14.9	14.5	17.8	18.3	17.9	17.7
Middlesbrough (% Maternal Obesity)	9.9	9.2	9.3	10.5	10.4	11.0	11.8	11.4	10.8	12.5	12.8	13.4	14.9	14.9	16.0
Glasgow (% Maternal Obesity)	9.4														18.9
Cardiff (% Maternal Obesity)	3.2									8.9					

Source: Heslehurst, N. (2011). "Identifying 'at risk' women and the impact of maternal obesity on National Health Service maternity services." Proceedings of the Nutrition Society 70 (04): 439-449 [31]

2.8.2 National studies of maternal obesity

In 2010, three national-level maternal obesity datasets were published in the UK; one retrospective study and two prospective studies (Table 2-2)

Heslehurst et al, 2010[5] carried out a retrospective analysis of routinely collected electronic data from maternity units in England. A sample size of 619,323 births was identified from 1989 to 2007. This national, longitudinal dataset identified a significant increase in first-trimester maternal obesity (defined as BMI >30 kg/m^2) over two decades.[5] By 2007, the incidence of maternal obesity within this population had doubled to 15.6% from 7.6% in 1989. Two-thirds of women who were classified as obese during pregnancy were moderately obese (BMI 30.0– 34.9 kg/m^2). The incidence was shown to decrease as the category of obesity increased. [5]

The Centre for Maternal and Child Enquiries (CMACE)[1], 2010 carried out a prospective cohort study of 5,068 births for the period of 1 March to 30 April 2009, using a notification system.[1] Maternity units throughout the UK completed notification forms for all women meeting the eligibility criteria which were: giving birth ≥24 weeks gestation, and had a record of pregnancy BMI ≥35kg/m^2 at any time of pregnancy, or no known BMI but a recorded pregnancy weight ≥100kg, or no known BMI or weight, but was judged by health professionals to have a BMI ≥35kg/m^2 or weight ≥100kg. The overall prevalence of maternal obesity with a known BMI ≥35 kg/m^2 (class II, BMI 35-39.9kg/m^2 and class III BMI ≥ 40kg/m^2) was 4.99%. This study identified a similar trend for decreasing obesity incidence as the level of obesity increased: BMI ⩾35, 4.99%; BMI ⩾40, 2.01%; and BMI ⩾50, 0.19% (Table 2-2).

The CMACE dataset also identified UK national differences in maternal obesity; Wales had the highest incidence of obesity (BMI ≥35kg/m^2) (6.5%) whereas England had the lowest (4.9%). [1]

Knight et al, 2010 [67] also carried out a prospective cohort study of 655 births, collected from the period September 2007 to August 2008. The study identified women with extreme obesity (BMI ≥50 kg/m^2) through the UK Obstetric Surveillance System (UKOSS), which represents 100% of all births in the 226 eligible UK hospitals (Table 2-2)[1]. The study reported the prevalence of extreme obesity to be 0.09%, which showed similar results to the above two studies of decreasing obesity incidence with increasing category of BMI. Data collected by the UKOSS suggested a calculated prevalence of “extreme obesity” (BMI ≥50 or weight >140 kg) within the UK obstetric population of 8.7 per 10 000 deliveries. [67] This study reported that more than 1 in every 1,200 women delivering in the UK is extremely obese (Table 2-2).[68]

Table 2-2: Summary of national data on maternal obesity in the UK

Authors	Study type	Population	Sample size	Period of data collection	Obesity measurement	Incidence of maternal obesity
Heslehurst, et al [5]	Retrospective analysis of routinely collected maternity data	England	619,323 births	1 January 1989 to 31 December 2007	BMI > 30kg/m^2	15.60%
					BMI 30-34.9kg/m^2	10.0%
					BMI 35- 39.9kg/m^2	3.8%
					BMI 40-49.9kg/m^2	1.6%
					BMI> 50kg/m^2	0.18%
CMACE[1]	Prospective cohort study (notification)	UK	5,068 births	1 March 2009 to 30 April 2009	BMI > 35kg/m^2	5.0%
					BMI 35-39.9kg/m^2	3.0%
					BMI 40-49.9kg/m^2	1.8%
					BMI > 50kg/m^2	0.19%
Knight et al [67]	Prospective cohort study (UKOSS)	UK	655 births (out of 764, 387)	September 2007 to August 2008	BMI > 50kg/m^2	0.09%

Source: Heslehurst, N. (2011). "Identifying 'at risk' women and the impact of maternal obesity on National Health Service maternity services." Proceedings of the Nutrition Society 70 (04): 439-449.[31]

The prevalence rates reported by Heslehurst et al[5] 2010 and CMACE[1] 2010 were consistent for women with a BMI ≥35kg/m^2. While the Knight et al study, 2010 [67] reports a prevalence of BMI >50 kg/m^2 of half that of the other two studies. This may have resulted because of the small number of women with a BMI >50kg/m^2 compared to the other two studies.[1, 5]

Heslehurst et al, 2010[5] found that obese pregnant women in England were more than twice as likely to be living in areas of most deprivation compared with those women living in areas of least deprivation.[5] This association increased with increasing BMI, and women with extreme obesity (>50kg/m^2) were almost five times as likely to be living in areas of most deprivation compared with areas of least deprivation.[64] A similar result was found by CMACE 2010; obese pregnant women were more likely to live in areas of most deprivation ($p<0.0001$).[1]

Regarding ethnicity, all three studies[1, 5, 67] found a relationship between maternal obesity and ethnicity. Heslehurst et al, 2010[5] showed that Black women were significantly more likely to be obese in pregnancy (BMI >30kg/m^2) compared with white women, while other ethnic groups, such as South Asian, mixed and Chinese were significantly less likely to be obese compared to white women.[5] The analysis showed that the relationship with black ethnic group was significant for moderate and morbid obesity. Knight et al, 2010[67] reported findings for the relationship between ethnic group and extreme obesity where white women were significantly more likely to have a BMI >50kg/m^2 compared with black and other ethnic groups. CMACE 2010[1] found a significant reduction in the proportion of non-white women among their obese cohort in comparison with all maternities in England. Both Knight et al [67] and CMACE study [1] found a reduced proportion of obesity among non-White ethnicity.

Furthermore, maternal obesity was significantly associated with increasing maternal age among all BMI groups after adjusting for socio-demographic confounders (parity, ethnicity, employment and deprivation), with extreme obesity showing the strongest association in the Heslehurst et al, 2010 study.[5, 69]

CMACE 2010,[1] reported an increased association of maternal obesity with increasing maternal age over 35 years for both morbid (22.4%) and extreme obesity (30.7%), compared to a decreased association with maternal age less than 20 years.

Knight et al, 2010 [67] found the same trend of a significantly negative association of extreme obesity with maternal age less than 20 years and an increased association of maternal age >35 years with extreme obesity, but the association was not significant [OR: 1.15 (95% CI: 0.89-1.49)].[67, 69]

A significant association was found between maternal obesity and parity in both the Heslehurst et al[5] and Knight et al[67] studies. Heslehurst et al reported a significant association between parity and all obesity categories (OR:1.17-1.19), with the exception of extreme obesity (OR:1.07).[5, 69] Knight et al showed a significant association between extreme obesity and parity ≥3 [OR: 2.85 (95%CI: 1.98-4.11)] compared to parity 0, and no significant association for parity 1-2 [OR: 1.23 (95% CI: 0.97-1.56)]. [67]

2.9 Health effects of obesity in pregnancy

Overweight and obesity can be associated with serious complications for both the mother and the baby.[13, 70, 71] These include pre-eclampsia, gestational hypertension, gestational diabetes, placenta previa, placenta abruption, thromboembolism, fetal macrosomia, stillbirth, congenital anomaly and caesarean section.[8, 9, 72]

2.9.1 Pre-eclampsia and hypertension

Maternal obesity is a well-established risk factor for the development of pre-eclampsia (defined as a condition in pregnancy characterised by hypertension (elevated blood pressure), albuminuria (leakage of large amounts of the protein albumin into the urine) and oedema (swelling) of the hands, feet and face. A systematic review by O'Brien et al 2003, which included 13 studies and over a million women, found that the risk of pre-eclampsia rose by 0.54% (95% CI: 0.27-0.80) for each increase in kg/m^2, which means that the risk of pre-eclampsia doubled with each 5-7 kg/m^2 increase in pre-pregnancy BMI. A continuous relationship was observed between pre-pregnancy BMI and the risk of pre-eclampsia in this study (Table 2-3).[21]

Since the publication of that review, more recent studies have confirmed this association.[7, 73,74,8] Bhattacharya et al, 2007 [7] found a linear increase in both pre-eclampsia and gestational hypertension with increasing BMI, resulting in an aOR of 7.2 (95% CI: 4.7-11.2) for pre-eclampsia and 3.1 (95% CI: 2.0-4.3) for gestational hypertension in the morbidly obese women compared to women with recommended BMI. Furthermore, Callaway et al, 2006[73] found an increase in the aOR of hypertensive disorders with increasing BMI: obese women were three times more likely to have a hypertensive disorder and morbidly obese almost five times.

Baeten et al, 2001[74] in a population- based study in the US of 96,801 pregnant women who delivered singleton babies, found that obesity was a strong risk factor for pre-eclampsia (OR: 3.3 (95% CI: 3.0-3.7)), not only for obese, but also for overweight women. In addition, Sebire et al, 2001[8] in a large UK study examining pregnancy outcome in 287,213 singleton pregnancies, found that pre-eclampsia is positively associated with increasing BMI. Hauger et al, (2008)[61] found that elevated BMI is a strong independent risk factor for pre-eclampsia (OR: 3.10 (95%CI: 2.54-3.78)). Moreover, Weiss et al, 2004[16] in a large prospective cohort study of 16,102 pregnant women found a significant association of obesity and morbid obesity with increasing gestational hypertension and pre-eclampsia risk is clear that increasing pre-pregnancy BMI is a significant risk factor for pre-eclampsia and gestational hypertension.

2.9.2 Gestational diabetes

Obesity has consistently been shown to be a risk factor for the development of gestational diabetes mellitus (GDM).[74-76] Two systematic reviews and meta-analyses have been published investigating the link between GDM and maternal obesity.[22, 77] Chu et al, 2007[22] included twenty studies and found that the unadjusted OR of developing GDM was 3.56 (95% CI: 3.05-4.21) among obese women. The second meta-analysis by Torloni et al, 2008[72] of 70 studies, assessed and quantified the risk for GDM according to pre-pregnancy maternal BMI. They found an increased risk of 3.01 (95% CI: 2.34-3.87). GDM in women with obesity. Thus, obese women are three times more likely to develop GDM during pregnancy.[78, 79]

Mechanism

GDM is a carbohydrate intolerance of varied severity that begins or is first recognised during pregnancy. GDM results from insufficient insulin secretion to compensate for increasing insulin resistance during pregnancy. The pathophysiology of gestational diabetes involves abnormalities of insulin – sensitive tissue. Beta cell sensing of glucose is also abnormal and is manifested as an inadequate insulin response for a given degree of glycaemia. [80]

2.9.3 Placental abnormalities

Placental abnormalities, such as placenta praevia and placental abruption, have also been reported to be associated with maternal BMI, but the literature is inconsistent. Biango et al, 1998 [23] reported an increased risk of placental abruption of 1.8% versus 0.9% ($p<0.05$) between obese and non-obese patients. In contrast, Weiss et al, 2004[16] and Sahu et al, 2007 [20] failed to find a significant association between overweight and obesity with placental abnormalities.

2.9.4 Preterm birth

Preterm birth is defined as the delivery of a live born infant before 37 weeks of gestation;[79] and early preterm birth is defined as the delivery of a baby before 32 weeks gestation. Preterm delivery can occur as a result of preterm labour or elective delivery. Preterm birth is a major cause of neonatal mortality and morbidity and childhood morbidity. There is contradictory data in the literature regarding maternal obesity and preterm birth, as some studies suggest that overweight and obese women are at increased risk of delivering preterm babies (<32 weeks gestation) and more likely to deliver before 37 weeks gestation.[74, 81]

While other studies [8, 82] have reported a significantly decreased risk for preterm delivery in obese women, whereas others have found no difference in the incidence of preterm birth by BMI.[23]

A systematic review by Sarah et al, 2010[83] aimed to determine the relationship between overweight and obesity in mothers and preterm birth in singleton pregnancies in developed and developing countries. The review included 84 studies. The review found that the overall risk of preterm birth before 37 weeks did not differ significantly among overweight or obese women with singleton pregnancies risk ratio (RR):1.06 (95% CI: 0.87-1.30) compared with women with recommended BMI. However, among overweight and obese women the risk of induced preterm birth was increased RR: 1.30 (95% CI: 1.23-1.37), the heavier the woman, the higher the risk of induced preterm birth before 37 weeks, with overweight, obese, and very obese women having a RR of 1.15 (95% CI: 1.04-1.27, 1.56 (95% CI: 1.42-1.71), and 1.71 (95% CI: 1.50- 1.94) respectively. The review also showed that overweight and obese women had an increased risk of preterm birth before 33 weeks RR: 1.26 (95% CI: 1.14-1.39), the heavier the woman, the higher the risk of early preterm birth, with overweight, obese, and very obese women having a RR of 1.16 (95% CI: 1.05-1.29), 1.45 (95% CI: 1.23-1.71), and 1.82 (95% CI: 1.48- 2.24), respectively.

A large-scale retrospective cohort study demonstrated an interaction between BMI and parity and preterm delivery; obese nulliparous women were at increased risk of very preterm deliveries ≤ 32 weeks gestation compared with recommended BMI women (OR: 1.6, 95% CI: 1.1-2.3), whereas among obese multiparous women the risk was highest among those who were lean. [70]

2.9.5 Thromboembolism

Obesity is a well-recognised risk factor for thromboembolism in pregnancy. Venous thromboembolism (VTE) is a major cause of maternal mortality, and was the leading direct cause of pregnancy-related mortality in the UK from 1985 to 2005.[12] VTE occurs in 10 per 100 000 women of childbearing age and affects 100 per 100 000 pregnancies.[84] The risk of VTE in pregnancy and the postpartum period is increased 4–5 fold compared with non pregnant women, with an overall risk of 1.72 per 1000 deliveries and an associated mortality of 1.1 per 100 000 deliveries.[85-87]

Deep vein thrombosis (DVT) and pulmonary embolism are the leading causes of maternal mortality in the UK.[88] Both antepartum, overweight and obese women are at higher risk of venous thromboembolism compared with women with recommended BMI.

The pathophysiology of VTE in pregnancy appears to relate to the increased venous stasis noted during this period but other factors such as alterations in the balance of proteins of the coagulation and fibrinolytic systems have also been implicated.[89]

Larsen et al, 2007[90] found that overweight and obese women are at higher risk of antepartum VTE with an aOR of 5.3 (95% CI: 2.1-13.5) compared to women with recommended BMI. Robinson et al[9] found that obese pregnant women were at a significantly increased risk of antepartum VTE, with the risk increasing with increasing maternal weight.

The Royal College of Obstetricians and Gynaecologists (RCOG) guideline[91] recommends that all women should undergo a documented assessment of risk factors for VTE in early pregnancy or before pregnancy. The guideline recommends that women with a BMI ≥30kg/m^2 should be assessed throughout pregnancy for the risk of VTE, in addition if they have two or more additional risk factors for VTE, they should be considered for prophylactic low molecular weight heparin (LMWH) antenatally. Moreover, women identified as having a lower level of elevated risk, based on the presence of certain risk factors, should also be considered for LMWH.

2.9.6 Stillbirth and neonatal death

Studies have suggested that overweight and obesity are associated with an increased risk of antepartum stillbirth (a fetus showing no signs of life at 24 or more completed weeks), and a neonatal death (death following live birth, of a baby before aged 28 days). [92]

A systematic review and meta-analysis of nine studies by Chu et al 2007 [93] suggests that maternal obesity increases the risk of stillbirth (OR: 2.07 (95% CI: 1.59-2.74)). Further, a large Danish study involving 24,505 singleton pregnancies,[94] were in agreement with the systematic review by Chu et al, 2007.[93] The overall rate of stillbirth was 4.6/1000 deliveries and of neonatal death was 3.1/1000 live births. Maternal obesity was associated with more than double the risk of stillbirth and neonatal death compared with women of normal weight. However, a higher proportion of stillbirths caused by unexplained intra-uterine death and fetoplacental dysfunction were found in children of obese women compared with children of recommended BMI women (BMI<30kg/m^2).

2.9.7 Congenital anomaly

A meta-analysis [95] consisting of twelve studies comparing obese women with women with recommended BMI found an increased risk of neural tube defects in fetuses of obese women. A further systematic review and meta-analysis[11] by Stothard et al (2009) included observational studies with an estimate of pre-pregnancy or early pregnancy weight or BMI and data on congenital anomalies. Eighteen papers were included in the meta-analysis which showed an overall association between maternal obesity and a range of structural anomalies, [OR: 2.24 (95% CI: 1.86-2.69)] (Table 2-3).

2.9.8 Birth weight

Several studies have shown that maternal obesity is associated with macrosomic (heavy) babies.[8, 16, 96] The definition of macrosomia varies in the literature between 4000 and 4,500g, while babies are define as large for gestational age (LGA) when their weight is ≥90th percentile for their gestation.[1]

Sheiner et al, 2004 [13] analysed pregnancy outcomes in a cohort of 126,080 deliveries, patients with hypertensive disordres and diabetes were excluded, and found that obese women (BMI>30kg/m^2) had an increased risk of fetal macrosomia [OR: 1.4 (95% CI: 1.2-1.7)]. A similar result was found in a Danish study by Jensen et al, 2003.[97]

Mechanism

Glucose is transferred to the fetus through the placenta, and insulin is a growth factor. High circulating fetal insulin levels stimulate fetal growth, which can lead to macrosomia.[83]

Table 2-3: Maternal and neonatal risks of obesity

Author(s), year	Risk	Odds ratio (95%CI) Obese women versus recommended BMI women
	Pregnancy complication	
Torloni et al 2009*	GDM	3.01(2.34-3.87)
Baeten et al, 2001	Pre-eclampsia	3.3 (3.0-3.7)
O'Brien et al 2003*	Pre-eclampsia	0.54 (0.27-0.80)
Sebire et al 2001	Pre-eclampsia	2.14 (1.85-2.47)
Ageno et al, 2008*	Venous thromboembolism	2.33 (1.68-3.24)
Chu et al, 2007*	Stillbirth	2.07 (1.59-2.74)
Rasmussen et al, 2008*	Neural tube defects	1.70 (1.34-2.15)
Stothard et al 2009*	Spina bifida	2.24 (1.86-2.69)
	Labour and delivery	
Heslehurst et al, 2008*	Failure to progress	2.31 (1.87-2.84)
Poobalan et al, 2009*	Total caesarean section	2.36 (2.15-2.59)
	Elective caesarean section	1.87 (1.64-2.12)
	Emergency caesarean section	2.23 (2.07-2.42)
Heslehurst et al, 2008*	Instrumental delivery	1.17 (1.13-1.21)
	Maternal haemorrhage	1.24 (1.24-1.28)
	Maternal infection	3.34 (2.74-4.06)
	Neonatal complication	
	Low Apgar score at 5min	1.57 (1.46-1.68)
	Fetal compromise	1.62 (1.54-1.70)
	Neonatal intensive care use	1.35 (1.22-1.49)

* A systematic review

2.9.9 Length of stay in hospital

Obese individuals experience longer hospital stays than normal weight individuals.[98] A study by Chu et al, 2008[99] investigated the association between obesity during pregnancy and increased use of health care with length of stay after delivery the primary outcome. The study investigated 13,442 pregnancies from 2000 to 2004 and found that the total length of hospital stay increased significantly with increasing BMI category. The length of stay was at least four days in 40.3% of pregnancies of women of normal weight and 60.4% of extremely obese women. Further, the total length of stay for overweight and obese postpartum women was significantly higher compared to recommended BMI women ($p<0.001$).

A systematic review by Heslehurst et al, 2008[6] which investigated the impact of obesity on obstetric care. They reported a significant gradual increase in mean length of hospital stay as BMI increased from 2.4 days for recommended BMI to 3.3 days for morbidly obese women.[6]

2.9.10 Breast feeding

Maternal obesity is associated with a reduction in breast feeding frequency.[8, 100] Fall in progesterone that occurs immediately postpartum is the start of the onset of abundant milk secretion, and the maintenance of prolactin and cortisol concentration is necessary for this start to be effective.[92,94] Although it is likely to be a multifactorial in origin, the simple mechanical difficulties of latching on and proper positioning of the infant when the mother is obese can pose a problem for starting breast feeding. [94] From an endocrine perespective, obesity is associated with a reduced prolactin response to suckling. [101]

A systematic review of maternal obesity and breast feeding intention, initiation and duration was conducted by Amir et al, 2007[102] and included 22 studies found that obese women plan for a shorter period of breast feeding than recommended BMI women. The majority of large studies included in the review found that obese women breast feed for a shorter duration than recommended BMI, even after adjustment for confounding factors, and the reasons may be biological, psychological, behavioural and /or cultural.[102]

The joint CMACE/RCOG guideline, 2010[103] recommends that women with a booking BMI >30 kg/m^2 should receive appropriate specialist advice and support antenatally and postnatally regarding the benefits, initiation and maintenance of breast feeding.

The WHO and the United Nations International Children's Fund (UNICEF) developed a programme for breast feeding called the Baby Friendly Initiative to encourage maternity hospitals to follow the ten steps to successful breast feeding and to practise in accordance with the International Code of Marketing of Breast Milk Substitutes. The ten recommended steps to breast feeding are:

1. Have a written breast feeding policy that is routinely communicated to all health care staff.
2. Train all health care staff in skills necessary to implement this policy.
3. Inform all pregnant women about the benefits and management of breast feeding.
4. Help mothers initiate breast feeding within half an hour of birth.
5. Show mothers how to breast feed, and how to maintain lactation even if they should be separated from their infants.
6. Give new born infants no food or drink other than breast milk, unless medically indicated.
7. Practise rooming-in-that is, allows mothers and infants to remain together 24 hours a day.
8. Encourage breast feeding on demand.
9. Give no artificial teats or pacifiers (also called dummies or soothers) to breast feeding infants.
10. Foster the establishment of breast feeding support groups and refer mothers to them on discharge from the hospital or clinic.

2.10 Caesarean section

2.10.1 History

Caesarean section is one of the oldest operations in history.[104] Caesarean section was reported as early as 140B.C.[104, 105] However, there is no evidence that the operation was ever successfully performed upon a living European woman until 1500 AD. In the British Isles, the first caesarean section, from which the mother survived, was carried out by an illiterate Irish midwife in 1738. In England the first successful case was reported in 1796. [104]

It has been reported that Julius Caesar was born by caesarean section, but the word caesarean section did not have its origin from Julius Caesar, but from the Latin verb ‘caedere’, which means “to cut”.[104, 105]

2.10.2 Prevalence

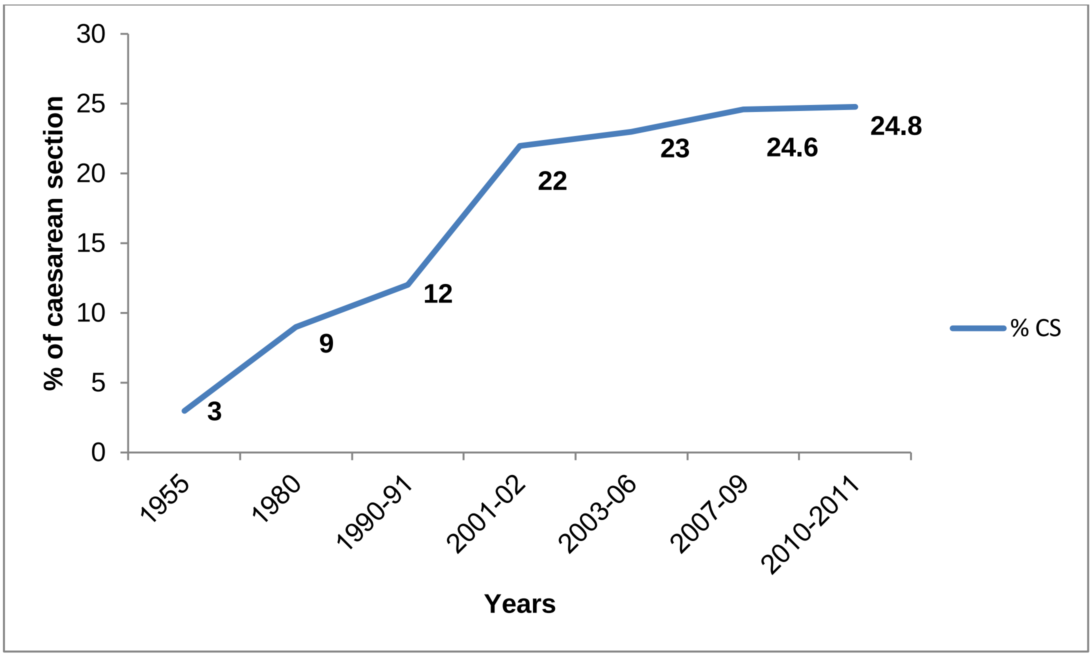
The prevalence of caesarean section is increasing.[14, 60] Although the timing and rate of increase is different between countries, there is increasing concern about the rising prevalence of caesarean section. In response to this increase, the WHO has stated that there is no additional benefit associated with a caesarean section rate above 10-15%.[106-108]

High rates of caesarean section are common in North America. In the USA, the caesarean section rate increased from 6% in 1970 to 17% in the 1980 then to 24% in 1990[108] and most recently has been reported to be 31.1%.[109] This represents a 50% increase over the past 10 years.[109] A similar increase has been reported in Canada; the caesarean section rate increased from 6% in 1970 to 16% in 1980 then 19% in 1998.[108, 109]

In the UK/England 2010-2011 the rate is currently 24.8%.[110] The greatest increase in caesarean section rate in England was seen in the 1970s, when rates doubled from 4% in 1970s to 9% in the 1980s. However, during the 1980s the increase was less marked. Rates increased again during the 1990s, with an estimated rate of 16% in 1995 and 19% by 1999, and in 2006-2008 the rate had increased to 23%.[108] Around 120,000 caesarean sections are performed annually in England and Wales.[111] Recent data from the NHS Information

Centre reported that the rate of caesarean section increased from 3% in 1955 to 24.8% in 2010-2011 (Figure 2-4). [112]

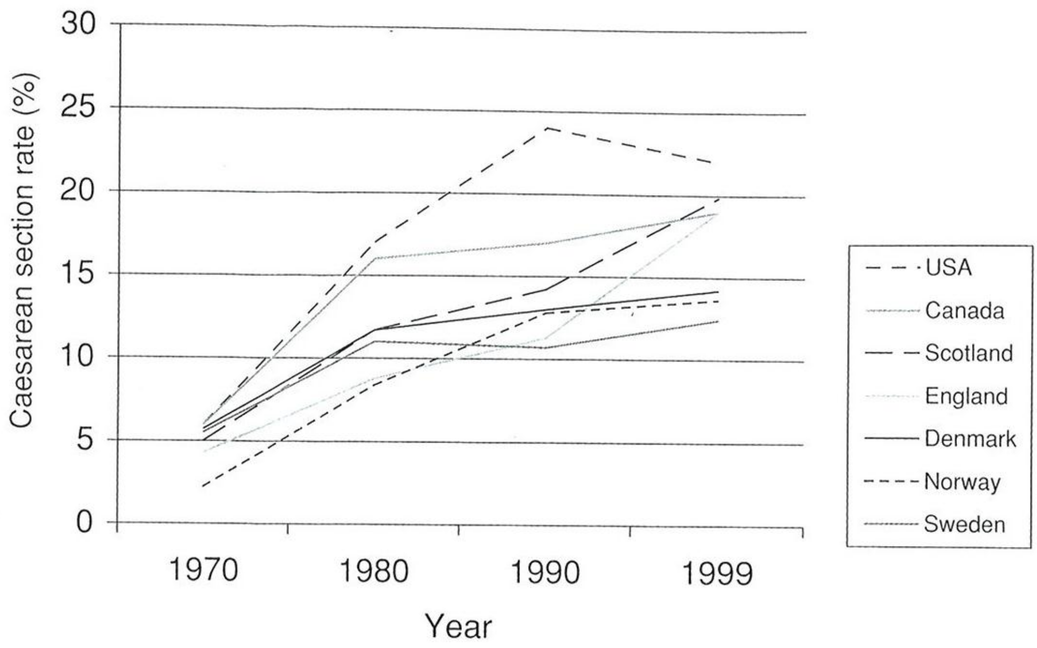
Figure 2-4: Caesarean section rate among pregnant women in England 1955-2011



Source: NHS Information Centre*, Maternity: Key facts*, *Englan*d, 2011

This indicates that the caesarean section rate in England has surpassed that recommended by the WHO. This rapid increase in caesarean section rate in England and the USA has not occurred in the Nordic countries probably due to their high quality of health services and differences in practice, which remain at a rate of 12-14% (Figure 2-5).[108]

Figure 2-5: International caesarean section rate



Source: The National Sentinel Caesarean Section Audit Report, 2001.

RCOG: Clinical Effectiveness Support Unit

2.10.3 Types of caesarean section

Caesarean section has been divided into two types, emergency and elective procedures.[108, 113] An emergency caesarean section (unplanned caesarean section) is the procedure undertaken within 30 minutes from taking the decision. An elective caesarean section or planned caesarean section, is the procedure that is scheduled before the onset of labour for specific clinical indications, such as breech presentation, multiple pregnancy, placenta praevia and maternal request.[72, 113] The National Sentinel Caesarean Sections Audit Report, (2001) has defined 30 minutes as a standard for decision-delivery interval in the category 1 situation. Category 1 emergency caesarean section taken in indications of fetal distress; bleeding; dystocia and uterine rupture.[107, 113]

It is quite difficult to consistently and robustly classify caesarean section urgency. Essentially, an elective caesarean section is one done when the women is not in labour and is not urgent. An emergency section is one done in labour due to complications arising during labour. However, within that broad classification, there are degrees of urgency which is why there have been more recent attempts to refine the classification to try to reflect the differing degrees of urgency.

2.10.4 Classification of caesarean section urgency

The traditional classification of caesarean section into “elective” and “emergency” is inadequate. In addition, the spectrum of urgency that occurs in obstetrics is lost within a single category.[114] The NICE has classified the urgency of caesarean section into four categories according to the following criteria;

1. If there is immediate threat to the life of the women or fetus (category 1).

2. Maternal or fetal compromise which is not immediately life threatening (category 2).

3. No maternal or fetal compromise but needs early delivery (category 3).

4. Delivery time to suit woman or staff (category 4). [108, 113]

2.10.5 Indications for caesarean section

A large proportion of caesarean sections are undertaken for four major reasons which have not changed despite the increasing rate of caesarean section in the last 10-15 years.[113] These indications are dystocia (failure of labour to progress), fetal distress, breech presentation and repeat caesarean section.[108, 113] More recently, maternal request has become a more common reason for a caesarean section.[108, 113, 115] Obese women are more likely to have a caesarean section due to dystocia and fetal distress compared to women with recommended BMI. [13,116]

Other factors associated with increasing caesarean section rates include organisational factors such as hospital size, availability of neonatal intensive care units, provision of one to one support in labour and obstetrician characteristics.[52, 108]

2.10.6 Impact of caesarean section

The increasing prevalence of overweight and obesity among pregnant women places these women at increased risks including being under greater anaesthetic risk, bleeding, postpartum wound infection and delay in healing, thrombophylaxis and hospitalisation, which results in an increased use of antibiotics, and intensive care requirement. Furthermore, the average cost of prenatal and postnatal hospital care is higher for overweight and obese mothers than recommended weight pregnant women.[9, 99, 117, 118]

The WHO has estimated that up to 7% of health care costs is absorbed by obesity related morbidity.[119] Two studies from Montpellier,[120, 121] France estimated the complications and cost of obesity during pregnancy in two time periods, 1980-1993 and 1993-1994. The average cost was higher in overweight and obese pregnant women than in normal weight pregnant women and staying at hospital and requiring admission to neonatal intensive care was higher in overweight and obese mothers.[120, 121]

In the UK, a recent qualitative study [64] interviewed 33 maternity and health professionals about their views regarding the effect of maternal overweight and obesity on using health care services and resources. The results showed that health professionals perceived that overweight and obese pregnant women have a major effect on the level of care required.[64]

Anaesthetic complication

Caesarean section exposes women to risk of general anaesthesia which carries the potential for complications. Overweight and obesity can be considered a risk for anaesthetic complications, for example an increased risk of failed intubation, difficulties in moving the anesthetised patient and postoperative care.[116]

Robinson et al[9] found that anaesthetic complications were increased among severely obese pregnant women, but not in the moderately obese pregnant women compared to women with recommended BMI. Saravanakumar et al[122] have stated that performing a caesarean delivery on obese women is technically more difficult as it results in an increased risk of anaesthetic complication.

Postpartum haemorrhage

Doherty et al, 2006[123] have reported in a retrospective study of data obtained from a randomised control trial (RCT) of 2,827 women of known pre-pregnancy BMI and a singleton pregnancy between 16-18 weeks gestation, that the risk of postpartum haemorrhage increases with increasing BMI. Perlow et al[124] found that massively obese pregnant women (>136.2kg), who delivered by caesarean section are at greater risk of blood loss of greater than 1000 mls (OR: 5.2, 95% CI 1.4-21.1). This has been confirmed in other studies.[8, 16] Kaiser et al[125] found that the increasing caesarean section rate will increase blood loss, especially when the emergency caesarean section is performed for large babies and postpartum haemorrhage will also increase with increasing BMI.

Wound infection and prophylactic antibiotics

Wound infection is a common complication of caesarean section. Antibiotics are commonly prescribed routinely to prevent this occurrence. Patients undergoing caesarean section, both elective and emergency, should have a start dose of antibiotics administered in theatre.[30]

Overweight and obese pregnant women are at greater risk of wound infection after caesarean section. Myles et al, 2002[126] in a study of 611 pregnant women, found that 86.6% of the 360 pregnant women who had had an emergency caesarean section used prophylactic antibiotics. The risk factors for postoperative infection in emergency caesarean section were length of labour (18.4 vs.10.9 hours, $p<0.003$) and the number of vaginal examinations (61 vs. 4.5, $p<0.001$). In addition, the incidence of infection was high in patients who had had a caesarean section due to cephalopelvic disproportion and failure to progress. There were no differences in infection rates between obese and non-obese pregnant women who were not given antibiotic prophylaxis.[79]

Robinson et al, 2005 [9] reported that the postpartum obese pregnant group were more likely to receive antibiotics, and wound infection rates increased with increasing BMI. This result agrees with that of Weiss et al, 2004[16] who found that wound infection increased among obese and morbidly obese postpartum pregnant women compared to women of recommended weight.

In a retrospective population-based study of 19,416 caesarean deliveries, 726 deliveries were followed by wound infections and this appeared in postpartum women that were older and obese.[80]

2.11 Conclusion

In conclusion, existing literature has reported an increase in the prevalence of obesity, particularly among women in reproductive age. To identify the association between maternal BMI and caesarean section, I will undertake a review of the available evidence relating to the association between maternal BMI and caesarean section and compare the outcomes of the international studies with the existing UK studies in the next chapter.

CHAPTER THREE

LITERATURE REVIEW

Chapter 3. Literature Review

3.1 Introduction

Both developed and developing countries are experiencing a rapid increase in the prevalence of obesity.[127] Studies in the UK show the rates of obesity in pregnancy have almost doubled in the last two decades.[64, 65] Recent estimates suggest the prevalence of obesity in pregnancy in the UK is at least 20% with 5% having severe or morbid obesity.[1, 5] Obesity increases the risks of GDM, [77] pre-eclampsia,[21] thromboembolism,[90] infection, [66] and caesarean section.[14]

This chapter is phase one of my PhD study. I will present the literature search strategy, the key words used to search for articles relating to the association between maternal BMI and caesarean section, the outcome from searching the literature databases and a summary of the studies included in the review. This chapter reports a comprehensive literature review and is not intended to be a systematic review.

3.2 Aim

To undertake a comprehensive review of the currently available international evidence relating to the association between maternal pre-pregnancy BMI in overweight and obese pregnant women and caesarean section.

The specific objectives were to:

1. Identify available articles on maternal BMI and caesarean section.

2. Undertake a review and appraisal of the international evidence for the association between maternal BMI and caesarean section in overweight and obese pregnant women compared to recommended BMI women.

3. Compare the outcome between the UK studies and other international studies.

4. Compare the outcomes between my current review and two recently published systematic reviews.

3.3 Method

I undertook a literature search of MEDLINE, EMBASE, Scopus, PubMed, OVID, Google, and Google Scolar for the years January 1966 to 2008. These searches were then updated from 2009 to December 2011. I used the terms for mother (e.g, matern*, wom#n, mother*, pregnan*), weight (e.g., obes*, body mass index, BMI, adiposity, fat*, overweight), and caesarean section (e.g, abdominal delivery, deliver*, caesarean delivery*) in my search (Table 3-1).

