TRENDS IN MATERNAL BODY MASS INDEX, HEALTH INEQUALITIES, AND THE IMPACT OF MATERNAL OBESITY ON NHS MATERNITY SERVICES

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A thesis submitted in partial fulfilment of the
requirements of the University of Teesside
for the degree of Doctor of Philosophy

This research was carried out in collaboration with the
North East Public Health Observatory and the
Regional Maternity Survey Office

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Declaration

This thesis contains no material that has been submitted for the award of another degree or diploma at this or any other university or institution. The dataset included in the pilot study (Chapter 2) was used for my MSc Health Sciences (Public Health) dissertation; however the data were coded using regional deprivation reference data, and ethnic subgroups. The data were re-coded for this thesis to be nationally comparable using national reference data for deprivation and overall ethnic group according to national census coding, and the data were reanalysed for this thesis.

I declare that this is my own original work and, except where reference is made in text, contains no material previously published by another person.

Nicola Heslehurst

Collaborative Project

This programme of research has been carried out in collaboration with the North East Public Health Observatory (NEPHO) and the Regional Maternity Survey Office (RMSO).

My individual contribution has been in the design of the research projects, the day to day project management, data collection, data analysis, and writing up the results and this thesis.

The collaboration from the NEPHO Prof. John Wilkinson (Director NEPHO, 2nd PhD supervisor) and the RMSO Dr. Judith Rankin (Academic Director RMSO, 3rd PhD supervisor) includes the guidance and expert knowledge that is provided in the supervisors capacity, the use of the NEPHO and RMSO logos on correspondence for the research, and the storage and analysis of identifiable data at the NEPHO which is authorised to hold confidential data on hospital activity by the Department of Health’s Security and Confidentiality Advisory Group. In the North East, the handling of confidential data is overseen by a Caldicott Guardian.

I am first author on all publications that have arisen from this programme of work, with all three of my supervisors being co-authors along with Dr. Helen Simpson (Consultant Obstetrician, South Tees NHS Trust), Dr Louisa Ells (Obesity Lead, NEPHO), and Tamara Brown (Research Fellow, University of Teesside).

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I would like to acknowledge all of the maternity units who provided data for this research, the staff who were responsible for exporting and transferring the data, and Dr. Helen Simpson for her valuable assistance with the translation of the research findings into clinical relevance.

Finally I would like to thank my parents, Pat and Arthur, and Adam for their continual faith in my abilities and the encouragement they have given me over the years, without which I would not have made it this far.

Background to the Development of the Research Programme

This doctoral programme of research has been developed in response to concerns from maternity service providers, and is part of a long term programme of research.

Midwives and obstetricians in the North East of England first drew attention to the apparent increase in obesity rates among women at the start of their antenatal care, and the impact this was having on maternity services, in 2004. Consequently it was deemed important to gauge the true extent of this problem, and the North East Maternal Obesity Research Group (NEMORG) was formed to address the issue. The groups' consists of academic and clinical members from the NEPHO (Prof. John Wilkinson and Dr Louisa Ells), the RMSO and Newcastle University (Dr Judith Rankin and Dr Ruth Bell), the University of Teesside (Nicola Heslehurst and Judith Porch), Durham University (Prof Carolyn Summerbell), the Local Supervisory Authority for Midwives (Kath Mannion), and the South Tees NHS Trust (Anne Holt and Dr Helen Simpson).

The long term programme of research includes identifying the trends in maternal obesity and the impact this has on NHS maternity services, the psychosocial impact of maternal obesity on pregnant women, public health initiatives for the prevention and management of maternal obesity, and engaging women with obesity services in pregnancy.

I carried out a pre-doctoral research project in 2005 as part of an MSc in Health Sciences (Public Health), which involved a scoping study. This study was funded by the NEPHO, and carried out in collaboration with the NEMORG. The scoping study involved two aims: to carry out an audit of routine data collection practice in all regional maternity units; and to identify the clinical issues relating to maternal obesity that have an impact on pregnancy, service delivery, and management of care. The research was published in the British Journal of Obstetrics and Gynaecology (Appendix p1), and in a NEPHO occasional paper (Appendix p2). The research identified that health care practitioners in the North East of England felt that maternal obesity had a major impact on services and resource, on the health of the mother and child, and on the psychological wellbeing of the mother. There was an absence of clinical guidelines in the maternity units, largely due to an absence of national guidelines, and health care practitioners felt that the service requirements were not meeting the needs of the mother.

The results of this scoping study, anecdotal reports from health care practitioners in the North East of England, and an absence of national epidemiological data and clinical guidelines led to the development of this doctoral programme of research as a starting point for the long term programme of research.

Abstract and Contribution to Knowledge

The primary objective of the work presented in this thesis was to identify trends in maternal body mass index (BMI) over time, the demographic predictors of those women most at risk of being obese in pregnancy, health inequalities, and the impact of maternal obesity on maternity services. A mixed methodology utilised quantitative and qualitative research to address these objectives.

Data were collated from 34 maternity units across England, including 619,323 deliveries between 1989 and 2007 inclusive. Analysis identified an increasing incidence of maternal obesity over time, regional differences in incidence, and significant inequalities with women residing in the highest levels of deprivation, and Black ethnic group.

A systematic review was carried out including 49 studies investigating obesity and pregnancy outcomes with acute maternity resource implications. The meta-analysis found significantly increased odds of a number of outcomes, and concluded that maternal obesity had a considerable impact on maternity resources, and contributed towards a poorer prognosis for the mother and the baby during delivery and in the immediate post-partum period.

Qualitative interviews and focus groups with 30 HCPs across eight NHS Trusts in the North East of England were carried out to identify barriers in implementing maternal obesity services, and to gain HCPs perspectives on what they felt was required in order to address maternal obesity effectively. The study identified the themes of ‘Service Development’, ‘Psychosocial Issues and Maternal Obesity Services’, ‘Information, Evidence, and Training’, and ‘Where to go From Here?’.

Overall this programme of research has identified that maternal obesity is increasing over time and is significantly associated with health inequalities. The increase in maternal obesity has an impact on acute services, and HCPs feel that a holistic

approach is required through partnership work in order to address maternal obesity effectively.

This programme of research has primarily contributed to the knowledge of maternal obesity with the provision of the first national level statistics for trends in maternal obesity. The research has also provided a holistic view of the impact of obesity in pregnancy on maternity services, including the impact on resources and the issues relating to addressing the maternal obesity in clinical practice. The research has also identified aspects of service that need to be improved, and knowledge gaps in how to move services forward to effective address maternal obesity.

The contribution of this research to the knowledge base is emphasised in the journal pre-publications, dissemination through UK and European, and international conference presentations, being an invited speaker at a number of conferences in the UK, and I received the 2007 Association for the Study of Obesity (ASO) Student Researcher Award for producing exemplary work in the study of obesity.