Table 3-1: Keywords used in my literature search

Population	Exposure	Outcome	Study design
matern* OR	Obes* OR	Abdominal	Cohort OR
Wom#n OR	Body mass index	delivery or	Case control OR
Mother* OR	OR	Deliver* or	Follow up OR
Pregnan* OR	BMI OR	Caesarean	Incidence OR
conception	Weight OR	deliver* or	Prospective OR
	Adiposity OR	Caesarean	Epidemiolog* OR
	Body composition	section	Prevalence OR
	OR		Population OR
	Fat* OR		Observation*
	Overweight OR		
	Waist OR		

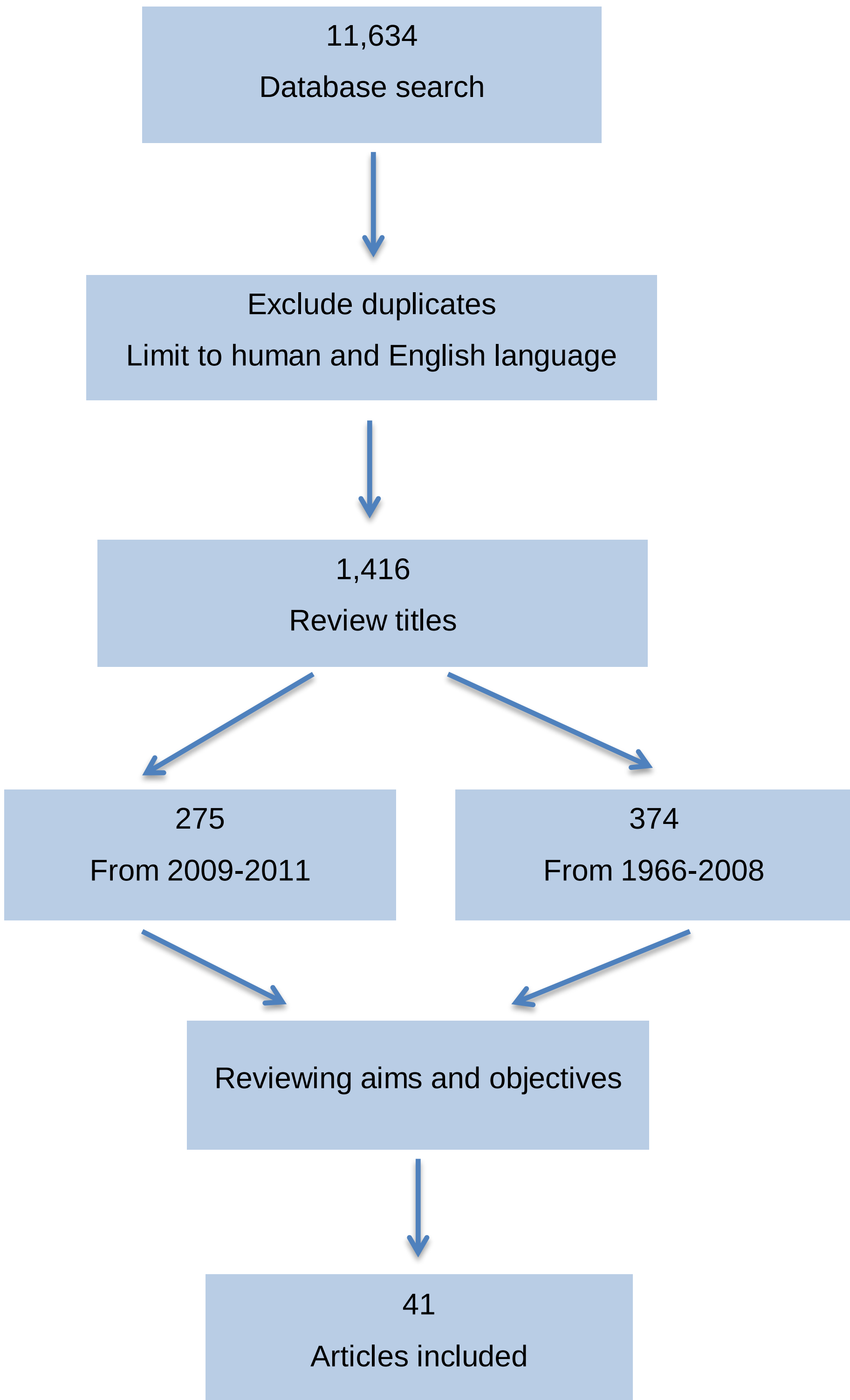
Additional articles were identified by reviewing reference lists and searching publishers, for example Elsevier, Blackwell, Science Direct, Birth, Informa and organisations such as the WHO, NICE, CEMACH, CMACE, NHS library, NHS Information Centre and auto alert services, such as the International Journal of Obesity, Health Science Periodical, Mimaz Zetoc, BioMed Central (BMC), British Medical Journal (BMJ), British Journal of Obstetrics and Gynaecology (BJOG), etc (Table 3-2).

Table 3-2: Literature search method

Method	Sources
Database search	Medline, Ovid, Pubmed, , Embase, Scholar Google, Google and Scopus
Search within publisher	Elsevier, Blackwell, Science Direct, Birth, Informa
Cross- referencing	Both in review articles and original articles
Search within organisations	WHO, NICE, CEMACH, CMACE, RMSO
Auto alert services	Elsevier, Health Science Periodical, International Journal of Obesity, Journal of Perinatology, Mimaz Zetoc, BioMed Central and Scopus
Search with journals	British Medical Journal, American Journal of Obstetrics and Gynaecology, International Journal of Obesity and Gynaecology, British Journal of Obstetrics and Gynaecology (BJOG), BioMed Central (BMC)

Searches were restricted to English-language articles and studies in humans. Articles were excluded from the search if they did not report BMI. Database searches elicited 11,634 articles. Further exclusions based on English language limitation, human, and removal of duplicates, reduced the articles to 1,416. A title review resulted in 374 articles from 1966 to 2008 and 275 from 2009 to 2011. After reading the aim and objectives of the articles, 41 articles remained which met my inclusion criteria (Figure 3-1: flow chart search method). The included articles are summarised in (Table 3-3).

Figure 3-1: Flow chart of literature search method



3.4 Study selection

3.4.1 Inclusion criteria

Articles of any study design that assessed the association between maternal BMI and risk of caesarean section were included. Studies with nulliparous and multiparous pregnant women conducted in any healthcare setting including general practice, midwifery, out-patients clinics and hospitals were included. Articles were included If the participants were pregnant women, a measure or estimate of pre-pregnancy or early pregnancy weight was reported according to BMI categories, and there was at least one obese and one comparison group. The outcome was caesarean delivery (emergency and elective).

3.4.2 Exclusion criteria

The studies were excluded if they were non-English language studies, were not carried out in humans or investigated gestational weight gain.

3.5 Results

3.5.1 Summary of overall review findings

Forty-one articles met my study inclusion criteria for my literature review. The characteristics of the included studies are presented in table 3-3. Of the included studies, 14 were from the USA[16, 19, 74, 78, 106, 116, 123, 125, 128-133], six were from the UK [7, 8, 17, 66, 134, 135] and one from Ireland [136], three from Australia,[15, 73, 137], two were from Canada[9, 138], two were from Sweden,[72,96] three from Denmark [97, 139, 140], and one from each of the; United Arab Emirates (UAE)[82], Israel [13], France [141], Italy [81], German,[142] India[20], Hong Kong [143], China[144], Thailand[145] and Greece. [146]

All the included studies were cohort studies, although only eleven out of 41 were of prospective design. All included studies investigated singleton deliveries. The study period ranged from 1976 to 2010, with most being conducted in the 2000s. BMI was the most frequent measure of obesity. Most articles used the WHO classification for BMI category. The BMI for the reference group ranged from 20-25kg/m^2, except for the study by Crane et al[128] which included all women <29 kg/m^2 in the reference group, Kiran et al[66], Sheiner et al[13] and Weiss et al[16] included all women with a BMI of 30 or less as a reference group, while Bergolt et al[17] used BMI <25kg/m^2 as the reference group. Three studies [74], [129 19] considered <20 kg/m^2 as a reference group. Six studies; [125, 116, 106, 78, 136,96] used the IOM category for BMI classification, while two studies; [130, 9] used weight only in kg to compare between groups.

3.5.2 Maternal body mass index and caesarean section

The overall conclusion from the summary of the included studies shows in Table 3-3., that the risk of caesarean section increases with increasing maternal BMI. Being overweight, obese and morbidly obese shows significant increased odds for overall caesarean section, which ranged from 5.1% to 31.4%. Furthermore, the included studies showed that pregnant women with BMII>30kg/m^2 are more likely to have an emergency caesarean section.[66] Obese and morbidly obese women have the highest rate of emergency caesarean section. In addition, there is more than two fold increase in emergency and elective caesarean section in obese compared to recommended BMI women.[78,8] From a total of 41 studies; 31 studies investigated the odds of caesarean section and ten studies investigated the risk of caesarean section among obese women. The overall odds ratios for caesarean section among obese women compared to recommended BMI women ranged from 1.6 to 9.3. Of these, seven studies [7, 8, 66, 82, 139, 140, 147] investigated the odds of emergency and elective caesarean section among obese women and found that the odds of emergency caesarean section ranged from 1.6 to 3.4 compared to elective caesarean section which ranged from 1.4 to 4.0. There was no specific definition for emergency and elective caesarean section; however the indications for each type were mentioned in some studies. [13, 15, 17, 19, 82, 116, 129, 139]

The review showed that the most common indications for emergency caesarean section are fetal distress, failure to progress and cephalo-pelvic disproportion, while the most common indications for elective caesarean section are previous caesarean section and malpresentation. Also, two studies showed that obese pregnant women are more likely to have caesarean section due to the presence of a macrosomic baby and other complications such as, pre-eclampsia and GDM.[15, 20]

The review also found that the caesarean section rate is greater among nulliparous women. Also, obese nulliparous women have a higher rate of emergency caesarean section than multiparous women, but obese multiparous women had more elective caesarean sections more than nulliparous women.[139] The review showed that obese primiparous women had a six times greater risk of caesarean section due to cephalo-pelvic disproportion and failure to progress, and nulliparous women were more likely to have a caesarean section due to dystocia.[129, 148]

3.5.3 UK studies

The review included six studies from the UK [9, 24-28] I will consider the UK studies in more detail in this section. The largest study was by Sebire et al, 2001 [8] which examined the pregnancy outcome of obese women compared to those with recommended BMI by reviewing 287,213 completed singleton pregnancies using a validated database in the West Thames region, London, from 1989 to 1997. This study compared the risk of caesarean section in overweight (25-29.9kg/m^2) and obese (>30kg/m^2) women compared to recommended BMI (20-24.9kg/m^2) women. This study found that the caesarean section rate was almost twice as high for very obese women than recommended BMI women.[8] The ORs of emergency caesarean section for obese women was OR: 1.83 (99% CI: 1.74-1.93) and the elective caesarean section was OR: 1.72 (99% CI: 1.62-1.83). The study found that the frequency of elective and emergency caesarean section was twice as high in obese women (BMI≥30kg/m^2). The findings were adjusted for different confounding factors such as ethnic group, parity, maternal age and history of hypertension. The study showed that the increased caesarean section rate, in particular the elective caesarean section rates were due to macrosomia, maternal request and obstetrician request. The increased emergency caesarean section was due to the increasing rate of large for gestational age infants which can lead to disproportion during labour, and due to failure to progress due to the presence of increased soft tissue in the pelvis of obese women. [8]

The study had several limitations including not being able to investigate the effect of socio-economic status. The proportion of women who booked after 20 weeks was 14% for obese women; calculating the weight at booking may affect the BMI category into which a woman is allocated to, as late bookers may have increased weight and may affect the numbers in the raised BMI group.

Another study from the UK was conducted by Usha Kiran et al, 2005 [66] which was a population- based study of the relationship between BMI and outcome of singleton pregnancy, in 8,350 uncomplicated singleton primigravid women with cephalic presentation at 37 weeks or more gestation. All women had height and weight recorded at the booking visit. BMI was divided into two groups, the comparison group (BMI 20-30kg/m^2) and the obese group (BMI >30kg/m^2). The OR of caesarean section in obese compared to the reference group was 1.6 (95% CI: 1.4-2.0). [66] This study found that there were more emergency caesarean sections than elective procedures in women with BMI >30kg/m^2 compared to recommended BMI women.

The study limitations included both overweight and recommended BMI women being included in the reference group; including high BMI in the reference group may underestimate the risk of caesarean delivery in obese women. Second, the inclusion criteria for this study were limited to primigravid women with spontaneous onset of delivery, uncomplicated pregnancy (defined as any women without medical disorders, such as diabetes mellitus, chronic hypertension, cardiac or endocrine disorders and surgical conditions) and delivering babies of ≥37 weeks gestational age. Including only uncomplicated pregnancies may explain the lower ORs, as it is well known that women with complications such as GDM and pre-eclampsia are more likely to deliver by caesarean section compared to women without complications.[66]

Another UK study was conducted by Bhattacharya et al.[7] This was a retrospective cohort study, based on all nulliparous women delivering singleton babies in Aberdeen between 1976 and 2005, to investigate the association between BMI and obstetric and perinatal outcomes. The total caesarean section rate among obese women was 30.8%; 4.7% were elective caesarean sections and 26.3% emergency caesarean sections.[7] The study reported a three fold increased risk of having an elective caesarean section in morbidly obese (BMI>35kg/m^2) women compared to women with recommended BMI, OR: 3.1(95% CI: 1.7-6.1) and a 2.8 times (95% CI: 2.0-3.9) higher risk of emergency caesarean section. The aOR of elective caesarean section for obese women (30-34.9kg/m^2) was 1.4 (95% CI: 1.0-1.8) compared to an aOR for emergency caesarean section of 2.0 (95% CI: 1.8-2.3). The study used data collected over 30 years, during which time there have been a number of changes in obstetric protocols, particularly with regard to caesarean section.

Bergholt et al, 2007 [17] evaluated the effect of maternal BMI on the incidence of caesarean delivery among 4,341 nulliparous women with a single cephalic presentation and spontaneous onset of labour from 37-42 weeks gestation at a district general hospital in London between 1995 and 2000. This study found that the caesarean section rate increased from 3.6% in women with a BMI <25 kg/m^2 to 18.5% in women with a BMI >35 kg/m^2 in the first trimester. The OR for caesarean section in the highest BMI category compared with recommended BMI was significantly higher at 3.8 (95% CI: 2.4-6.2).

This study[17] had very restricted inclusion criteria, and the comparison group of BMI is not within the criteria defined by the WHO; the recommended BMI was categorised as <25 kg/m^2 which may include underweight women. Underweight women are clearly different from those in the recommended BMI group; they have their own unique risks for adverse pregnancy outcomes,[116] and may have an inverse relationship with the risk for a caesarean delivery.

A study by Khashan et al, 2009[134] examined the effect of BMI in early pregnancy on adverse pregnancy outcome. The study was a population-based register cohort study using data from the North Western perinatal survey, including 99,403 live born or stillborn babies during 2004-2006. The risk of delivery by caesarean section and unplanned caesarean section in relation to BMI were presented as adjusted and unadjusted relative risks. Underweight women showed a protective effect for delivering by caesarean section aRR=0.88 (95% CI: 0.44-0.82), whereas women who were overweight (25-29.9kg/m^2) were at a higher risk of caesarean section aRR: 1.31 (95% CI: 1.28-

1.35). Furthermore, the risk of caesarean delivery increased with BMI such that obese women had an aRR of 1.66 (95% CI: 1.61-1.71). The study found that morbidly obese women were at a greater than two fold increased risk of caesarean section compared to women with recommended BMI.

A study conducted by Mantakas et al,[135] investigated the influence of BMI in pregnancy on rates of adverse pregnancy outcome in overweight nulliparous women. The study was a retrospective review of data from a local hospital database in Sheffield from 2001-2008 and involved 6,500 nulliparous, singleton pregnancies. BMI was categorised for underweight as <19.9kg/m^2 and the recommended BMI categorised as 20-24.9kg/m^2. The study found that the total RR for caesarean section in obese women were 1.6 (1.4-1.7) and RR: 1.7 (1.5-1.9) for emergency caesarean section.

Table 3-3: Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Crane et al, [128] 1997 1994-1995, US	19,699 completed data for women with live births after 20 weeks gestation	Retrospective cohort from a regional data system	NA	<29 Control group	NA	≥29	22.7	aOR: 1.66 (1.51-1.82)	Maternal age, parity, hypertension, diabetes, birth weight, excluded multiple gestations and previous.
Cnattingius et al,[147] 1998 1992-1993, Sweden	92,623 nulliparous women with singleton birth	Retrospective cohort study from Swedish Birth Registrar	20-24.9 Control group	25-29.9		≥30	11.9	aOR: 2.4 (2.1-2.7) emergency CS in BMI≥30 was aOR:2.7 (2.3-3.0)	Maternal age, height, country of birth, education and type of hospital.
Kaiser et al,[125] 2001 1994-1998, US	1881 Pregnant women	Retrospective cohort from medical midwifery clinics	≤19.7	19.8-26.0 Control group	26.1-28.9	≥29	5.1	aOR: 3.99 (2.0-7.95) p<0.001)	Maternal race (black), marital status, age> 35 primigravidity, very low birth weight, parity, failure to progress and pre-eclampsia.

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m²)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Baeten et al,[74] 2001 1992-1996, US	96,801 Singleton births of nulliparous pregnant women	Prospective cohort from state birth certificate records	<20 Control group	20-24.9	25-29.9	≥30	NA	aOR : 2.9 (2.7-3.1)	Maternal age, marital status, education, smoking, prenatal care, payer prenatal care, excluded diabetes and hypertension.
Sebire et al,[8] 2001 1989-1997, UK	287,213 singleton deliveries	Retrospective cohort from a maternity ward database	<20 Excluded from further analysis	20-25 Control group	25-30	>30	20	OR: (99% CI) Emergency CS OR:1.83 (1.74-1.93) Elective CS OR:1.72 (1.62-1.83)	
Kumari, 2001[82] 1996-1998, United Arab Emirate	188 singleton deliveries	Retrospective study from maternity units	NA	22-28 Control group		Morbid Obese >40	19.1	OR: 2.3 (1.4-3.9; p<0.001) Emergency CS OR: 1.6 (0.8-3.1; p<0.2). Elective CS OR: 3.4 (1.5- 7.8; p<0.01)	

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/Study period/Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Young et al,[129] 2002 1993-2001, US	3,375 Primparous women who delivered in a private practice	Retrospective cohort from private obstetric practice	<20 Control group	20-25	25-30	>30	21.7	OR: 3.3 (3.0-3.5)	
Rosenberg et al,[130] 2003 1998-1999, US	213,208 Live birth singleton deliveries	Retrospective cohort from state birth certificate file	<45kg	45- 67kg Control group	68-90kg	91- 135kg Severe obese ≥136kg	NA	aOR: 2.1 (2.0-2.2)	Maternal age, ethnicity or race, marital status, mother's education, parity and smoking.
Jensen et al,[97] 2003 1992-1996, Denmark	2,495, women underwent screening for GDM using oral glucose tolerance tests	Prospective cohort from University hospital clinics		18.5-24.9 Control group	25-29.9	≥30	22 in obese	OR: 2.7 (1.9-3.8)	Ethnic group, age, smoking, gestational age, glucose tolerance, screening indicators for GDM, previous macrosomic infants, previous stillbirth

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Weiss et al,[16] 2004 2004, US	16,102 patients: 3,752 control group, 1,473 obese, 877 morbidly obese patients	Prospective Multicentre database study		<30 Control group		30-34.9 Morbidly obese ≥35	22.7	aOR: 1.7 (1.4-2.2)	Age, ethnic origin, parity, gestational age, education, marital status, birth weight, assisted reproductive technology.
Sheiner et al,[13] 2004 1988-2002, Israel	1,769 Singleton deliveries	Retrospective cohort from university hospital perinatal database		<30 Control group		≥30	27.8	OR: 3.2 (2.9-3.5, p<0.001)	
Ehrenberg et al, 2004[133] 1997-2001, US	12,303 Singleton deliveries	Retrospective cohort from medical centre	<19.8	19.8-25 Control group	25-30	>30	NA	OR:2.5 (1.68-3.71)	

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Cedergren M I,[96] 2004 1992-2001 Sweden	610,969 singleton pregnancies	Prospective cohort study from National Birth Registry		19.8-26 Control group		29.1-35 severely obese 35.1-40 Morbidly obese >40	NA	aOR: 2.69 (2.49-2.90)	Age, parity, smoking, year of birth, maternal education (1992-1995), excluded pre-existing hypertensive and insulin dependent DM.
Usha Kiran et al,[66] 2005 1990-1999, UK	8,350 primigravid with a singleton, uncomplicated pregnancy	Retrospective cohort from city birth survey		20-30 Control group		>30	NA	OR: 1.6 (1.4-2) Emergency CS OR: 2.0 (1.2-3.5).	
Dempsey et al,[19] 2005 1996-2000, US	738 Nulliparous deliveries	Prospective cohort study	<20 Control group	20-24.9	25-29	≥30	26.0	aRR: 3.05 (1.80-5.18)	Height, race, and maternal age.

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Vahratian et al,[116] 2005 1995-2002, US	641 nulliparous term pregnancies	Prospective cohort study from medical records in prenatal clinic	NA	19.8-26.0 Control group	26.1-29	>29	31.4	aRR: 1.5 (1.05, 2.0)	
Robinson et al,[9] 2005 1988-2002, Canada	142,404 singleton pregnancies	15 years Retrospective cohort study from perinatal database		55-75kg Control group	90-120kg Moderate obese	>120kg Severe obese	30.6	aOR: 1.60 (1.66-1.83) for moderate obese	Maternal age, marital status, smoking, parity, and socio-economic status.
Rode et al,[139] 2005 1998-2001, Denmark	8,092 pregnancies with single cephalic delivery at ≥37 weeks gestation	Prospective cohort from hospital clinics		<25 Control group	25-29.9	≥30	21.5	OR: 1.7 (1.3-2.2) OR: 3.4 (2.8–4.2) emergency CS in nulliparous. OR: 4.0 (3.0 –5.3) Elective CS in multiparous	

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m²)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Dietz et al,[106] 2005 1998-2000, US	24,423 nulliparous women with singleton term infant, ≥37 weeks	Retrospective cohort study based on a multistate surveillance system from birth certificates	<19.8	19.8-26.0 Control group	26.1-29.0	>29 Very obese ≥35	22.0	aRR: 1.5 (1.1-2.1)	Age, education, race, marital status, medical recipient, maternal height, birth weight, gestational age, DM, GDM, hypertension during pregnancy.
Graves et al,[78] 2006 1998-2000, US	1,500 pregnant women	Retrospective cohort study from two midwifery practices	<19.8	19.8-26.0 Control group	26.1-29	>29	7.8, Emergency CS (10.6%) in obese nulliparous compared to (7%) multiparous.	OR: 2.5 (1.6-3.9)	

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Barau et al,[141] 2006 2001-2005, France	16,952 consecutive singleton live births	Prospective cohort from maternity hospital	10-14	15-19.9 Control group		30-34.9	17.2	OR: 2.37 (2.02-2.77)	
Callaway et al,[73] 2006 1998-2002, Australia	11,252 Included singleton pregnancy	Retrospective cohort study from tertiary maternity hospital	≤20 excluded	20.1-25.0 Control group	25.1-30	30.1-40 Obese	NA	aOR: 2.54(1.94-3.32)	Maternal, age, educational level, smoking, parity and ethnicity.

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Doherty et al,[123] 2006 2006 US	2,827 singleton pregnancy (16-18)weeks gestation	Data recruited from RCT between 16-20 weeks gestation	<18.5	18.5-25 Control group	25-30	>30	19.0	OR: 2.26 (1.63-3.13; p<0.001) aOR: 2.22 (1.58-3.12, p<0.001)	Maternal age and parity.
Bhattacharya et al,[7] 2007 1976- 2005, UK	24,241 Nulliparous women delivering singleton babies	Retrospective cohort study from maternity and neonatal databank	<20	20-24.9 Control group	25-29.9	30-34.9 Obese >35 Morbidly obese	30.8 CS rate in obese	aOR in obese 2.0 (1.8-2.3) emergency CS 1.4 (1.0-1.8) elective CS	Just mentioned potential confounders were adjusted for using logistic regression.
Bergholt et al,[17] 2007 1995- 2000, UK	4,341 nulliparous women, single cephalic presentation	Prospective cohort study from general hospital		<25 Control group	25-30	30-35 Obese >35 Morbidly obese	18.5	aOR: 1.9 (1.3-2.8) BMI>35, aOR: 3.8 (2.4-6.2).	Maternal, age, birth weight, gestational age, height, oxytocine use and epidural analgesia.

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Sahu MT et al,[20] 2007 2005- 2006, India	380 women with singleton pregnancies	Prospective cohort evaluation from a tertiary hospital.	<19.8	19.9-24.9 Control group	25-29.9	≥30	NA	RR: 2.3 (1.2-4.5, p<0.01)	Obese pregnant women were more likely to deliver by CS.
Abenhaim et al,[138] 2007 1987-1997, Canada	18,643 deliveries	Retrospective cohort from database on all deliveries in 10 years.	<20	20-24.9 Control group	25-29.9	30-39.9 Morbidly obese ≥40	NA	aOR: 1.85 (1.62-2.11)	Maternal; age, smoking, parity, pre-existing diabetes.
Druil et al,[81] 2008 1 January- 31 August 2006, Italy	916 consecutive singleton gestations	Retrospective cohort from maternal and perinatal database.	<18.5	18.5-24.9 Control group	25-29.9	>30	NA CS rate in obese women was 56.9%	OR: 2.17 (1.21-3.89, p=0.009)	

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Leung et al,[143] 2008 1995-2005, Hong Kong	29,303 Pregnant women delivered singleton babies	Retrospective study from university obstetric unit	<18.5	18.5-22.9 Control group Lower normal 23-24.9 Upper normal	25-27.4 Pre-obese I 27.5-29.9 Pre-obese II	≥30 Obese	7.8 In obese	aOR: 2.42 (2.02-2.91) aOR: 2.68 (2.20-3.27) After excluding cases of previous CS	Year of delivery, maternal age, parity, gestation at booking, previous CS and DM.
Roman et al,[148] 2008 1994-2004, US	6,949 low risk women delivering a singleton at term	Historical cohort study		18.5-24.9 Control group	25-29.9	30-34.9	13.3	OR: 9.3 (6.6-13.2, p<0.001)	Nulliparous women had a significant higher risk of CS due to dystocia than other reasons.

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m²)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Lynch et al,[136] 2008 2001-2003, Ireland	5,162 deliveries for primigravid and multigravid women	Retrospective cohort from antenatal clinic in a tertiary referral centre	≤19.8	19.81-25.9 Control group	26-29.9	30-34 Obese ≥35 Morbidly obese	NA	Obese primigravid emergency CS, RR: 2.16: (1.72 - 2.73), multigravid obese women, RR: 1.97 (1.45- 2.67)	
Briese et al,[142] 2008 1998-2000, German	243,571 primiparous women	Retrospective cohort study from German perinatal statistics		18.5-24.9 Control group		≥30	45.7% CS rate in obese women aged >32 years	aOR: 2.23 (2.15- 2.30, p<0.001)	Age, smoking status, single mother status, maternal education.

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Liu X et al, [144] 2009 2007-2009, China	5,047 Singleton nulliparous pregnancies	Retrospective cohort from three hospital database	<18.5	18.5-24 Control group	24-28	≥28	CS rate in obese was 69.9%	aOR: 2.5 (2.0-3.2)	Maternal, age, education.
Khashan et al,[134] 2009 2004-2006, UK	Mothers of 99,403 singleton, live born or still born infants	Retrospective cohort from perinatal survey database	<18.5	18.5-24.9 Control group	25-29.9	30-40 Obese >40 Morbidly obese	NA	aRR: 1.66 (1.61-1.71)	aRR for emergency CS in obese women; 1.59 (1.45-1.75). 37% of BMI data were missing in this study.

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m²)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Kominiarek et al,[149] 2010 2002-2008, US	124,389 deliveries, singleton, ≥37 weeks gestation, live born, cephalic presentation	Retrospective cohort based on data from Consortium on Safe Labour database	<25 Control group	25-29.9	30-34.9	≥40	14.0 Obese women had 29.6% CS	aRR: 1.96 (1.84-2.09)	Maternal, age, race, parity, gestational age, short stature (height<1.50), pre-gestational diabetes, previous CS, parity, cervical dilatation on admission.
Mantakas et al, [135], 2010 2001-2008, UK	6,509 singleton, nulliparous women	Retrospective cohort from hospital maternity database	<19.9	20-24.9 Control group	25-29.9	30-40 >40 Morbidly obese	NA	RR: 1.6 (1.4-1.7) Emergency CS in obese, RR: 1.7 (1.5-1.9).	

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Athukorala et al, [15] 2010 2001-2005, Australia	1661 Nulliparous women with singleton pregnancy 14-22 weeks gestation	Secondary analysis for data from RCT		18.5-24.9 Control group	25-29.9	30-34.9	36.4% CS rate in obese	RR: 1.63 (1.34-1.99, p<0.0001) Emergency CS RR: 1.77 (1.40-2.23, p<0.0001).	
Ovesen et al, [140] 2011 2004-2010, Denmark	369,347 Danish pregnant women with singleton delivery	Retrospective cohort from medical birth registry	<18.5	18.5-24.9 Control group	25-29.9	Obese 30-34.9 Severe obesity ≥35	NA	emergency CS: aOR: 1.73 (1.67-1.80). Elective CS aOR: 1.29 (1.24-1.34).	Maternal, age, smoking during pregnancy, birth weight, gestational age, GDM and sex of the fetus.

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Saereepornchare nkuli, K,[145] 2011 January 2009-December 2009, Thailand	3,715 deliveries	Retrospective cohort from maternal and perinatal database	<18.5	18.5-24.9 Control group	25-29.9	≥30	CS rate in obese 52.5%	OR: 2.11 (1.53-2.90, p<0.001)	
Dodd et al,[137] 2011 2008, South Australia	11,233 out of 19,672 pregnant women with a valid BMI and singleton pregnancy	Retrospective cohort from Pregnancy Outcome Unit's population database	<18.5	18.5-24.9 Control group	25-29.9	30-34.9, Obese I, 35-39.9, Obese II, ≥40 Obese III	NA	aRR: 1.36 (1.20-1.53) emergency CS. aRR 1.55 (1.35-1.78). elective CS	Maternal, age, parity, smoking status, hospital status, onset of labour and mode of birth.

Table 3-3: (continued) Overview of studies investigating the relationship between body mass index and caesarean section

Citation/ Study period/ Setting	Population	Study type/ data source	BMI definition (kg/m^2)				Overall caesarean section rate (%)	Caesarean section result for obese vs control	Variables adjusted for (confounders)
			Underweight	Recommended BMI	Overweight	Obese			
Alexandra et al, [146]2011 1983 & 1998 Greece	18,752 mother-infant pair; 7,208 from the 1st National Perinatal Survey and 11,544 from the 2nd NPS	Prospective cohort, data derived from National Perinatal Survey	<18.5	18.5-24.9 Control group	25-29.9	≥30	CS rate in obese was 34.4%	aOR: 1.87 (1.17-2.99, p<0.009	Age, education, place of residence, parity, smoking, history of pre-eclampsia, stillbirth, toxaemia, birth weight and fetal presentation.

CS: Caesarean section

OR: odds ratio

aOR: Adjusted odds ratio

RR: Risk ratio

aRR: Adjusted risk ratio

BMI: Body mass index

NA: Not available

DM: diabetes mellitus

GDM: Gestational diabetes mellitus

≥: More than or equal

3.6 Systematic reviews investigating the association between maternal obesity and caesarean section

Two systematic reviews assessing the association between BMI and caesarean section were also published during this time period.[10, 14] The first systematic review [10] included 33 studies and the second systematic review included eleven studies[14] (Table 3-4).

The aim of the first published systematic review and meta-analysis by Chu et al, 2007[10] was to provide a quantitative estimate of the association of obesity and the risk of caesarean section for the study years 1980 to 2005. Thirty-three studies were included in the meta analysis, and the inclusion criteria for the studies were; BMI was measured or self-reported pre-pregnancy or during the first trimester or at the first prenatal visit, and that there was a comparison group of recommended weight women. In addition, the data had to be presented as tables or figures or as a text that allowed for quantitative measurement of obesity and risk of caesarean delivery. Only cohort studies were included and the outcome was caesarean section, both elective and emergency. Among the included studies there were; 16 studies from the US [19, 23, 74, 106, 116, 125, 128, 129, 150-157], each five from France[121, 158-161] and Denmark [97, 139, 162-164], two from Sweden [96, 165] and one each from Israel[166], Canada[167], UK[8], Poland[168] and the United Arab Emirates.[82] Eleven studies[19, 74, 97, 116, 139, 152-154, 162, 163, 169] were prospectively designed. The prevalence of caesarean delivery varied among recommended weight pregnant women in the studies; ranging from 2.1% to 40.3%.[10]

The risk of caesarean section was about two to three times higher among obese and severely obese compared to recommended weight pregnant women in this meta-analysis.[10] The unadjusted ORs of a caesarean delivery were 1.46 (95% CI: 1.34-1.60), 2.05 (95% CI: 1.86-2.27) and 2.89 (95% CI: 2.28-3.79) among overweight, obese and severely obese women respectively, compared to the normal weight pregnant women.

This review was limited to one literature database (PubMed) for searching for studies. Due to differences in weight/BMI categories among the included studies in the review, there was some misclassification in BMI categories. If the result highly significant, the finding might be biased or caused significant heterogeneity in the meta-analysis model[10] (Table 3-4).

The second study was a systematic review and meta-analysis [14] which aimed to quantify the risk of overweight and obesity as independent risk factors for planned and unplanned caesarean delivery in nulliparous and singleton pregnancies. The review searched a number of databases from 1966 to May 2007. Eleven studies were included in the review.[7, 17, 66, 74, 106, 116, 129, 141, 147, 164, 170]

All of the studies were cohort studies, and only three included studies were prospective in design. The review compared caesarean delivery rates in overweight, obese and morbidly obese pregnant women with normal weight pregnant women. The inclusion criteria were primary studies of any design that assessed the association between increased BMI during pregnancy and the risk of caesarean delivery. Multiple pregnancies, women with complications, caesarean deliveries associated with other health outcomes, such as diabetes and hypertension, were excluded. As with the other review, this review found that increasing BMI increases the caesarean section rate.[14] The review found that the risk of caesarean delivery in nulliparous, singleton pregnancies is increased; the crude pooled ORs (95% CI) for caesarean section in overweight, obese and morbidly obese, were 1.53 (95% CI=1.48, 1.58), 2.26 (95% CI= 2.04, 2.51) and 3.38 (95% CI= 2.49, 4.57) respectively. Among the included studies in this review,[14] only four studies[7, 66, 116, 147] investigated emergency and elective caesarean section delivery rates among overweight and obese women. The review found that both types increased with increasing BMI, but the risk of emergency caesarean section was slightly higher than elective caesarean section.[14] The review by Poobalan et al[14] showed the unadjusted ORs for both emergency caesarean section; 1.64 (1.55-1.73) in overweight and 2.23 (2.07-2.42) in obese, and elective caesarean section in overweight was 1.32 (1.21-1.45) and 1.87 (1.64-2.12) in obese respectively.[14] Both reviews[10, 14] presented their results as crude ORs because most of the studies included in the meta-analysis did not present their results as adjusted ORs.

Both reviews[10, 14] included cohort studies with no language restriction. The review by Poobalan et al, 2009[14] included only primary studies that assessed the association between increased BMI during pregnancy and caesarean section in nulliparous women with singleton pregnancies,[14] and excluded the studies in multiparous women or the studies with mixed group which were no separate analysis were conducted for nulliparous. In addition, multiple pregnancies and pregnant women with comorbidities, and studies reporting associations between caesarean section and other health outcomes (diabetes, hypertension) were excluded. This review had very restrictive inclusion criteria; therefore there was only an overlap with five studies with the first review, [74, 106, 116, 129, 164] while there were six new studies in the second review which were not included in the first review. [7, 17, 66, 70, 141, 171]

Both reviews showed a two fold increase risk of caesarean section among obese pregnant women and their results were consistent, although the second review[14] only included nulliparous women. However, the second review [14] added further results on the impact of obesity on elective and emergency caesarean delivery by showing that the increased risk of caesarean delivery with increasing BMI is greater for emergency caesarean section.

Table 3-4: Summary of the main characteristics from two recent systematic reviews

Author/ Study year	Included studies	Aim	Outcome	Result
Chu et al, [10] 2007	33 cohort studies	Provide a quantitative estimate of the association between maternal obesity and risk of caesarean deliveries.	Caesarean section was the outcome measure assessed.	ORs of caesarean delivery were: 1.46 (1.34-1.60) among overweight, 2.05 (1.86-2.27) among obese, 2.89 (2.28-3.79) among severely obese women.
Poobalan et al,[14] 2009	11 cohort Studies	Quantify the risk of overweight and obesity as independent risk factors for planned and unplanned caesarean delivery in nulliparous and singleton pregnancy.	Emergency and elective caesarean section	ORs for caesarean delivery were 1.53 (1.48-1.58) among overweight, 2.26 (2.04-2.51) among obese, 3.38 (2.49-4.57) among morbidly obese.

The current review included 41 studies. Only 14 studies were overlapped with the first systematic review by Chu et al 2007.[10] The remaining 19 studies were not included as they did not meet my inclusion criteria. While only one study from second review not included in the current review as it did not meet my inclusion criteria.

In general when comparing the studies in the current review in (Table 3-3) and the included UK studies, and the results from the two systematic reviews,[10, 14] the results consistently show that the risk of caesarean section is almost two to three fold higher among obese and morbidly obese women and being underweight is protective for delivering by caesarean section. Moreover, the risk of emergency caesarean section is more than that for elective and it is more among primiparous women. The most common reasons for caesarean section are fetal distress or failure to progress (dystocia) with cephaopelvic disproportion, while the most common reasons for elective caesarean section is previous caesarean section, or malpresentation. Furthermore, the studies showed that the risk of caesarean section can increase due to increasing birth weight >4kg (macrosomia) and having other complications such as pre-eclampsia and GDM.

3.7 Mechanism for association between body mass index and caesarean section

Obesity is a modifiable risk factor, and the biological pathway through which obesity affects the labour process is not well understood. [106] Some studies have suggested that obesity increases maternal pelvic soft tissue which narrows the diameter of the birth canal and increases the risk of dystocia.[125, 128, 129] Other reasons suggested are a macrosomic infant, cephalopelvic disproportion,[13, 66] differences in labour progression among obese women and their response to oxytocine.[72] Obesity can affect the risk of caesarean section by increasing the risk of other complications such as GDM and hypertensive disorders.[9, 73] However, it has been suggested by some studies,[125, 172] and found by Chu et al[10] in the systematic review, that there is an increased risk of caesarean section among obese women with or without GDM. Therefore, overweight and obesity during pregnancy should be considered as a risk factor for caesarean section regardless of other complications.