Pre-Publication and Dissemination of Work

Peer Reviewed Journals

Heslehurst, N., Ells, L.J., Simpson, H., Batterham, A., Wilkinson, J., Summerbell, C.D. (2007) Trends in maternal obesity incidence rates, demographic predictors, and health inequalities in 36 821 women over a 15-year period. *BJOG: An International Journal of Obstetrics and Gynaecology*; 114:187-194 (Preface Appendix p3)

Heslehurst, N., Simpson, H., Ells, L.J., Rankin, J., Wilkinson, J., Lang, R., Brown, T.J., Summerbell, C.D. (2008) The Impact of Maternal BMI Status on Pregnancy Outcomes with Immediate Short-Term Obstetric Resource Implications: A Meta-analysis. *Obesity Reviews*; 9 (6): 635-683 (Preface Appendix p4)

Conference Proceedings

Heslehurst N., Lang R., Wilkinson J., Rankin J., Summerbell C.D. (2006) Trends in maternal obesity incidence rates, predictors, and health inequalities in 36,821 women over a 15-Year period. *Obesity Reviews, 10th International Congress on Obesity (ICO) Conference Proceedings;* 7(S2): 227, PO0389 (Preface Appendix p5)

Heslehurst, N., Simpson, H., Ells, L.J., Rankin, J., Wilkinson, J., Lang, R., Brown, T.J., Summerbell, C.D. (2008) The Impact of Maternal BMI Status on Pregnancy Outcomes with Immediate Short-Term Obstetric Resource Implications: A Meta-analysis. *International Journal of Obesity, 16th European Congress on Obesity (ECO) Conference Proceedings*; 32(S1): S21, T2 OS2.1 (Preface Appendix p6)

Presentations

‘Trends in maternal obesity incidence rates, predictors, and health inequalities in 36,821 women over a 15-Year period’
10th International Congress on Obesity (ICO) conference, September 2006
Sydney Convention and Exhibition Centre, Sydney, Australia
Poster presentation (Preface Appendix p7)

‘Trends in Maternal Obesity Incidence Rates, Demographic Predictors, and Health Inequalities in 36,821 Women over a 15-Year Period’
Fatness, Food and Childbearing Workshop, October 2006
School of Anthropology, Oxford University, Oxford, UK
Invited Speaker (Preface Appendix p8)

‘Maternal Obesity’
Poverty and Maternal and Child Nutrition Conference, February 2007
Mother and Infant Research Unit, University of York, York, UK
Invited Speaker with Prof. Carolyn Summerbell, Dr. Ruth Bell, and Dr. Louisa Ells (Preface Appendix p9)

‘Maternal Obesity: Trends’
South Tees NHS Trust Annual R&D Conference, March 2007
The Academic Centre, James Cook University Hospital, Middlesbrough, UK
Oral Presentation (Preface Appendix p10)

‘Maternal Obesity’
Obesity, Diabetes, and Pregnancy conference, May 2007
Warwick Medical School, University of Warwick, Coventry, UK
Invited Speaker (Preface Appendix p11)

‘Maternal Obesity’
ASO conference on Women, Weight, and Reproductive Health, June 2007
Zeeman Building, The University of Warwick, Coventry, UK
Invited Speaker with Dr. Judith Rankin (Preface Appendix p12)

‘Maternal Obesity: Regional ASO Group Meeting’
Leeds Obesity Group Meeting, March 2008
Institute of Health Sciences, Leeds University School of Medicine
Invited Speaker with Prof. Carolyn Summerbell (Preface Appendix p13)

‘The Impact of Maternal BMI Status on Pregnancy Outcomes with Immediate Short-Term Obstetric Resource Implications: A Meta-analysis’
16th European Congress on Obesity (ECO), May 2008
Palexpo Exhibition and Congress Centre, Geneva, Switzerland
Oral Presentation (Preface Appendix p14)

‘Trends in Pregnancy Body Mass Index and the Impact of Obesity in Pregnancy on Maternity Services’
Inaugral University Postgraduate Conference, May 2008
Centre for Enterprise, University of Teesside, Middlesbrough, UK
Poster Presentation (Preface Appendix p15)

‘**The Impact of Obesity on Maternity Services’**
Pregnancy and Childbirth, HCP Study Days, November 2008
Solihull Institute of Medical Training and Research, Conference Centre, Solihull, UK
Medical Research Council, Cambridge, UK
Invited Speaker (Preface Appendix p16)

‘**The Impact of Obesity on Maternity Services: a qualitative study of healthcare professionals’ perceptions of the impact of obesity on maternity services’**
Confidential Enquiry into Maternal and Child Health (CEMACH) Obesity in Pregnancy conference, January 2009
British Library, London, UK
Invited Speaker (Preface Appendix p17)

Table of Contents

Preface

Table of Contents

Chapters

Chapter One

Chapter Two

2. Pilot Study to Identify Trends in Maternal BMI Incidence and the Demographic Predictors of Maternal Obesity

Chapter Three

3. National Survey of Data Collection in Maternity Units in England, and Sampling for the National Epidemiological Study

Chapter Four

Chapter Five

5. Systematic Review of the Impact of Maternal BMI Status on Pregnancy Outcomes with Immediate Short-Term Obstetric Resource Implications

Chapter Six

Chapter Seven

7. Discussion and Conclusions

References

Appendices

List of Tables

List of Figures

List of Abbreviations

$\bar{x}$	Mean
χ^2	Chi Squared Test for Association
χ^2_1	Chi Squared Test for Trend
-	Poor Quality Score
+	Good Quality Score
++	Excellent Quality Score
BJOG	British Journal of Obstetrics and Gynaecology
BMI	Body Mass Index
C.I.	Condition Index
CEMACH	Confidential Enquiry into Maternal and Child Health
CI	Confidence Interval
COREC	Central Office for Research Ethics Committees
DETR	Department of the Environment, Transport and the Regions
DH	Department of Health
DM	Design Method
GDM	Gestational Diabetes Mellitus
GOR	Government Office Region
GP	General Practitioner
GTT	Glucose Tolerance Test
H_0	Null Hypothesis
HC	Health Committee
HCP	Health Care Practitioner
HSE	Health Survey for England
IGT	Impaired glucose Tolerance
IMD	Index of Multiple Deprivation
IOM	Institute of Medicine
IUGR	Intra Uterine Growth Restriction
IVF	In Vitro Fertilisation
LREC	Local Research Ethics Committee
LSOA	Lower Super Output Area

MIDIRS	Midwives Information and Resource Service
MREC	Multicentre Research Ethics Committee
n	Number
NCMP	National Child Measurement Programme
NHS	National Health Service
NICE	National Institute for Health and Clinical Excellence
NRES	National Research Ethics Service
OR	Odds Ratio
p	Probability Measure
PAS	Patient Administration System
PCOS	Poly Cystic Ovarian Syndrome
PROM	Premature Rupture of Membranes
R&D	Research and Development
R^2	Correlation Co-efficient
RCOG	Royal College of Obstetricians and Gynaecologists
RCT	Randomised Controlled Trial
RGF	Research Governance Framework
RMSO	Regional Maternity Survey Office
RR	Relative Risk
SD	Standard Deviation
SE	Standard Error
SHA	Strategic Health Authority
SIGN	Scottish Intercollegiate Guidance Network
UK	United Kingdom
VIF	Variance Inflation Factor
VP	Variance Proportion
VTE	Venous Thromboembolic
WHO	World Health Organisation
WHR	Waist Hip Ratio

Preface Appendices

Chapter Appendices

Chapter One
Introduction to the Research Programme and Literature Review

This chapter describes the objectives of the doctoral research programme, and summarises the background literature that has led to the development of this programme of research. This includes the relationship between obesity and health inequalities, causes of obesity, the impact of obesity on the health of the mother and her infant, and a discussion of maternity services and health service policy. An overview of mixed methods research is presented, and a description of the mixed methods principles utilised in this thesis is described.

1.1 Objectives of the Research

This thesis documents a doctoral research programme undertaken within the School of Health and Social Care at the University of Teesside between the years 2005 and 2008. The programme of research for this PhD thesis comprises of a series of research projects to identify trends in maternal obesity and the impact these have on National Health Service (NHS) maternity services. The aims of the research programme included:

1. To identify the current incidence of obesity in pregnancy in England and to explore the trends in the incidence of maternal obesity over time.

2. To determine the characteristics of the women who are most at risk of being obese in pregnancy and any associated health inequalities.

3. To identify the immediate impact of obesity in pregnancy on maternity unit resources.

4. To identify the level of services, policies or guidelines in place in the North East region of England specific to maternal obesity, and any barriers to, and successes in, the development of obesity specific services.