In an attempt to try to further understand this relationship, I have drawn a simple direct acyclic graph (DAG), or causal diagram, to demonstrate the mechanism underlying the association between high BMI (exposure) and the increasing risk of caesarean section (outcome) among overweight and obese pregnant women (see Figure 3-2).

To identify a relationship between an exposure and an outcome, it would be helpful to draw a cause-effect diagram which is a graphic tool that helps identify, sort, and display possible causes of a problem. The benefit of using this diagram is to help in demonstrating the root causes of a problem. [173]

Figure 3-2 shows the diagram for the effect of high early pregnancy BMI on the risk of caesarean section. The figure illustrates a direct relationship between high BMI and caesarean section. In addition, maternal age, ethnicity, education, socio-economic status and parity are potential confounders for the increasing risk of caesarean section among overweight and obese women. Maternal age can play an important role in the progression of labour in nulliparous women, particularly women aged 32 years or over and can lead to caesarean delivery[142]. Obese, older, pregnant women with poorer education and from minority ethnic groups have a higher risk of delivery by caesarean section. [73,156]

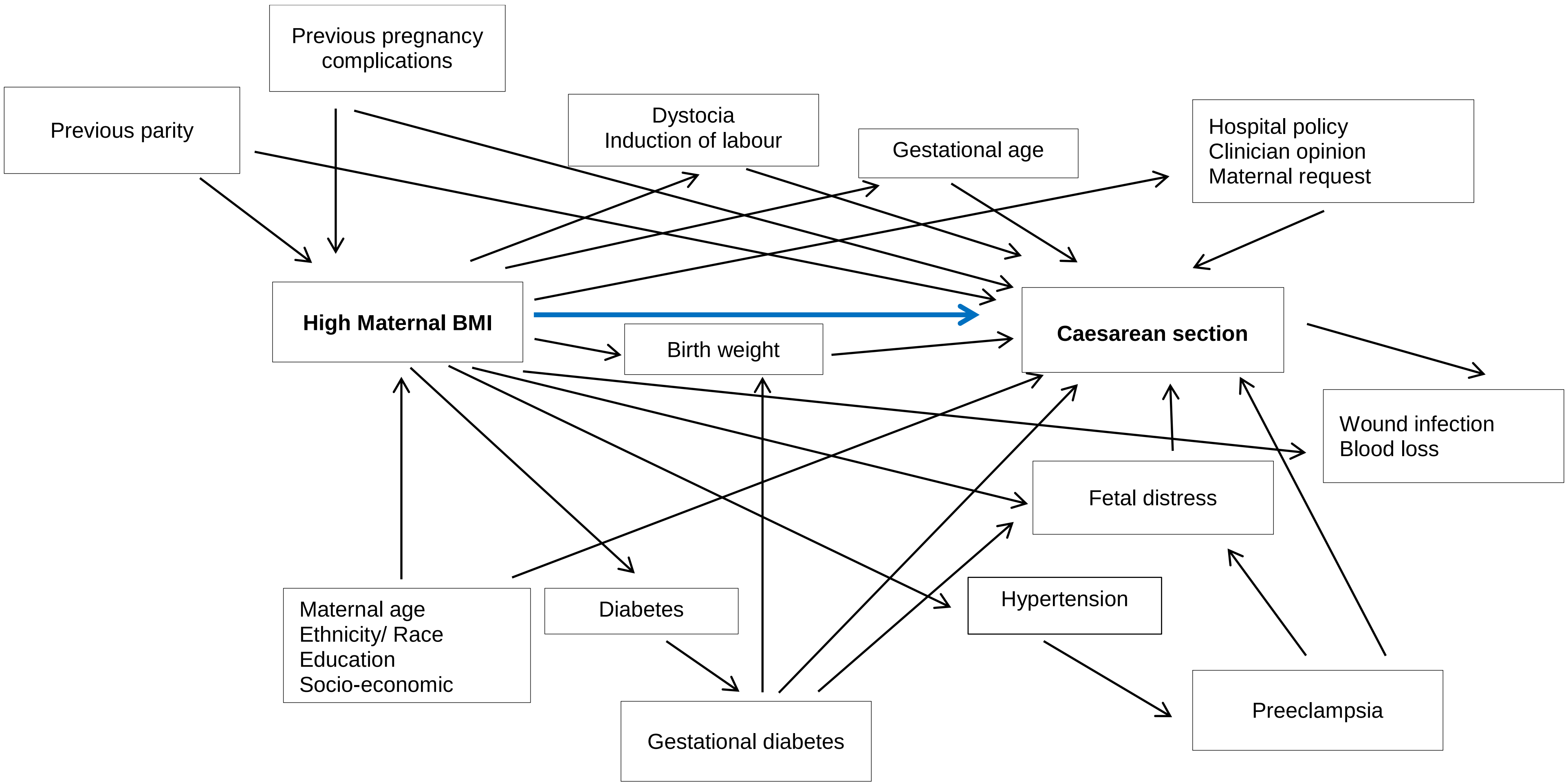
Birth weight may be viewed as an intermediate factor. Birth weight >4kg is more common among obese and morbidly obese women compared to women with recommended BMI. Increasing maternal BMI will increase the risk of increasing fetal size and increase the risk of a delivery by caesarean section.[7, 8, 16] Having a macrosomic infant increases the risk for cephalopelvic disproportion and fetal distress which can lead to delivery by caesarean section.[82, 129]

Pre-eclampsia and GDM are shown as being on the causal pathway in the diagram. The literature has shown an increased risk of pre-eclampsia and GDM with pre-pregnancy BMI, [96, 130 81], which in turn increases the risk for complications during labour and deliver by caesarean section.[116] However, the association between BMI and caesarean section remains significant even after controlling for these factors.[13]

Obese women are more likely to be induced due to failure to progress, particularly in the first stage of labour.[8] Studies suggest that this may result from soft tissue deposits in the pelvis of obese women which leads to the need for more time for stronger contractions to progress through labour.[10, 14, 116]

This diagram shows the possible association between pre-pregnancy BMI and caesarean section. Obesity exerts a significant influence on the mode of delivery, independent of other risk factors such as pre-eclampsia, GDM and macrosomia.

Figure 3-2: Direct acyclic graph showing the causal pathway between body mass index and caesarean section



3.8 Conclusion

Existing international literature suggests that there is a significant association between maternal obesity and caesarean section, although there have only been six studies within a UK setting.

To further investigate this association in the UK obstetric population, I will investigate the association between maternal BMI in early pregnancy and caesarean section by using data from five hospitals in the North East of England in the next chapter.

CHAPTER FOUR

NORTH EAST FIVE HOSPITALS

COHORT STUDY

Chapter 4. North East Five Hospitals Cohort Study

4.1 Introduction

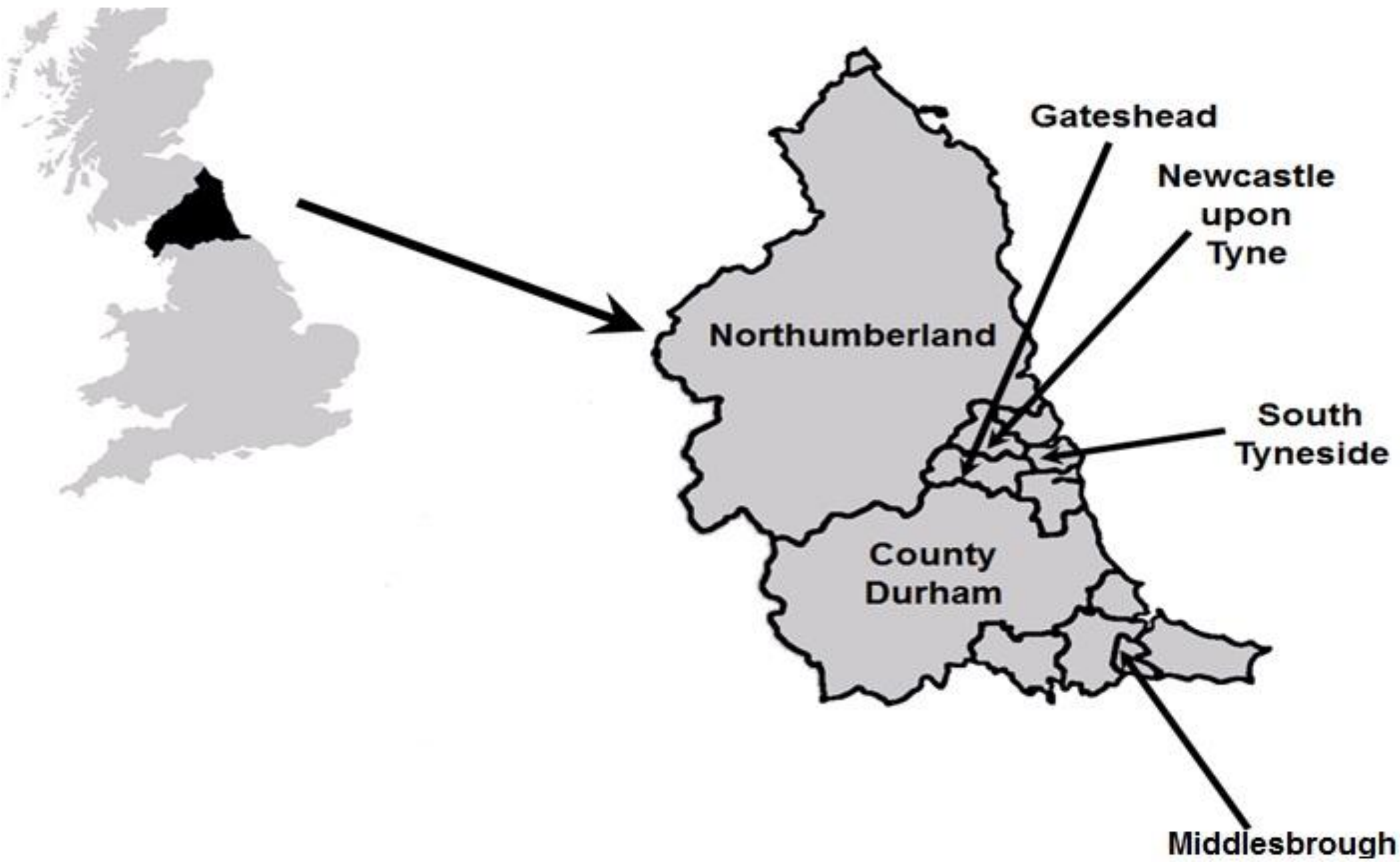
In this chapter, I am going to present the results of analyses using existing data from five maternity hospitals in the North East of England to investigate the association between maternal pre-pregnancy BMI and caesarean section. This study will examine the independent impact of maternal BMI on caesarean section adjusting for potentially confounding variables including maternal age at delivery, gestational age at delivery, birth weight, ethnicity and socio-economic status in overweight and obese pregnant women compared to women with recommended BMI. The results of this cohort study will provide accurate overweight and obesity prevalence rates among the North East of England obstetric population, as well as provide estimates of the caesarean section rate among the five hospitals in this region.

4.2 North East of England

4.2.1 Background

The setting of this study was the North East of England (UK), which is one of nine health regions in England at the time of writing. This region covers an area of 8,573 square kilometres from the Scottish border south to North Yorkshire. This region is divided into four sub regions areas and local authorities; Northumberland in the north of the region which has six districts, Tyne and Wear in the east which has five districts, County Durham in the south which has six districts and Tees Valley in the south east of the region which has five unitary authority areas (Figure 4-1).[174] The region has a population of 2.6 million in mid-2008 [175] and approximately 30,000 deliveries per year with over 80% of the population living in urban areas. [176,177] The largest city in the region is Newcastle upon Tyne with a population of 274,000. The region has eight NHS hospital Trusts and nineteen hospitals of which seven are general hospitals, eight are community hospitals, and four are University hospitals.[178]

Figure 4-1: Map of the North East of England and the areas covered by the Five Hospitals Cohort Study



4.2.2 Hospitals in the North East of England

There are 16 maternity units in the North East of England; six of these units are midwifery-led units and 10 units are consultant- led. In addition, there are four neonatal intensive care units and five special care baby units.[179]

4.2.3 North East Five Hospitals Cohort Study

A study undertaken by Heslehurst et al in 2007[118] showed that maternal height and weight had been recorded in 16 maternity units in the NHS Trusts in the North East region of England since 1975. Only five of these units (Royal Victoria Infirmary (RVI), Newcastle; Queen Elizabeth Hospital, Gateshead; University Hospital of North Durham, Durham; South Tyneside District Hospital, South Shields; James Cook University Hospital, Middlesbrough) stored this information electronically at that time. These five units cover over 42% of all births in this region. These five hospitals were chosen for a study of maternal BMI and pregnancy outcome because of the availability of electronic data.[118] Data for the years 2003-2005 were used in this study (Table 4-1).

4.2.4 Royal Victoria Infirmary, Newcastle upon Tyne

The RVI has a consultant-led maternity unit and is part of the Newcastle upon Tyne Hospitals NHS Foundation Trust. This hospital is a tertiary referral centre for the region. The maternity unit had between 4,859- 5,176 births at the time of the study [180-182] and provides a full range of maternity services including antenatal clinics and pregnancy assessment [180, 183, 184] .

4.2.5 University Hospital of North Durham, Durham

This hospital has been opened since 2001, with 2,230-2,512 births per year during the study period. [181, 182] This hospital is operated by County Durham and Darlington NHS Foundation Trust. The maternity unit is consultant-led and provides a full range of maternity care services[185].

4.2.6 James Cook University Hospital, Middlesbrough

This hospital is part of the South Tees Hospitals NHS Foundation Trust. It provides maternity services to approximately 3,800 women[182] and their families every year in the South Tees area of Tees Valley, with 3,560-3,714 annual births. [181, 182] This hospital provides specialist (tertiary) services, has a neonatal intensive care unit and supports a neonatal transport service.[184, 186]

4.2.7 Queen Elizabeth Hospital, Gateshead

Queen Elizabeth Hospital is run by Gateshead Health NHS Foundation Trust. The maternity unit of this hospital is consultant- led. [187,184] This hospital had about 1,620-1,682 births during the study period [181, 182, 188] and has acute hospital services for a population of around 200,000 [189] in Gateshead and the surrounding area.

4.2.8 South Tyneside District Hospital, South Shields

This hospital was established as an NHS Trust in 1993 to provide community and hospital services to the people of South Tyneside and surrounding areas, and it is run by the South Tyneside NHS Foundation Trust. This hospital is consultant-led with approximately 1,400 births annually at the time of the study. [181, 182 190]

Table 4-1: Overview of hospitals in the North East Five Hospitals Cohort Study

Hospital	Number of births per year during study period	Number of beds	Geographical area served
Royal Victoria Infirmary (RVI), Newcastle	4,859-5,176	673	Newcastle and North East
James Cook University Hospital, Middlesbrough	3,560-3714	988	South Tees Valley
University Hospital of North Durham, Durham	2,230-2,512	591	County Durham and Darlington, Sunderland and South Tyneside
Queen Elizabeth Hospital, Gateshead	1,620-1,682	693	Gateshead
South Tyneside District Hospital, South Shields	1,400	394	South Tyneside area

4.3 Aim

The aim of this study is to investigate the association between BMI in early pregnancy and caesarean section.

The specific objectives of this study are:

1. To identify caesarean section rates among five hospitals in the North East of England.

2. To describe the caesarean section rate in these hospitals, and overall by BMI.

3. To investigate the relationship between BMI in early pregnancy and the rate of caesarean section in overweight and obese pregnant women compared to pregnant women with recommended BMI.

4. To examine the independent impact of BMI on caesarean section adjusting for potentially confounding variables including maternal age at delivery, gestational age at delivery, birth weight, ethnicity and socio-economic status in overweight and obese pregnant women compared to women with recommended BMI.

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4.4 Materials and methods

4.4.1 Data sources

The data used in this study were derived from that used in another project investigating maternal BMI and pregnancy outcome. Electronic data from each of the five maternity units was transferred by the information department staff in the five maternity units to researchers in the Institute of Health and Society at Newcastle University. In accordance with research governance procedures, all identifiable data were removed before transfer to the project team. Permission for me to use the data to investigate the association between BMI and caesarean section was granted from the Northumberland Research Ethics Committee (07/Q0902/2) on the 16 April 2009 (see appendix III).

4.4.2 Inclusion and exclusion criteria

Data on all singleton pregnancies resulting in a live birth (delivery of an infant showing signs of life, such as respiration, heartbeat and voluntary movement of the muscle) or stillbirth (delivery of a fetus showing no signs of life at 24 or more completed weeks of gestation), booked and delivered in the five maternity units between 01 January 2003 and 31 December 2005 were included in this study. Multiple pregnancies (a pregnancy of more than one fetus in the uterus) were excluded as they are known to have higher caesarean section rates than singleton pregnancies.[191] Late miscarriages (the spontaneous loss of a fetus at 20-23 completed weeks of gestation) and terminations of pregnancy for fetal anomaly were also excluded. The study included singleton pregnancies resulting in a live birth or stillbirth.

4.4.3 Maternal pre-gestational diabetes

Information on maternal pre-gestational diabetes status was derived from the Northern Survey of Diabetes in Pregnancy (NorDIP).[192] The NorDIP is held at the Regional Maternity Survey Office (RMSO) in Newcastle upon Tyne. It is a collaborative survey of all pregnancies in women with diabetes diagnosed at least six months before the index pregnancy. NorDIP coordinators in each hospital notify pregnancies in women with pre-gestational diabetes, and data collection is undertaken by clinicians within the unit. [192]

4.4.4 Data manipulation

After receiving the data, I ran frequencies on the variables, and then made some changes to re-categorise some data variables (see appendix IV). For example, for the mode of delivery variable, the categories; spontaneous vertex, breech, cephalic, forceps, ventouse, and others were combined to create a spontaneous and/or assisted deliveries category. Elective caesarean section and emergency caesarean section were combined to give a caesarean section variable (see appendix IV). For the ethnicity variable, I combined Mixed, Asian or Asian British, Black or Black British and other ethnic group into one category 'Non-White' as more than 83% of the sample was White (see appendix IV).

The exposure variable was BMI and it was categorised according to the WHO classification.[193] as: underweight <18.5kg/m^2, recommended BMI 18.5-24.9kg/m^2, overweight BMI 25-29.9kg/m^2 and obese BMI≥30kg/m^2 (see Table 2-1). Maternal age was categorised into five groups: <20 years, 20-24 years, 25-29 years, 30-34 years and ≥ 35 years. Gestational age was divided into two groups; preterm (<37 weeks gestational age) and term (≥ 37 weeks). Birth weight was categorised into five groups; <2.5kg, 2.5-2.99kg, 3-3.49kg, 3.5-3.99kg and ≥ 4kg. The Index of Multiple Deprivation (IMD), a UK census-derived area-based measure of socio-economic deprivation, was determined from the mother's residential postcode at booking. The IMD is based on seven census domains: income deprivation, employment deprivation, health deprivation and disability, education, skills and training deprivation, barriers to housing and services, living environment deprivation, and crime.[194] IMD was divided into three tertiles; most deprived, moderate deprived and least deprived. The pre-gestational diabetes variable was dichotomised into Yes and No. Parity was grouped into primipara and multipara.

4.4.5 Data analysis

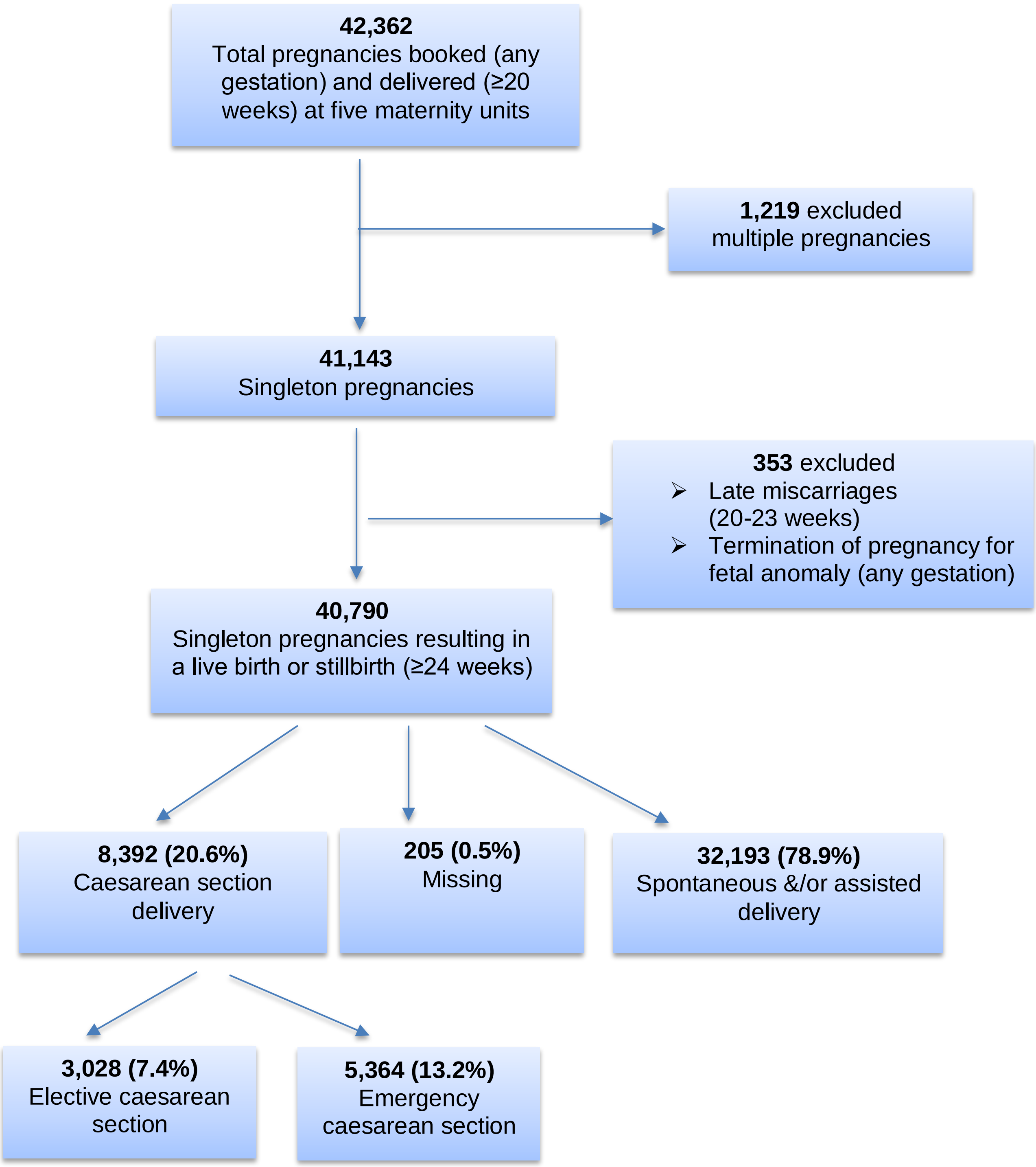
I used frequency and percentages to show the distribution of the study variables. Cross tabulation was used to show the comparisons between key study variables. Variables were treated as categorical to account for potentially non-linear relationships. Unadjusted odds ratios (ORs), adjusted odds ratios (aORs) and 95% confidence intervals (CIs) were estimated using maximum likelihood logistic regression models which compared the risk of a caesarean delivery among overweight and obese women with women with recommended BMI. Adjusted models included maternal age at delivery, gestational age at delivery, birth weight, ethnicity, IMD and maternal history of pre-gestational diabetes to find the association between maternal overweight, obesity and caesarean section. Interactions between parity and BMI were examined by the addition of cross product terms. The analyses comprised all individuals with complete data on maternal BMI, thus 10,177 (24.9%) with missing BMI were excluded. Individuals with incomplete data for other variables were also excluded when that variable was included in the analysis. The statistical package SPSS 17.0 was used for all data manipulation and statistical analysis and a p value less than 0.05 ($p<0.05$) was considered statistically significant.

4.5 Results

4.5.1 Total sample

The total number of pregnancies booked and delivered at the five maternity units during the study period (2003-2005) was 42,362 pregnancies. After excluding multiple pregnancies, late miscarriages and terminations of pregnancy for fetal anomaly, a total of 40,790 singleton pregnancies resulting in a live birth or stillbirth remained. Of these, 8,392 (20.6%) pregnant women were delivered by caesarean section. 3,028 (7.4%) were elective caesarean sections, 5,364 (13.2%) were emergency caesarean sections. 32,193 (78.9%) were delivered by spontaneous and/or assisted delivery (spontaneous vertex, breech, cephalic, forceps, ventouse and others) with 205 (0.5%) missing values for mode of delivery (Figure 4-2).

Figure 4-2: Flow chart showing the derivation of the North East Five Hospitals Cohort Study sample



4.6 Descriptive statistics

4.6.1 Maternal-fetal characteristics

Table 4-2 shows the characteristics of those women in the sample with known BMI. Overall, 5,007 (16.4%) pregnancies were to women who were obese, 8,065 (26.3%) to overweight women and 16,460 (53.8%) to women with recommended BMI.

Just over a quarter (10,649; 26.1%) of women with a singleton pregnancy were aged 30-34 years and 6,284 (15.4%) were aged 35 years or over, with a mean maternal age of 27.8 (±6.1). The majority of the sample (34,077; 91.0%) was of White ethnicity.

A total of 34,964 (92.7%) pregnancies had a gestational age ≥37 weeks (term), and the mean gestational of age was 39.1 (SD±2.17). Just over a third (14,445; 35.4%) had a birth weight between 3-3.49kg. The mean birth weight was 3.34 (SD±6.0).

The proportions of missing data varied by variables. The variables with the highest missing data were maternal BMI with about a quarter of the sample missing (10,177; 24.9%) and parity with almost half of the data missing (18,973; 46.5%). While other variables were more complete (Table 4-2).

Table 4-2: Maternal and fetal characteristics of the North East Five Hospitals Cohort Study sample

Categorical variables	Number 40,790 (%)	Percentage Non missing
Body mass index (kg/m^2)		
<18.5	1,081	3.5
18.5-24.9	16,460	53.8
25-29.9	8,065	26.3
≥30	5,007	16.4
Total	30,613 (75.1)	100
Missing	**10,177 (24.9)**	
Mean	**25.2**	
SD	**5.3**	
Maternal age (years)		
<20	4,151	10.2
20-24	9,378	23.0
25-29	10,326	25.3
30-34	10,649	26.1
≥35	6,284	15.4
Total	**40,788 (100)**	
Missing	**2 (0.0)**	
Mean	**27.8**	
SD	**6.1**	
Ethnicity		
White	34,077	91.0
Non white	3,354	9.0
Total	**37,431 (91.8)**	
Missing	**3,359 (8.2)**	

Table 4-2: (continued) Maternal and fetal characteristics of the North East Five Hospitals Cohort Study sample

Categorical variables	Number 40,790 (%)	Percentage Non missing
Index of multiple deprivation (IMD) (tertiles)		
Tertile 1 (most deprived)	13573	33.4
Tertile 2 (moderate deprived)	13,503	33.3
Tertile 3 (least deprived)	13,521	33.3
Total	**40,597 (99.5)**	
Missing	**193 (0.5)**	
Diabetes		
No	40,598	99.5
Yes	192	0.5
Gestational age		
Pre-term (<37 weeks)	2,769	7.3
Term (≥ 37weeks)	34,964	92.7
Total	**37,733 (92.5)**	
Missing	**3,057 (7.5)**	
Mean	**39.1**	
SD	**2.1**	

Table 4-2: (continued) Maternal and fetal characteristics of the North East Five Hospitals Cohort Study sample

Categorical variables	Number 40,790 (%)	Percentage Non missing
Birth weight (kg)		
<2.5	2,769	6.8
2.5-2.99	6,714	16.5
3.0-3.49	14,445	35.4
3.5-3.99	11,977	29.4
≥4	4,870	11.9
Total	**40,775 (100)**	
Missing	**15 (0.0)**	
Mean	**3348.5**	
SD	**609.0**	
Mode of delivery		
Spontaneous &/or assisted	32,193	79.4
Caesarean section	8,392	20.6
Total	**40,585 (99.5)**	
Missing	**205 (0.5)**	
Parity		
Primiparous	9,934	45.5
Multiparous	11,883	54.5
Total	**21,817 (53.5)**	
Missing	**18,973 (46.5)**	

4.6.3 Maternal- fetal characteristics by BMI category

Table 4-3 shows maternal and fetal characteristics by BMI category. Significant associations were found between many maternal and fetal variables and BMI category. Obese women were older, less likely to be of non- White ethnicity, less likely to deliver pre-term babies, but more likely to have babies with birth weight more than or equal to 4 kg.

Table 4-3: Maternal and fetal characteristics, by BMI category, of the North East Five Hospitals Cohort Study sample

Variables	Total N (%)	BMI categories				P value
		<18.5 kg/m² N (%)	18.5-24.9kg/m² N (%)	25-29.9kg/m² N (%)	≥30kg/m² N (%)	
Maternal age (years)						<0.0005
<20	3,163 (10.3)	251 (23.2)	1,984 (12.1)	625 (7.7)	303 (6.1)	
20-24	7,172 (23.4)	353 (32.7)	3,886 (23.6)	1,777 (22.0)	1,156 (23.1)	
25-29	7,833 (25.6)	239 (22.1)	4,111 (25.0)	2,107 (26.1)	1,376 (27.5)	
30-34	7,923 (25.9)	161 (14.9)	4,210 (25.6)	2,204 (27.3)	1,348 (26.9)	
≥35	4,522 (14.8)	77 (7.1)	2,269 (13.8)	1,352 (16.8)	824 (16.4)	
Total	**30,613**	**1,081**	**16,460**	**8,065**	**5,007**	
Ethnicity						<0.0005
White	26,200 (91.1)	851 (84.4)	14,035 (91.0)	6,881 (91.0)	4,433 (93.3)	
Non white	2,547 (8.9)	157 (15.6)	1,391 (9.0)	681 (9.0)	318 (6.7)	
Total	**28,747**	**1,008**	**15,426**	**7,562**	**4,751**	
Index of multiple deprivation (IMD) tertiles						<0.0005
Tertile 1 (most deprived)	10,626 (34.9)	486 (45.0)	5,422 (33.1)	2,770 (34.5)	1,948 (39.0)	
Tertile 2 (moderate deprived)	10,155 (33.3)	360 (33.3)	5,257 (32.1)	2,732 (34.0)	1,806 (36.2)	
Tertile 3 (least deprived)	9,695 (31.8)	235 (21.7)	5,691 (34.8)	2,528 (31.5)	1,241 (24.8)	
Total	**30,476**	**1,081**	**16,370**	**8,030**	**4,995**	

Table 4-3: (continued) Maternal and fetal characteristics, by BMI category, of the North East Five Hospitals Cohort Study Sample

Variables	Total	BMI categories				P value
	N (%)	<18.5 kg/m^2 N (%)	18.5-24.9kg/m^2 N (%)	25-29.9kg/m^2 N (%)	≥30kg/m^2 N (%)	
Diabetes						<0.0005
No	30,453 (99.5)	1079 (99.8)	16,398 (99.6)	8015 (99.4)	4961 (99.1)	
Yes	160 (0.5)	2 (0.2)	62 (0.4)	50 (0.6)	46 (0.9)	
Total	**30,613**	**1,081**	**16,460**	**8,065**	**5,007**	
Gestational age						<0.0005
Pre-term (<37 weeks)	1,942 (6.8)	106 (10.4)	1,107 (7.2)	437 (5.8)	292 (6.2)	
Term (≥ 37weeks)	26,768 (93.2)	917 (89.6)	14,318 (92.8)	7,130 (94.2)	4,403 (93.8)	
Total	**28,710**	**1,023**	**15,425**	**7,567**	**4,695**	
Birth weight (kg)						<0.0005
<2.5	1,881 (6.1)	147 (13.6)	1,093 (6.6)	401 (5.0)	240 (4.8)	
2.5-2.99	5,102 (16.7)	312 (28.9)	3,036 (18.5)	1,147 (14.2)	607 (12.1)	
3.0-3.49	10,892 (35.6)	371 (34.4)	6,146 (37.4)	2,772 (34.4)	1,603 (32.0)	
3.5-3.99	9,041 (29.5)	203 (18.8)	4,645 (28.2)	2,578 (32.0)	1,615 (32.3)	
≥4	3,683 (12.0)	47 (4.4)	1,533 (9.3)	1,163 (14.4)	939 (18.8)	
Total	**30,598**	**1,080**	**16,453**	**8,061**	**5,004**	
Mode of delivery						<0.0005
Spontaneous &/or assisted delivery	24,244 (79.6)	945 (87.7)	13,459 (82.2)	6,267 (78.1)	3,573 (71.6)	
Caesarean section	6,212 (20.4)	133 (12.3)	2,905 (17.8)	1,755 (21.9)	1,419 (28.4)	
Total	**30,456**	**1,078**	**16,364**	**8,022**	**4,992**	

4.6.4 Maternal and fetal characteristics in each hospital of the North East Five Hospitals Cohort Study

Table 4-4 shows the maternal and fetal characteristics for each participating hospital. Sixteen per cent of deliveries at the RVI were to obese women. The RVI had the highest rate (2,585,18%) of women aged ≥ 35 years, and the lowest rate (11,474, 87.5%) of women of White ethnicity.

The James Cook University Hospital had the lowest rate (1,365,15.4%) of pregnancies in obese women, and the highest rate (5,128, 48.3%) of women living in the most deprived areas.

The University Hospital of North Durham had the highest rate of pregnancies in obese women (745, 18.6%) and the highest rate (1,881, 29%) of pregnancies among women aged 30-34 years. Pregnant women in this hospital had the lowest rate (968, 15%) of mothers living in the most deprived areas.

The Queen Elizabeth Hospital, Gateshead had the highest rate (887,17.8%) of babies weighing 2.5-2.99kg at delivery. The South Tyneside Hospital had the highest rate of pregnancies in overweight woman (1,044, 27.4%). Twelve per cent of these pregnancies were to women under 20 years of age, and the highest rate (3,986, 95.2%) of babies born at term (Table 4-4).