1.2 Literature Review

1.2.1 Obesity and the General Population

Obesity is a growing problem in most developed countries worldwide, and the World Health Organisation (WHO) estimates that at least 300 million people worldwide are obese (Foresight, 2007). Tackling obesity is a major focus for public health in the United Kingdom (UK) and the 2004 Health Committee (HC) report shows that the prevalence of obesity has grown by almost 400% in the UK in the last 25 years, and states that obesity will soon surpass smoking as the greatest cause of premature death (House of Commons Health Committee, 2004). The estimated cost of obesity in the UK is £3.3 – 3.7 billion per year[1]; this estimate includes NHS expenditure and loss of earnings through sickness and premature death (House of Commons Health Committee, 2004).

Government recognition of the importance of interventions to prevent obesity at a young age is seen with specifically targeted health policies for childhood obesity and increasing school targets related to nutrition and physical activity, such as the National Healthy Schools Standard (Department for Education & Employment, 1999) and Healthy Start: Proposals for reform of the welfare food scheme (Department of Health, 2002b). The theory behind targeting prevention of obesity during childhood is that this will reduce the prevalence of obesity in adult life, as evidence shows that obesity tracks from childhood to adulthood (Garn and La Velle, 1985, Parsons et al., 1999, Unger et al., 1990, Whitaker et al., 1997). Related prevention initiatives include schools increasing the availability of fresh fruit, healthier breakfast club and school meals, encouraging walking to school, increased levels of exercise during and beyond school hours, and comprehensive health education within the National Healthy Schools Programme. The importance of a healthy diet during pregnancy and infant years is also recognised by the Healthy Start Scheme which aims to tackle inequalities in health from an early age by supplying vouchers for fresh fruit and vegetables, milk and infant formula to eligible mothers during pregnancy and

[1] Health Committee estimation of obesity costs note: “This figure should still be regarded as an under-estimate. …these analyses are for the 20% of the adult population who are already obese. If in crude terms the costs of being overweight are on average only half of those of being obese then, with more than twice as many overweight as obese men and women, these costs would double. This would yield an overall cost estimate for overweight and obesity of £6.6–7.4 billion per year”. (HC 2004)

breastfeeding, and to young children in low-income families (Department of Health, 2002b). In 2007 the government also announced it's 'Health in Pregnancy Grant' which is an initiative to provide a lump sum payment of £190 to all women in the last months of their pregnancy, due to be implemented in 2009 (Her Majesty's Treasury, 2007). The grant's intention is to provide women with financial support alongside advice from a health care practitioner (HCP) at their 25th week antenatal appointment for first time mothers, and at the 28th week appointment for subsequent pregnancies.

1.2.1.1 Definition of Obesity in the General Population

The National Institute for Health and Clinical Excellence (NICE) guidelines state that obesity and health risk should be identified using a combination of Body Mass Index (BMI) and waist circumference (National Institute for Health and Clinical Excellence, 2006). BMI is a measurement of weight for height:

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m}^2\text{)}}$$

Internationally recognised definitions for BMI groups consider a BMI>25kg/m^2 to be overweight and a BMI>30kg/m^2 to be obese, with further categories of obesity subgroups (Table 1). However it is recognised that risk of disease can increase throughout populations at lower BMIs, and that some ethnic groups also have a lower BMI cut off for increased risk (World Health Organisation, 1998).

Table 1 BMI Categories

Classification	BMI (kg/m^2)	Risk of co-morbidities
Underweight	<18.5	Low (but risk of other clinical problems increased)
Normal range	18.5-24.9	Average
Overweight	25.0-29.9	Mildly increased
Obese	>30.0	
Class I (Moderately Obese)	30.0-34.9	Moderate
Class II (Severely Obese)	35.0-39.9	Severe
Class III (Morbidly Obese)	>40.0	Very severe

(World Health Organisation, 1998)

The NICE guidance states that adults with a BMI >35kg/m^2 have a high health risk, and those with a BMI<35kg/m^2 have a high health risk if their waist circumference is high (94-102 cm in men and 80-88 cm in women) or a very high risk if their waist circumference is very high (>102 cm in men and >88 cm in women), indicating abdominal obesity (National Institute for Health and Clinical Excellence, 2006).

1.2.1.2 Prevalence of Obesity in the General Population

The latest Health Survey for England (HSE) data shows that in 2006 the prevalence of overweight in adults was higher in men than women (43% in men compared to 32% in women), whereas obesity prevalence was approximately 24% for both men and women, with women having a significantly higher prevalence of morbid obesity (3% compared to 1% in men) (The Information Centre, 2008a). The HSE has been monitoring annual BMI group prevalence since 1993 and figures show an increasing prevalence of obesity over time in both men and women, with obesity in men having increased from 13% in 1993, and from 16% in women to the current levels.

The HSE also records the waist circumference data for adults and shows that the proportion of women with a very high waist circumference (>88cm) has also increased from 26% in 1993 to 41% in 2006 (The Information Centre, 2008a). This increasing trend is also seen in men where the proportion with a very high waist circumference (>102cm) has increased from 20% to 32% in the same time period. According to the NICE guidelines for assessing health risk of BMI and waist circumference, the HSE 2006 data shows that 13% of men had a high health risk and 21% a very high risk, and 16% of women had a high health risk and 23% very high risk (The Information Centre, 2008a).

The results of the Government's National Child Measurement Programme (NCMP) show that one in four children in Reception (aged 4-5 year old) and one in three children in Year 6 (10-11 year old) in 2006/2007 in England were overweight or obese, the prevalence of obesity was higher in the Year 6 group, and obesity was higher among boys than girls in both age groups (Table 2) (The Information Centre, 2008b).

Table 2 Prevalence of Obese and Overweight Children by Year and Gender for Reception (4-5 year olds) and Year Six (10-11 year olds), England, 2006/07

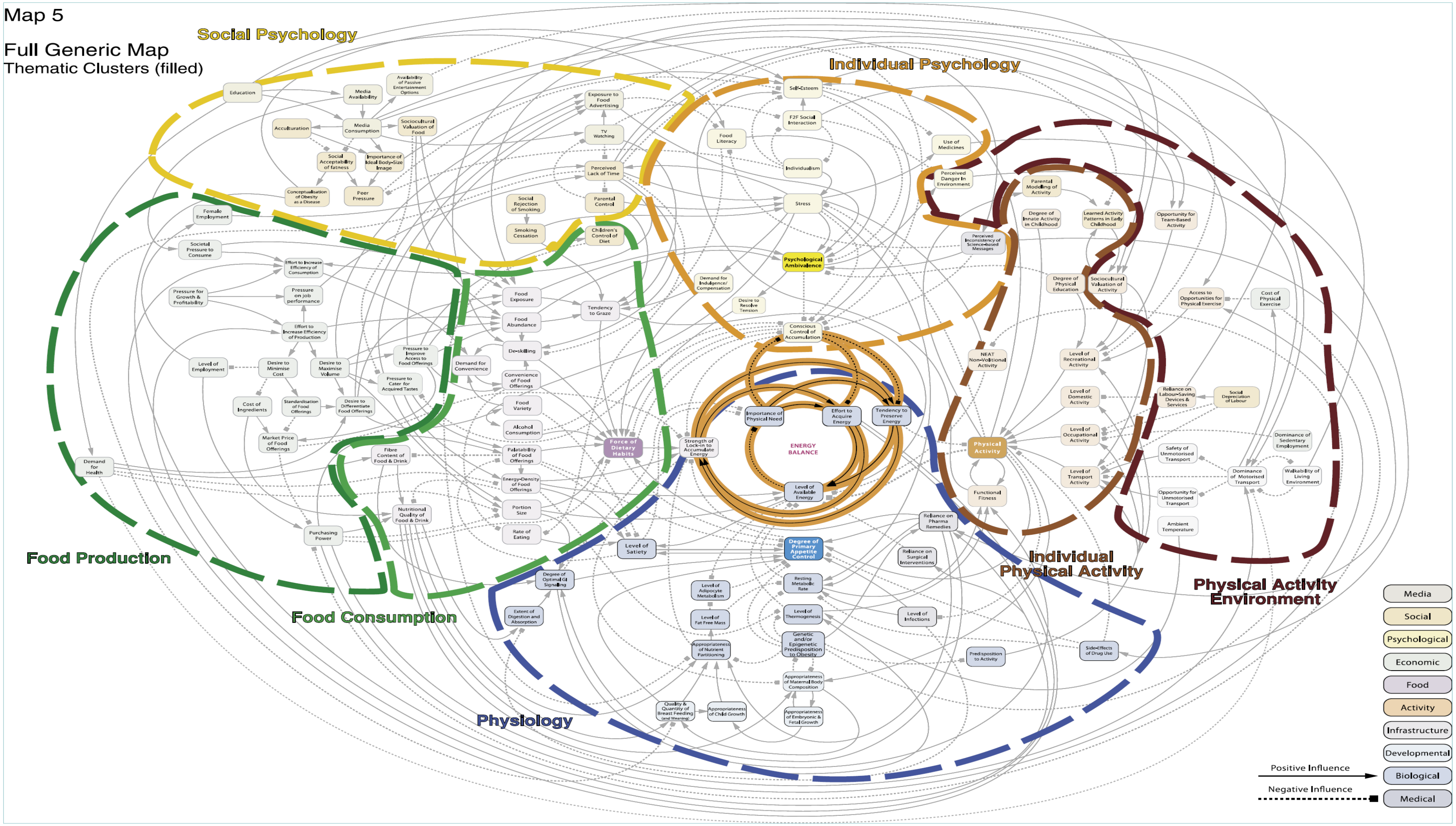
		Overweight but not obese	Obese	Overweight and obese combined	Number measured
Year R	Boys	13.6%	10.7%	24.3%	223,361
	Girls	12.4%	9.0%	21.5%	212,566
	Both	**13.0%**	**9.9%**	**22.9%**	**435,927**
Year 6	Boys	14.2%	19.0%	33.2%	227,984
	Girls	14.1%	15.8%	30.0%	212,505
	Both	**14.2%**	**17.5%**	**31.6%**	**440,489**

(The Information Centre, 2008b)

1.2.2 Causes of Obesity

The causes of obesity are complex and multi-faceted, and do not simply relate to the energy balance of the individual. Wider society also has a role to play in the increasing prevalence of obesity among adults and children. The Foresight report ‘Tackling Obesity: Future Choices’ translates science for policymakers to inform government policy and strategy, and aims to improve how science and technology are used within Government and by society (www.foresight.gov.uk). The Foresight panel were commissioned to develop a map of the obesity system (Figure 1) and this highlights just how complex the determinants of obesity are (Foresight, 2007). Despite the complexities the report broadly groups the determinants into physiological factors, eating habits, activity levels and psychosocial influences, and concludes that people in the UK do not have less willpower and are not more gluttonous than previous generations, and that their biology is not significantly different, whereas there have been major changes in society particularly changes in work patterns, transport, food production and food sales, with the pace of technology far exceeding human evolution, and it is likely that the societal changes have influenced the growing levels of overweight and obesity seen today (Foresight, 2007).

Figure 1 The Obesity System (Foresight, 2007)



1.2.2.1 Obesity Interventions

The Foresight report also discusses the critical opportunities for intervention throughout the life course, which commences prior to conception (Figure 2).

Figure 2 Critical Opportunities for Intervention during the Life Course

Age	Stage	Issue
	Preconception In utero	Maternal nutrition programmes foetus
0—6 months	Post-natal	Breast-vs bottle-feeding to programme later health
6—24 months	Weaning	Growth acceleration hypothesis
2—5 years	Pre–school	Adiposity rebound hypothesis
5—11 years	1st school	Development of physical skills Development of food preferences
11—16 years	2nd school	Development of independent behaviours
16—20 years	Leaving home	Exposure to alternative cultures/behaviour/lifestyle patterns (e.g. work patterns, living with friends etc.)
16+ years	Smoking cessation	Health awareness prompting development of new behaviours
16—40 years	Pregnancy	Maternal nutrition
16—40 years	Parenting	Development of new behaviours associated with child-rearing
45—55 years	Menopause	Biological changes Growing importance of physical health prompted by diagnosis or disease in self or others
60+ years	Ageing	Lifestyle change prompted by changes in time availability, budget, work-life balance. Occurrence of ill health.

Life course

(Foresight, 2007)

The authors note that there is not one stage during the life course at which interventions are likely to be most successful, but rather that the life course offers a number of naturally occurring opportunities in which intervention could be applied, such as periods of metabolic plasticity (for example early life, pregnancy and menopause), times linked to spontaneous changes in behaviour (for example leaving home and becoming a parent), and periods of significant shifts in attitudes (for example peer group influences or diagnosis of ill health), with the relationship between breastfeeding and early growth patterns, and establishing healthy food preferences in early childhood being critical periods that have strong evidence of success of long term health consequences (Foresight, 2007). In addition to this the

NICE clinical guidelines for Obesity describe practical evidence based recommendations for the prevention and management of obesity (National Institute for Health and Clinical Excellence, 2006). The NICE identifies many factors that can affect an individual's ability to stay at a healthy weight or succeed in losing weight, and the guidance advises that advice given should be tailored to different groups. This is particularly important for people from minority ethnic groups, vulnerable groups (such as low income, young children and families, people with disabilities, and looked-after children and young people) and people at vulnerable life stages for increased risk of weight gain (such as during and after pregnancy, menopause, or when stopping smoking), and that health professionals should discuss weight, diet, and activity with people at times when weight gain is more likely, such as during and after pregnancy, the menopause, and while stopping smoking (National Institute for Health and Clinical Excellence, 2006). However the guidelines also state that there is little UK-based evidence for the effectiveness of multi-component interventions among these key risk groups.

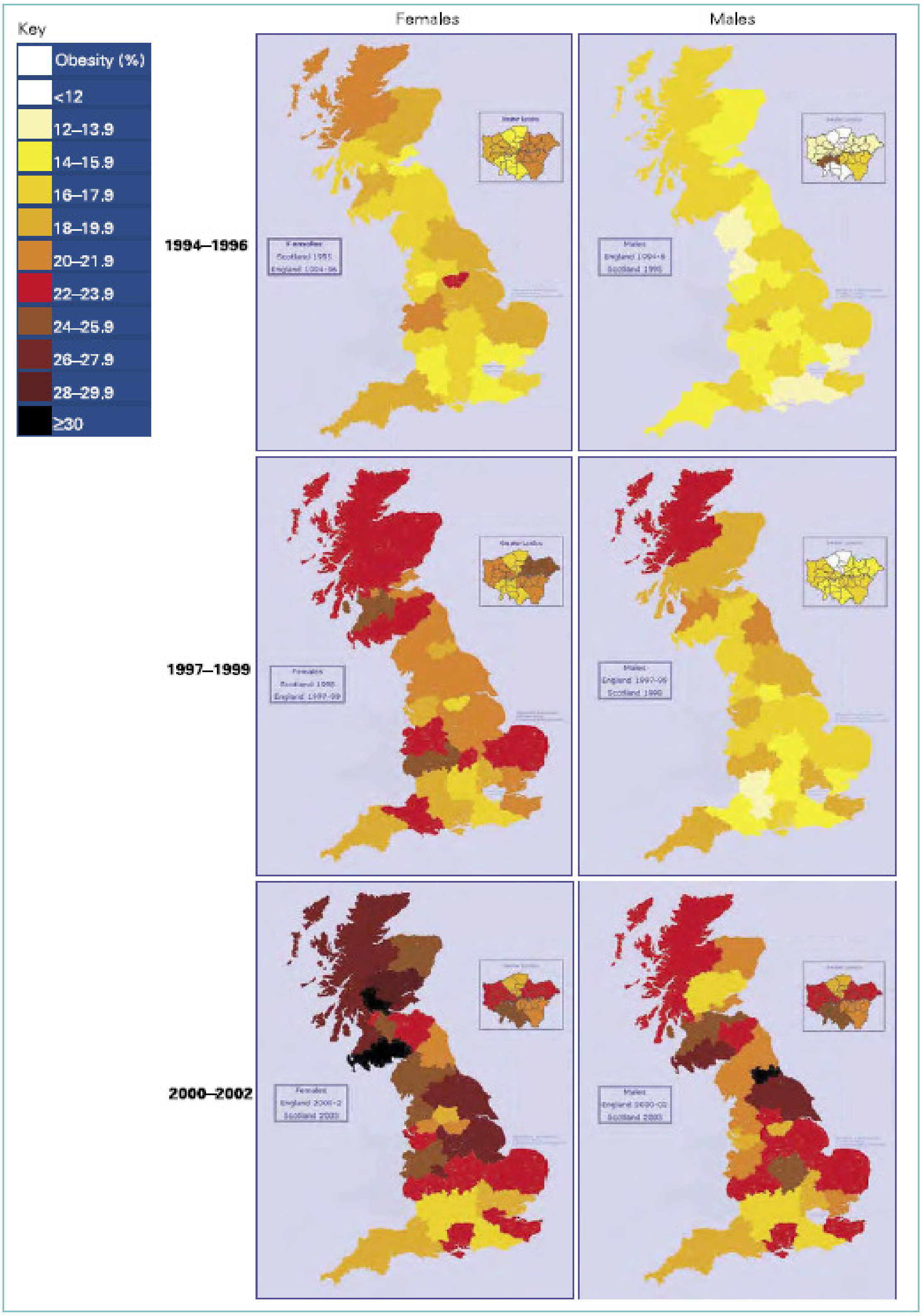
1.2.3 Health Inequalities Relating to Obesity and the General Population