Table 4-4: Maternal and fetal characteristics among each hospital in the North East Five Hospitals Cohort Study

Variable	Total N=40,790	Royal Victoria Infirmary, Newcastle N=14,367	James Cook Hospital, Middlesbrough N=10,710	University Hospital of North Durham, Durham N=6,485	Queen Elizabeth Hospital, Gateshead N=4,997	South Tyneside District Hospital, South Shields N=4,231
Maternal BMI (kg/m^2)						
<18.5	1,081 (3.5)	313 (3.4)	354 (4.0)	113 (2.8)	177 (3.7)	124 (3.3)
18.5-24.9	16,460 (53.8)	4,940 (54.0)	4,882 (55.2)	2,065 (51.6)	2,585 (53.6)	1,988 (52.2)
25-29.9	8,065 (26.3)	2,422 (26.5)	2,245 (25.4)	1,077(26.9)	1,277 (26.5)	1,044 (27.4)
≥30	5,007 (16.4)	1,467 (16.0)	1,365 (15.4)	745 (18.6)	780 (16.2)	650 (17.1)
Total	**30,613**	**9,142**	**8,846**	**4,000**	**4,819**	**3,806**
Maternal age (years)						
<20	4,151 (10.2)	1,279 (8.9)	1,218 (11.4)	598 (9.2)	547 (10.9)	509 (12.0)
20-24	9,378 (23.0)	2,982 (20.8)	2,800 (26.1)	1,319 (20.3)	1,209 (24.2)	1,068 (25.2)
25-29	10,326 (25.3)	3,527 (24.6)	2,793 (26.1)	1,645 (25.4)	1,267 (25.4)	1,094 (25.9)
30-34	10,649 (26.1)	3,993 (27.8)	2,499 (23.3)	1,881 (29.0)	1,275 (25.5)	1,001 (23.7)
≥35	6,284 (15.4)	2,585 (18.0)	1,400 (13.1)	1,042 (16.1)	699 (14.0)	558 (13.2)
Total	**40,788**	**14,366**	**10,710**	**6,485**	**4,997**	**4,230**
Ethnicity						
White	34,077 (91.0)	11,474 (87.5)	9,376 (89.1)	5,684 (97.5)	3,693 (96.8)	3,850 (92.6)
Non White	3,354 (9.0)	1,632 (12.5)	1,147 (10.9)	148 (2.5)	121 (3.2)	306 (7.4)
Total	**37,431**	**13,106**	**10,523**	**5,832**	**3,814**	**4,156**

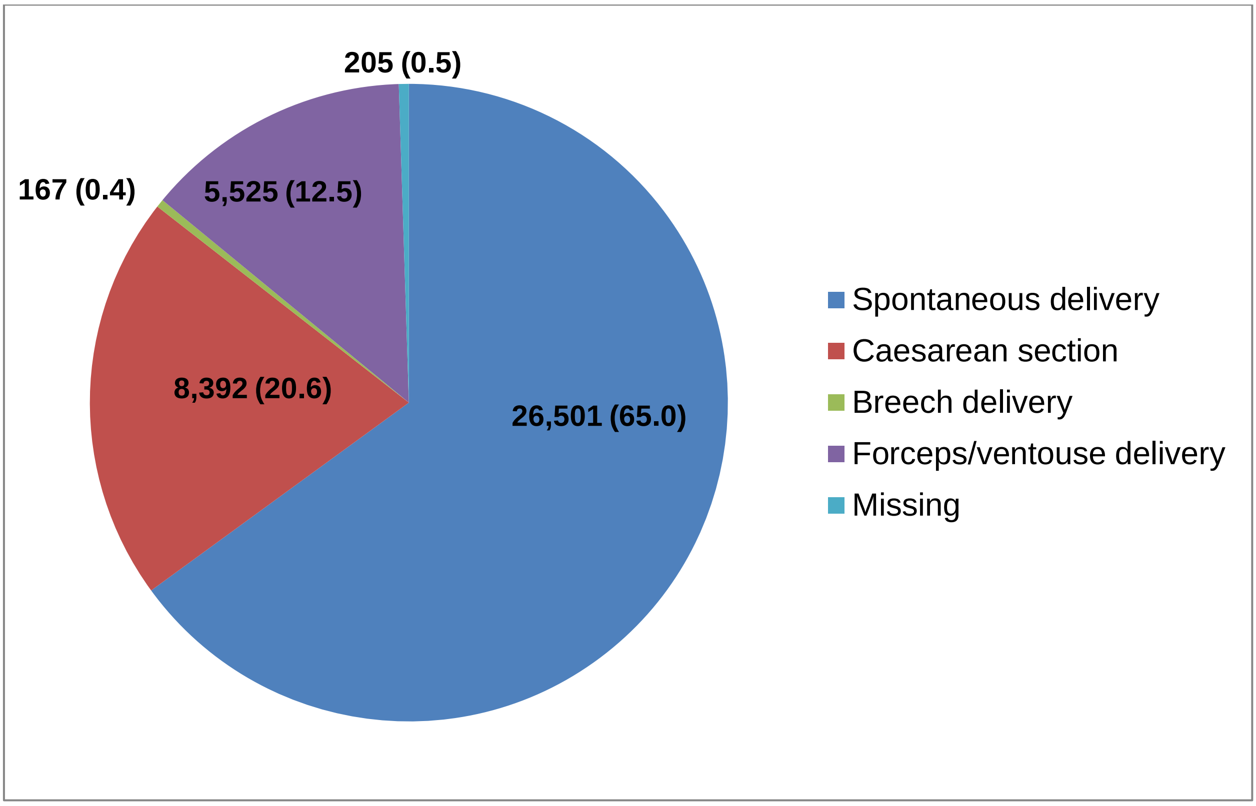
Table 4-4: (continued) Maternal and fetal characteristics among each hospital in the North East Five Hospitals Cohort Study

Variable	Total N=40,790	Royal Victoria Infirmary, Newcastle N=14,367	James Cook Hospital, Middlesbrough N=10,710	University Hospital of North Durham, Durham N=6,485	Queen Elizabeth Hospital, Gateshead N=4,997	South Tyneside District Hospital, South Shields N=4,231
Index of Multiple Deprivation (tertiles)						
Tertile 1(most deprived)	13,573 (33.4)	4,337 (30.3)	5,128 (48.3)	968 (15.0)	1,649 (33.3)	1,491 (35.3)
Tertile 2 (moderate deprived)	13,503 (33.3)	4,385 (30.6)	2,426 (22.9)	2,805 (43.3)	2,040 (41.2)	1,847 (43.7)
Tertile 3 (least deprived)	13,521 (33.3)	5,609 (39.1)	3,058 (28.8)	2,699 (41.7)	1,265 (25.5)	890 (21.1)
Total	**40,597**	**14,331**	**10,612**	**6,472**	**4,954**	**4,228**
Gestational age						
Pre-term (<37 week)	2,769 (7.3)	934 (8.2)	901 (8.4)	391 (6.0)	341 (6.8)	202 (4.8)
≥37 week	34,964 (92.7)	10,449 (91.8)	9,779 (91.6)	6,094 (94.0)	4,656 (93.2)	3,986 (95.2)
Total	**37,733**	**11,383**	**10,680**	**6,485**	**4,997**	**4,188**
Birth weight (kg)						
<2.5	2,769 (6.8)	1,073 (7.5)	828 (7.7)	347 (5.4)	313 (6.3)	208 (4.9)
2.5-2.99	6,714 (16.5)	2,389 (16.6)	1,814 (16.9)	993 (15.3)	887 (17.8)	631 (15.0)
3-3.49	14,445 (35.4)	5,126 (35.7)	3,762 (35.1)	2,281 (35.2)	1,779 (35.6)	1,497(35.5)
3.5-3.99	11,977 (29.4)	4,084 (28.4)	3,101 (29.0)	2,046 (31.5)	1,433 (28.7)	1,313 (31.1)
≥ 4	4,870 (11.9)	1,695(11.8)	1,203 (11.2)	818 (12.6)	585 (11.7)	570 (13.5)
Total	**40,775**	**14,366**	**10,708**	**6,485**	**4,997**	**4,219**

4.6.5 Mode of delivery in the North East Five Hospitals Cohort Study Sample

Figure 4-3 shows the different modes of delivery among singleton pregnancies before combining them into two groups, spontaneous and assisted delivery, and caesarean section. From the 40,790 pregnant women, 26,501 (65.0%) delivered by spontaneous vaginal delivery compared to 8,392 (20.6%) women who delivered by caesarean section. Only 167 (0.4%) pregnant women had a breech delivery and 5,525 (13.5%) had a forceps or ventouse delivery.

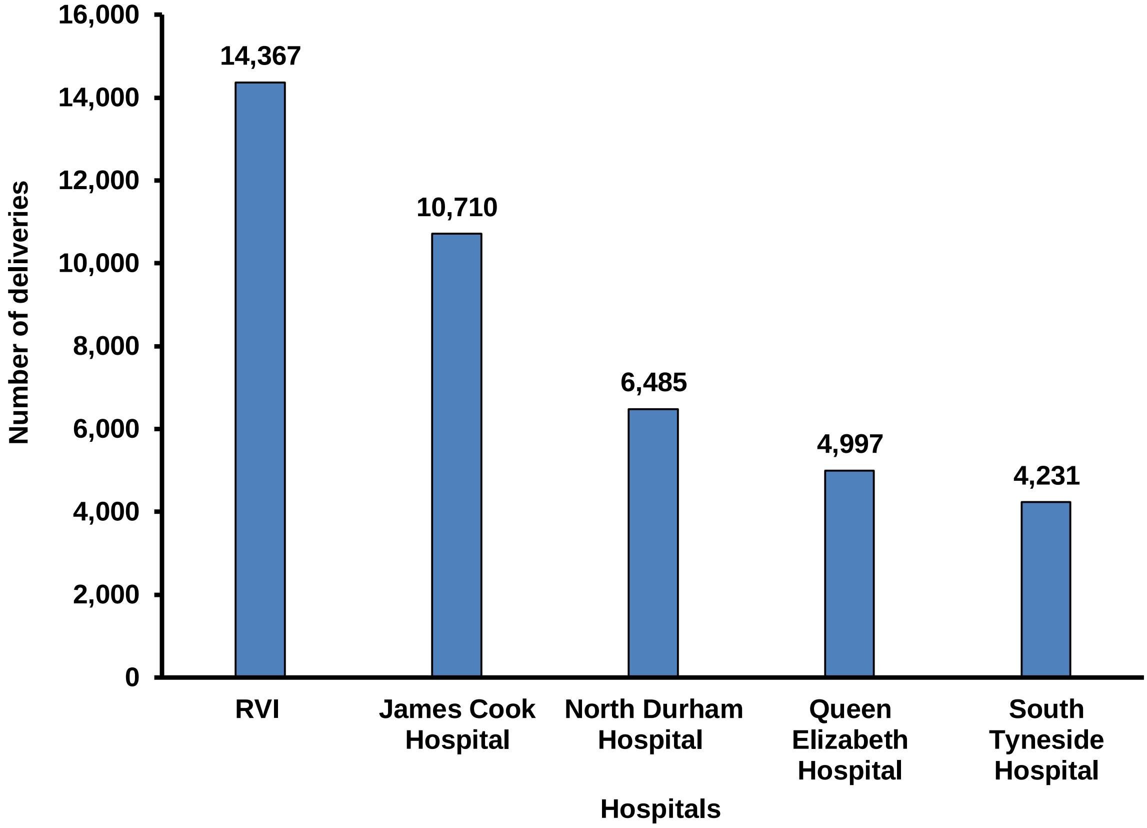
Figure 4-3: Mode of delivery among pregnant women in the North East Five Hospitals Cohort Study



4.6.6 Total deliveries in the North East Five Hospitals Cohort Study

The total number of singleton deliveries in the five hospitals in the study period is shown in (Figure 4-4).

Figure 4-4: Total deliveries within the hospitals in the North East Five Hospitals Cohort Study



4.6.7 Total deliveries and caesarean section

Table 4-5 shows the total deliveries and the total caesarean sections in each study hospital; the rate was very similar across all five hospitals at 19.7-21.3%.

Table 4-5: Total deliveries and total deliveries by caesarean section by hospital in the North East Five Hospitals Cohort Study

Hospital	Total deliveries with known mode of delivery	Total caesarean section N (%)
Royal Victoria Infirmary, Newcastle	14,366	3,053 (21.3)
James Cook University Hospital, Middlesbrough	10,522	2,136 (20.3)
University Hospital of North Durham, Durham	6,485	1,308 (20.2)
Queen Elizabeth Hospital, Gateshead	4,996	1,064 (21.3)
South Tyneside District Hospital, South Shields	4,216	831 (19.7)
Total	40,585	8,392 (20.6)

* Proportion of deliveries by caesarean section was not significantly different between hospitals (p=0.08)

4.6.8 Characteristics of missing and non-missing body mass index data

In this cohort of 40,790 singleton pregnancies, maternal BMI was missing for one quarter of the sample (10,177; 24.9%) resulting in 30,613 singleton pregnancies with known BMI.

A total of 8,392 women had a caesarean section delivery. Of these, 2,180; (26.0%) were missing BMI compared to 6,212 (74.0%) none missing. Just over a quarter of women who had a spontaneous and/ or assisted delivery (7,949, 24.7%) were missing BMI compared to 24,244 (75.3%) with non- missing BMI.

Those with missing BMI were more likely to be older, live in a least deprived area, and delivered smaller infants, which were more likely to be pre-term, and have an had emergency caesarean section compared to those with known BMI (Table 4-6).

Table 4-6: Maternal and fetal characteristics of missing and non-missing BMI for variables with unequal distribution of missing data

Categorical variables	BMI recorded (% in category)	Missing BMI (% in category)	% Missing from category
Maternal age (years)			
<20	3,163 (10.3)	988 (9.7)	23.8
20-24	7,172 (23.4)	2,206 (21.7)	23.5
25-29	7,833 (25.6)	2,493 (24.5)	24.1
30-34	7,923 (25.9)	2,726 (26.8)	25.6
≥35	4,521 (14.8)	1,763 (17.3)	28.1
Index of Multiple Deprivation (tertiles)			
Tertile 1 (most deprived)	10,626 (34.9)	2,947 (29.1)	21.7
Tertile 2 (moderate deprived)	10,155 (33.3)	3,348 (33.1)	24.8
Tertile 3 (least deprived)	9,695 (31.8)	3,826 (37.8)	28.3
Gestational age			
Pre-term (<37week)	1,942 (6.8)	827 (9.2)	29.9
≥37 week	26,768 (93.2)	8,196 (90.8)	23.4
Birth weight (kg)			
<2.5	1,881 (6.1)	888 (8.7)	32.1
2.5-2.99	5,102 (16.7)	1,612 (15.8)	24.0
3-3.49	10,892 (35.6)	3,553 (34.9)	24.6
3.5-3.99	9,041 (29.5)	2,936 (28.8)	24.5
≥4	3,682 (12.0)	1,188 (11.7)	24.4
Mode of delivery			
Spontaneous &/or assisted delivery	24,244 (79.6)	7,949 (78.5)	24.7
Elective caesarean section	2,286 (7.5)	742 (7.3)	24.5
Emergency caesarean section	3,926 (12.9)	1,438 (14.2)	26.8

Criteria for unequal missing data was $p<0.05$ chi square test result, all variables shown were $p<0.0005$

4.6.9 Parity

There were 9,934 (24.4%) pregnancies that were primipara, 11,883 (29.1%) were multipara and 18,973 (46.5%) pregnancies had missing parity data.

Parity among the North East Five Hospitals Cohort Study

The James Cook University Hospital had complete parity data. Conversely, the RVI had poor completeness of parity data with a large amount of missing data (14,068, 97.9%). The University Hospital of North Durham and South Tyneside District Hospital had 2,530 (39%) and 1,592 (37.6%) missing parity data respectively, while Queen Elizabeth Hospital, Gateshead had only 783 (15.7%) cases with missing parity data.

Table 4-7: Parity data among the hospitals in the North East Five Hospitals Cohort Study

Hospital	Primipara N (%)	Multipara N (%)	Missing N (%)	Total N (%)
Royal Victoria Infirmary (RVI), Newcastle	166 (1.2)	133 (0.9)	14,068 (97.9)	14,367 (100)
James Cook University Hospital, Middlesbrough	4,570 (42.7)	6,140 (57.3)	0 (0.0)	10,710 (100)
University Hospital of North Durham, Durham	1,729 (26.7)	2,226 (34.3)	2,530 (39)	6,485 (100)
Queen Elizabeth Hospital, Gateshead	2,144 (42.9)	2,070 (41.4)	783 (15.7)	4,997 (100)
South Tyneside District Hospital, South Shields	1,325 (31.3)	1,314 (31.1)	1,592 (37.6)	4,231 (100)
Total	9,934 (24.4)	11,883 (29.1)	18,973 (46.5)	40,790 (100)

* Proportion of missing parity data was significantly different between hospitals ($p<0.0005$)

Among those with known parity data, the total number of caesarean sections among primiparous women was 2,229 (22.6%) compared to 2,328 (19.8%) among multiparous women.

Proportion of caesarean section by parity

Table 4-8 shows the proportion of caesarean section among the five hospitals by parity. There were significant differences in delivery by caesarean section between primiparous and multiparous women in the James Cook University Hospital ($p<0.003$) and University Hospital of North Durham ($p<0.0005$). There was no significant difference in delivery by caesarean section in primiparous and multiparous in the Queen Elizabeth and South Tyneside Hospitals.

A significant differences were found in the rate of caesarean section between missing and non-missing parity in the University Hospital of North Durham ($p<0.0005$) and South Tyneside Hospital ($p=0.01$).

The RVI was excluded from this analysis due to the high number of missing parity data.

Table 4-8: Number (%) of caesarean section deliveries in each parity group among the hospitals in the North East Five Hospitals Cohort Study

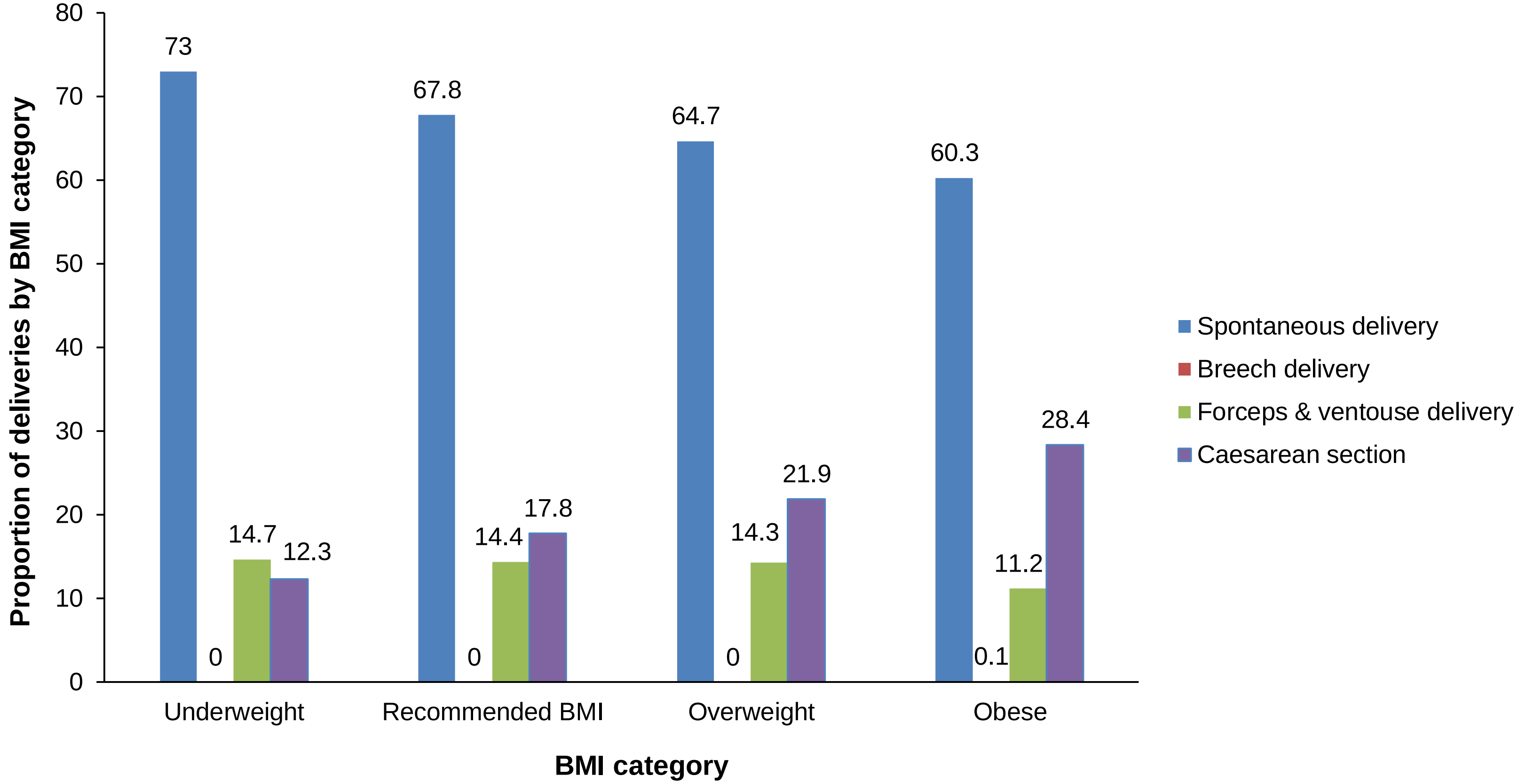
Hospital*	Caesarean section N (%) 8,392	Spontaneous & /or assisted N (%) 32,193	Total N=40,585	p value
James Cook University Hospital, Middlesbrough				0.003
Primipara	974 (21.6)	3,529 (78.4)	4,503	
Multipara	1,162 (19.3)	4,857 (80.7)	6,019	
Missing	0	0		
Total	**2,136**	**8,386**	**10,522**	
University Hospital of North Durham, Durham				<0.0005
Primipara	436 (25.2)	1,293 (74.8)	1,729	
Multipara	434 (19.5)	1,792 (80.5)	2,226	
Missing	438 (17.3)	2,092 (82.7)	2,530	
Total	**1,308**	**5,177**	**6,485**	
Queen Elizabeth Hospital, Gateshead				0.07
Primipara	489 (22.8)	1,655 (77.2)	2,144	
Multipara	414 (20)	1,655 (80)	2,069	
Missing	161 (20.6)	622 (79.4)	783	
Total	**1,064**	**3,932**	**4,996**	
South Tyneside District Hospital, South Shields				0.24
Primipara	268 (20.3)	1,055 (79.7)	1,323	
Multipara	272 (20.7)	1,040 (79.3)	1,312	
Missing	291 (18.4)	1,290 (81.6)	1,581	
Total	**831**	**3,385**	**4,216**	

* RVI hospital not included due to high missing values

4.6.10 Maternal body mass index and mode of delivery

Figure 4-5 shows the mode of delivery by maternal BMI category. The result shows that obese women (28.4%) and overweight women (21.9%) were more likely to deliver by caesarean section compared to women with recommended BMI (17.8%). Twenty-five (0.1%) obese women had a breech delivery and 560 (11.2%) a forceps and ventouse delivery (Figure 4-5).

Figure 4-5: Mode of delivery among BMI categories in the North East Five Hospitals Cohort Study



4.6.11 Maternal BMI and type of caesarean section

The total rate of caesarean section in this study was 8,392 (20.6%). Table 4-9 shows the proportion of elective and emergency caesarean section among the BMI categories. There was a significant association between both types of caesarean section and BMI categories. There was a significant difference between emergency and elective caesarean section by BMI category ($p<0.0005$). 882 (17.7%) obese women had an emergency caesarean section and 537 (10.8%) had elective caesarean section. Both types of caesarean section have high ORs for overweight and obese women compared to women with recommended BMI, while underweight seems to have a protective effect for both emergency and elective caesarean section.

There was no difference in the size of the effect for emergency or elective caesarean section.

Table 4-9: Caesarean section rate among BMI categories

BMI category (kg/m^2)	**Emergency caesarean section N (%)**	**ORs (95% CI) for emergency caesarean section P<0.0005**	**Elective caesarean section N (%)**	**ORs (95% CI) for elective caesarean section p<0.0005**
<18.5	95 (8.8)	0.76 (0.61-0.95)	38 (3.5)	0.52 (0.38-0.73)
18.5-24.9	1,841 (11.3)	Reference	1,064 (6.5)	Reference
25-29.9	1,108 (13.8)	1.26 (1.17-1.37)	647 (8.1)	1.26 (1.14-1.40)
≥30	882 (17.7)	1.69 (1.55-1.85)	537 (10.8)	1.73 (1.55-1.93)
Total	**3,926 (12.9)**		**2,286 (7.5)**	

4.6.12 Caesarean section rate by sample characteristics

Table 4-10 shows the crude ORs and aORs for maternal and fetal characteristics of caesarean section among the five hospitals. There were 26,667 (65.4%) individuals with complete data that were included in the adjusted logistic regression analysis. I used the recommended BMI as the reference group to compare the results of the overweight and obese pregnant women groups. I found a significant relationship between maternal BMI and caesarean section among obese [OR=1.84 (95% CI: 1.71-1.98; p<0.0005)] and overweight [OR=1.30 (95% CI: 1.21-1.39; p<0.0005] women. After adjustment for maternal age, gestational age, ethnicity, birth weight, IMD and diabetes, the association between BMI and caesarean section remained significant and did not change among obese pregnant women [aOR=1.80 (95% CI: 1.67 -1.95; p<0.0005)] and overweight pregnant women [OR=1.28 (95% CI: 1.19-1.37; p<0.0005)] compared to those women with recommended BMI.

For underweight pregnant women, the risk of a caesarean section delivery was lower than for women with a recommended BMI (12.3%) [OR= 0.65 (95% CI: 0.54-0.78; p<0.0005)]. After adjustment for maternal age, gestational age, ethnicity, birth weight, IMD and diabetes, the protective association between low BMI and caesarean section remained [aOR= 0.66 (95% CI: 0.54-0.81; p<0.0005)].

4.6.13 Caesarean section and other factors

There was a relationship between caesarean section rate and maternal age, with older mothers more likely to deliver by caesarean section, compared to those mothers in the younger age categories (Table 4-10). There was a significant association between caesarean section and women aged 30-34 years [aOR=1.29 (95% CI: 1.19-1.40; p<0.0005) and women aged ≥ 35 years [aOR= 1.74 (95% CI: 1.58-1.91; p<0.0005)].

Just over a third (36.2%) of deliveries by caesarean section were preterm compared to 19.3% term deliveries. The risk of caesarean section was reduced among women who delivered preterm babies after adjustment for the other factors [aOR= 1.70 (95% CI: 1.49-1.94; P<0.0005)] compared to those women who delivered at term.

There was a significant relationship between caesarean section and birth weight; women whose baby had a birth weight less than 2.5 kg or ≥ 4kg were more likely to deliver by caesarean section (Table 4-10)

No significant association was found between ethnicity and risk of caesarean section delivery.

For pregnant women living in the most deprived tertile, the risk of a caesarean section delivery was significantly less [aOR=0.91 (95% CI: 0.85-0.99; P<0.01)] compared to those women living in the moderate deprived tertile even after adjustment. The risk of caesarean section was significant among pregnant women living in the less deprived tertile [OR= 1.14 (95% CI: 108-1.21; P<0.0005)] compared to women living in the moderate deprived tertile, but this association did not reach statistical significance after adjusting for the other factors.

Table 4-10: Caesarean section rate by maternal and fetal characteristics

Maternal categories	Caesarean section N (%)	Odds Ratio (95% CI)	p value	Adjusted odds ratio (95% CI)[1]	p value
Maternal BMI (kg/m²)					
<18.5	133 (12.3)	0.65 (0.54-0.78)	<0.0005	0.66 (0.54-0.81)	<0.0005
18.5-24.9	2,905 (17.8)	Reference		Reference	
25-29.9	1,755 (21.9)	1.30 (1.21-1.39)	<0.0005	1.29 (1.20-1.39)	<0.0005
≥30	1,419 (28.4)	1.84 (1.71-1.98)	<0.0005	1.81 (1.67-1.97)	<0.0005
Missing	2,180 (5.3)				
Maternal age (years)					
<20	565 (13.7)	0.66 (0.59-0.73)	<0.0005	0.72 (0.64-0.82)	<0.0005
20-24	1,453 (15.6)	0.76 (0.71-0.82)	<0.0005	0.80 (0.73-0.87)	
25-29	2,002(19.5)	Reference			
30-34	2,523 (23.8)	1.29 (1.21-1.38)	<0.0005	1.29 (1.19-1.40)	<0.0005
≥35	1,849 (29.5)	1.73 (1.60-1.86)	<0.0005	1.74 (1.58-1.91)	<0.0005
Missing	0 (0.0)				

Table 4-10: (continued) Caesarean section rate by maternal and fetal characteristics

Maternal categories	Caesarean section N (%)	Odds Ratio (95% CI)	p value	Adjusted odds ratio (95% CI)[1]	p value
Diabetes					
No	8,276 (20.5)	Reference		Reference	
Yes	116 (60.4)	5.92 (4.43-7.91)	<0.0005	3.89 (2.77-5.46)	<0.0005
Birth weight (kg)					
<2.5	1,001 (36.3)	2.62 (2.40-2.86)	<0.0005	1.87 (1.62-2.17)	<0.0005
2.5-2.99	1,342 (20.1)	1.16 (1.08-1.25)	<0.0005	1.15 (1.05-1.26)	<0.004
3.0-3.49	2,562 (17.8)	Reference		Reference	
3.5-3.99	2,249 (18.9)	1.07 (1.00-1.14)	0.033	1.01 (0.94-1.00)	<0.737
≥4	1,235 (25.5)	1.57 (1.46-1.70)	<0.0005	1.33 (1.21-1.47)	<0.0005
Missing	3 (25.0)				
Gestational age					
Preterm (<37weeks)	998 (36.2)	2.37 (2.18-2.57)	<0.0005	1.70 (1.49-1.94)	<0.0005
≥ 37 weeks	6,719 (19.3)	Reference		Reference	
Missing	675 (22.1)				

Table 4-10: (continued) Caesarean section rate by maternal and fetal characteristics

Maternal categories	Caesarean section N (%)	Odds Ratio (95% CI)	p value	Adjusted odds ratio (95% CI)[1]	p value
Ethnicity					
White	6,987 (20.6)	Reference			
Non White	704 (21.1)	1.03 (0.94-1.12)	<0.510	1.05 (0.94-1.17)	<0.418
Tertiles of Index of Multiple Deprivation					
Tertile 1 (most deprived)	2,432 (18.0)	0.83 (0.79-0.89)	<0.0005	0.91 (0.85-0.99)	<0.021
Tertile 2 (moderate deprived)	2,804 (20.9)	Reference		Reference	
Tertile 3 (least deprived**)**	3,120 (23.2)	1.14 (1.08-1.21)	<0.0005	1.05 (0.97-1.34)	<0.197

[1] Adjusted for maternal age, gestational age, and ethnicity, index of multiple deprivation, birth weight and pre-gestational diabetes.

4.6.14 Maternal body mass index and caesarean section in each parity group

Table 4-11 shows the relationship between BMI and caesarean section by parity. The caesarean section rate increased with increasing BMI. There was no significant interaction between parity and BMI on the risk of caesarean section; the effect of BMI is consistent in primiparous and multiparous women.

Table 4-11: Maternal body mass index and caesarean section by parity

Maternal BMI	Caesarean section N (%)	OR (95%CI)	p value	aOR* (95%CI)	p value
Primipara					
<18.5kg/m^2	55 (15.6)	0.75 (0.55-1.0)	<0.052	0.82 (0.59-1.14)	0.242
18.5-24.9kg/m^2	937 (19.8)	Reference		Reference	
25-29.9kg/m^2	482 (24.5)	1.31 (1.16-1.48)	<0.0005	1.26 (1.10-1.44)	<0.001
≥30kg/m^2	379 (32.5)	1.95 (1.69-2.24)	<0.0005	1.77 (1.52-2.07)	<0.0005
Multipara					
<18.5kg/m^2	26 (8.4)	0.47 (0.32-0.71)	<0.0005	0.48 (0.32-0.74)	<0.001
18.5-24.9kg/m^2	795 (16.2)	Reference		Reference	
25-29.9kg/m^2	577 (21.5)	1.41 (1.26-1.59)	<0.0005	1.44 (1.27-1.63)	<0.0005
≥30kg/m^2	477 (27.5)	1.96 (1.72-2.23)	<0.0005	1.99 (1.73-2.29)	<0.0005
Missing					
<18.5kg/m^2	52 (12.5)	0.68 (0.50-0.91)	<0.010	0.67 (0.47-0.95)	<0.024
18.5-24.9kg/m^2	1,173 (17.4)	Reference		Reference	
25-29.9kg/m^2	696 (20.7)	1.23 (1.11-1.37)	<0.0005	1.22 (1.08-1.38)	<0.001
≥30kg/m^2	563 (26.9)	1.75 (1.55-1.96)	<0.0005	1.78 (1.56-2.04)	<0.0005

* aOR= Adjusted for maternal age, gestational age, birth weight, ethnicity, IMD and pre-gestational diabetes.

4.7 Discussion

In this cohort study, I investigated the relationship between maternal BMI obtained from electronic maternity records based on self-reported BMI recorded at the first antenatal visit, and the risk of caesarean section among the obstetric population of five hospitals covering a total of 40,790 births in the North East of England between 2003 and 2005.

4.8 Summary of key findings

My study results show that there were no differences in caesarean section rate among the five hospitals included in the study. Overall one third of obese and one fifth of overweight women delivered by caesarean section compared to 18% of women with recommended BMI. The risk of caesarean section was nearly doubled for obese women and 30% higher for overweight women. In contrast, underweight pregnant women were at a lower risk of delivery by caesarean section.

Other factors were significantly associated with caesarean section. Older women were more likely to deliver by caesarean section. Babies with a birth weight less than 2.5 kg and ≥4kg were more likely to be delivered by caesarean section. In addition, preterm deliveries were more likely to be caesarean sections.

There was a three fold increase in delivery by caesarean section in pregnant women with diabetes compared to non- diabetic pregnant women.

There was no statistical association between ethnicity and caesarean section. More women living in the most deprived residential areas delivered by caesarean section compared to women living in moderate deprived areas. In contrast, women living in least deprived tertile were at increased risk of delivering by caesarean section, but this association did not reach statistical significance after adjustment for other factors.

4.9 Strengths of the study

This study has several strengths; my study data was derived from five hospitals in the North East of England and the women who deliver in these five hospitals are likely to reflect the obstetric population of the region as a whole making my results generalisable to the North East of England obstetric population. In addition, my results should be generalisable to any white population where body fat distributions are similar for a given BMI.

I had a large sample size giving my study sufficient power to detect differences. Further, many of my study variables were complete. The data was collected from routine data systems, and ascertainment of variables was independent of BMI status.

Another strength is that I was able to include a number of potentially confounding variables which have not always been included in such studies, including maternal age, birth weight, gestational age, ethnicity and socio-economic status.

4.10 Limitations of the study

The study has a number of limitations. The BMI data were routinely collected by the five hospitals and at the time of the data collection, height is likely to have been self-reported and, in some cases also weight. I was unable to distinguish between height and weight measurements which were self-reported rather than measured, nor was it possible to know what proportion might have been self-reported. Pregnant women have been shown to underreport their weight. [195] In a systematic review of 64 studies, the trend was for self-reported height to be overestimated and self-reported weight and BMI to be underestimated.[196] This can lead to an underestimation of the BMI and consequently of obesity prevalence, and this may have occurred in my study.[196,195, 197]

This study was only able to analyse BMI at booking and there was no measurement of BMI at delivery to estimate gestational weight gain during the pregnancy. The IOM update guidelines recommend that women with recommended BMI should aim to gain no more than 25-35 pounds (11-16kg); overweight women 15-25 pounds (7-11kg); and obese women 11-20 pound (5-9kg) throughout other pregnancy.[33]

BMI information was missing for almost a quarter of the sample. It is not clear whether missing data resulted from not being collected at the time of the first antenatal visit, or it was recorded in the notes but not added to the hospital information system. The magnitude of the missing data may reduce the study power. I compared the characteristics of those with missing BMI with those with known BMI and found that those with missing BMI are more likely to be older in age, live in the least deprived tertile, delivered smaller infants, which more likely to be preterm compared to those with known BMI. In my analyses, those with missing BMI and other missing variables were excluded. Thus only 65.4% of the initial samples were included. It is possible that the results are not representative of what would be found in the complete maternity population. Use of multiple imputation may have provided a more representative result, however the number of predictive variables was limited, and this approach also relies on the data being “missing- at- random” which has been shown not to be the case. However, even with a quarter of participants’ BMI missing, the results showed a significant relationship between BMI and the risk of caesarean section.

As my study was limited to routinely collected data, information on some key variables was not available, for example gestational age at booking was not available so it is not possible to confirm if the BMI was collected at the first booking visit and in which gestational week.

Other limitations include that there was no information on the educational level for the mother, which I think it would have been useful to investigate the effect of increasing BMI and risk of caesarean section among women with high and low educational attainment.

Further, this study was unable to examine some potential factors, such as antenatal care and blood pressure and other factors which may lie on the causal pathway between maternal obesity and caesarean section. Different studies found that the risk of pre-eclampsia and hypertensive disorders increases with increasing BMI.[20, 143]

Another limitation was that about 46.5% of parity data were missing in this study. Only one hospital had complete parity data while the others had different proportions of missing data. However the missing data was mainly accounted for by one hospital. This hospital provided data in the parity variable field, but it was not possible to use the data. Rather than indicating parity during the index pregnancy, it showed the most up-to date parity of the mother, regardless of her parity for that delivery. That means, if she was primiparous for the delivery on the file, but then had three more children, she would be recorded as parity 4 for all deliveries. It is clear that the hospital does not have a robust method for recording parity in the index pregnancy. Parity has been found as an important risk factor for caesarean section in obese women. A study by O'Dwer et al (2011) found that the influence of maternal obesity on the increase in caesarean section rates was different in primipara compared with multipara women. In primiparas, the increase in caesarean section rate in obese women was due to an increase in emergency caesarean sections ($p < 0.005$) and in multiparas the increase was due to an increase in elective caesarean section ($p < 0.01$). I was unable to explore this association. However, I found no evidence of interaction between parity, caesarean section and BMI.

This study did not have access to information on the indications for caesarean section and the complications after caesarean section delivery, which limits investigation about reasons why obese women are at an increased risk of a caesarean section.

4.11 Comparison with other studies

4.11.1 Comparison with two systematic reviews

My results are consistent with two recently published systematic reviews,[10,14] (Table 4-12). The first review by Chu et al [10] showed that the risk of caesarean section was about 2-3 times higher among obese and severely obese women compared to women with recommended BMI. The second review by poobalan et al, 2009 [14]reported that the risk of delivery by caesarean section was increased by 50% in overweight women more than doubled among obese women and three times higher in morbidly obese women compared to women with recommended BMI.

My study results were similar to those presented in these reviews.[10, 14] However the crude ORs were lower than in both reviews; 1.30 (1.21-1.39) in overweight and 1.84 (1.71-1.98) in obese women. Moreover, when presented as aORs: adjusted for maternal age at delivery, gestational age at delivery, ethnicity, IMD, birth weight and diabetes, the aORs remained significant but was slightly lower than in the two reviews; 1.29 (1.20-1.39) in overweight and 1.81 (1.67-1.97) in obese women.

There are a number of possible reasons why the results differ. There may be differences in the population and settings of the studies included in the two reviews. Half of the included studies in the first review[10] were from the US with only one study from the UK. [8] In the second review,[14] most studies were from the US, with only three studies from the UK. The differences in population characteristics and the health systems in different countries in terms of the practice of caesarean delivery may affect the rate of caesarean section. However, my results overall were consistent with the reviews and other studies, but show a slightly diminished effect.

My study data is from the North East of England, and the relationship between maternal BMI and caesarean section is not as high as in other settings. This might be due to differences in clinical practice, such as less recognition of obesity as a specific risk factor, particularly at the time when my study data was collected, which was from 2003 to 2005. My study was not able to show detailed analysis by parity due to the high missing data in this variable. The second review showed an increasing risk of both emergency and elective caesarean section with increasing BMI and an increase in emergency caesarean section in nulliparous women.

My results were consistent with the second review in that I found an increase in the risk of both emergency and elective caesarean section with increasing BMI, and that emergency caesarean delivery was higher in nulliparous pregnant women compared to elective caesarean section among multiparous pregnant women. This result has also been shown by O' Dwyer et al (2011), who showed that there is a difference in the risk of caesarean section among high BMI by parity. Nulliparous obese women had more emergency caesarean sections compared to multiparous women who had more elective caesarean sections.[198]

My study does not include severely or morbidly BMI category due to the small number of women in this category and I grouped them with the obese group as (>30kg/m^2).

Table 4-12: Comparison among two systematic reviews and current study

Author/study period	Effect size for caesarean section among BMI category
Chu et al, 2007	OR of caesarean delivery were: 1.46 (1.34-1.60) among overweight women 2.05 (1.86-2.27) among obese women 2.89 (2.28-3.79) among severely obese women.
Poobalan et al, 2009	OR: 1.53 (1.48-1.58) among overweight women, 2.26(2.04-2.51) among obese women, 3.38 (2.49-4.57) among morbidly obese women.
Current study	OR: 1.30 (1.21-1.39) among overweight women OR: 1.84 (1.71-1.98) among obese women aOR: 1.29 (1.20-1.39) among overweight aOR: 1.81 (1.67-1.97) among obese women

4.12 Comparison with other based UK studies

There have been other UK studies that have investigated the relationship between maternal BMI and pregnancy outcome (Table 4-13). [7, 8, 17, 66, 134,135]

The largest study was by Sebire et al, 2001[8] examined the pregnancy outcome of obese women compared to those with recommended BMI women among large sample from valid database in London, from 1989-1997. This study compared the risk of caesarean section in overweight and obese women compared to recommended BMI and found that the caesarean section rate was almost twice as high for very obese women than recommended BMI women. The ORs of emergency caesarean section for overweight were 1.30 (99% CI: 1.25-1.34) and obese 1.83 (99% CI: 1.74-1.93). This study reported an incidence of obesity of (10.9%) in their population and a caesarean section rate for obese women of 20%.