Although the prevalence of obesity in the general population is increasing over time, trends in the prevalence of obesity vary. When looking at relative rates of obesity within affluent countries, increased prevalence is associated with low socio-economic status, making it a health inequality issue, the prevention of which is high on the UK government's agenda (Department of Health, 2002a, House of Commons Health Committee, 2004). This is reflected in the White Paper 'Choosing Health – Making Healthy Choices Easier' which identifies obesity as one of the key priority areas in public health, and encompasses various issues relating to obesity, including the impact of obesity-related morbidities, inequalities in health, and child health and nutrition (Department of Health, 2004a). In addition to this, the UK Government's Foresight Programme aims to identify a sustainable response to obesity over the next 40 years (Foresight, 2007).

1.2.3.1 Obesity and Regional Prevalence

The increasing prevalence of obesity among adults throughout England and Scotland is illustrated in Figure 3, which uses the HSE and Scottish Health Survey data.

Figure 3 Increasing Prevalence of Obesity among Men and Women in England and Scotland



(Foresight, 2007)

The maps show regional differences in the prevalence of obesity with increased obesity clusters particularly in Scotland and the North of England, which can in part be explained by the health inequalities related to socio-economic status, ethnicity, and age (Foresight, 2007). The issue with health inequalities and regional prevalence of obesity relates to the implications for the long term health of these clusters of the population, and in addition to the recognised contributors to the regional differences, there may also be region specific factors.

1.2.3.2 Obesity and Socio-economic Status

The HSE data shows that the relationship between socio-economic status and obesity is most pronounced in women, with the prevalence of obesity in the highest socio-economic group (based on household income) being 19% compared to 32% in the lowest group (The Information Centre, 2008a). The positive relationship between obesity and reduced socio-economic status is also apparent for men, though not as marked, with 21% in the highest and 25% in the lowest groups (Table 3). The same trend for raised waist circumference was present in both men and women, where the highest socio-economic group had a prevalence of 31% of men and 36% of women having a raised waist circumference compared to 35% of men and 47% of women in the lowest group (Table 4).

The NCMP also showed that there were regional variations in the prevalence of obesity among children, with significantly higher than national average obesity prevalence in the North East, West Midlands and London Strategic Health Authorities (SHA) for children in both school years being measured; Reception (4-5 years old), and Year 6 (10-11 years old) (The Information Centre, 2008b). There was also a strong positive relationship between obesity and deprivation and this was especially evident in Year 6 where obesity prevalence was almost 10% higher in the most deprived local authorities compared with the least deprived[2] (Figure 4).

[2] Using the 2007 Index of Multiple Deprivation scores

Table 3 BMI[1] Among Adults[2] by Equivalised Household Income Quintiles and Gender, 2006

England — Percentages / Numbers

	Highest	2nd	3rd	4th	Lowest
Men					
Underweight	0	1	1	2	2
Normal	32	31	31	32	32
Overweight	47	45	44	39	41
Obese	21	23	24	27	25
Overweight including obese	68	68	68	66	65
Morbidly obese	1	2	1	1	2
Mean BMI (kg/m^2)	27.1	27.3	27.3	27.3	27.1
Women					
Underweight	2	2	2	2	3
Normal	48	42	41	37	33
Overweight	31	34	33	31	32
Obese	19	23	24	29	32
Overweight including obese	50	57	57	60	64
Morbidly obese	1	3	3	3	4
Mean BMI (kg/m^2)	25.9	26.8	26.9	27.5	27.6
Bases (unweighted)					
Men	*1,079*	*1,052*	*949*	*806*	*655*
Women	*1,036*	*1,117*	*1,135*	*1,152*	*886*
Bases (weighted)					
Men	*1,193*	*1,165*	*998*	*809*	*699*
Women	*979*	*1,061*	*1,047*	*1,035*	*813*

1. Using the following BMI definitions: Underweight: less than 18.5 kg/m^2; normal: 18.5 to less than 25 kg/m^2; overweight: 25 to less than 30 kg/m^2; obese 30 kg/m^2 or more; overweight including obese 25 kg/m^2 or more; morbidly obese: 40 kg/m^2 or more
2. Adults aged 16 and over with a valid height and weight measurement
3. Figures presented are age standardised

(The Information Centre, 2008a)

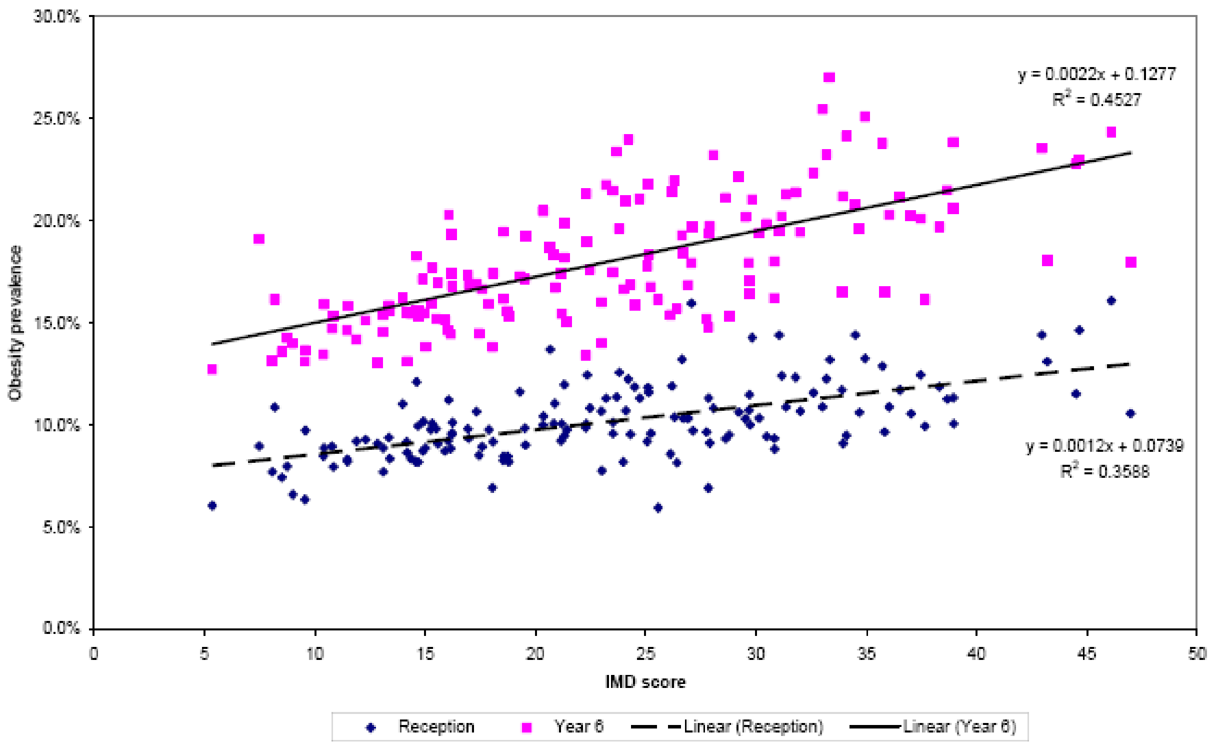
Table 4 Waist Circumference[1] Among Adults[2] by Equivalised Household Income Quintiles and Gender, 2006

England					Percentages / Numbers
	Highest	2nd	3rd	4th	Lowest
Men					
Raised waist circumference	31	32	31	35	35
Mean waist circumference (cm)	96.7	96.7	96.6	97.2	96.9
Women					
Raised waist circumference	36	41	41	45	47
Mean waist circumference (cm)	84.6	85.9	86.7	88.2	88.3
Bases (unweighted)					
Men	*906*	*888*	*812*	*699*	*551*
Women	*894*	*971*	*994*	*999*	*763*
Bases (weighted)					
Men	*985*	*983*	*822*	*695*	*603*
Women	*826*	*904*	*908*	*912*	*716*

1. Raised waist circumference has been taken to be greater than 102 cm in men and greater than 88 cm in women
2. Adults aged 16 and over with a valid waist circumference measurement
3. Figures presented are age standardised

(The Information Centre, 2008a)

Figure 4 Prevalence of Obese Children against 2007 IMD Score, by LA, England, 2006/07



(The Information Centre, 2008b)

1.2.3.3 Obesity and Ethnic Group

Health inequalities among both men and women are also apparent in the differences in the prevalence of obesity among ethnic minority groups. The HSE published a report on the health of minority ethnic groups using 2004 data, and found that Black Caribbean and Irish men had a higher prevalence of obesity than the general population (Table 5), although age standardised risk ratios for men found that there were no increased risk of obesity among any of the ethnic groups (Figure 5) (The Information Centre, 2006). The prevalence of obesity among women was highest among Black African, Black Caribbean and Pakistani ethnic groups, and this remained significant for age standardised data.

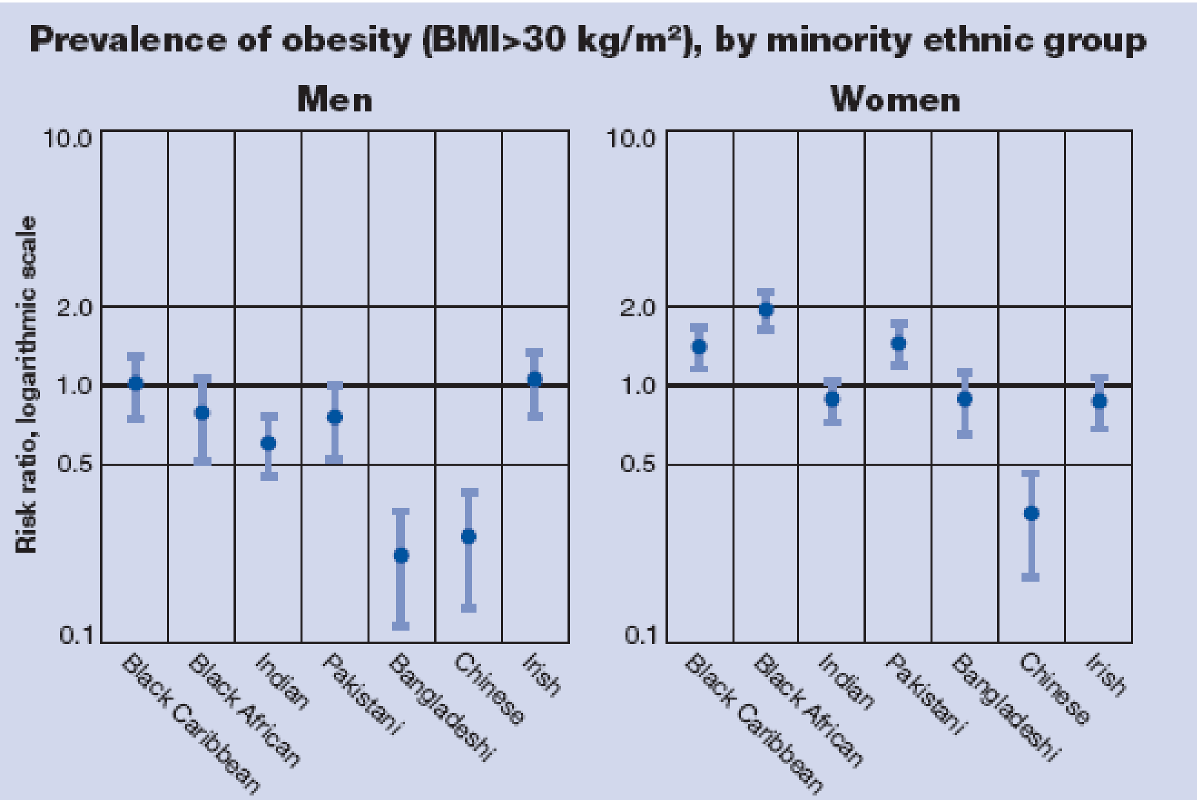
Table 5 Prevalence of Obesity among Ethnic Minority Groups 2004

Prevalence of obesity (BMI>30kg/m^2)

	Black Caribbean	Black African	Indian	Pakistani	Bangladeshi	Chinese	Irish	General population
Men								
Observed %	25	17	14	15	6	6	25	23
Standardised risk ratio	1.03	0.79	0.60	0.76	0.22	0.26	1.07	1
Women								
Observed %	32	38	20	28	17	8	21	23
Standardised risk ratio	1.43	2.00	0.89	1.48	0.89	0.32	0.88	1

(The Information Centre, 2006)