The second UK study by Usha Kiran et al [66] was a retrospective study on the relationship of BMI with outcome of singleton pregnancy. The ORs of caesarean section in obese compared to the reference group was1.6 (95% CI: 1.4-2.0).

Bhattacharya et al, 2007[7] had a retrospective cohort study, based on all nulliparous women delivering singleton babies in Aberdeen between 1976 and 2005 investigate the association between BMI and obstetric and perinatal outcomes. Total caesarean section rate among obese women was 30.8%, with being 4.7% of elective caesarean section and 26.3% for emergency caesarean section. This study reported a three fold increased risk of having an elective caesarean section in morbidly obese (BMI>35kg/m^2) women compared to women with recommended BMI, [ORs: 3.1(95% CI: 1.7-6.1) and 2.8 times (95% CI: 2.0-3.9) higher risk of emergency caesarean section. The aORs of elective caesarean section for obese (30-34.9kg/m^2) were 1.4 (95% CI: 1.0-1.8) compared to aORs of emergency caesarean section in the same group 2.0 (95% CI: 1.8-2.3). The aORs for emergency caesarean section increased with increasing BMI. There was a protective effect in underweight women [(ORs: 0.7 (95% CI: 0.6-0.8)].

Bergholt et al[17] evaluated the effect of maternal BMI on the incidence of caesarean delivery among nulliparous women at a district general hospital between 1995 and 2000. This study found that the caesarean section rate increased from 3.6% in women with a BMI <25 kg/m^2 to 18.5% in women with a BMI >35kg/m^2 in the first trimester. The OR for caesarean section in the highest BMI category compared with recommended BMI was significantly higher at 3.8 (95% CI: 2.4-6.2).

A large cohort study published after the two reviews from the UK by Khashan et al, 2009 [134], examined the effect of BMI in early pregnancy on adverse pregnancy outcome between 2004-2006. The RR of delivery by caesarean section and unplanned caesarean section in relation to BMI were 0.88 (95% CI: 0.44-0.82), whereas overweight women were at a higher risk of caesarean section 1.31(95% CI: 1.28-1.35). Obese women had an aRR of 1.66 (95% CI: 1.61-1.71). The study found that morbidly obese women were at greater than two fold risk of caesarean section compared to women with recommended BMI.

The study by Mantakas et al, 2010[135] demonstrate the influence of BMI in pregnancy on rates of adverse pregnancy outcome in overweight nulliparous women from 2001-2008. The study found that the total RR of caesarean section among obese women was 1.6 (95% CI: 1.4-1.7) and 1.7 (95% CI: 1.5-1.9) for the emergency caesarean section.

My study result showed a similar risk effect of caesarean section for overweight and obese women with these studies. My study showed an obesity rate 16.4% and a caesarean section rate 28.4% among obese women compared to recommended BMI women (17.8%).

The results from Usha Kiran et al study showed an effect size less than my study. This may be because the comparison group was from 20-30kg/m^2. Including only uncomplicated women may be explain the lower rate of odds ratios, as it is well known that women with complications such as gestational diabetes mellitus (GDM) and pre-eclampsia are more able to deliver by caesarean section compared to women without complication. Obese women are more insulin resistant than recommended BMI women and the risk for gestational diabetes is positively associated with obesity in pregnancy. Furthermore, the data was not recent (1990-1999) and the BMI rate has increased in the UK population since the 1990's. Another reason for lower rate of caesarean section from my study is that, Usha Kiran et al study included only primigravid women while my study included all parity groups.

Bhattacharya et al presented results by type of caesarean section (elective and emergency) not overall. In addition, this study showed a higher caesarean section in morbidly obese women, and my study does not include this group for comparison with recommended BMI. The study used data collected over 30 years, during which time there have been several changes in obstetric protocols, particularly with regard to caesarean section. The total rate of caesarean section in my study is close to the caesarean section rate in this study; however my study showed the risk of overall caesarean section. I found a similar protective effect of underweight regarding the risk of caesarean section.

In overall my results is consistent with the above studies, and this may due to the period of my study data is similar with some of the reviewed studies and the might be the similarity in the population showed this result.

UK studies have showed similar incidence and effect size of the association between increasing maternal BMI and caesarean section. This means that this problem is global and developing among population in different setting.

Table 4-13 Comparison between the UK studies results and the current study

Citation/ study period	CS rate (%)	OR and aOR for caesarean section result for obese vs reference
Sebire et al, 2001	20	OR: (99% CI), Emergency CS 1.83 (1.74-1.93), Elective CS 1.72 (1.62-1.83)
Usha Kiran et al, 2005	NA	Total CS : OR: 1.6 (1.4-2) Emergency CS: OR: 2.0 (1.2-3.5).
Bhattacharya et al, 2007	30.8 in obese	aOR: 2.0 (1.8-2.3) emergency CS 1.4 (1.0-1.8) elective CS
Bergolt et al, 2007	18.5	aOR: 1.9 (1.3-2.8)
Khashan et al, 2009	NA	aRR1.66 (1.61-1.71)
Mantakas et al, 2010	NA	RR: 1.6 (1.4-1.7) RR in emergency CS: 1.7 (1.5-1.9)
Current study	20.6	aOR: 1.81 (1.67-1.97) OR in emergency CS: 1.69 (1.55-1.85) OR in elective CS: 1.73 (1.55-1.93)

CS: caesarean section
OR: Odds ratio
RR: Risk ratio
aOR: Adjusted odds ratio
aRR: Adjusted risk ratio
NA: Not available

4.13 Comparisons with studies from other settings

Two different studies from India and Australia [17, 52] not included in the systematic reviews, and investigated the effect of maternal BMI on obstetric outcomes. The study from India was conducted by Sahu et al, 2007[20] investigated 380 pregnant women in one unit of a teritary care teaching hospital in North India from 2005-2006. This study found that obese pregnant women were significantly more likely to deliver by caesarean section [RR: 2.3 (95% CI: 1.2-4.5; p=0.01)]. This study had a small sample size and the pregnant women were divided into four BMI groups; the underweight group was categorised as BMI <19.8kg/m^2 and the recommended BMI group as BMI 19.9-24.9kg/m^2. This categorisation of the underweight group included recommended BMI women. Women with diabetes and hypertension were excluded. The obesity rate in this study was 7.9% compared to 26.1% overweight and 53.9% recommended BMI women. The study found an increasing risk of caesarean delivery with increasing BMI, despite the low rate of obesity in this population compared with Western countries.

A study from Australia conducted by Athukorala et al, 2010[15] assessed the prevalence and impact of mothers who were overweight and obese in early to mid pregnancy on maternal peripartum and neonatal outcomes in a sample of 1661 nulliparous women with singleton pregnancies between 2001-2005. The obesity rate in this study was 16% compared to 27% for overweight and 57% for recommended BMI women. The caesarean section rate among obese women was 36.4% compared to 31.6% in overweight and 22.3% in recommended BMI women. This study also found that overweight and obese women were more likely to undergo a caesarean section. The relative risks were: 1.42 (95% CI: 1.18-1.70; p=0.0002) and: 1.63 (95% CI: 1.34-1.99; p<0.001) for overweight and obese pregnant women respectively.

The overweight and obesity rates in this study are similar to those I report, while the caesarean section rate is higher than my study. This may be due to the fact that the obesity rate is increasing among the Australian obstetric population.[15] Moreover, it is probably explained by the inclusions of women with other complications. Obese women were more likely to require caesarean section for pre-eclampsia compared to recommended BMI women. However, the effect sizes reported in this study were slightly lower for obese and slightly higher for overweight women than in my study.

4.14 Other factors associated with caesarean section

My study showed independent associations of a number of other variables with caesarean section, for example: hospitals, maternal age at delivery, parity, gestational age at delivery, birth weight, socio-economic status, ethnicity, and diabetes.

4.14.1 Hospital and caesarean section

Different non-medical factors may affect the caesarean section rate among hospitals, such as geographical region, physicians' practice styles, type of birth attendant, and larger hospital may have a high rate of caesarean sections compared with the rate in teaching hospitals.[199]

In the UK, the caesarean section rate rose from 21% in the 1990s to 23% in 2008. The NHS Maternity Statistics in England has reported that the caesarean section rate rose from 9% in 1980 to 23.5% in 2006 [59], and the last report from the NHS Information Centre, Maternity Key Facts shows that the rate of caesarean section increased from 9% in 1980 to 24.8% in 2010-2011[110]. The rate of caesarean section in the North East of England was 21.2% in 2006.[59] The North East had the lowest caesarean section rate compared to the North West (22.5%), South West (23.8%); the highest rate was found in London (26.1%).

The RMSO annual report showed the caesarean section rate in the maternity units of the North East region ranged from 16.0-17.0% in North Tees to 22.5-23.2% at Wansbeck Hospital during 2003-2005.[181, 182]

My results showed that the caesarean section rate among the five hospitals included in my study period (2003-2005) ranged between 19.7 and 21.3%. The overall caesarean section rate in my study is similar to the rate of caesarean section in the North East region as a whole but lower than the national rate at the time of my study.

4.14.2 Maternal age

Maternal age less than 20 years and over 35 years is known to be a risk factor for poor pregnancy outcome.[1] Research has shown that maternal age 30 years or over is a significant risk factor for delivery by caesarean section. [148, 200] The risk for delivery by caesarean section increases with increasing maternal age and increasing pre-pregnancy BMI. Compared to younger women, the risk for caesarean section is more than doubled among women aged 30-34 years and more than four fold among women aged 35 years or older. [70]

In my study; older women aged ≥ 35 years were more likely to deliver by caesarean section.

4.14.3 Parity

Parity has a very important influence on the risk of having a delivery by caesarean section.

This issue has been reported by a recent study by Kominiarek, et al, 2010, [149] that caesarean section rate increased with increasing BMI category and this rate was higher in multipara women with previous caesarean section, while those multiparous with no previous caesarean section had a lower risk of delivering by caesarean section.

A similar study from Dublin, Ireland by O' Dwyer et al, 2011 [198] looked at the association between caesarean section and BMI in primipara compared to multipara, and found that multiparous obese women (BMI>29.9kg/m^2) had a greater risk of caesarean section 7.3% due to repeat elective caesarean section compared to 3.2% women with recommended BMI. Moreover, a study by Lynch, et al, 2008[136] showed that primiparous and multiparous women with a BMI more than 30kg/m^2 have two fold risk for delivery by caesarean section compared to those women of recommend BMI.

My results showed that the caesarean section rate among primiparous and multiparous women were similar across the five hospitals. Moreover, my results showed that the effect of BMI is consistent in primiparous and multiparous women.

Unfortunately, I was not able to investigate this association fully due to the high missing parity data from the RVI hospital.

4.14.4 Gestational age and caesarean section

Preterm birth is the major cause for neonatal mortality in developed countries. [15] The increasing trend of delivering at earlier gestational ages will increase the adverse impact on both the mother and infant health. A study by Seyb et al, 1999 [201] reported that the caesarean section rates among nulliparous women are the lowest between gestational weeks 36- 40 and rise significantly after week 40 of gestation.

The study by Heffner, et al, 2003[202] also showed that the caesarean delivery rate are lowest between 36- 40 of gestation for women with spontaneously labour, whereas the rate begins to rise at 39 weeks in women with induced labour.

My study results are in agreement with these two studies.[201, 202] I found a significant association between gestational age of preterm delivery < 37 weeks and caesarean section [OR: 2.37 (95% CI: 2.18-2.57; p<0.0005)]. Although, this association remained significant after adjustment for other confounding factors, it was lower (aOR: 1.70).

4.14.5 Birth weight and caesarean section

Birth weight is a key determinant of health. Low birth weight is associated with fetal prematurity and growth retardation, and increases the risk of serious neonatal morbidity or death. In addition, high birth weight is also associated with adverse obstetric complications, such as shoulder dystocia and caesarean section.[6, 203]

A study by Shy, et al[204] found that low birth weight less than 2500gm and high birth weight more than 4000gm, had a significant association with caesarean section in nulliparous women.

High maternal pre-pregnancy BMI has been shown to be related to high birth weight.[123] A higher significant association was found between birth weight and obese women and there were higher rates of fetal macrosomia. [13] Moreover, maternal diabetes also predicts birth weight. [1]

My study showed that obese women had a higher rate of delivering babies weighing ≥4kg (18%) compared to underweight (4%), recommended BMI (9%) and overweight women (14%). In contrast, underweight women had the highest rate (13.6%) of delivering babies <2.5kg compared to recommended BMI (6%), and (5%) for overweight and obese women respectively.

My results regarding birth weight are consistent with these studies [123, 204] which showed that the risk of caesarean section is higher for birth weight less than 2500gm and birth weight more than or equal to 4000gm compared to birth weight between 3-3.49 kg.

4.14.6 Socio-economic status and caesarean section

Evidence suggests that increasing caesarean section rates may, in part, be explained by women in higher-income brackets requesting elective caesareans without any medical indications. [199, 205]

A study by Gould et al, 1990, investigating the rate of caesarean section and socio-economic status in a cohort study of 245,854 between 1982-1983 in California found that the rate of primary caesarean section varied directly with socio-economic status and that this association cannot be accounted for by differences in maternal age, parity, birth weight, race, ethnic group or pregnancy or child birth complications. [199] While a study from Canada by Leeb et al, 2005[205] investigating the association between caesarean section and socio-economic status from 2002 to 2003, after adjustment for maternal age, found that women in Canada’s highest income urban neighbourhoods were significantly less likely to have a caesarean section than those in the lowest income areas.

I found a significant association between socio-economic status and caesarean section; women living in less deprived areas were more likely to deliver by caesarean section compared to women living in moderate deprived areas. However, after adjustment for maternal age, gestational age, ethnicity, birth weight and pre-gestational diabetes, the result showed that the association was no longer significant.

4.14.7 Ethnicity and caesarean section

Delivery by caesarean section varies between some ethnic groups, for example higher rates of caesarean section have been reported in Black women.[108] Non White ethnicity is associated with an increased risk of poor pregnancy outcome in the UK.[206]

A study by Ramos, et al, 2005, [156] evaluating the interrelationship between ethnicity and obesity on obstetric outcomes, found that when compared with obese white women, higher rates of caesarean section were noted in obese African American and Asian women. Another cohort study by Loetscher, et al, 2007[207] found that certain ethnic–cultural groups had reduced odds of caesarean delivery compared with the other ethnicity in control group .

There was no significant association between ethnicity and caesarean section in my study. However, the majority of my study population (91.0%) were of White ethnicity, thus the study had limited opportunity to investigate ethnic differences in caesarean section rates.

4.14.8 Pre-gestational diabetes and caesarean section

Pre-existing maternal diabetes is associated with substantial increased risks of perinatal mortality and congenital anomaly. [192 176]

A study by Bell, et al, 2008[192] described recent trends in prevalence, outcome and indications of care for women with pre-existing type 1 or type 2 diabetes in a regional population-based survey of 1,258 pregnancies women with pre-existing diabetes delivered between 1996 and 2004 in all maternity units in the North of England. This study showed that 61% of pregnancies were delivered by caesarean section and 62% before 38 completed weeks of gestation. There was no significant change in these indicators over the study period.

Although there was a small number of women with pre-gestational diabetes in my study, there was a significant relationship between increasing risk of caesarean section and pre-gestational diabetes among overweight and obese singleton pregnancies; the risk of caesarean section was four times higher in pregnant women with pre-gestational diabetes than those without pre-gestational diabetes.

4.15 Conclusion

This chapter showed that the rate of caesarean section among the North East of England obstetric population is increasing with the increasing BMI. In the next chapter, I will investigate this relationship further by investigating the indications for caesarean section among obese women, post caesarean complications and length of stay in hospital.

CHAPTER FIVE

WANSBECK GENERAL HOSPITAL STUDY

Chapter 5. Wansbeck General Hospital Study

5.1 Introduction

Evidence suggests that delivery by caesarean section in obese women carries a higher risk of post-operative complications for the mother such as wound infection after caesarean section, postpartum haemorrhage, DVT and pulmonary embolism (PE) which may lead to a longer stay in hospital.[6] Complications for the baby include a low Apgar score after caesarean section, admission to the intensive care unit, difficulty in breast feeding after caesarean section and a longer length of stay in hospital. [6-8, 66, 99]

Previous reports showed that DVT and PE are the second most common causes of maternal mortality; obese women are at a high risk of developing both DVT and PE.[208] A doubling of risk has been reported after caesarean section compared to vaginal delivery.[209]

Previous studies have investigated the length of hospital stay with increasing BMI category[73, 99] or the cost of hospitalisation by maternal BMI[120]. To my knowledge, none of the studies have investigated how maternal length of stay in hospital after caesarean section varies by BMI category. This study will investigate maternal length of stay in hospital after caesarean section by BMI category within a UK setting.

This chapter is phase three of my PhD study. In this phase I investigated the association between maternal BMI and caesarean section in more detail by investigating the indications for caesarean section among obese women and the complications that occur after caesarean section, which may result in a longer length of stay in hospital compared to women with a recommended BMI.

5.2 Background information on Wansbeck District

Wansbeck is the smallest of six districts in Northumberland, and lies around 15 miles north of Newcastle upon Tyne.[210] The district covers 67 km^2 with a population density of 921 people per square meter. A recent population estimate, for mid 2006, was 61,700, with a projected population of 64,000 by 2026.[211, 212]

Wansbeck district was established as a result of a local government re-organisation in 1974, and this district ceased to be a local authority in 31 March 2009. The administrative centre of Wansbeck is Ashington. The majority (98%) of the Wansbeck population are of White British ethnicity.[210]

Previously, employment in the district was centred on mining, but now is centred around public administration, education and health [210] which together account for 47% of all employment. Some areas within the district have high levels of poverty and other forms of social disadvantage. In the 2004 Index of Multiple Deprivation, Wansbeck is ranked 47 out of 354 districts in England. Of the 41 Super Output Areas in the district, 16 (39%) are within the most deprived 20% and seven within the most deprived 10% in England. The percentage of people of working age who are unemployed and seeking job seekers allowance is higher than the national average.[210]

5.3 Wansbeck General Hospital

Wansbeck General Hospital is a consultant-led maternity unit, located in the outer edge of Ashington in Northumberland. This hospital is run by the Northumbria Healthcare NHS Foundation Trust, which is one of the largest Trusts in the country.[213] The Trust's maternity service covers a large geographical area, extending from the rural areas of Northumberland, Berwick upon Tweed in the North, Hexham and Tynedale to the west and Ashington and the surrounding areas in the southeast, together with the more urban area of North Tyneside in the south[214] (Figure 5-1). The Northumbria Healthcare NHS Foundation Trust serves a total population of about 580,000, and the characteristics of the population range from affluent in the West of the region to areas with high unemployment in the South and the East of the region.

Wansbeck General Hospital opened in 1993 with a capacity for 24,000 inpatients and 21,000 outpatients. The hospital has 15 wards and 384 beds for different specialties. The maternity ward in this hospital consists of 32 beds, giving care to pregnant women from 20 weeks gestation and those with medical complications during pregnancy. The women and their babies stay for six hours in the maternity ward if they have no complications after delivery.[215]

5.4 Why was Wansbeck General Hospital chosen for this study?

Wansbeck General Hospital was chosen as the site for this study for two reasons: firstly, the medical staff at this hospital had identified the maternal obesity rate to be high and to be of concern within their obstetric practice; secondly, one of my supervisors works closely with staff at this hospital which facilitated the setting up of my study.

5.5 Guidelines for antenatal, intrapartum and postnatal care in Wansbeck General Hospital (in the period of my study)

The antenatal care, intrapartum and postnatal guidelines followed in 2008 are summarised in (Appendix V).

Figure 5-1: Map of Wansbeck General Hospital location and surrounding area

Source: http://darlingtonfloorsanding.com/locations.html

5.6 Aim

This study tested the hypothesis that overweight (BMI 25-29.9kg/m^2) and obese (BMI≥30kg/m^2) pregnant women have more post caesarean section complications compared to recommended BMI women resulting in a longer length of stay in hospital.

5.7 Objectives

The specific objectives of this study were:

1. To identify indications for caesarean section in overweight / obese pregnant women compared with pregnant women with recommended BMI.

2. To compare complications after caesarean section in overweight / obese pregnant women, e.g. hemorrhage, wound infection, DVT, length of stay in hospital and admission to the Intensive Care Unit (ICU) with pregnant women with recommended BMI.

3. To assess the quality of care in terms of using thrombophylaxis, prophylaxis before surgery and using antibiotics after caesarean section and the grade attendants during caesarean section for overweight / obese pregnant women compared to pregnant women with recommended BMI.

5.8 Method

5.8.1 Study design

A case note review of overweight and obese pregnant women who had delivered by caesarean section in 2008.

5.8.2 Sample size and power calculation

With the help of a statistician, a sample size calculation was performed to estimate the number of case notes that would need to be reviewed in order to detect a one day difference in postpartum length of stay between obese and recommended BMI women, with 80% power, and a two tailed significance level of 0.05. In the North East of England, the standard deviation (SD) for length of stay after caesarean deliveries was estimated from the HES Maternity statistics (for the North East Strategic Health Authority) to be 1.62 days. Thus, to detect a difference of one day would be equivalent to an effect size of 1/1.62 = 0.617. However, since the data were not expected to be normally distributed, the power was predicted to be 0.864 times lower[216] with the effect size of 0.617 equivalent to 0.617*0.864 = 0.533.

To detect such a difference, assuming the same ratio of obese to recommended BMI women seen among caesarean section deliveries in the five hospitals dataset, the G* Power programme[217] predicted there would need to be at least 42 obese women and 86 women with recommended BMI. Again assuming the BMI distribution seen in the five hospitals dataset, [216] it was estimated that 183 case notes would need to be reviewed in order to contain the required number of obese women and women with recommended BMI (the distribution was predicted to be: 42 obese women, 51 overweight women, 86 women with recommended BMI, and four underweight women).

The final number of case notes reviewed for this study was 208, with three cases being excluded as there was no BMI measurement. Eighty-six case notes were for women with recommended BMI, 54 for overweight and 65 for obese women.

5.8.3 Sample size

The total sample of this study consists of 205 women with a singleton pregnancy, who had delivered by caesarean section in the maternity units of Wansbeck General Hospital during 2008.

5.8.4 Inclusion and exclusion criteria

Women with a singleton pregnancy, aged 16 years or over, with a BMI ≥18.5kg/m^2, and who delivered a live born or stillborn baby by caesarean section at Wansbeck Hospital during 2008 were eligible to be included in this study. Women aged ≤16 years, with a BMI <18.5kg/m^2, who did not deliver by caesarean section or who had multiple pregnancy (which are known to have more complications than singleton pregnancies),[218,191,219] were excluded from this study.

5.8.5 Research Governance

An application for Research Ethics Committee (REC) approval was made with the intention that I should collect patient data from the case notes. However, the Newcastle and North Tyneside 1 REC did not approve this application because I was not part of the direct clinical care team. They recommended that I either obtained patient consent to extract the data from the case notes or I should submit an application to the National Information Governance Board for Health and Social Care (NIGB) to be able to access the data without patient consent. My supervisors and I felt that it would not be possible to get patient consent for three reasons:

1. Seeking consent during the antenatal period would be inappropriate as the majority of women would not require a caesarean section.

2. Less than 25% of pregnant women have a caesarean section[112], and in most cases this decision is made urgently during labour thus consent could not be requested at this time.

3. Eligibility for the study can only be determined after delivery, and it would be impractical to require midwifery staff to seek consent from women during the postnatal stay whilst they are recovering from a caesarean section.

The NIGB advised that the application would not be approved; therefore I and my supervisors decided a new approach was needed. Thus, following discussions with Dr Shonag Mackenzie, a Consultant Obstetrician at Wansbeck Hospital and co-investigator in this study, I worked with a specialist registrar (SpR) under the supervision of Dr Mackenzie, to extract the data from case notes onto the proforma that I designed for this study (see Appendix VI).

With this amendment to the protocol, the REC approved my study (10/H0906/4) on 13th May 2010 (Appendix VII). The Northumbria Healthcare NHS Foundation Trust agreed to act as sponsor for this study on the 19th June 2010 (Appendix VIII).

5.8.6 Study proforma for data collection

I designed a proforma (Appendix VI) based on the National Sentinel Caesarean Section Audit Report , 2001[108], to extract data from the case notes. The study proforma consisted of three sections:

Section 1: Demographic data

- Mother's details (maternal height and weight at booking, how height and weight were measured; gestation at booking; date of delivery; maternal age at delivery; marital status; maternal occupation; and ethnicity).

Section 2: Obstetric information

- Obstetric details: past obstetrical history; current obstetrical history and labour history; type of caesarean section; whether using prophylaxis; indication for caesarean section; and date of discharge.

Section 3: Postnatal and fetal information

- Postnatal complications:
  1. Mother: wound infection; requiring a blood transfusion; DVT; prescribed antibiotics; and admission to the ICU.
  2. Baby: Apgar score at 1 min; whether admission to the special care baby unit (SCBU) was needed; date of admission; date of death or date of discharge.
  3. Feeding: breast feeding; full breast or partial breast feeding.

5.8.7 Piloting the proforma

A pilot study was undertaken involving 20 case notes to test the relevance of the proforma. Based on this pilot study, a question on maternal educational level was removed from the proforma as the information was found to be unavailable in the case notes.

5.8.8 Data collection

The clinical team at Wansbeck Hospital prepared a list of caesarean deliveries in 2008 that met the study inclusion criteria. Staff working at the Cobalt Business Park, where the case notes for Wansbeck Hospital are stored, prepared the eligible files for the study (see Figure 5-2 for the study flow chart).

Figure 5-2: Flow chart of data collection in the Wansbeck General Hospital Study

2008 caesarean section delivery list prepared by the clinical team in Wansbeck General Hospital checked against the study's inclusion criteria

Eligible case notes identified by the staff at Cobalt Business Park

Eligible cases

Women

- ≥16 years
- BMI≥18.5kg/m^2
- Singleton pregnancy
- Delivered by caesarean section

Data extracted from case notes by a SpR from Wansbeck Hospital onto a proforma designed for the study

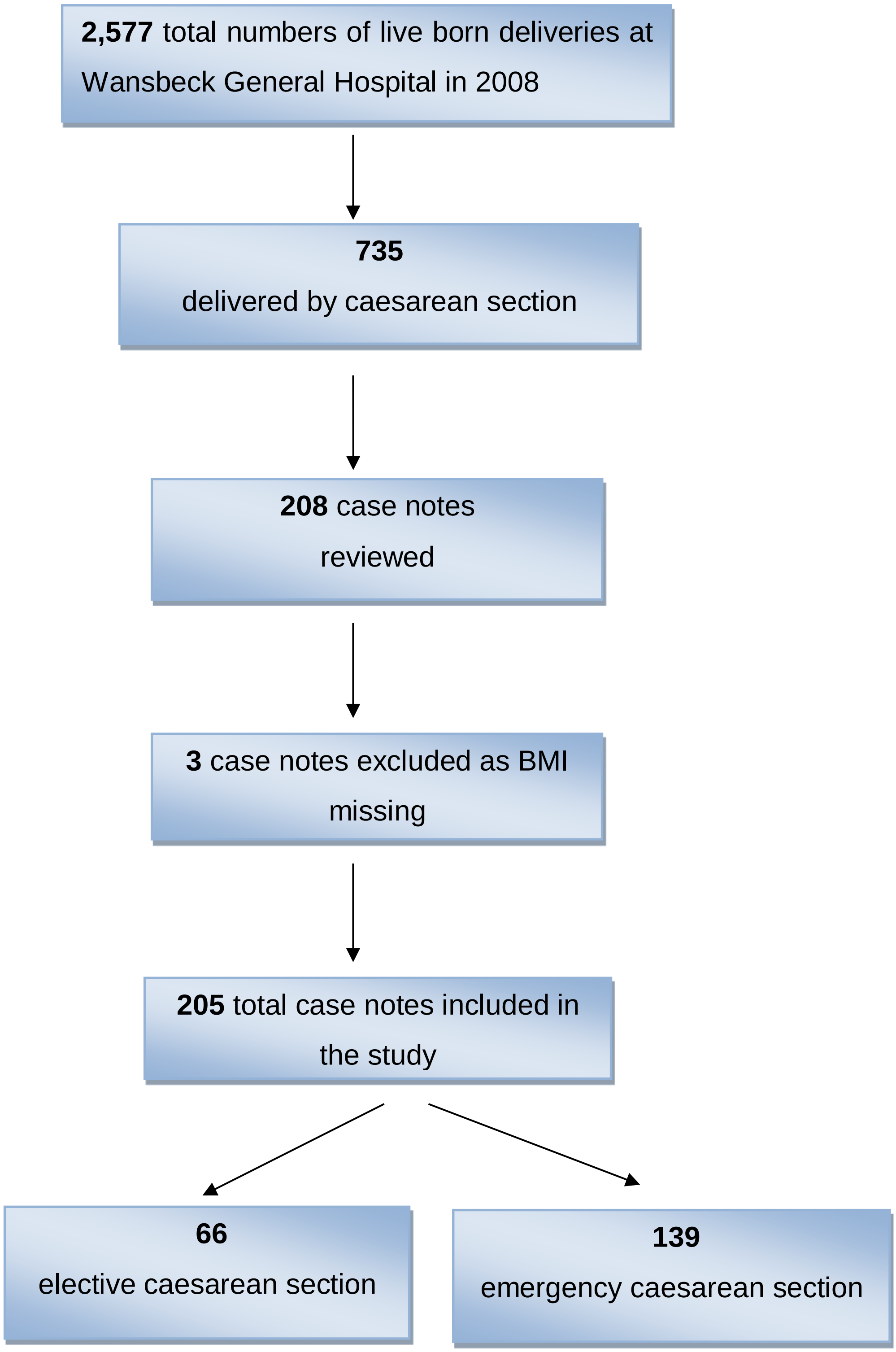
Anonymised data on the proforma checked by Jenan Shakoor and entered onto an SPSS file at Newcastle University

5.8.10 Total deliveries and case note review

In 2008, 2,577 babies were delivered at Wansbeck General Hospital. Of these deliveries, 735 (28.5%) were delivered by caesarean section, 294 (11.4%) by elective caesarean section and 441 (17.1%) by emergency caesarean section. [214]

The process of reviewing case notes to extract the data onto the proforma involved asking the Cobalt Business Park staff to prepare the case notes in advance of the SpR going there. The Cobalt staff prepared about 50 case notes on each occasion. From the 735 case notes for women who had delivered by caesarean section, 205 case notes included after exclusion of three case notes as the BMI measurement was missing (Figure 5-3).

Figure 5-3: Flow chart of total deliveries by caesarean section and number of case notes reviewed



5.8.11 Collecting and cleaning the data

The SpR returned the completed proformas to me after each visit to Cobalt Business Park. I checked the proformas against the study inclusion and exclusion criteria and recalculated the BMI measures from the weight and height measurements to ensure they were correct. I also checked the proformas for data completion. After receiving all the data, I entered them into a Statistical Package of Social Science (SPSS, version 17) file. The accuracy of data entry was checked using two methods; by re-checking each proforma against the downloaded data in the SPSS file, and by running frequencies to find any errors in data entry or data that was outside expected values. When an error was found, I referred back to the proforma and changed the entry accordingly.

After checking the data entry, some of the data variables were categorised. This included maternal age at delivery, gestational age at delivery, birth weight, parity and socio-economic status. Also, I re-coded some variables into categories, such as indications for caesarean section into eight categories (Table 5-1), previous complications and complications in pregnancy (Table 5-2).

Table 5-1: Categories for indications for caesarean section

Caesarean section Indication	Categories Free text entries on proforma
1- Malpresentation	Breech presentation, transverse lie in labour, brow presentation, mento anterior presentation
2- Fetal distress	Abnormal fetal blood sampling (FBS), pathological cardiotocography (CTG)
3- Previous caesarean section and/or other obstetric indications	Previous caesarean section, previous traumatic delivery, previous third degree perineal tear
4- Failure to progress	Deep transverse arrest, secondary arrest, high head, cervical dystocia
5- Failed operative delivery	Failed ventouse, failed forceps delivery, failed induction
6- Maternal request	Maternal request, tocophobia (uncontrolled fear of child birth)
7- Antenatal complications	Abruptio placenta, low lying placenta, cord prolapse, hand prolapse at 3cm dilatation, antepartum haemorrhage, ruptured membrane
8- Medical obstetric complications	Severe pre-eclampsia, pre-eclampsia, eclampsia, haemolytic elevated liver enzyme low platelet (HELLP) syndrome

Table 5-2: Previous and current complications in pregnancy in women in the study sample

Code number	Previous complication	Categories included
1	Previous obstetric complications	Previous caesarean section, traumatic delivery, stillbirth, miscarriage, previous preterm labour, large fibroid uterus, ovarian cystectomy, three degree perineal tear, vaginal cyst and previous labrectomy
2	Medical obstetric complication	Previous gestational diabetes mellitus, hypothyroidism, asthma, alcoholic, depression, previous pre-eclampsia and thrombosis
Code number	**Complications in current pregnancy**	**Categories included**
1	Medical obstetric complication	Pre-eclampsia, gestational diabetes mellitus
2	Current obstetric complication	Large for gestational age, macrosomic baby, intra uterine growth, reduced fetal movement, preterm rupture membrane 36 weeks, antepartum pyrexia

5.8.12 Statistical analysis

I first undertook descriptive analysis of the data by running frequencies and percentages to show the distribution of the study variables and the demographic characteristics of the Wansbeck Hospital study sample by BMI category. I used cross tabulations to show the characteristics of the women undergoing caesarean section among the three BMI groups.

I used the chi-squared test to examine if there was a significant association between the categorical variables and BMI. For continuous data that were normally distributed such as maternal age at delivery, I used the Analysis of Variance (ANOVA) test and t-test to compare overweight and obese pregnant women to women with recommended BMI.

For variables not normally distributed such as gestational age at delivery, birth weight and blood loss, non parametric tests (Kruskal-Wallis test, an alternative to the ANOVA test to compare more than two groups and the Mann Whitney U test, an alternative to the t test to compare two groups) were used to compare overweight/obese women to women with recommended BMI.

The length of maternal and infant stay in hospital was not normally distributed. The non-parametric tests; Kruskal- Wallis test and Mann-Whitney U test, were used to estimate the differences in median and interquartile range of length of stay in hospital among overweight and obese compared to recommended BMI women.

I analysed the length of the baby's stay in the SCBU according to reasons for admission to the SCBU. I used cross-tabulation to compare the length of stay of the baby in the SCBU by BMI categories.

I used SPSS version 17 for all data manipulation and statistical analyses. A p value less than 0.05 ($p<0.05$) was considered statistically significant.

5.8.13 Data manipulation

The BMI data was categorised according to the WHO classification.[193] Table 5-3 shows the categorisation of maternal age, gestational age at booking, gestational age at delivery, birth weight at delivery, blood loss and maternal and baby's length of stay in hospital. The length of the mother's and the baby's stay in hospital was calculated by subtracting the date of delivery from the date the mother and the baby were discharged from hospital. The length of the baby's stay in the SCBU was calculated by subtracting the date of admission to SCBU from the date of discharge from the SCBU.

Parity was categorised into primipara (a woman who is pregnant and has given birth for the first time and had one or more a viable live birth or stillbirth) and multipara (a woman who has had two or more pregnancies resulting in viable baby or stillbirth).[220]

The 2007 Index of Multiple Deprivation (IMD), a UK census-derived area-based measure of socio-economic deprivation, was determined from the mother's residential postcode at booking. The IMD is based on seven census domains: income deprivation, employment deprivation, health deprivation and disability, education, skills and training deprivation, barriers to housing and services, living environment deprivation, and crime.[194] IMD score was obtained from the maternal postcode using the Office for National Statistics; Neighbourhood statistics (ONS) then looking up Indices of Deprivation 2007 for Lower Layer Super Output Areas (LLSOA), which gives the IMD score and rank of the area. The IMD was divided into three internal tertiles; the lowest score, highest rank were scored as 3 for the least deprived area, 2 for the moderate deprived area, and the highest score, lowest rank as 1, for the most deprived area.

Ethnicity was categorised into White and non-White (Black Caribbean, Black African, Black others, Indian, Bangladeshi, Chinese, Asian other, Pakistani, other not known).[108]

Classification of indications for caesarean section was based on the National Sentinel Caesarean Section Audit Report, 2001[108] and reviewed by the consultant obstetrician and the SpR involved in the study. The indications for caesarean section data were grouped into eight groups and further categorised into sub-groups (see Table 5-1). Both previous complications and complications in current pregnancy grouped into two categories, and were categorised based on the study by Homer et al, [221] 2011 (see Table 5-2).

Other variables, such as using acid prophylaxis, sodium citrate, need for a blood transfusion, admission to ICU and if there was any evidence for DVT and PE were dichotomised into Yes and No.

The decision to delivery time data were categorised into three categories: <30 minutes, <60 minutes and ≥ 60 minutes.

Documented wound infection and whether the women was receiving antibiotics, such as Augmentin (1.2gm, IV) or Clindamycin (600mg, IV) were also dichotomised into Yes and No. The period (days) of receiving antibiotics was categorised into <7 days and ≥ 7 days.

Apgar score assessments at 1 minute, 5 minutes and 10 minutes were categorised into three categories: 0-3, 4-7 and 8-10 respectively (Table 5-3).

Breast feeding after delivery and breast feeding at discharge were dichotomised into Yes and No.

Table 5-3: Variables categorised in the study

Variable	Categories
Maternal age (year)	<20
	20-24
	25-29
	30-34
	≥35
Gestational age at booking (week)	<12
	12-23
	≥24
Gestational age at delivery (week)	<24
	24-36
	≥37
Birth weight at delivery (grams)	<2500
	2500-2999
	3000-3499
	3500-3999
	≥4000
Blood loss (mls)	<1000
	≥1000
Length of the mother's stay in hospital (days)	<3
	3-5
	≥6
Length of the baby's stay in hospital (days)	<3
	3-5
	≥6
Decision-delivery time (minutes)	<30
	<60
	≥60
Apgar score (minutes)	
1, 5, 10	0-3
	4-7
	8-10
Breast feeding	
After delivery	Yes/No
At discharge	Yes/No

5.9 Results

5.9.1 Total sample

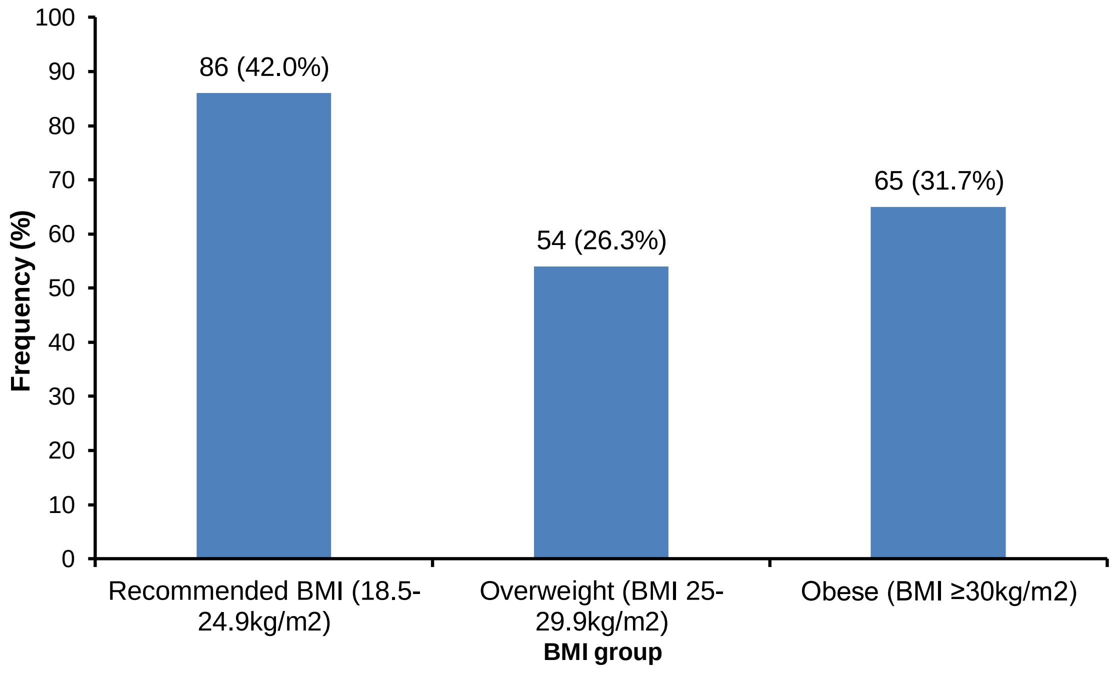
A total of 205 case notes of women with a singleton pregnancy who delivered by caesarean section in 2008 were included in my sample. Of these, 139 (67.8%) were delivered by emergency caesarean section; 105 (75.5%) were attended by a SPR and 34 (24.5%) were attended by a consultant. Sixty-six (32.2%) were delivered by elective caesarean section; 23 (34.8%) of these were attended by a SpR and 43 (65.2%) by a consultant.

5.10 Descriptive statistics

5.10.1 BMI distribution among the sample

Figure 5-4 shows the distribution of cases within my sample by BMI. Overall, 86 (42.0%) pregnancies were to women with recommended BMI, 54 (26.3%) to overweight women and 65 (31.7%) to women who were obese.

Figure 5-4: BMI distribution among the study sample



5.10.2 Maternal and fetal characteristics by BMI category

Table 5-4 shows the maternal and fetal characteristics of the cases included in the sample by BMI category. Fifty-five (27.0%) women were aged between 30-34 years and 44 (21.6%) were aged 35 years or more, with a mean maternal age of 29.3 (SD±6.1) years.

One hundred and fourteen (57.0%) of these women were married, 118 (57.6%) were multipara and 87(42.4%) were primiparous women. The majority of the women (96.5%) were of White ethnicity.

A total of 183 (89.7%) babies were delivered at a gestational age of ≥37 weeks (term) with a mean gestational age of 38.9 (±2.2) weeks. Nineteen (9.4%) had a birth weight <2500g and 30 (14.8%) with a birth weight ≥ 4000g. The mean birth weight was 3317.2 g (±1.8). Sixty-two (96.9%) obese women had a caesarean section at a gestation age of ≥37 weeks (p=0.06).

There were no statistically significant differences in maternal age (p=0.59), parity (p=0.24), deprivation (p=0.08), marital status (p=0.94) and employment status (p=0.40) among women in the different BMI categories. Obese women were less likely to be of non-White ethnicity (p=0.007) and to deliver heavier babies (p=0.02).

In summary, the findings show that obese women were of White ethnicity and deliver heavier babies.

Table 5-4: Maternal and fetal characteristics by BMI category among the study sample

Variables	Total N (%)	BMI category: Recommended BMI 18.5-24.9kg/m^2 N=86	Overweight BMI 25-29.9kg/m^2 N=54	Obese BMI ≥30kg/m^2 N=65	p value
Maternal age (years)					0.18
<20	11 (5.4)	9 (10.6)	0 (0.0)	2 (3.1)	
20-24	39 (19.1)	17 (20.0)	11 (20.4)	11 (16.9)	
25-29	55 (27.0)	19 (22.4)	16 (29.6)	20 (30.8)	
30-34	55 (27.0)	23 (27.1)	12 (22.2)	20 (30.8)	
≥ 35	44 (21.6)	17 (20.0)	15 (27.8)	12 (18.5)	
Mean	**29.3**	**28.9**	**30.0**	**29.3**	
SD	**6.1**	**6.7**	**6.1**	**5.3**	
Marital status					0.60
Single	31 (15.5)	14 (17.1)	10 (18.5)	7 (10.9)	
Married	114 (57.0)	44 (53.7)	29 (53.7)	41 (64.1)	
Living with partner	48 (24.0)	22 (26.8)	13 (24.1)	13 (20.3)	
Divorced	6 (3.0)	2 (2.4)	1 (1.9)	3 (4.7)	
Separated	1 (0.5)	0	1 (1.9)	0	

Table 5-4: (continued) Maternal and fetal characteristics by BMI category among the study sample

Variables	Total N (%)	BMI category			p value
		Recommended BMI 18.5-24.9kg/m^2 N=86	**Overweight BMI 25-29.9kg/m^2 N=54**	**Obese BMI ≥30kg/m^2 N=65**	
Parity					0.24
Primipara	87 (42.4)	42 (48.8)	22 (40.7)	23 (35.4)	
Multipara	118 (57.6)	44 (51.2)	32 (59.3)	42 (64.6)	
IMD tertile					0.11
Most deprived	68 (33.8)	24 (28.9)	16 (30.2)	28 (43.1)	
Moderate deprived	66 (32.8)	24 (28.9)	22 (41.5)	20 (30.8)	
Least deprived	67 (33.3)	35 (42.2)	15 (28.3)	17 (26.2)	
Gestational age at delivery (weeks)					0.06
24-36	21 (10.3)	13 (15.1)	6 (11.1)	2 (3.1)	
≥37	183 (89.7)	73 (84.9)	48 (88.9)	62 (96.9)	
Mean	**38.9**	**38.7**	**38.8**	**39.3**	
SD	**2.2**	**2.3**	**2.4**	**1.6**	

Table 5-4: (continued) Maternal and fetal characteristics by BMI category among the study sample

Variables	Total N (%)	BMI category: Recommended BMI 18.5-24.9kg/m^2 N=86	BMI category: Overweight BMI 25-29.9kg/m^2 N=54	BMI category: Obese BMI ≥30kg/m^2 N=65	p value
Ethnicity					0.007
White	195 (96.5)	78 (91.8)	53 (100)	64 (100)	
Non white	7 (3.5)	7 (8.2)	0	0	
Birth weight (gm)					0.04
<2500	19 (9.4)	12 (14.3)	5 (9.3)	2 (3.1)	
2500-2999	34 (16.7)	11 (13.1)	10 (18.5)	13 (20.0)	
3000-3499	71 (35.0)	34 (40.5)	22 (40.7)	15 (23.1)	
3500-3999	49 (24.1)	18 (21.4)	11 (20.4)	20 (30.8)	
≥4000	30 (14.8)	9 (10.7)	6 (11.1)	15 (23.1)	
Mean	**3317.2**	**3209.7**	**3242.4**	**3518.3**	
SD	**1.8**	**703.4**	**620.6**	**646.6**	

5.10.3 Indications for caesarean section by type of caesarean section

Table 5-5 shows the indications for caesarean section by type of caesarean section. Fetal distress was the most common indication for emergency caesarean section (54, 38.8%), while previous caesarean section and/ or other obstetric indications were the most common indications for elective caesarean section (39, 59.1%).

Table 5-5: Indications for caesarean section by caesarean section type

Indication for caesarean section	Emergency caesarean section N=139	Elective caesarean section N=66	Total N=205	p value
Malpresentation	16 (11.5)	10 (15.2)	26 (12.7)	<0.05
Fetal distress	54 (38.8)	0 (0.0)	54 (26.3)	
Previous caesarean section and/or other obstetric indications	4 (2.9)	39 (59.1)	43 (21.0)	
Failure to progress	37 (26.6)	3 (4.5)	40 (19.5)	
Failed operative delivery	13 (9.4)	0 (0.0)	13 (6.3)	
Maternal request	0 (0.0)	7 (10.6)	7 (3.4)	
Antenatal complications	8 (5.8)	4 (6.1)	12 (5.9)	
Medical obstetric complications	7 (5.0)	3 (4.5)	10 (4.9)	

My results show that there was a significant difference ($p<0.05$) in the obstetric grade attending the caesarean section by caesarean section type. For emergency caesarean section, three quarters (105, 75.5%) were attended by a SpR. For elective caesarean section, just over a third (23, 34.8%) were attended by a SpR (Table 5-6).

Table 5-6: Obstetric grade attending the caesarean section by type of caesarean section

Obstetric category	Emergency caesarean section N (%)	Elective caesarean section N (%)	Total	p value
Specialist registrar (SpR)	105 (75.5)	23 (34.8)	128 (62.4)	<0.05
Consultant	34 (24.5)	43 (65.2)	77 (37.6)	
Total	**139**	**66**	**205**	

5.10.4 Caesarean section type, indications, urgency and obstetric grade by BMI category

The findings of Table 5-7 show that the proportions of indications for caesarean section among BMI categories were not significantly different. The most common indications for caesarean section among overweight and obese women were fetal distress and repeat caesarean section and/or other obstetric indications compared to women with recommended BMI.

There were no significant differences in caesarean section type, urgency of caesarean section and obstetric grade attending caesarean section by BMI category.

Table 5-7: Caesarean section type, indications, urgency and obstetric grade attendant by BMI category

Variables	Total N (%)	BMI category			p value
		Recommended BMI 18.5-24.9kg/m^2 N (%)	Overweight BMI 25-29.9kg/m^2 N (%)	Obese BMI ≥30kg/m^2 N (%)	
Caesarean section type					0.86
Emergency caesarean section	139 (67.8)	59 (68.6)	35 (64.8)	45 (69.2)	
Elective caesarean section	66 (32.2)	27 (31.4)	19 (35.2)	20 (30.8)	
Indications for caesarean section					0.62
Malpresentation	26 (12.7)	16 (18.6)	4 (7.4)	6 (9.2)	
Fetal distress	54 (26.3)	17 (19.8)	18 (33.3)	19 (29.2)	
Previous caesarean section and/ or other obstetric indications	43 (21.0)	15 (17.4)	12 (22.2)	16 (24.6)	
Failure to progress	40 (19.5)	16 (18.6)	10 (18.5)	14 (21.5)	
Failed operative delivery	13 (6.3)	7 (8.1)	3 (5.6)	3 (4.6)	
Maternal request	7 (3.4)	3 (3.5)	2 (3.7)	2 (3.1)	
Antenatal complications	12 (5.9)	6 (7.0)	4 (7.4)	2 (3.1)	
Obstetric medical complications	10 (4.9)	6 (7.0)	1 (1.9)	3 (4.6)	
Caesarean section urgency					0.92
Delivery <30min	54 (26.3)	23 (26.7)	15 (27.8)	16 (24.6)	
Delivery <60min	51 (24.9)	19 (22.1)	14 (25.9)	18 (27.7)	
Delivery >1 to <12hour	34 (16.6)	17 (19.8)	6 (11.1)	11 (16.9)	
Delivery to suit woman and staff	66 (32.2)	27 (31.4)	19 (35.2)	20 (30.8)	
Obstetric grade					0.10
Specialist registrar (SpR)	128 (62.4)	60 (69.8)	28 (51.9)	40 (61.5)	
Consultant	77 (37.6)	26 (30.2)	26 (48.1)	25 (38.5)	

5.10.5 Previous obstetric complications

Table 5-8 shows that sixty-eight (79.1%) women had a previous obstetric complication; of these 25 (80.6%) were obese women compared to 22 (75.9%) women were with recommended BMI. There were no significant differences in the proportion of women with previous complications by BMI category (p=0.87).

Table 5-8: Previous complications among the study sample by BMI category

Previous complications	**BMI category**			**Total N (%)**	**p value**
	Recommended BMI 18.5-24.9kg/m^2 N (%)	**Overweight BMI 25-29.9kg/m^2 N (%)**	**Obese BMI≥30kg/m^2 N (%)**		
Previous obstetric complications	22 (75.9)	21 (80.8)	25 (80.6)	68 (79.1)	0.87
Medical obstetric complications	7 (24.1)	5 (19.2)	6 (19.4)	18 (20.9)	
Total	**29/86**	**26/54**	**31/65**	**31/65**	

5.10.6 Current obstetric complications

Table 5-9 shows that just over half (30, 51.7%) of the pregnant women delivered by caesarean section had medical complications. Of these, 17 (29.3%) women had pre-eclampsia, 11 (19.0%) had GDM and two (3.4%) women had both pre-eclampsia and GDM. A further 28 (48.3%) women had other obstetric complications, for example large for gestational age babies, macrosomic baby, IUGR, reduced fetal movement, preterm rupture of membrane at 36 weeks and antepartum pyrexia.

Table 5-9: Current complications in pregnancy among the study sample by BMI category

Complications in pregnancy	BMI category			Total N (%)	p value
	Recommended BMI 18.5-24.9kg/m^2 N (%)	Overweight BMI 25-29.9kg/m^2 N (%)	Obese BMI ≥30kg/m^2 N (%)		
Current obstetric complications	13 (52.0)	6 (60.0)	9 (39.1)	28 (48.3)	0.48
Medical obstetric complications	12 (48.0)	4 (40.0)	14 (60.9)	30 (51.7)	
Pre-eclampsia	6 (24.0)	2 (20.0)	9 (39.1)	17 (29.3)	
Gestational diabetes mellitus	5 (20.0)	2 (20.0)	4 (17.4)	11 (19.0)	
Both	1 (4.0)	0 (0.0)	1 (4.3)	2 (3.4)	
Total	25	10	23	58	

Although there were no significant differences for current pregnancy complications by BMI category (p=0.48), 14 (60.9%) obese women had an obstetric medical complication compared to 12 (48.0%) pregnant women with recommended BMI. Of these, nine (39.1%) obese women had pre-eclampsia compared to six (24.0%) women with recommended BMI (Table 5-9).

5.11 Maternal length of stay in hospital

Table 5-10 shows that the median length for maternal stay in hospital by BMI category. The median length for overweight and obese women were three days compared to 2 days of women in recommended BMI, with an Interquartile Range (IQR) from 2-3. There were no significant differences among BMI categories in length of stay in hospital compared to women with recommended BMI (p=0.23).

Two mothers were admitted to the ICU; one of the cases had a hysterectomy (aged 29 years, BMI 26.9 kg/m^2, parity four, delivered at gestational age of 38 weeks, a blood loss of 11,000 mls). The second case had severe pre-eclampsia and HELLP (aged 21 years, BMI 26 kg/m^2, primipara, delivered at gestational age of 34 weeks and a blood loss of 1000 mls).

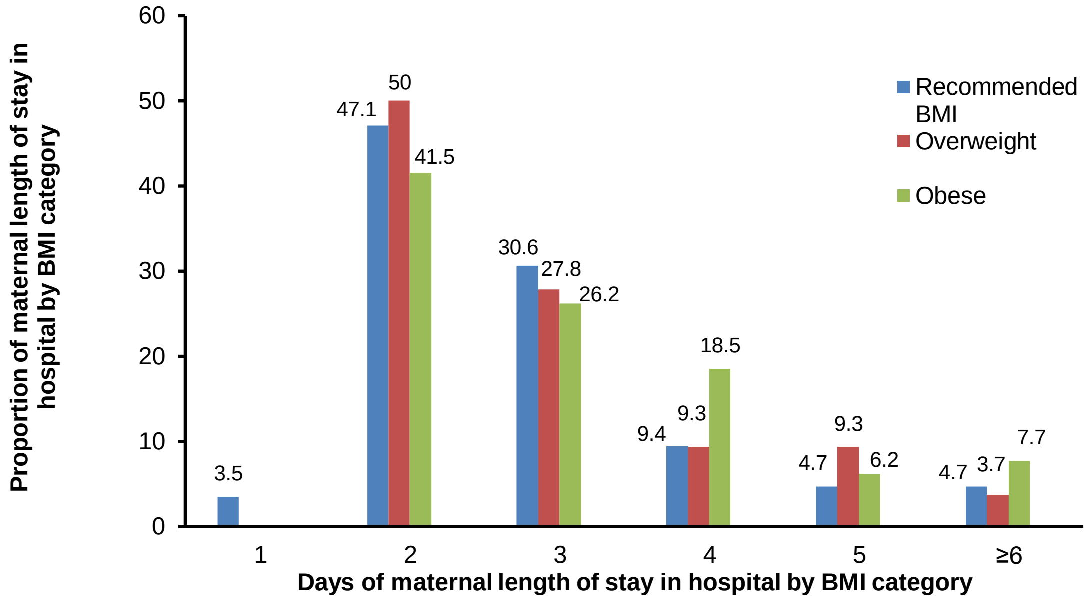
Table 5-10: Maternal length of stay in hospital by body mass index category

Maternal length of stay in hospital	No (%)	BMI category			P value
		Recommended BMI 18.5-24.9kg/m^2 N=86	Overweight 25-29.9kg/m^2 N=54	Obese ≥30kg/m^2 N=65	
Total	204 (99.5)	85 (41.6)	54 (26.5)	65 (31.9)	
Median		2	3	3	
Interquartile range (IQR)	2-3				
Kruskal-Wallis test					0.23
Mann-Whitney test					
Recommended BMI & overweight					0.67
Recommended BMI & obese					0.09

Figure 5-5 shows the distribution of maternal length of stay in hospital by BMI category. This data were not normally distributed.

My findings show that 18.5% of obese women stayed in hospital after caesarean delivery for four days compared to 9.3% overweight and 9.4% women with recommended BMI. In addition, 7.7% obese women stayed in hospital after caesarean delivery for ≥6 days compared to 3.7% overweight and 4.7% women with recommended BMI. However, there were no significant differences in maternal length of stay in hospital among BMI groups (Figure 5-5).

Figure 5-5: Maternal length of stay in hospital by BMI category



5.12 Baby's length of stay in hospital

Most of the babies stayed in hospital for the same period of time as their mother. Ninety-six (47.1%) babies stayed in hospital for less than three days compared with 92 (45.0%) babies who stayed in hospital for 3-5 days and 15 (7.4%) babies who stayed in hospital for ≥ 6 days (Table 5-11). Of these, six (9.2%) babies to obese mothers stayed in hospital for six days or more, compared with three (5.6%) babies to overweight mothers and six (7.1%) babies to women with recommended BMI (p=0.66) (Table 5-11).

Five babies stayed longer than their mothers as they were transferred to other hospitals for different reasons.

The median length of baby's stay in the hospital was 3 with a range of 1-45 days and IQR 2-3 days. There were no significant differences among BMI categories in length of stay in hospital compared to women with recommended BMI (p=0.12) (Table 5-11).

Table 5-11: Length of baby's stay in hospital by BMI category

Length of stay (days)	Total N (%)	BMI category: Recommended BMI 18.5-24.9kg/m^2 N (%)	Overweight BMI 25-29.9kg/m^2 N (%)	Obese BMI ≥30kg/m^2 N (%)	p value
Baby's length of stay in hospital (days)					0.66
< 3	96 (47.1)	44 (51.8)	26 (48.1)	26 (40.0)	
3-5	92 (45.0)	34 (36.9)	25 (27.1)	33 (35.8)	
≥ 6	15 (7.4)	6 (7.1)	3 (5.6)	6 (9.2)	
Total	203 (99.0)	84 (41.4)	54 (26.6)	65 (32.0)	
Median		2	3	3	
Interquartile range (IQR)	2-3				
Kruskal-Wallis test					0.12
Mann-Whitney test					
Recommended BMI & overweight					0.49
Recommended BMI & obese					0.05
Maternal length of stay (days)					0.73
< 3	97 (47.5)	43 (50.6)	27 (50.0)	27 (41.5)	
3-5	96 (47.1)	38 (44.7)	25 (46.3)	33 (50.8)	
≥ 6	11 (5.4)	4 (4.7)	2 (3.7)	5 (7.7)	

5.12.1 Baby's admission to the Special Care Baby Unit

Thirty (14.6%) babies were admitted to SCBU for different reasons. Of these, five babies were transferred to a different hospital; three babies were transferred to the Royal Victoria Infirmary in Newcastle, while two babies were transferred to Freeman Hospital in Newcastle. The remaining 25 babies included: three cases of potential infection, 14 cases of poor feeding and preterm (<37weeks), four cases of respiratory distress and in a further four cases the reason for admission to SCBU was not stated.

Table 5-12 shows the baby's length of stay in SCBU by BMI category. Two (50%) babies who stayed in SCBU for six days or more were to obese women, compared with five (29.4%) babies to women with recommended BMI (p=0.27).

Table 5-12: Baby's length of stay at SCBU by BMI category

Baby length of stay at SCBU (days)	Total N (%)	BMI category			p value
		Recommended BMI 18.5-24.9kg/m^2 N (%)	Overweight BMI 25-29.9kg/m^2 N (%)	Obese BMI ≥30kg/m^2 N (%)	
<3	10 (33.3)	7 (41.2)	1 (11.1)	2 (50.0)	
3-5	10 (33.3)	5 (29.4)	5 (55.6)	0 (0.0)	0.27
≥6	10 (33.3)	5 (29.4)	3 (33.3)	2 (50.0)	
Total	**30**	**17**	**9**	**4**	

5.12.2 Apgar score

All babies delivered to obese women had an Apgar score assessment (Table 5-13). An Apgar score at 1 minute was undertaken for 204 (99.5%) cases, and at 5 minutes for 203 (99%) cases. Only six (2.9%) babies had an Apgar score at 10 minutes recorded. However, there were no significant differences for Apgar score at 1 minute, 5 minutes and 10 minutes by BMI category (Table 5-13).

Table 5-13: Apgar score assessment after delivery for study sample

Apgar score assessment	BMI category				P value
	Recommended BMI 18.5-24.9kg/m^2 N (%)	Overweight BMI 25-29.9kg/m^2 N (%)	Obese BMI ≥30kg/m^2 N (%)	Total N (%)*	
1 min score					
Yes	86 (100)	53 (98.1)	65 (100)	204 (99.5)	0.24
Not recorded	0 (0.0)	1 (1.9)	0 (0.0)	1 (0.5)	
0-3	9 (10.5)	3 (5.7)	8 (12.3)	20 (9.8)	0.79
4-7	6 (7.0)	5 (9.4)	5 (7.7)	16 (7.8)	
8-10	71 (82.6)	45 (84.9)	52 (80.0)	168 (82.4)	
5 mins score					
Yes	86 (100)	53 (98.1)	64 (98.5)	203 (99.0)	0.47
Not recorded	0 (0.0)	1 (1.9)	1 (1.5)	2 (1.0)	
0-3	2 (2.3)	0 (0.0)	0 (0.0)	2 (1.0)	0.17
4-7	2 (2.3)	1 (1.9)	5 (7.8)	8 (3.9)	
8-10	82 (95.3)	52 (98.1)	59 (92.2)	193 (95.1)	
10 mins score					
Yes	2 (2.3)	1 (1.9)	3 (4.6)	6 (2.9)	0.61
Not recorded	84 (97.7)	53 (98.1)	62 (95.4)	199 (97.1)	
0-3					0.69
4-7	1 (50.0)	0 (0.0)	1 (33.3)	2 (33.3)	
8-10	1 (50.0)	1 (100)	2 (66.7)	4 (66.7)	

* valid %

5.13 Breast feeding

5.13.1 Breast feeding after delivery

Table 5-14 shows the proportion of babies who were breast fed after delivery and at discharge from hospital by BMI category. Overall, 97 (47.3%) women in the sample started breast feeding after delivery; twenty nine (44.6%) were obese women, 26 (48.1%) overweight and 42 (48.8%) were women with recommended BMI. There was no significant difference in the proportion of babies breast fed after delivery by BMI category (p=0.87).

A total of 103 (50.2%) women breast fed at discharge; twenty eight (43.1%) were obese women, 31 (57.4%) overweight and 44 (51.2%) were women with recommended BMI (Table 5-14). There was no significant difference for breast feeding at discharge by BMI category (p=0.23) (Table 5-14).

Table 5-14: Breast feeding after delivery and at discharge from hospital by BMI category

Breast feeding	**BMI category**			**Total N=205**	**P value**
	Recommended BMI 18.5-24.9kg/m^2 N=86	**Overweight BMI 25-29.9kg/m^2 N=54**	**Obese BMI >=30kg/m^2 N=65**		
Breast feeding after delivery					0.87
No	44 (51.2)	28 (51.9)	36 (55.4)	108 (52.7)	
Yes	42 (48.8)	26 (48.1)	29 (44.6)	97 (47.3)	
Breast feeding at discharge					0.23
No	42 (48.8)	22 (40.7)	37 (56.9)	101 (49.3)	
Yes	44 (51.2)	31 (57.4)	28 (43.1)	103 (50.2)	
Missing	0 (.0)	1 (1.9)	0 (.0)	1 (0.5)	

5.14 Postpartum complications

5.14.1 Wound infection

Table 5-15 shows that 36 (17.9%) women in the study sample had a wound infection after delivery by caesarean section. Thirty four (16.9%) women received antibiotics. Of these 27 (79.4%) used antibiotics for ≥ 7 days compared to seven (20.6%) women who used antibiotics for less than seven days.

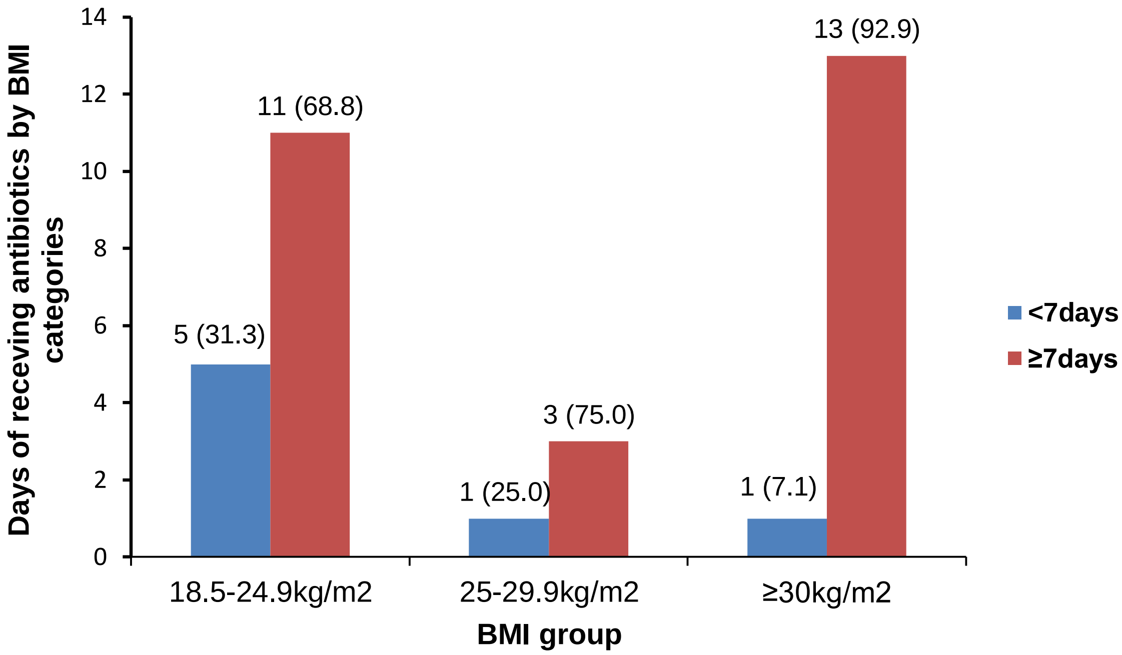
Table 5-15: Wound infection, antibiotic use and number of days of antibiotic use by BMI category

Variables	Total N (%)	BMI category			p value
		Recommended BMI 18.5-24.9kg/m^2 N (%)	Overweight BMI 25-29.9kg/m^2 N (%)	Obese BMI ≥30kg/m^2 N (%)	
Wound infection					0.15
Yes	36 (17.9)	17 (20.2)	5 (9.3)	14 (22.2)	
No	165 (82.1)	67 (79.8)	49 (90.7)	49 (77.8)	
Received antibiotics					0.08
Yes	34 (16.9)	16 (19.0)	4 (7.4)	14 (22.2)	
No	167 (83.1)	68 (81.0)	50 (92.6)	49 (77.8)	
Number of days of antibiotic use*					0.26
<7 days	7 (20.6)	5 (31.3)	1 (25.0)	1 (7.1)	
≥7 days	27 (79.4)	11 (68.8)	3 (75.0)	13 (92.9)	

* % of those who received antibiotics

The lowest rate of wound infection (9.3%) was among overweight women, compared to obese 14 (22.2%) and 17 (20.2%) women with recommended BMI. Overweight women had the lowest rate, four (7.4%) compared to 14 (22.2%) obese and 34 (16.9%) women with recommended BMI. However, of 34 (16.9%) women who had received antibiotics, 13 (92.9%) were obese women and used the antibiotics for ≥ 7 days compared to three (75.0%) overweight and 11 (68.8%) women with recommended BMI, although this did not reach statistical significance (Table 5-15), (Figure 5-6).

Figure 5-6: Number of days of antibiotic use among the study sample by BMI category



5.14.2 Deep vein thrombosis and pulmonary embolism

There were no cases of deep vein thrombosis or pulmonary embolism among my study sample.

5.14.3 Blood loss

Table 5-16 shows reported blood loss following caesarean section delivery among the study sample by BMI category. Overall, 39 (19.0%) women had a blood loss ≥ 1000 mls. Overweight women (16, 29.6%) were more likely to have an estimated blood loss of ≥ 1000 mls compared to 12 (18.5%) obese and 11 (12.8%) women with recommended BMI (p=0.04).

Table 5-16: Blood loss following caesarean section delivery among the study sample by BMI category

Blood loss	BMI category				
	Recommended BMI 18.5-24.9kg/m^2 N (%)	**Overweight BMI 25-29.9kg/m^2 N (%)**	**Obese BMI >=30kg/m^2 N (%)**	**Total N (%)**	**p value**
<1000 mls	75 (87.2)	38 (70.4)	53 (81.5)	166 (81.0)	0.04
≥ 1000 mls	11 (12.8)	16 (29.6)	12 (18.5)	39 (19.0)	
Total	**86**	**54**	**65**	**205**	

5.15 Quality of care

5.15.1 Thrombophylaxis

All pregnant women in my sample were given Tinzaparin (an anticoagulant used to prevent blood clot) before having a caesarean section.

5.15.2 Anti-acid prophylaxis

Table 5-17 shows that from a total of 205 pregnant women who delivered by caesarean section, 201 (98%) were given one dose of anti-acid prophylaxis (acid aspiration prophylaxis, such as sodium citrate) before having a caesarean section; sixty five (100%) were obese women, 53 (98.1%) overweight and 83 (96.5%) were women with recommended BMI (p=0.30).

All 205 pregnant women in my study sample received prophylactic antibiotics. 197(96.1%) received Augmentin (1.2gm, IV); eight (3.9%) women who had an allergy to Augmentin received Clindamycin (600mg, IV) (Table 5-17).

Table 5-17: Prophylaxis used among the study sample by BMI category

Prophylaxis used	Total N (%)	BMI category			p value
		Recommended BMI 18.5-24.9kg/m^2 N (%)	Overweight BMI 25-29.9kg/m^2 N (%)	Obese BMI ≥30kg/m^2 N (%)	
Acid-prophylaxis					0.30
Yes	201(98.0)	83 (96.5)	53 (98.1)	65 (100)	
No	4 (2.0)	3 (3.5)	1 (1.9)	0 (0.0)	
Prophylactic antibiotic					0.20
Yes	205 (100)				
Augumentin (1.2gm)	197 (96.1)	82 (95.3)	54 (100)	61 (93.8)	
Clindamycine (600mg)	8 (3.9)	4 (4.7)	0 (0.0)	4 (6.2)	

5.15.3 Decision to delivery time

Table 5-18 shows that the overall time from the decision to have a caesarean section to delivery was 30 minutes in 51 (24.9%) cases and 60 minutes in 47 (22.9%) cases. 19 (29.2%) obese women delivered at 60 minutes, compared to 12 (22.2%) overweight and 16 (18.6%) women with recommended BMI but this finding did not reach statistical significance (p=0.42).

Table 5-18: Decision to delivery time by BMI category

Decision-delivery time	BMI category			Total N=205	p value
	Recommended BMI 18.5-24.9kg/m^2 N=86	Overweight BMI 25-29.9kg/m^2 N=54	Obese BMI >=30kg/m^2 N=65		
30 mins	21 (24.4)	15 (27.8)	15 (23.1)	51 (24.9)	0.42
60 mins	16 (18.6)	12 (22.2)	19 (29.2)	47 (22.9)	
> 60mins <12hr	21 (24.4)	6 (11.1)	11 (16.9)	38 (18.5)	
Missing	28 (32.6)	21 (38.9)	20 (30.8)	69 (33.7)	

There was a significant difference (p<0.005) in the decision to delivery time by obstetric grade attending the delivery; where there was a decision-delivery time of 30 minutes, it was more likely that the caesarean section was attended by a consultant (Table 5-19).

Table 5-19: Decision to delivery time by obstetric grade

Decision–Delivery time	Obstetric grade category		Total N=205	p value
	SPR N=128	Consultant N=77		
30 mins	31 (24.2)	20 (26.0)	51 (24.9)	0.0005
60 mins	40 (31.3)	7 (9.1)	47 (22.9)	
> 60 mins<12hr	32 (25.0)	6 (7.8)	38 (18.5)	
Missing	**25 (19.5)**	**44 (57.1)**	**69 (33.7)**	

5.16 Discussion

The present study of 205 women who had delivered by caesarean section at Wansbeck Hospital in 2008 was designed to test the hypothesis that overweight and obese pregnant women have more post-caesarean section complications compared with women with recommended BMI and that this resulted in a longer length of stay in hospital.

5.16.1 Summary of key findings

My study population showed no differences in maternal age, parity, socio-economic status, employment and marital status among different BMI groups having a caesarean section. However, obese women were more likely to be of White ethnicity and delivered heavier babies.

A total of 97 (47.5%) women stayed in hospital for <3 days and 107 (52.5%) women stayed in hospital for three days or more. The results of my study did not show significant differences in maternal length of stay in hospital by BMI category. Nevertheless, about two thirds of obese women who had a caesarean section stayed in hospital for three days or more compared with 50% of overweight women and 49% of recommended BMI women.

The proportion of emergency caesarean section was about two thirds among the study population compared to one third elective caesarean section.

Fetal distress was the most common indication for caesarean section in this study. A quarter of obese women had a repeat caesarean section following a previous caesarean section and/or other obstetric indications compared to 22% of overweight and 17% of recommended BMI women.

There was a significant difference in the amount of blood loss following the caesarean section by BMI category. More overweight women (29.6%) had a blood loss of 1000 mls or more compared to 18.5% of obese and 13% of recommended BMI women.

More than one fifth of obese women had a wound infection and used antibiotics for seven days or more compared to 9% of overweight and 20% with recommended BMI women but this result was not statistically significance.

There were no cases of deep vein thrombosis or pulmonary embolism in the study sample.

All study women had received pre-operative anti-acid prophylaxis, thrombophylaxis and prophylactic antibiotics before caesarean section.

5.16.2 Study strengths

This study has a number of strengths. Data were derived from a large hospital with well documented data on maternal BMI and caesarean section. An important strength of this study is that maternal height and weight was measured by the midwife at the first antenatal visit. Self-reported BMI shows a characteristic pattern of error.[222] Research has found that women who self-report their BMI overestimate their height and underestimate their weight. [197]

Another strength of this study is that much of the data were complete, for example data on delivery by caesarean section were complete, such as type of caesarean section, indications for caesarean section, decision to delivery time, urgency of caesarean section, parity, admission to ICU and complications after caesarean section. Data for the baby after deliver were complete as well, such as baby weight, Apgar score assessment, breast feeding and admission to the SCBU.

Moreover, data on blood loss and wound infection with the use of prophylaxis were complete. This hospital follows the standard guidelines and has very good documented records on DVT and using thrombophylaxis and prophylaxis before caesarean section.