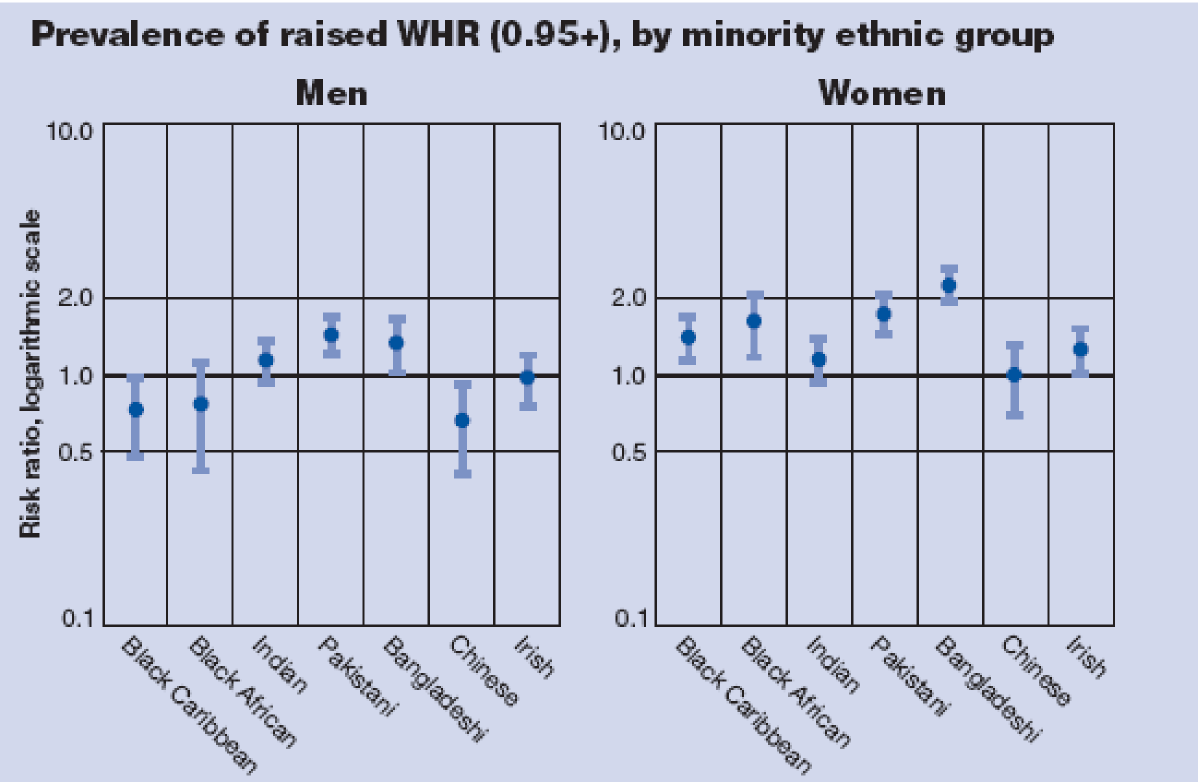
Figure 5 Age Standardised Risk Ratio for Prevalence of Obesity among Ethnic Minority Groups Compared With the General Population



(The Information Centre, 2006)

In addition to the increased risk of obesity among women from some ethnic minority groups, the HSE also identified a relationship with raised waist circumference and waist-hip ratios (WHR). The mean WHR among the general population was 0.82 for women and following age standardisation, there was a significantly higher prevalence of raised WHR among almost all ethnic minority groups in women with the exception of Chinese and Indian women (Figure 6). Following age standardisation there was also a significantly increased risk of having a raised waist circumference among Black African, Black Caribbean, Pakistani, and Bangladeshi women (Table 6). The relationship with WHR and raised waist circumference was lower among men from ethnic minority groups compared with women, as there was a significantly higher prevalence of raised WHR among Pakistani and Bangladeshi men only (Figure 6), and following age standardisation there was only a significant relationship with Pakistani men and raised waist circumference (Table 6).

Figure 6 Age Standardised Risk Ratio for Prevalence of Raised WHR among Ethnic Minority Groups Compared With the General Population



(The Information Centre, 2006)

Table 6 Increased Waist Circumference among Men (>102cm) and Women (>88cm) for Ethnic Minority Groups

Prevalence of raised waist circumference

	Black Caribbean	Black African	Indian	Pakistani	Bangladeshi	Chinese	Irish	General population
	%	%	%	%	%	%	%	%
Men								
Observed %	22	19	20	30	12	8	33	31
Standardised risk ratio	0.66	0.81	0.70	1.23	0.51	0.28	0.96	1
Women								
Observed %	47	53	38	48	43	16	43	41
Standardised risk ratio	1.23	1.51	0.97	1.49	1.39	0.50	1.00	1

(The Information Centre, 2006)

1.2.3.4 Obesity and Employment

There is also a relationship between obesity and employment, and the relationship is especially significant for unemployment and obesity in women. Data provided in two rounds of the HSE (1997 and 1998) was further analysed for the relationship between obesity and employment (Morris, 2004). This analysis estimated separate models for males and females, adjusting for the effects of age, education (educational attainment and years of schooling), health (general health, acute ill health, long standing illness, and psycho-social health), home and family (housing, marriage, and family size), and obesity indirect variables (ethnicity, region of residence, and HSE year). Following analysis of the direct effects of obesity on employment, Morris (2004) found that obese women were 33% less likely to be employed than non-obese women, and the relationship increased as obesity levels rose; 55% of severely obese women were less likely to be in employment. Following exclusions of the obesity-independent variables (education, health, and home and family) 71% of obese women and 87% of severely obese women were less likely to be employed than non-obese women.

1.2.4 Obesity and the Pregnancy Population

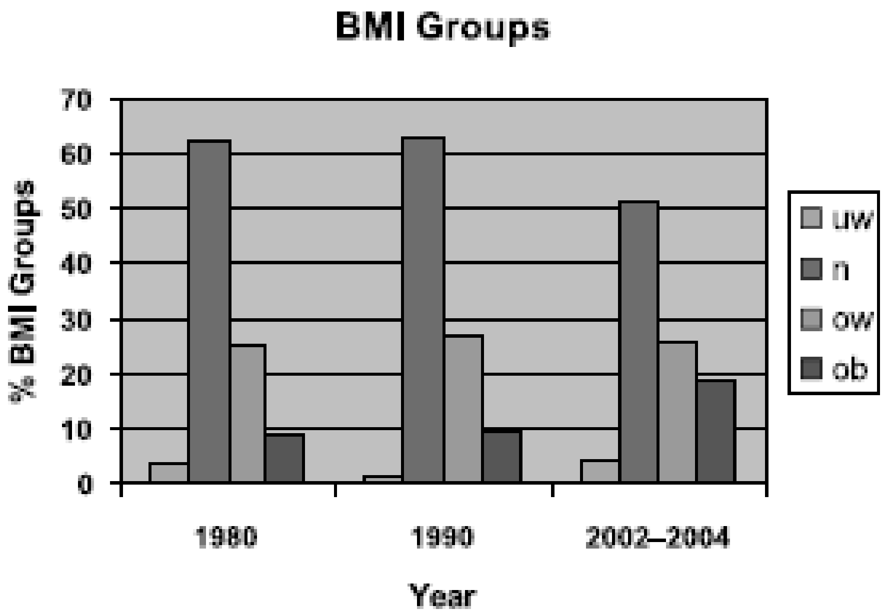
1.2.4.1 Definition and Incidence of Maternal Obesity

There is no pre-existing range of BMI to specifically define maternal obesity, and therefore BMI groups for the general population tend to be used as a measure of obesity in pregnancy. The rising prevalence of obesity among women in the general population as reported by the HSE is also reflected in the prevalence of obesity among women of childbearing age[3], with an increase from 12.0% in 1993 to 18.5% in 2006 (The Information Centre, 2008a). In addition to this the Confidential Enquiry into Maternal and Child Health (CEMACH) reported that the highest increase in obesity prevalence between 1993 and 2002 was among women aged 25–34 years, with an increase of 10%, and that 30% of all mothers who died during 2000-2002 in the UK were obese (BMI>30kg/m^2) (Confidential Enquiry into Maternal and Child Health, 2004). An absence of reliable weight data records in previous years meant that there was no comparison figure to identify trends. By the 2007 report, of all mothers who died between 2003-2005, more than half were overweight or obese (BMI>25kg/m^2), with over 15% being morbidly (BMI>40kg/m^2) or super morbidly obese (>50kg/m^2) (Lewis, 2007).

This rise in the prevalence of obesity among women in the general population, and among women of childbearing age, suggests that the number of women who are obese at the start of pregnancy will also be increasing; however there is an absence of national or international statistics on the impact this increasing prevalence of obesity in women has on obesity in pregnancy. Despite the absence of national statistics, two UK studies have shown that the incidence of maternal obesity has increased from 3.2% to 8.9% between 1990-1999 in Cardiff (Usher Kiran et al., 2005) and from 9.4% to 18.9% between 1990-2002/4 in Glasgow (Figure 7) (Kanagalingam et al., 2005). A study in England also reported 10.9% of pregnant women living in London between 1989 and 1997 were obese (Sebire et al., 2001); however this was the average for the entire cohort and did not account for changes in BMI over time (Figure 8).