Breast feeding at Wansbeck Hospital is also very well documented in the notes, as it is one of their indicators for the CQUIN (Commissioning for Quality and Innovation) programme. The CQUIN payment framework is a national framework for locally agreed quality improvement schemes.

5.16.3 Study limitations

The study also had several limitations. A favourable ethical opinion for this study was granted based on the data being extracted from the case notes by a member of the direct care team (a named SpR). This meant that I was dependent on the SpR's time to extract the data and to the system for providing the medical files within Cobalt Business Park. I had hoped to review all caesarean section case notes for the study period although the power calculation gave me the case notes number that I needed. This process reduced my chance to review all caesarean section case notes for the study period (2008). In addition, I was unable to have direct control over the transcription of the data from the notes onto the proforma, or to cross check this process.

Another limitation is the possibility of selection bias in the included case notes. Women could only be included in the study if their notes were available. This may not have been the case if the women were pregnant again. It is also likely that case notes that are missing or unavailable are likely to be biased towards more complicated cases. My study included less half of the women who had caesarean section and therefore my study population may not be representative of all women.

I created categories from the indications for caesarean section that were written on the case notes. There were no prospectively defined categories and I was dependent on the clinical judgment of the person completing the caesarean section record. Some of the proformas included more than one indication for caesarean section; therefore I grouped similar indications under one category after consulting with the obstetrician working in Wansbeck hospital who helped us with data collection.

My study sample was derived from a sample size calculation powered on a difference of one day in length of stay in hospital between groups. Not such difference was found. This may have been a false negative, or the difference may have been genuinely less than one day.

My study examined various outcomes with no adjustment for multiple testing (due to the modest power), therefore the possibility of false positive results should not be discounted. No Sample size calculation was performed for any of the other outcomes examined (e.g wound infection, blood loss, etc). The study may have been underpowered to explore these associations.

All individuals with obese BMI were combined into a single group for analyses. This may obscure effects for heavier individuals, such as morbidly obese women, who may have had for example longer lengths of stay. However, only nine women had a BMI over 40, thus such an analysis would have been underpowered.

5.16.4 Comparison with other studies

Type of caesarean section

My study showed that more than two thirds of women had an emergency caesarean section compared to one third who had an elective caesarean section. Obese women had more emergency caesarean sections compared to overweight and recommended BMI women, while overweight women had more elective caesarean sections compared to obese and recommended BMI women. My results are consistent with the rate reported in the National Sentinel Caesarean Section Audit Report,[108] which showed an overall emergency caesarean section rate of 63%, and 37% for elective caesarean section.

The systematic review by Poobalan et al, 2009[14] showed an increase in both emergency and elective caesarean section among overweight and obese pregnant women; there was a 2.23 fold increase in emergency caesarean section and a 1.87 fold increase for elective caesarean section among obese women.

Other studies[7, 8] have reported that obese women are particularly likely to have an emergency caesarean section, although the rate of elective caesarean section was also increased. [116] For example, a study by Vahratian et al, 2005 [116] investigating maternal pre-pregnancy BMI and the risk of caesarean section in 641 nulliparous women with a term pregnancy participating in the pregnancy, infection, and nutrition study from 1995-2002 in the US found that elective caesarean section was slightly higher among obese women, and emergency caesarean section was higher among overweight and obese compared to recommended BMI women.[116]

A study from Cardiff [66] found that women with increased BMI have 1.6 times the risk of caesarean sections compared to spontaneous vaginal delivery, and emergency caesarean section were more likely than elective procedures in women with a BMI>30kg/m^2 compared to those with recommended BMI women.

Indications for caesarean section

In my study, indications for caesarean section were grouped into eight main indications based on the National Sentinel Caesarean Section Audit Report (2001)[108], and reviewed by the consultant obstetrician and the SpR who were part of the study team.

Indications for caesarean section in my study revealed almost similar trends to the indications reported in the National Sentinel Caesarean Section Audit Report.[108] Fetal distress was the commonest indication in the National Sentinel Caesarean Section Audit Report, [108] comprising almost 22% of all indications for caesarean section In my study, fetal distress was also the most common indication for caesarean section accounting for almost a quarter of caesarean sections among the study sample. The fetal distress rate in the National Sentinel Caesarean Section Audit Report was lower than in my study (26.3%). This might have resulted from differences in the definition of fetal distress. In my study, fetal distress during labour as well as those indications such as non-reassuring and abnormal CTGs, were included in the category fetal distress. The use of CTG continuously without FBS leads to an increase caesarean section rate. It is recommended to use FBS where technically feasible to increase the accuracy of fetal distress “Technical feasibility” is defined as a cervical dilatation of greater than 4cm.[223] The NICE guidelines clearly recommend the use of CTGs only in units where there are facilities available for FBS which have been clearly shown to reduce caesarean section rates.[224]

The second most frequent indication for caesarean section in my study was previous caesarean section and other obstetric indications accounting for 21%.

The rate of previous caesarean section in my study is much higher than in the National Sentinel Caesarean Section Audit Report (14%). My study found that around a quarter of obese women had a previous caesarean section as an indication for caesarean section. This difference in the results between the two studies may also have resulted from differences in the definition of indications used in the two studies. For example, my definition of previous caesarean section included not only previous caesarean section, but also previous traumatic delivery and previous third degree perineal tear.

Previous caesarean section, or repeat caesarean section, as the only indication represents 44% of the repeat caesarean section in the UK.[108] Attempts to reduce repeat caesarean section by practising VBAC are being made. The NICE (2004)[113] guidelines has strongly recommended vaginal birth after caesarean (VBAC). However, according to the National Sentinel Caesarean Section Audit Report, only one in three women (33%) have a VBAC in the UK.[108]

Failure to progress was the third most frequent indication (19.5%). The proportion undergoing caesarean section for failure to progress was not dissimilar to the Sentinel Audit (20%). One fifth of obese women in my study sample had failure to progress as an indication for caesarean section compared to 10 (18.5%) overweight and 16 (18.6%) women with recommended BMI.

Women who fail to progress in the first or second stage of labour may require an emergency caesarean section; failure to progress in labour is over two fold higher in obese women. [6]

Active management of labour following national guidelines and proper use of oxytocine with adequate supervision during labour will reduce the caesarean section rate from such indication. The National Sentinel Caesarean Section Audit Report reported that 81% of women in their first pregnancy who had a caesarean section for failure to progress, had oxytocin before the caesarean section.[108]

The fourth commonest indication for caesarean section in my study was malpresentation (12.7%), which corresponds with the national audit (11%). My study showed that those with malpresentation delivered by elective caesarean section. Hannah et al (2000)[225] recommended elective caesarean section as the preferred mode of delivery for term singleton breech presentations.

External cephalic version (ECV) has been found to reduce the incidence of caesarean section in breech presentations.[226] ECV has also been found to be safe in women with previous caesarean section. [227] The NICE (2004) recommends offering ECV to women with breech pregnancies.

Maternal request contributed a significant 7% of non-medical reasons. In my study only 3.4% of caesarean section was for maternal request (including toco phobia).

The 2004 NICE guideline[113] recommends VBAC, and the 2011 NICE caesarean section guideline suggests that women should be given the opportunity to discuss with healthcare professionals, verbally and in printed information, birth options for any future pregnancies while they are in hospital. If there are no other indications, overall risks and benefits of caesarean section compared with vaginal should be discussed. In addition, if the request is due to anxiety, the women should be referred to the perinatal-mental health support, and if the request is still the same after all this, the women should be offered a planned caesarean section and be referred to an obstetrician who will carry out the procedure.

A study from Wales[228] investigated the trends in indications for caesarean section over seven (2001-2007) years in a district hospital and found that previous caesarean section was the commonest indication for caesarean section accounting for about one fifth of all sections, while failure to progress was the second indication (13-17%) and fetal distress accounted for only 14-17% of all cases.[229] My study is similar to this study in the rate of previous caesarean section.

A study from the US[229] investigated the percentage of caesarean section attributable to specific indications between 1985 and 1994 found that dystocia was the most frequent indication for a caesarean section in both years. In comparison with 1985, the percentage of caesarean sections performed in 1994 was increased for dystocia and breech presentation, while there were no significant changes in caesarean section performed for fetal distress, and the percentage declined for elective repeat caesarean section.[230]

My study did not find significant differences in the proportion of elective or emergency section, or indications for caesarean section among BMI categories.

5.16.5 Postpartum complications

Length of stay in hospital

My study investigated the length of maternal stay in hospital following a caesarean section for overweight and obese women compared to recommend BMI women. No significant differences were found in the length of stay in hospital after caesarean section between BMI groups. However, one fifth of obese women stayed in hospital for four days compared to 9% of overweight and recommended BMI women.

The study was powered to detect a one day difference in postpartum length of stay in hospital among BMI groups. Length of maternal stay in hospital was represented by median as it was not normally distributed. The total median length of maternal stay was 3.0 days and IQR (2-3) range (1-21) day.

Few previous studies have investigated length of stay after delivery by maternal BMI category. Most have investigated overall length of stay, and found an increased length of stay in women with high BMI. This is likely to reflect, in part, the increased risk of caesarean section with increased BMI. For example, a study by Chu et al, 2008 [230] investigated 13,442 pregnancies aged 18 or older at conception and resulted in live births or stillbirths from 2000-2004. The study investigated the association between obesity during pregnancy and increased use of health care, by assessing whether the association between length of hospital stay and BMI varied according to mode of delivery or the presence of high risk conditions. The study found that there was an increased length of stay with increased maternal BMI. Most of this increase in length of stay was related to increased rates of caesarean section and obesity related high-risk conditions, such as pre-eclampsia and GDM. The total length (defined as number of days from delivery to discharge) of hospital stay was four days in 40.3% of pregnancies with recommended BMI and 60.4% of pregnancies to women with morbid obesity (≥40kg/m^2). A significant interaction was found between BMI and mode of delivery ($p<0.001$) in analysis of total length of stay. For pregnancies resulting in vaginal delivery, the total length of stay was greater when the BMI≥30kg/m^2 compared to recommended BMI women. However, there was no significant association found between BMI and total length of stay for pregnancies resulting in caesarean section delivery. This was consistent with my findings.

A meta-analysis from the UK by Heslehurst, et al, 2008 [93] which investigated the impact of obesity on obstetric care, reported a significant gradual increase in mean length of hospital stay after all deliveries, as BMI increased, from 2.4 days for recommended BMI women to 3.3 days for morbidly obese women. However, this study did not present data separately by mode of delivery. The study found that the data from individual studies included in the meta-analysis showed an overall length of stay of 2–3 days for those women with recommended BMI, 2–4 days for women who were overweight or obese and 3–5 days for women who were morbidly obese.[6]

Length of stay after child birth is declining; a recent report from the HSE online, Maternity Key Facts reported that the average postnatal stay for deliveries where the postnatal stay was known, by method of delivery was 1.2 days for spontaneous delivery, 1.8 days for instrumental delivery and 2.8 days for caesarean section delivery.[6]

Although my results did not reach statistical significance, the findings suggest that there is a small difference in the maternal length of stay in hospital following a caesarean section by BMI category. However, any difference is small and unlikely to be of clinical importance. This small difference in length of stay may be explain by insufficient power to detect within this sample size, or that there was no real difference between overweight and obese pregnant women's length of stay in hospital after a caesarean section.

Wound infection

Previous research suggests that women undergoing caesarean section have a five to 20 fold greater chance of getting an infection compared to women delivering vaginally. Moreover, one of the major risk factors for postoperative infection after caesarean section is high maternal BMI. [38, 110 231 7, 9, 66]. My study showed that 18% of the study sample had a wound infection after caesarean section. Thirty-four (16.9%) women received antibiotics and more than three quarters of women were prescribed antibiotics for seven days or more. Overweight women were the lowest group in terms of having wound infection and using antibiotics after caesarean section.

A study from Australia found that overweight women were more likely to receive antibiotics postpartum compared to recommended BMI women, and that obese women were more likely to receive antibiotics for wound infection compared to recommended BMI women.[232]

In this study, all women received antibiotics in line with the hospital protocols. This may explain why there were no apparent differences in rates of infection or antibiotic use by BMI.

Blood loss

The RCOG [15] define primary postpartum haemorrhage (PPH) as a blood loss ≥ 500 mls within 24 hours of giving birth. PPH can be minor (500–1000 mls) or major (more than 1000 mls). [233] Major could be divided to moderate (1000–2000 mls) or severe (more than 2000 mls). In the general maternity population in England, PPH (primary and secondary) affects 10% of all deliveries. [233]

My study showed a significant association of blood loss after caesarean section and BMI. One third of overweight women had more blood loss compared to 18.5% who were obese women and 13% women with recommended BMI.

A study by Bhattacharya et al, 2007 showed a significant association of PPH after caesarean section among obese women compared to women with recommended BMI. Sebire et al, 2001 found this association to be 70% more frequent among women with a high BMI compared to women with recommended BMI. Women with obesity may have higher rates of insufficient uterine activity, and this may explain the higher rate of PPH.[59]

A meta-analysis by Heslehurst et al, 2008 [234] aimed to investigate relationships between obesity and the impact on obstetric care. Forty-nine studies found that overweight, obese and morbidly obese pregnant women had a significantly increased risk of PPH after delivery compared with women with recommended BMI. Another study by Liu et al, 2011[6] found that obese women had a nearly four times higher risk of having PPH after delivery. While in contrast, Bianco et al, 1998 [144] found no such differences after delivery among BMI groups.

As measurement of blood loss is subjective and the definition of PPH variable is difficult to make comparisons across the studies, as the method of blood loss measurement is different. Blood loss is usually measured by weighing pads, linen and so forth and this may lead to an underestimation of blood loss.

In my study, being overweight was more likely to lead to blood loss after caesarean section compared to being obese or of recommended BMI. This may partly explained as a result of treating obese women ≥30kg/m^2 in the Wansbeck hospital by prophylactic doses to prevent bleeding during caesarean section for those women who are recognised as a high risk group. The usual treatment prescribe by the staff is to give syntocinon (oxytocine) used as 40 units in 500 mls normal saline at a rate of 125 mls/ hour for a period of four hours. The other prophylactic is Misoprostol used in a dose of 1000 mcg as a rectal prophylactic.

Deep vein thrombosis and pulmonary embolism

Venous thromboembolism (VTE) is a major cause of maternal mortality, and was the leading direct cause of pregnancy-related mortality in the UK from 1985 to 2005.[23] The risk of VTE in pregnancy and the postpartum period is increased 4–5-fold with an overall risk of 1.72 per 1000 deliveries and an associated mortality of 1.1 per 100 000 deliveries.[12]

In this study of 205 caesarean deliveries, there were no cases of DVT or PE. This is not unexpected in a sample of this size as DVT/PE are rare events. However, it was reassuring to note that all women in the study received appropriate prophylaxis, in line with hospital protocols.

A RCT by Hannah et al, 2000[85-87] compared planned caesarean section and planned vaginal birth and measured thromboembolic disease as an outcome and found that there were no events in either group.

A population-based study [225] evaluated the risk of thromboembolism by mode of delivery from 1987-1995, found that the risk of PE was increased about four times for women who had caesarean section compared with those who had vaginal delivery.

NICE guidelines (2004)[235] recommended that women having a caesarean section should be offered thromboprophylaxis because they are at increased risk of VTE. The choice of method of prophylaxis could be, graduated stockings, hydration, early mobilisation, low molecular weight heparin (LMWH). Following the NICE guidance there is some evidence of decreases in the rate of thrombosis and PE. According to the CMACE,[113] in 2006-2008, 261 maternal deaths in the UK were directly or indirectly related to pregnancy. The overall maternal mortality rate declined to 11.39 per 100,000 maternities from a previous rate of 13.95 per 100,000 maternities from 2003 to 2005. Direct deaths decreased from 6.24 per 100,000 maternities in 2003–2005 to 4.67 per 100,000 maternities from 2006 to 2008 ($p = 0.02$). This decline was predominantly due to the reduction in deaths from VTE and, to a lesser extent, PPH. [236]

Urgency of caesarean section

Wansbeck hospital categorises planned caesarean section as elective, while all the other are categorised as emergency according to the NICE guideline for caesarean section.[236] The NICE guidelines in 2004[113] and 2011[113] recommended that the classification of the urgency of caesarean section should be documented using the standard scheme in order to aid clear communication between healthcare professionals about the urgency of a caesarean section. The standard categorisation consists of four categories; immediate threat to the life of the woman or fetus, maternal or fetal compromise which is not immediately life threatening, no maternal or fetal compromise but needs early delivery and delivery timed to suit the woman or staff.

The updated 2011[228] NICE guideline added a recommendation on the decision-to-delivery interval for unplanned (emergency) caesarean section to perform category 1 and 2 caesarean section as quickly as possible after making the decision, particularly for category 1. Moreover, to perform category 2 caesarean sections in most situations within 75 minutes of making the decision. Furthermore, the guideline recommended that the condition of the woman should be taken into account and the unborn baby when making the decision about rapid delivery, as it may be harmful in certain circumstances. The guideline recommended the decision to delivery for category 1 as 30 minutes and both 30 and 75 minutes for category 2. [228] Wansbeck hospital classifies the urgency of caesarean section as 30 minutes for category 1, 60 minutes for category 2, >1hour<12 hour for category 3 and 4 for elective caesarean section.

The findings of my study did not show significant differences in the decision to delivery time by BMI category. However, one third of obese women had caesarean section at 60 minutes compared to one fifth of overweight and 18.6% women with recommended BMI. In contrast, I found significant differences in decision-delivery time by obstetric grade attending category; deliveries at 30 minutes were more likely to be attended by a consultant.

Tuffnel et al, 2001[228] suggested that longer decision to delivery times arise because different factors such as preparation of the team before the caesarean can take place, staff shortage, poor training and lack of appropriate facilities all have the potential to slow the process.

5.17 Quality of care

5.17.1 Antibiotic prophylaxis

Infectious complications after delivery are an important cause for maternal morbidity, including urinary tract infection, postpartum endometritis and wound infection. [237]

The NICE updated guideline 2011[228] recommended women are offered prophylactic antibiotics at caesarean section before skin incision. In the UK, 85% of surgeons use prophylactic antibiotics, 12% do so if other factors are present and 3% rarely use them. [228]

A systematic review by Smaill et al, 2010[238] evaluated the effect of prophylactic antibiotics compared with no prophylactic antibiotics on infectious complications in women undergoing caesarean section. The review included 81 RCTs, of which 12 included women having a planned caesarean section, and 23 included women having an unplanned caesarean section. Forty-eight RCTs included women having planned or unplanned caesarean section. In most trials, the antibiotic prophylaxis was administered intravenously after clamping the cord, and overall the use of antibiotics reduced the incidence of complications, such as endometritis, fever, UTI and wound infection. The study concluded that giving prophylactic antibiotics to all women undergoing elective or non elective caesarean section is clearly beneficial for women.[231]

In my study all the women undergoing a caesarean section had prophylactic antibiotics before the procedure. It is therefore, to be expected that there no significant differences in prophylactic use by BMI.

5.17.2 Breast feeding

Most studies investigating whether maternal obesity has an independent effect on breast feeding intention, initiation, and duration, have found that overweight and obese women are less likely to breast feed and typically breast feed for a shorter duration compared with women of recommended BMI. [231]

After a caesarean section, the baby may not be put to the breast until sometime after delivery, particularly if the baby is admitted to the SCBU or there are operative complications. This may explain the increased rate of breast feeding at discharge compared to breast feeding after delivery.

A study by Kitsantas et al, 2010 [100, 239, 240] investigated whether maternal pre-pregnancy overweight or obesity has independent effects on breast feeding initiation and duration and whether these effects are different for women who experience medical problems during pregnancy in comparison with those without medical problems in 10,700 women with a singleton birth. The study found that overweight/obesity exerts an independent effect on breast feeding initiation only among mothers who experienced medical problems during pregnancy or had labour/delivery complications.[240] These women were less likely to initiate breast feeding compared with those with recommended BMI women even after adjusting for a number of potential confounders. However, the overweight/obesity effect on breast feeding initiation was not found among mothers who did not experience medical or labour/delivery complications. Furthermore, the study found that obese women with medical conditions or delivery complications were more likely to not begin breast feeding if they had a caesarean section.

The updated caesarean section NICE guideline, (2011)[240] recommended that women who have had a caesarean section should be offered additional support to help them to start breast feeding as soon as possible after the birth of their baby. This is because women who have had a caesarean section are less likely to start breast feeding in the first few hours after the birth, but when breast feeding is established, they are as likely to continue as women who have a vaginal birth.

My study did not show significant differences in breast feeding after delivery and at discharge by BMI category. This is due to the hospital following national guidelines regarding supporting breast feeding after delivery particularly after caesarean section. Wansbeck hospital is involved with the CQUIN programme and staff have followed women after delivery and encouraged them to breast feed as soon as possible after delivery.

5.18 Conclusion

In conclusion, the findings of this chapter showed that there was no association between maternal BMI and post-operative complications or length of stay in hospital.

The next chapter is the final chapter of my thesis which provides an overall discussion of the three phases of my PhD and implications for researchers and practitioners of my findings.

CHAPTER SIX

OVERALL DISCUSSION AND CONCLUSION

Chapter 6. Overall discussion and conclusion

6. 1 Introduction

More than half of women of reproductive age in the UK are overweight or obese.[228] Increasing maternal BMI is associated with an increase in adverse outcomes for the mother and infant, and one of these implications is to increase the risk of delivery by caesarean section. [4]

6.1 Aim of the thesis

In this thesis I aimed to investigate the relationship between maternal BMI and caesarean section. To achieve this aim, my thesis comprised of three phases:

Phase one reviewed the available published literature that investigated the association between maternal BMI and caesarean section rate. The review found that most studies have been carried out in the USA, with only six from the UK. The review highlighted the need for further research in the UK setting.

Phase two of my thesis therefore aimed to identify the rate of caesarean section among five hospitals in the North East of England, and to investigate the relationship between BMI in early pregnancy and the rate of caesarean section in overweight and obese pregnant women compared to pregnant women with recommended BMI. This was achieved by using routinely collected data from five maternity units in the North East of England, and involved singleton deliveries between 2003-2005. The cohort found that the risk of delivery by caesarean section among obese women was almost two fold, and there was a 30% increased risk of caesarean section among overweight women, compared to women with recommended BMI, after adjusting for confounders.

The third phase was a case note review to investigate the indications for the increasing rate of caesarean section among overweight and obese women by testing the hypothesis that overweight and obese women have more post-caesarean section complications compared to women with recommended BMI resulting in a longer length of stay in hospital. The case note review showed that there was no significant difference in the length of stay in hospital following a caesarean section among overweight and obese pregnant women compared to women with recommended BMI.

6.2 Discussion of findings

6.2.1 Maternal body mass index and caesarean section

The prevalence of caesarean section is increasing. In England the rate of caesarean section has increased from 9% in the 1980s to 24.8% in 2010-2011, and this rate has surpassed those recommended by the WHO. [8, 14, 21]

6.2.2 Why is the rate of caesarean section rising?

There are several potential reasons why the caesarean section rate is increasing. The increase may be partly explained by changes in the demographic characteristics of the childbearing population. [144] For example, women are delaying child birth and having fewer children. The risk of caesarean section is reported to be five fold greater in older women (aged ≥30 years) compared to women aged < 25 years.[110, 241] In this thesis, I found a significant association between the risk of caesarean section and maternal age.

The caesarean section rate also varies according to ethnic group, with a higher caesarean section rate reported among women who are black African or black Caribbean.[17, 125, 148 108] Limited data was available on the differences among ethnic groups as many studies have included a small sample of women from non-White ethnic groups and this does not allow reliable comparisons or predictions to be made. [156, 207] The majority of the sample population in my study was of White ethnicity with very few women from other ethnic minority groups. Therefore, my study was unable to explore the relationship between the risk of caesarean section and ethnicity in detail.

Parity can play a significant role in the association between maternal obesity and the risk of caesarean section. One study[43] showed that the effect of maternal obesity on the increase in caesarean section rate is different between obese primiparous women compared to obese multiparous women. Emergency caesarean section was found to be greater in obese primiparous women, while in contrast, the elective caesarean section was found to be greater among obese multiparous women.[198] The findings of my study showed that the relationship between caesarean section and maternal BMI was similar among primiparous and multiparous women.

6.2.3 Determinants of caesarean section

Although caesarean section rates have increased over the last 20 years, the four major clinical determinants for caesarean section have not changed. These are fetal distress, failure to progress in labour (dystocia), repeat or previous caesarean section and breech. A fifth reason given for performing a caesarean section has also been identified more recently, that is maternal request.[198] Factors that may influence the increasing rate of caesarean section include organisational factors, such as hospital size, availability of neonatal intensive care, provision of one to one support in labour, women's choices about childbirth, and obstetrician characteristics such as age and experience.

Vahratian et al, 2005[108] and Sheiner et al, 2004[116] reported that obese women are more likely to deliver by caesarean section due to fetal distress and failure to progress in the first stage of delivery. Similar results were reported by Sahu et al 2007[13] and Athukorala et al, 2010. [20] The findings from my study showed that the most common indications for caesarean section among overweight and obese women were fetal distress, failure to progress and previous caesarean section and/or other obstetric indications.

A study by Bragg et al[15] assessed whether the variations in unadjusted caesarean section rate among NHS trusts in England can be explained by the characteristics of the women and their clinical risk factors. The study showed a significant variation in the rate of caesarean delivery among the NHS trusts in England, after adjustment for several risk factors (age, parity, ethnicity, socio-economic deprivation, and clinical risk factors; previous caesarean section, breech presentation and fetal distress). However, the study was unable to adjust for some important factors including maternal BMI, gestational age at delivery, indications for caesarean section and model of care suggesting that further work is needed to completely assess which factors have a role.

6.2.4 *Potential explanations for the association of caesarean section with obesity*

Studies have shown an increasing rate of caesarean section in high BMI women with complications such as pre-eclampsia, GDM and macrosomia.[18] A study by Sebire et al, 2001[19, 134, 138] found that obese women are more likely to have a caesarean section due to pre-eclampsia and GDM. Similar results were found by other studies, that is increasing caesarean sections in obese women with complications.[8] A study by Dempsey et al, 2005[16, 74] reexamined the association between maternal prepregnancy BMI and caesarean delivery after excluding women with a diagnosis of pre-eclampsia and /or GDM to reduce the likelihood of confounding, and they found that the association was reduced only slightly.

Similar results were found for increasing cesarean section due to macrosomia. A study by Khashan et al, 2009[19] found a three fold increased risk of caesarean delivery in obese women with a macrosomic baby . Similar results were found by Driul et al, 2007 [134] and Sebire et al, 2001.[81]

The emergency caesarean section rate is increased among obese women undergoing a caesarean section compared to women with recommended BMI.[8,66] Delay during the first stage of labour could be one of the reasons for this increase.

Another potential reason to explain the association of obesity and caesarean section could be failure in induction of labour. Kerrigan et al [14] found that unsuccessful induction of labour was three times more common amongst obese women ($p<0.001$) compared to recommended BMI women. One of the reasons for induction of labour is preeclampsia. [242] It was also found that the risk of caesarean section is doubled among nulliparous women who had elective induction of labour compared to nulliparous who had spontaneous labour.[72] Unsuccessful induction of labour could be related to an unfavourable cervix because of preterm induction for pregnancy complications. [243] Evidence suggested that obesity increases maternal pelvic soft tissue which narrows the diameters of the birth canal and increases the risks associated with dystocia which together with a larger fetus might require more time and stronger contractions to progress through labour.[242,116, 128]

Thus, there are a number of potential reasons for the increase in caesarean section among obese pregnant women including complications of pregnancy, macrosomia, failure in induction of labour or delay during the first stage of labour.

6.2.5 Complications after caesarean section

Obese women are not only at increased risk of caesarean section, but they are also at increased risk of infection and other complications from the surgery compared to women with recommended BMI.[125, 129] Evidence suggests that women undergoing caesarean section are at a five to 20 fold increased risk of getting infection after surgery compared to women delivering vaginally, and high BMI is one of the major risk factors for postoperative infection.[244] According to the NICE guidelines, women should be offered a prophylactic antibiotic at caesarean section to reduce the risk of postoperative infections, particularly antibiotics that reduce endometritis and urinary tract infection and wound infections which occur in 8% of women who have had a caesarean section.[7, 66, 74, 232] My findings showed no statistically significant differences in rates of wound infection after caesarean section for obese women. The most likely explanation for this is high compliance with the local protocol for antibiotic prophylaxis as all women were prescribed antibiotics before delivery. Thus adherence to local protocols can reduce rates of wound infection.

Most previous studies investigating the overall length of stay in hospital by maternal BMI category have not considered length of stay after caesarean section specifically.[228] These studies found an increase in overall length of stay in hospital among women with high BMI compared to women with recommended BMI. [6, 99] Obese women are more likely to have an emergency caesarean section than elective caesarean section[6, 99], and this may lead to more complications, such as wound infection after operation which leads to a longer length of stay in hospital or re-admission. However, the findings from my study showed no significant association between length of stay in hospital and

BMI after a caesarean section. This difference in the result between my study and the published literature may be explained by the hospital compliance with national clinical guidelines; all women had prophylactic antibiotics before caesarean section in my study with no difference by BMI.

6.2.6 Implications for prevention and intervention

It is generally accepted that women should not try to lose weight during pregnancy due to the potential risks for the fetus, such as growth retardation and development of congenital anomalies.[66] However, there is little concrete evidence of harm. Obese women may benefit from pre-pregnancy counseling regarding specific problems associated with obesity in pregnancy, and advice to aim for moderate weight loss prior to conception would be of benefit. A study by Krishnamoorthy et al, 2006[30, 245] has shown that a modest reduction in weight of ten pounds can reduce the risk of GDM among obese women.[246]

Heslehurst et al, 2011 [246] have suggested that the antenatal period is an appropriate time to engage women with behavior change interventions as concern about the baby's health provides an influential motivator. Treatment options, such as pharmacological or surgical means are contraindicated. However, increased physical activity and healthy food may result in better pregnancy outcome for both the mother and the child. Research has shown that women who were obese at the time of conception, but exercised regularly, had lower rates of GDM.[245] Obese women should be advised to follow a healthy diet and to be physically active. [42, 43]

6.2.7 Pregnancy interventions to reduce caesarean section rate among obese pregnant women

There is not yet sufficient evidence to support any particular intervention during pregnancy to reduce the rate of caesarean section in obese women.[247] Pregnancy is a crucial life event when interventions to challenge the growing trend of obesity may be effective.[248] At this time the mother may be motivated to change lifestyle habits to benefit the health of her unborn child. Management of weight at this time is not only useful for preventing complications of obesity for the woman herself, but also to improve the health of the pregnancy and the neonate.[127] However, there is thus far limited evidence that limiting weight gain is effective in reducing caesarean section. [127]

Pregnancy also contributes towards the development of obesity through excessive gestational weight gain and postnatal weight retention.[248] Guidelines for weight management during pregnancy vary internationally. As the IOM recommends limits for gestational weight gain, published studies use this parameter.[245] In the UK, however, the NICE guidance [248] for weight management in pregnancy does not advise regular weighing of a pregnant women after the first antenatal visit, because the evidence for an effective intervention to improve clinical outcomes in a UK population is lacking.[30]

6.2.8 Reducing obesity prevalence among pregnant women.

A reduction in weight prior to becoming pregnant may result in fewer caesarean sections; a 1% reduction in the caesarean section rate could save the NHS £5 million a year, resulting in economic as well as health benefits. [248] Targeting overweight and obese women to reduce their weight prior to becoming pregnant might be an effective solution but this is very difficult to implement, as many pregnancies are unplanned. Therefore, it would be difficult to define a target population which included all at risk women. In addition, even in the case of a planned pregnancy, very few women consult a health professional before considering becoming pregnant and fewer still are likely to then agree to delay their family planning for a number of months or years in order to lose weight if so advised.[246] Therefore, general obesity prevention in children and young adults is important.

The evidence on the effectiveness of interventions to change pregnant women's weight-related behaviors is limited. However, a recent systematic review and meta-analysis conducted by Thangaratinam et al, 2012[127], aimed to evaluate the effects of dietary and lifestyle interventions in pregnancy on maternal and fetal weight and to quantify the effects of these interventions on obstetric outcomes. The review identified 44 relevant RCTs which evaluated three categories of interventions; diet, physical activity and a mixed approach.[249] The control and intervention groups in the review did not differ in the proportion of women who achieved IOM gestational weight gain limits.[250] The review reported that overall there was a 1.42 kg reduction (95% CI: 0.95-1.89) in gestational weight gain with any of the interventions compared with the control arm. Dietary intervention resulted in the largest reduction in maternal gestational weight gain (3.84kg, 95% CI: 2.45-5.22). However, the overall evidence rating was low to very low for important outcomes, such as pre-eclampsia, GDM, gestational hypertension, and preterm delivery and many of included studies were small in size and limited in quality.[33] Findings from the study by Thangaratinam et al 2012[251] showed that the proportion of women who achieved the IOM gestational weight gain limits in control and intervention groups did not show a significant difference. Therefore, this may explain why there was no effect on clinically relevant outcomes, such as birth weight or macrosomia, and there was no reduction in the caesarean section rate.

6.2.9 Ongoing trials

Ongoing RCTs involving overweight and obese women that are adequately powered for clinical outcomes and assess the different elements of the intervention include the Australian LIMIT trial (Limiting Weight Gain in Overweight and Obese Women During Pregnancy) in overweight and obese pregnant women[249] and the UK UPBEAT trial (UK Better Eating and Activity Trial) in obese pregnant women.[252]

The UPBEAT trial will develop and evaluate a dietary and physical activity intervention aimed at improving pregnancy outcome, including reducing caesarean section rates in obese women. The intervention is based on improvement of blood glucose control by diet and physical activity changes. The pilot study started in January 2010, and following a successful feasibility pilot trial, a multicentre RCT is now underway in (London Guys and St Thomas' and King's College Hospital Foundation Trusts; Newcastle University and Newcastle upon Tyne NHS Foundation Trust, Sunderland City Hospitals Foundation Trust, Bradford, Manchester and Glasgow). The study aims to recruit 1,560 pregnant women by August 2013. The primary outcomes for this trial are maternal improvement of glycaemic control and neonatal macrosomia. The secondary outcomes are mode of delivery, blood loss at delivery and admission to neonatal unit. If the intervention is effective, it could improve the health of the mother and her baby and may decrease the complications from obesity.

In my opinion, to achieve a better pregnancy outcome and reduce the rate of caesarean sections among obese women, it is important to detect and manage, or prevent, the key complications such as pre-eclampsia and GDM. Furthermore, it is essential that women are given the correct advice and in a timely manner which would involve communicating with them the risks of entering pregnancy with a high BMI and encouraging them to reduce their weight before conception through regular physical activity and a healthy diet.

6.2.10 Implications for policy

Increasing obesity among the UK population has significant implications for women of childbearing age, and has recently been described as the biggest challenge facing maternity services.[253] It is a challenge not only because of the magnitude of the problem, but because of the impact that obesity has on the woman's reproductive health and that of her babies. [1, 245]

Although national guidance on obesity management has been published, [1] overweight and obese women are not receiving education about pregnancy-related issues on a national level, leaving the responsibility with the local healthcare professionals. A woman's BMI should be measured at booking and an explanation given to her about why the measurement is needed, how it will used to plan her care and the risks associated with obesity in pregnancy.[30] Although the healthcare professionals view it as their role to explain the potential risks and complications of obesity to women during pregnancy, this is a very difficult task.[30] Discussing the implications of obesity with pregnant women is challenging, as it is a sensitive and stigmatised topic,[32] and healthcare professionals have described their difficulties in raising the topic with women during pregnancy.[250] Midwives have described their concerns about labelling women as obese and the need for sensitive risk communication and fear about raising the issue due to previous experience of complaints from women.[32, 254] Communication needs to be sensitively delivered to encourage continued engagement with antenatal services and to promote engagement with the appropriate public health services. In the study by Heslehurst et al, 2011, midwives identified that maternal obesity care is of great importance and that they require specific training similar to other public health issues such as, domestic violence and smoking cessation.[251, 254]

My studies were based on data collected between 2003 to 2005, and during 2008. Since then, new guidelines have been published and more attention given to maternal obesity. For example, obesity in pregnancy is recognised by the NHS Litigation Authority (NHSLA)'s Clinical Negligence Scheme for Trusts (CNSTs) as one of the high risk conditions requiring the availability of local guidelines at all maternity units. Further, the RCOG guideline 2010 recommended that all maternity units must approve documentation for the management of obesity in pregnancy, including: calculation and documentation of BMI in the health records and electronic patient information system; and the requirement that all women with BMI $\geq 30 kg/m^2$ should be; advised to book for maternity team based care and have a documented antenatal consultation with an appropriately trained professional to discuss possible intrapartum complications.

The caesarean section rate in both study periods ranged from 23% to 24.6%. Recent data from the NHS Information Centre reported a caesarean section rate of 24.8% in 2010- 2011 in England.

Dr Heslehurst is currently developing a pilot of a guideline implementation intervention for maternal obesity management among midwives. The results of this work will hopefully lead to better training of midwives to support communication about obesity with pregnant women.

It is important to measure the BMI by healthcare staff and midwives at the first antenatal visit to accurately identify those women who are at risk, to engage those groups of pregnant women with high BMI in antenatal services and to communicate the advantages of preconception counselling to reduce the BMI among women planning for future pregnancy.

6.3 Implications for research

The findings of my thesis add to the growing body of evidence on the adverse outcomes of maternal obesity. The findings of my thesis add to the growing body of evidence on the adverse outcomes of maternal obesity. My results showed a significant increased risk of caesarean section among overweight and obese pregnant women after adjusting for a number of important confounding factors. In chapter four, results of the Five Hospitals Cohort Study showed a significant association between caesarean section and diabetes mellitus. Obese women with pre-gestational diabetes had greater than three fold risk of delivering by caesarean section compared to women without diabetes. This relationship was summarised in a DAG in chapter three (p76) which showed different factors that act as potential confounding factors and the causal pathway. Entering pregnancy with high BMI increases the risk of gestational diabetes mellitus and pre-eclampsia, which in turn can have an adverse impact on fetal health and may (in the case of gestational diabetes) increase fetal size, which can lead to increasing the risk of delivery by caesarean section.

The results of chapter five (Wansbeck study) showed no significant differences among BMI groups in the length of stay in hospital and the use of prophylaxis and thrombophylaxis before delivery. The results showed that most of my study sample had prophylaxis and thrombophylaxis before delivery. This suggests that following the national guidelines may help to improve outcomes, in particular for pregnant women with high BMI and having caesarean section.

For future research, it would be helpful to expand the study to include a larger sample size to allow investigation of important factors such as parity, socio-economic status, and ethnicity for example.

Evidence on the true association between high BMI and caesarean section is still limited and further research is needed to describe this association, more fully for example if it is related to biological reasons or to the complications associated with high BMI. If the mechanism behind the association can be elucidated, this will lead to improve the outcome of the pregnancy and decrease complications.

From this study, I have learned several things about my practice as a future public health researcher. Although I have answered all my research questions, I was not able to investigate the association of caesarean section in overweight and obese women by parity in the five hospitals study, due to the high level of missing data. There are a number of questions that I would like to think about in future research such as:

1. As a researcher how can I become more aware of the health interventions that reduce pregnancy complications, such as gestational diabetes and pre-eclampsia to reduce delivery complications later?

2. Expand my study to include a larger sample size to allow investigation of important factors such as parity and socio-economic status.

3. Investigate the impact of high BMI and caesarean section among pregnant women with mixed ethnicity to see if there is a difference among different ethnic groups.

4. What methods could be used to increase the awareness of women with high BMI regarding the risk of being obese during pregnancy?

6.4 Conclusion

In summary, this study has highlighted several factors that influence the risk of caesarean section among overweight and obese women. The study included a range of confounding factors that may affect the increasing risk of caesarean section among overweight and obese pregnant women, such as maternal age at delivery, gestational age at delivery, ethnicity, socio-economic status, diabetes, and birth weight, which not all previous studies have been able to include in their analysis. However, the study was limited in exploring the association between maternal ethnicity and increasing risk of caesarean section among BMI groups, due to small numbers of non White ethnicity.

In phase 2, although the sample size was large and the deliveries from the five hospitals represent the obstetric population of the North East of England, the results cannot be considered representative due to high missing BMI.

Phase 3 of my PhD explored the length of stay in hospital after caesarean section among BMI groups. The findings showed no statistical significance for postpartum caesarean section complications and length of stay in hospital, but this may be explained in terms of the study hospital being compliant with national clinical guidelines. Therefore, this suggests that following the national guidelines in the maternity units can reduce complications after caesarean section. A larger sample of pregnant women from different NHS units with mixed ethnicity would be needed to investigate this question further.

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APPENDICES

Appendix I: Posters

British Maternal and Fetal Medicine Society (MFMS) 2010, Newcastle, UK

Newcastle University

Institute of Health&Society

MATERNAL BODY MASS INDEX IN PREGNANCY AND CAESAREAN SECTION: A COHORT STUDY FROM NORTH EAST ENGLAND

Jenan Shakoor[1] (j.a.shakoor@ncl.ac.uk), Ruth Bell[1,2], Peter Tennant[1], Judith Rankin[1,2]

[1] Institute of Health and Society, Newcastle University, [2] Regional Maternal Survey Office

The problem

Background

- Prepregnancy obesity is a major public health problem in the UK.
- According to recent data from the 2006 Health Survey for England, there has been an increase in the prevalence of obesity among women of childbearing age from 12.0% in 1993 to 18.5% in 2006[1].
- Overweight and obesity in pregnancy have adverse clinical implications for the mother. Women with high prepregnancy body mass index (BMI) are at increased risk of caesarean delivery[2].
- The prevalence of caesarean section among the UK obstetric population has been increasing in recent years. The rate of caesarean section in 2009 in England was 24.6 %[3] **(Figure 1)**.

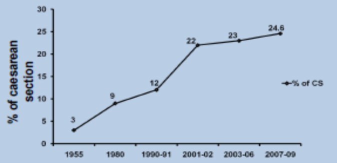
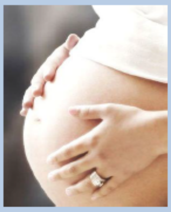


Figure 1 : Caesarean section rate in England 1955-2009 [3]

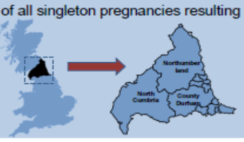


Aim

The aim of this study is to investigate the association between maternal BMI in early pregnancy and caesarean section in overweight and obese pregnant women.

Methods

- Data were collected from five maternity units in the North East of England between 01 January 2003 and 31 December 2005.
- The five hospitals were chosen as they have electronically stored maternity care information for recent years.
- BMI was obtained from electronic maternity records and was based on BMI recorded at booking.
- Multiple pregnancies were excluded as they are known to have a higher caesarean section risk than singleton pregnancies.
- Data consists of all singleton pregnancies resulting in live or stillbirth.



Results

- There were 40,790 singleton pregnancies, of which 8,392 (20.6%) were delivered by caesarean section.
- 26.1% of pregnant women with a singleton pregnancy were aged 30-34.9 years.
- Of those who were 30-34.9 years and ≥ 35 years, 23.8% and 29.5% had delivered by caesarean section.
- 16.4% of singleton pregnant women were obese and 26.3% were overweight, while 53.8% were of recommended weight **(Table 1)**.

Table 1 : maternal categories

40,790 pregnancies		Frequency	%	Caesarean Section 8,392 (%)	Adjusted Odds ratio (95% CI)	P value
Maternal age	30-34.9 years	10,649	26.1	2,523 (23.8)	1.29 (1.19- 1.40)	<0.0005
	≥ 35 years	6,284	15.4	1,849 (29.5)	1.69 (1.55-1.85)	<0.0005
Maternal BMI	25-29.9 kg/m²	8,065	26.3	1,755 (21.9)	1.27 (1.19-1.36)	<0.0005
	≥ 30 kg/m²	5,007	16.4	1,419 (28.4)	1.81 (1.68-1.96)	<0.0005

- 28.4% of obese pregnant women and 21.9% of overweight women had delivered by caesarean section, compared to 17.8% of women of recommended BMI.
- The adjusted odds ratio of caesarean section (adjusted for maternal age, gestational age, birth weight, pre-gestational diabetes, ethnicity and index of multiple deprivation) was significantly increased among obese [OR=1.81 (95% CI: 1.68-1.96; P<0.0005)] and overweight [OR=1.27 (95% CI: 1.19-1.36; P<0.0005)] pregnant women, compared to women of recommended BMI **(Table 1), (Figure 2)**.

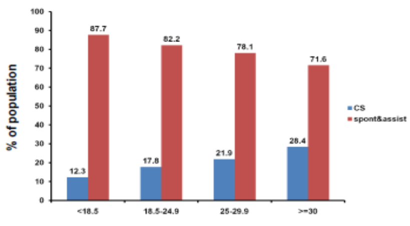


Figure 2 : Caesarean section among singleton pregnancies by BMI

Conclusion

There was an almost two- fold increased risk of delivery by caesarean section among women who are obese and an increased risk for women who are overweight.

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COMPLICATIONS ASSOCIATED WITH DELIVERY BY CAESAREAN SECTION: IS THERE A DIFFERENCE BY BODY MASS INDEX?

Jenan Shakoor[1], Judith Rankin[1,2], Shonag Mackenzie[3], Tony Chalhoub[3] and Ruth Bell[1,2]

[1]Institute of Health & Society, Newcastle University, UK; [2]Regionl Maternal Survey Office,
[3]Northumbria Healthcare NHS Foundation Trust

j.a.shakoor@ncl.ac.uk

Background

Evidence suggests that delivery by caesarean section in obese women (body mass index (BMI) ≥ 30kg/m^2) carries a higher risk of postoperative complications.

Aim

This study tested the hypotheses that overweight (BMI 25-29.9kg/m^2) and obese pregnant women have most post caesarean section complications than pregnant women of recommended BMI (18.5-24.9kg/m^2) resulting in a longer length of stay in hospital.

Methods

Using a piloted proforma, we undertook a case note review of a sample of women with a singleton pregnancy, aged ≥ 16 years and delivered by caesarean section in a district general hospital in 2008.

Results

- A total of 205 case notes were reviewed (27.9%) of all caesarean section deliveries in (DGH) in 2008.
- Overall, 86 (42.0%) women were of recommended BMI. 54 (26.3%) were overweight and 65 (31.7%) were obese **(figure 1)**.

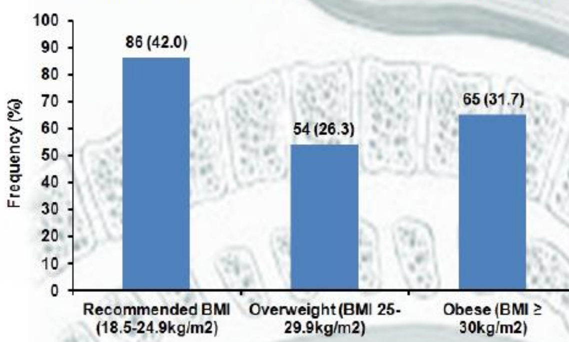

Figure 1: BMI distribution among women in the study sample

- Thirty eight (58.5%) obese women stayed in hospital for ≥ 3 days compared to 27(50.0%) overweight and 42 (49.4%) women of recommended BMI. However, none of these findings reached statistical significance **(figure 2)**.

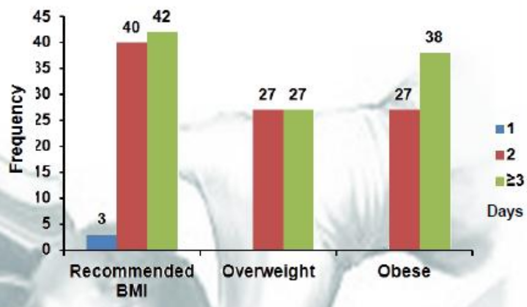

Figure 2: Maternal length of stay (days) in hospital

- Fourteen (22.2%) obese women had a wound infection compared to five (9.3%) overweight and 17 (20.2%) women of recommended BMI.
- Of these, 13 (92.9%) obese women received antibiotics for ≥7 days compared to three (75.0%) overweight and 11 (68.8%) women of recommended BMI **(table 1)**.

Variables	Total N (%)	BMI category			P value
		Recommended BMI N (%)	Overweight N (%)	Obese (N (%)	
Wound infection					
Yes	36 (17.9)	17 (20.2)	5 (9.3)	14 (22.2)	0.15
Received antibiotics					
Yes	34 (16.9)	16 (19.0)	4 (7.4)	14 (22.2)	0.08
Number of days of antibiotic use					
<7 days	7 (20.6)	5 (31.3)	1 (25.0)	1 (7.1)	0.26
≥7 days	27 (79.4)	11 (68.8)	3 (75.0)	13 (92.9)	

Table 1: Wound infection, antibiotic use and number of days of antibiotic use by BMI category

Conclusion

We did not find significant differences in postoperative complications and length of stay in hospital between overweight and obese pregnant women compared to women of recommended BMI.

Acknowledgment

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BODY MASS INDEX IN PREGNANCY AND CAESAREAN SECTION: A HOSPITAL BASED STUDY

Jenan Shakoor[1]; Rankin J[1,2]; Mackenzie S[3]; Chalhoub T[3] and Bell R[1,2]

[1] Institute of Health & Society, Newcastle University, UK; [2] Regional Maternal Survey Office, Newcastle Upon Tyne, UK; [3] Northumbria Healthcare NHS Foundation Trust

BACKGROUND

Evidence suggests that delivery by caesarean section in obese women (body mass index (BMI) ≥ 30kg/m2) carries a higher risk of postoperative complications.

AIM

This study tested the hypotheses that overweight (BMI 25-29.9kg/m²) and obese pregnant women have most post caesarean section complications than pregnant women of recommended BMI (18.5-24.9kg/m²) resulting in a longer length of stay in hospital.

METHODS

Using a piloted proforma, we undertook a case note review of a sample of women with a singleton pregnancy, aged ≥16 years and delivered by caesarean section in a district general hospital in 2008.

RESULTS

- A total of 205 case notes were reviewed (27.9%) of all caesarean section deliveries in (DGH) in 2008.
- Overall, 86 (42.0%) women were of recommended BMI. 54 (26.3%) were overweight and 65 (31.7%) were obese **(figure 1)**.

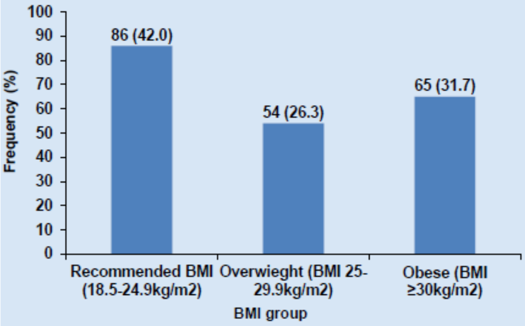

Figure 1: BMI distribution among women in the study sample

- Thirty eight (58.5%) obese women stayed in hospital for ≥ 3 days compared to 27 (50.0%) overweight and 42 (49.4%) women of recommended BMI. However, none of these findings reached statistical significance **(figure 2)**.
- Fourteen (22.2%) obese women had a wound infection compared to five (9.3%) overweight and 17 (20.2%) women of recommended BMI.
- Of these, 13 (92.9%) obese women received antibiotics for ≥7 days compared to three (75.0%) overweight and 11 (68.8%) women of recommended BMI **(table 1)**.

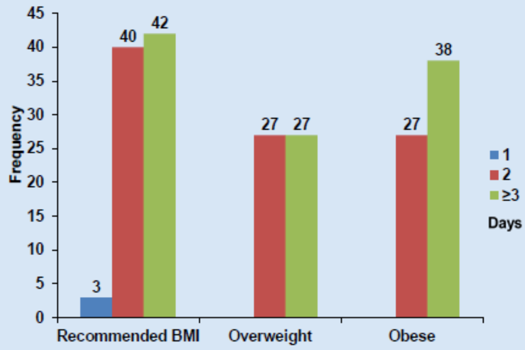

Figure 2: Maternal length of stay (days) in hospital

Variables	Total N (%)	BMI category			P value
		Recommended BMI N (%)	Overweight N (%)	Obese N (%)	
Wound infection	36 (17.9)	17 (20.2)	5 (9.3)	14 (22.2)	0.15
Received antibiotics	34 (16.9)	16 (19.0)	4 (7.4)	14 (22.2)	0.08
Number of days of antibiotic use <7 days ≥7 days	 7 (20.6) 27 (79.4)	 5 (31.3) 11 (68.8)	 1 (25.0) 3 (75.0)	 1 (7.1) 13 (92.9)	0.26

Table 1: Wound infection, antibiotic use and number of days of antibiotic use by BMI category.

CONCLUSIONS

We did not find significant differences in postoperative complications and length of stay in hospital between overweight and obese pregnant women compared to women of recommended BMI.

ACKNOWLDGEMENTS

This study was supported by the Ministry of Higher Education and Scientific Research, Iraqi Government. We thank the staff in the Cobalt Business Park for providing the case notes during data collection.

CONTACT DETAILS

Name: Jenan shakoor

Address: Institute of Health & Society, Medical School, Baddiley-Clark Building, Newcastle University, NE2 4AX, Newcastle Upon Tyne, UK.

Telephone: +44 (0) 191 222 3814 E-mail: j.a.shakoor@ncl.ac.uk

Appendix II: NICE guidance summary on the prevention, identification, assessment and management of overweight and obesity in adults and children

Recommendations for the public

1. Everyone should aim to maintain or achieve a healthy weight to improve health and reduce the risk of diseases associated with overweight and obesity, such as coronary heart disease, type 2 diabetes and some cancers.

2. People should follow the diet and physical activity strategies which may make it easier to maintain a healthy weight by balancing "calories in" from food and drink and "calories out" from being physically active.

   - Strategies of diet could be by (using wholegrain in starchy foods, eating plenty of fibre-rich foods, fruits and vegetables, eat low fat diet and avoid or eat as little as possible the fried foods, some take away and fast foods, as well as drinks with high sugar. Should eat breakfast, watch portions of snacks and size of meals, and for adult minimise the calories taking from alcohol.
   - Strategies for physical activity could be making enjoyable activities, for example walking, cycling, swimming, aerobics and gardening as part of everyday life. Minimise sitting for long time watching TV, at a computer or playing video games. Built activity into the working day-for example take the stairs instead of the lift, take a walk at lunchtime.
   - All adults should be encouraged for periodically check their weight, waist measurement.
   - People who have any queries or concerns about their or their family diet-activity levels should discuss these with a health professional such as a nurse, GP, pharmacist, health visitor or school nurse.

NHS recommendation for senior managers, GPs, commissioners for care and directors of public health

1. Managers and health professionals in all primary health care settings should ensure that preventing and managing obesity is a priority at both strategic and delivery levels. Dedicated resources should be allocated for action.
2. In their role as employer, NHS organisations should set an example in developing public health policies to prevent and manage obesity by following existing guidance and (in England) the local obesity strategy. In particular; promote healthy food and drink choices by signs, posters, pricing and positioning of products, there should be policies, facilities and information that promote physical activity, for example through travel plans, by providing showers and secure cycle parking and by using signposting.
3. All primary care settings should ensure that systems are in place to implement the local obesity strategy. This should enable health professionals with specific training, including public health practitioners working singly and as part of multidisciplinary teams to provide interventions to prevent and manage obesity.
4. All primary care settings should address the training needs of staff involve in preventing and managing obesity, allocate adequate time for the staff to take action and enhance opportunities for health professionals to engage with a range of organisations and to develop multidisciplinary teams.

Clinical recommendations

1. Regular, non-discriminatory long term follow up by the trained professional with continues care and good record keeping.

2. The choice for any intervention for weight management should be made through negotiation between the person and their health professionals.

3. The components of health management should be tailored to the person's preferences, initial fitness, health status and life style.

4. Body mass index should be used as a measure for overweight in adults, but needs to be interrupted with caution because it is not a direct measure of adiposity.

5. Waist circumference may be used, in addition to BMI, in a people with a BMI less than 35kg/m2.

6. After making an initial assessment, health professionals should use clinical judgment to investigate comorbidities and other factors in an appropriate level of detail, depend on the person, timing of the assessment, the degree of overweight or obesity and the results of previous assessments.

7. Any comorbidities should be managed rather than waiting for the person to lose weight, and people who are not ready to change should be offered the chance for further consultation when they are ready to discuss their weight gain and willing for their lifestyle change. They should be given information for the benefits of losing weight and healthy eating with physical activity.

8. Patients and their careers should have information on the test and the reasons for the test and how it performs and the results and meaning

Appendix III: North East Five Hospitals Cohort Study access permission

NHS
National Research Ethics Service

Northumberland Research Ethics Committee
Room 144, TEDCO Business Centre
Viking Industrial Park
Rolling Mill Road
Jarrow
Tyne & Wear
NE32 3DT

Tel: 0191 222 3581
Fax: 0191 222 3582

16 April 2009

Dr Judith Rankin
Reader in Maternal & Perinatal Epidemiology
Institute of Health and Society
Newcastle University
Medical School
William Leech Building
Newcastle upon Tyne
NE2 4HH

Dear Dr Rankin

Study title:	**Is maternal weight at booking associated with an increased risk of pregnancies being affected by a congenital anomaly, or resulting in a stillbirth or infant death?**
REC reference:	**07/Q0902/2**
Protocol number:	
Amendment number:	**Dr Judith Rankin**
Amendment date:	**24 March 2009**

Thank you for your letter of 24 March 2009, notifying the Committee of a minor amendment to the above study to include a PhD student (Jenan Shakoor) to the research team so that she can use the data on mode of delivery as part of her PhD work.

The amendment has been considered by the Chair.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees and may be implemented immediately, providing the data is anonymised and that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received

The documents received were as follows:

Document	Version	Date
Notification of a Minor Amendment	Dr Judith Rankin	24 March 2009

This Research Ethics Committee is an advisory committee to North East Strategic Health Authority
The National Research Ethics Service (NRES) represents the NRES Directorate within the National Patient Safety Agency and Research Ethics Committees in England

Appendix IV: Modified tables

Mode of delivery before combination in North East of England

Mode of Delivery	Frequency (%)
Spontaneous vertex	26,307 (64.5)
Breech	151 (0.4)
Cephalic	194 (0.5)
Forceps	1,917 (4.7)
Ventose	3,608 (8.9)
Elective caesarean	3,028 (7.5)
Emergency Caesarean	5,364 (13.2)
Other	16 (.0)
Total	40,585 (99.5)
Missing	205 (0.5)

Mode of delivery after combination

Mode of delivery	Frequency	percent
Spontaneous and assisted	32,193	78.9
Caesarean section	8392	20.6
Missing system	205	0.5
Total	40,790	100.0

Ethnicity group before combination

Maternal ethnicity	Frequency %
White	34,077 (83.5)
Mixed	255 (0.6)
Asian or Asian British	1,994 (4.9)
Black or Black British	332 (0.8)
Other Ethnic Group	773 (1.9)
Total	37,431 (91.8)
Missing	3,359 (8.2)

Ethnic group after combination

Maternal ethnicity	Frequency %
White	34,077 (83.5)
Non White	3,354 (8.2)
Total	37,431 (91.8)
Missing	3,359 (8.2)

Appendix V: Guidelines followed by Wansbeck General Hospital (in the period of my study)

Antenatal care guideline

1. A midwife should refer a women with a BMI> 35kg/m^2 for consultant antenatal booking.

2. Dietary advice regarding low sugar and low fat diet should be given to avoid significant weight gain during pregnancy.

3. Medical issues related to obesity need to be discussed with the women and documented. This is often a difficult issue for women to discuss and must be handled with compassion and respect.

4. A mid trimester fetal anomaly scan should be performed at 20-21 weeks and the presence of obesity should be noted on the ultrasound request form to allocate more time for the scan if needed.

5. Women with a BMI>40kg/m^2 should have a repeat scan for fetal growth, liquor volume and umbilical artery Doppler at 34 weeks. This is helpful to rule out fetal growth retardation as it can be difficult to estimate growth from palpation alone in obese women.

6. It is recommended that antenatal visits with the midwife are scheduled every 2 weeks from 28 weeks and weekly from 36 weeks. The blood pressure should be checked with appropriate sized cuff at each visit.

7. Anaesthetic referral should be arranged at the hospital booking visit by completing the referral form. The women will be contacted by the consultant anaesthetist to discuss risks associated with analgesia and anaesthesia and an assessment appointment will be arranged if indicated.

8. Delivery should be arranged in the consultant led unit.

9. Antenatal thrombophylaxis is recommended in obese women who require prolonged hospital admission over one week. This should be discussed with the obstetrician responsible for the woman's care.

10. Refer to the guidelines for screening for diabetes in pregnancy.

Intrapartum care guidelines

1. Women with a BMI>35kg/m^2 are at significantly higher risk of operative delivery, including caesarean section with increased obstetric and anaesthetic risks.

2. On admission the midwife will inform the obstetric registrar and the duty anaesthetist for delivery suite.

3. Details of expecting women with a BMI>50kg/m^2 are written on the serious anaesthetic alert chart situated in the delivery suite office.

4. For woman in labour an intravenous cannula should be inserted and a blood sample for a full blood count and group.

5. Continuous fetal monitoring is recommended. Fetal scalp electrode should be considered if a satisfactory recording is not obtained with external monitoring.

6. There is an increased risk of shoulder dystocia therefore the obstetric registrar should be present in the delivery suite for delivery.

7. During caesarean section the use of delayed absorption suture for the rectus sheath may be considered to reduce the risk of wound dehiscence.

8. Prophylactic antibiotics should be administered during caesarean section as per protocol.

Postpartum care guideline

1. Women with a BMI>30kg/m^2 should be encouraged to breast feed which may enhance maternal weight loss and reduce the likelihood of childhood obesity in the infant.

2. Women should be assessed before or during labour for risk factors for venous thromboembolism. Age >35 and BMI>30kg/m^2 or weight >90kg are important independent risk factors for postpartum DVT.

Grading of urgency of caesarean section in Wansbeck General Hospital

- **Grade 1: Immediate delivery<30mins** (Imminent life threat to mother or baby).

  pH (potential hydrogen; acid/alkaline balance)

  - pH <7.2
  - Prolonged bradycardia (Theatre 6 mins, decision 9 mins)
  - Pathological CTG, FBS not indicated
  - Massive haemorrhage
  - Prolapsed cord
  - Failed instrumental delivery with pathological CTG
  - 2^{nd} twin with pathological CTG

- **Grade 2: <60mins** (Maternal or fetal compromise with no immediate threat to life of mother or baby)

  - Suspicious CTG, FBS not possible
  - Failed instrumental delivery with normal CTG
  - Failure to progress in 2^{nd} stage with normal CTG
  - 2^{nd} twin with normal CTG
  - Eclampsia after stabilisation of mother
  -

- **Grade 3: >1 hour <24 hours** (No maternal or fetal compromise but needs early delivery)

  - Breech or malpresentation in labour
  - Delay in 1^{st} stage with normal CTG
  - Booked elective caesarean section in early labour
  - Stabilisation of BP with mother with pre-eclampsia

1. **Grade 4: Elective caesarean section**

Antibiotic prophylaxis for women undergoing caesarean section In Wansbeck General Hospital

1. Patients undergoing caesarean section elective/ emergency should have a start dose of Augumentine 1.2 grams intravenous administered whilst in theatre.

2. NB: Women with a known allergy to pencillin should be prescribed Clindamysin 600 mgs IV infusion in 100 mls of 0.9% sodium chloride over 30 minutes.

3. This treatment should be prescribed and signed for administration on to the patient's medicine kardex.

4. The midwife must check on the patient's return from theatre that the patient has received this medication.

Care of women when undergoing elective caesarean section at Wansbeck General Hospital

1. A member of medical staff will counsel the woman to ensure that there is a need for a caesarean section.

2. A consent form will be completed in the antenatal clinic by senior medical staff agreeing to the operation. A copy of the caesarean section leaflet will be given to the woman.

3. Swabs for methicillin resistant staphylococcus aureus screening (MRSA) will be taken at antenatal clinic in the same appointment of consent agreement.

4. When the need for caesarean section is identified at 34-36 weeks the woman's details are forwarded to the pregnancy assessment unit on Wansbeck, North Tyneside Hospital.

5. High risk patients (twins, placenta previa, and diabetes) will be 1st on am list preferably.

6. Breech presentation will be on pm list, if the am list is full.

7. A date, no longer than 3 days prior to operation, will be given to attend the pregnancy assessment unit (PAU) for assessment and information documentation. This assessment will include:

- Blood for FBC and group.
- Weighing women and recalculate the BMI-anaesthetist to be alerted if BMI above 35kg/m^2.
- Completeness of consent form to be checked.
- Calf measurements taken and documented.
- Drug allergies should be highlighted.
- Prescription for anti-acid, Randitine (two tablets, 150mg to be taken before surgery).

8. A patient information leaflet will be given with instructions for admission, items required and pre-op procedure to be carried out at home.

9. A pack with all relevant documentation will be prepared in advance with relevant documentation by the woman's own unit. This is essential for smooth running of the list.

10. Women will be review by the anaesthetist and prepared for surgery after completing checks in ward 15.

11. Breech presentation to be scanned on delivery suite prior to surgery.

12. Venous and arterial cord bloods will be taken to delivery suit where they will be analysed and the print out of the results will be taken to theatre.

13. Observations will be recorded every 15 minutes for 120 minutes. Then hourly for 2 hours (if necessary and then 4 hourly when normal trends are sustained).

Appendix VI: Wansbeck General Hospital proforma

Institute of Health&Society

Newcastle University

Wansbeck Hospital Study

Date of data collection----/----/--------

Hospital Number:

Study Number: --------------------------

Section 1

Mother's Details

1. Age at delivery ------------------years
2. Expected date of delivery (EDD) ---/----/--------
3. Date of delivery ---/----/--------
4. Marital status (circle one)
   a. single
   b. married
   c. live with partner
   d. divorced
   e. separated
5. Maternal occupation at booking
   a. employed
   b. unemployed
6. Mother's postcode of residence ---------, ------------ **IMD**…………………
7. Ethnic group (circle one) White / Black Caribbean / Black African / Black others/ Indian/ Bangladeshi/ Chinese/ Asian other/Pakistani/other/ not known
8. Maternal height at booking
   a. cm ------ b. not known

9. How was height determined?

a. self report
b. measured (by midwife)
c. not stated
d. date of measurement ---/----/--------

10. Maternal weight at booking?
a. kg ------ b. not known

11. How was weight determined?

a. self report
b. measured (by midwife)
c. not stated
d. date of measure ----/----/---------

12. Gestation at booking? ------------- Weeks

13. Date of booking ----/----/---------

Section 2

Obstetric Details

A. Past obstetric history

Outcome					year	Caesarean section performed	Vaginal delivery trial given
NO.	Less than 12 weeks	More than 12 weeks	Still birth	Live birth			
1.						Yes/ No	Yes/ No
2.						Yes/ No	Yes/ No
3.						Yes/ No	Yes/ No
4.						Yes/ No	Yes/ No

14. Total previous pregnancies

a. < 12 weeks -------------
b.12-24 weeks --------------
c. ≥ 24 weeks -------------

B. Current obstetric history and labour

15. Was the mother diagnosed with?

a. pre-existing complications Yes / No
If yes, state --------------------

b. complications in pregnancy Yes / No
If yes, state ---------------------

16. Last weight recorded ----- kg

a. self reported
b. measured
c. date ----/----/-------

17. Gestation at delivery ----------Weeks

18. Was the onset of labour spontaneous? Yes / No

19. Was pre- labour prostaglandin used? Yes / No
If yes, what was the number of the doses? ---------------

20. Was oxytocine used before delivery?
a. yes / no b. not known

21. Was the caesarean section an: emergency/ elective

22. What was the time of delivery decision? ----------------

23. What was the time of caesarean section? ---------------

24. Which of the following statements most accurately describes the urgency of this CS?

category 1. delivery <30 min

category 2. delivery <60 min

category 3. delivery >1 hour <12 hour

category 4. delivery timed to suit the woman and staff

25. What was the indication for caesarean section?

No.	Indications for caesarean section	Evidence
1-		
2-		
3-		

26. What was the highest grade of obstetrician present at the delivery (in theatre)?

a. SPR
b. Consultant

27. What type of anesthesia was used for the CS?

a. epidural
b. general anesthesia
c. spinal

28. What was the highest grade of anesthetist present at the caesarean section?

a. SPR
b. Consultant

29. If there were no maternal, medical, obstetric or fetal complications, was the only reason to perform a caesarean section an unprompted maternal request?

a. yes/ no b. not known

30. Was acid prophylaxis used for CS? Yes / No

31. Was Tinzaparin given? Yes / No

32. Was prophylactic antibiotic given? Yes / No
If yes, did the mother receive?

a. Augmentin (1.2 gm IV) Yes / No
b. Clindamycin (600 mg IV) Yes / No

33. What was the estimated blood loss? --------------mls

34. What was the presentation of the baby?

a. cephalic Yes/ No
b. breech Yes/ No

35. Was the caesarean section performed for breech presentation? Yes/ No
If yes, was the mother offered a trial of external cephalic version (ECV)?
a. yes/ no
b. declined

36. What was the sex of the infant?

a. male
b. female
c. unknown

37. Date of discharge (mother) ---/----/-------

38. Was the mother alive at discharge? Yes/ No
If yes, what was the destination at the mother's discharge?

a. home
b. other hospital

39. Date of mother's death if before discharge ---/----/-------

40. Date of discharge (baby) ---/----/-------

41. Was the baby alive at discharge? Yes/ No
If yes, what was the destination at the baby's discharge?

a. home
b. other hospital

42. Date of baby's death if before discharge ---/----/-------

Section 3

Postnatal complications

Mother

43. Was there any documented evidence of wound infection after caesarean section? Yes/No

If yes, did the mother receive any antibiotics? Yes / No

If any antibiotics received, for how many days? Days------

44. Was there evidence of deep vein thrombosis? Yes / No

45. Was there any evidence of pulmonary embolism? Yes/ No

46. Did the mother need a blood transfusion? Yes / No

47. Was the mother admitted to the intensive care unit (ICU)? Yes / No
If yes:

a. date of admission ---/-----/-----
b. number of days at ICU? --------- Days
b. date of discharge ----/----/---------

48. Was the mother alive at discharge? Yes/ No
If yes, what was the destination at the mother's discharge?

a. home
b. other hospital

49. Date of death if before discharge ----/----/---------

50. Was the mother readmitted to hospital? Yes / No
If yes:

a. date of admission ----/----/--------
b. date of discharge ----/----/-------
c. ward number

Baby

51. Was there an Apgar score?

1 minute	**5 minute**	**10 minute**	**Not done**
Yes/ No	**Yes/ No**	**Yes/No**	
0-3	0-3	0-3	
4-7	4-7	4-7	
7-10	7-10	7-10	

52. Was arterial cord PH measured? Yes/No
If yes, what was the value? ----------

53. Was venous cord PH measured? Yes/ No
If yes, what was the value? ----------

54. Was the baby's weight recorded after delivery? Yes/ No
If yes, give weight ------- gm

55. Did the baby need to be transferred to a special care baby unit (SCBU)? Yes/ No
If yes, what was the reason? ------------------------------

a. date of admission ----/-----/------
b. date of discharge ---/-----/-------

56. Date of death of the baby if before discharge ----/----/---------

57. Any congenital anomaly noted? Yes/ No
If yes, state the type --------------------

Feeding

58. Was breast feeding initiated after delivery? Yes/ No

59. Was the baby being breastfed at discharge? Yes/ No
If yes, was this

a. full breast feed
b. partial breast feed

Appendix VII: Research ethics governance

Newcastle & North Tyneside 1 Research Ethics Committee
TEDCO Business Centre
Room 002
Rolling Mill Road
Jarrow
NE32 3DT

Telephone: 0191 428 3564
Facsimile: 0191 428 3432

13 May 2010

Mrs Jenan Shakoor
PhD student
Institute of Health and Society
Medical School New Building
Richardson Road
NE2 4AX

Dear Mrs Shakoor

Study Title:	**Wansbeck Hospital Study: Body mass index (BMI) in pregnancy and caesarean section**
REC reference number:	**10/H0906/4**
Protocol number:	**Version 4.0**

Thank you for your letter of 04 May 2010, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

For NHS research sites only, management permission for research ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk. *Where the only involvement of the NHS organisation is as a Participant Identification*

Centre, management permission for research is not required but the R&D office should be notified of the study. Guidance should be sought from the R&D office where necessary.

Sponsors are not required to notify the Committee of approvals from host organisations.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Protocol	Version 4.0	12 November 2009
Covering Letter	Jenan Shakoor	15 December 2009
REC application	IRAS Version 2.5 35867/84441/1/737	21 December 2009
Investigator CV	Jenan Shakoor	15 December 2009
Investigator CV	Dr Judith Rankin	16 December 2009
Investigator CV	Ruth Bell	16 December 2009
Evidence of insurance or indemnity	Kelly Lovelock (Insurance Officer)	14 December 2009
Letter from Sponsor	Caroline Potts	02 December 2009
Questionnaire: Data Collection Proforma	Version 4.0	12 November 2009
Letter from Caldicott Guardian	Dr David Evans	08 December 2009
Caldicott Approval	Karen May - Email	05 December 2009
Post Graduate Project Approval	Lin James - Email	13 February 2009
Covering Letter	Dr Judith Rankin	04 May 2010
Response to Request for Further Information	Dr Judith Rankin	04 May 2010
Referees or other scientific critique report	Professor Eileen Kaner	28 April 2010
Summary/Synopsis	6.0	26 April 2010
Email from NIGB	Melanie Kingston	28 April 2010
Investigator CV	Dr Tony Chalhoub	

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Service website > After Review

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments

- Adding new sites and investigators
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

10/H0906/4	**Please quote this number on all correspondence**

Yours sincerely

Mr Chris Turnock
Chair

Email: laura.kirkbride@sotw.nhs.uk

Enclosures: "After ethical review – guidance for researchers"

Copy to: *Ms Caroline Potts*

Appendix VIII: Sponsor agreement

Northumbria Healthcare NHS
NHS Foundation Trust
Research Support Unit

Prof Richard Walker
Director of Research & Development

Direct Line: 0191 293 2709
Fax: 0191 293 2709

Tel: 0844 811 8111

Caroline Potts	*R&D Manager*	*Caroline.potts@nhct.nhs.uk*	*Ex 2842*
Andrew West	*R&D Facilitator*	*Andrew.west@nhct.nhs.uk*	*Ex 2816*
Liz Reed	*Admin Assistant*	*Liz.reed@nhct.nhs.uk*	*Ex 2829*

19th June 2010

Mrs Jenan Shakoor
Newcastle University
Institute of Health and Society
4th Floor William Leech Building
Medical School/Framlington Place
Newcastle Upon Tyne
NE2 4HH

Dear Mrs Shakoor

Study title: 0021 - Wansbeck Hospital Study: Body mass index (BMI) in pregnancy and caesarean section

I confirm that I am happy to give approval and provide indemnity for the above study to take place within this Trust. I am authorised by the Chief Executive to do so on his behalf.

Please note that this it is a condition of this agreement that the Research Support Unit ***must*** be notified of:

- Any significant changes to the study design.
- Commencement and completion of the study.
- Any decision made by a Research Ethics Committee regarding this study.
- Any adverse effects upon subjects.
- Any suspension or abandonment of the study.
- All funding, awards and grants pertaining to this study, whether commercial or non-commercial.
- All final reports, publications and/or conference presentations of the findings of the study.

Commencement of any work related to this study, using Trust resources or premises, implies agreement with the above conditions.

Yours sincerely

Prof Richard Walker
Director of Research & Development

Carbon Copy: Dr Judith Rankin, Dr Shonag Mackenzie

In association with the University of Newcastle upon Tyne

LP30255