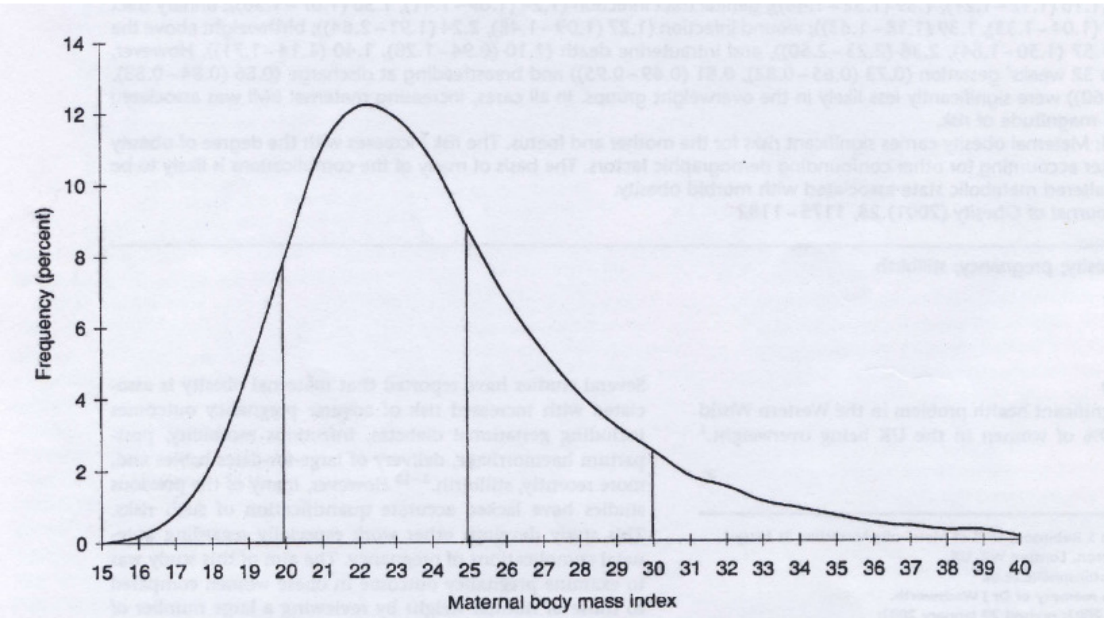
[3] Where women of childbearing age are considered to be 16-44 years old

Figure 7 Trends in Booking BMI Over Two Decades in Glasgow



(Kanagalingam et al., 2005)

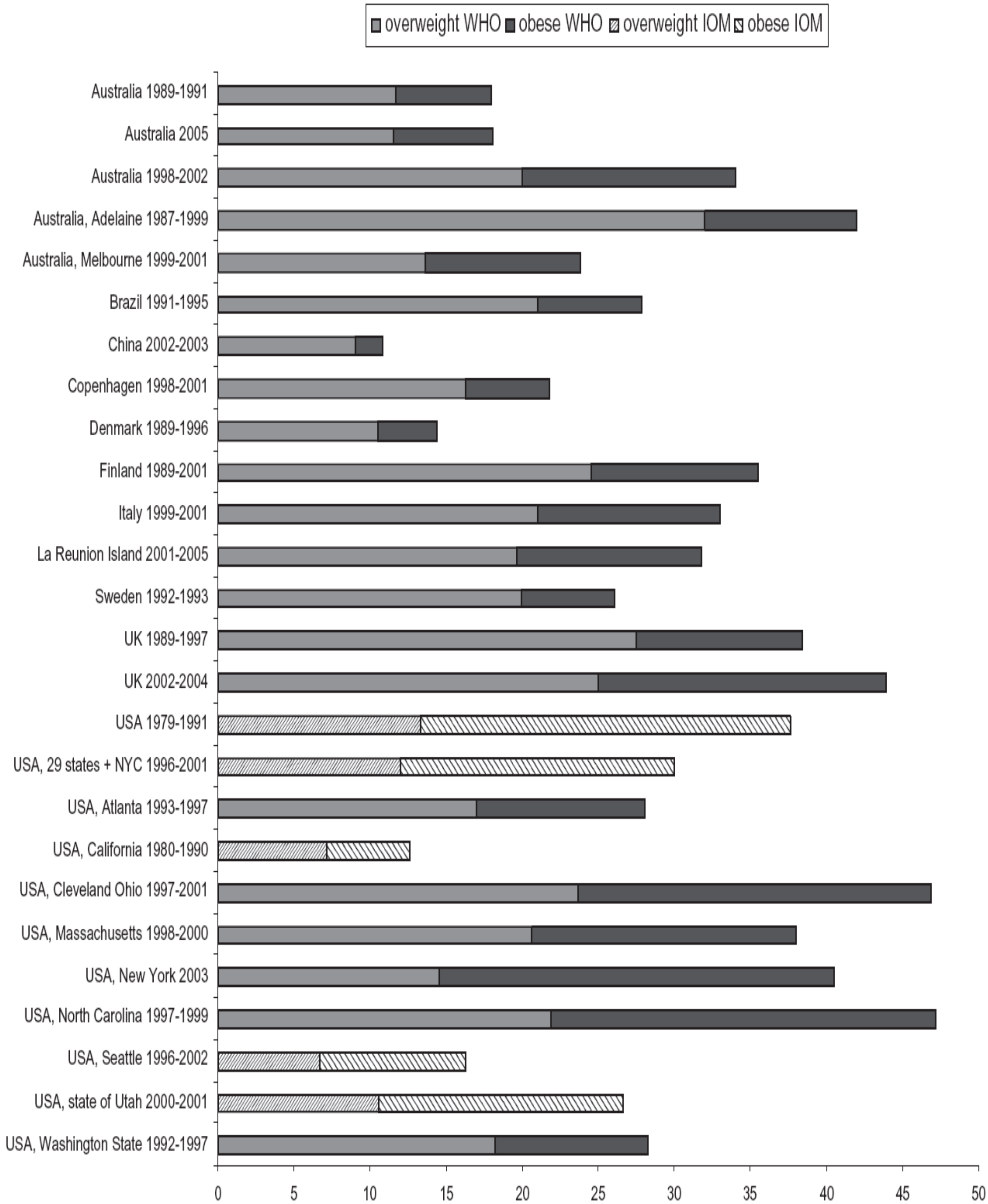
Figure 8 Distribution of Maternal BMI in London



(Sebire et al., 2001)

The scale of obesity in the pregnancy population on an international level, according to published studies, is summarised by Guelinckx et al (2008) (Figure 9).

Figure 9 Percent of Overweight and Obesity in Pregnant Women: Institute of Medicine (IOM) and WHO Definitions of Obesity



(Guelinckx et al., 2008)

The findings of published studies on international rates of maternal obesity are difficult to compare directly due to the variation in the categories used to define obesity, the differences in time periods of the published studies, and the fact that the majority of the studies included focus on the United States and Australia and therefore do not give a true international representation. However, the incidence of maternal obesity on an international level ranges between 1.8% and 25.3% using the WHO definition of obesity of a BMI>30kg/m^2 (Guelinckx et al., 2008).

1.2.5 Biomedical Health Risks to the Mother

Obesity has an impact on women's reproductive health, and there are health risks to both mother and infant. There is a relationship with polycystic ovarian syndrome (PCOS), infertility, and the success of infertility treatment (Wang et al., 2002), whereas weight loss has been shown to alleviate these conditions and improve the success of infertility treatment (Clark et al., 1995). There is an increased risk of mothers developing gestational diabetes (Andreasen et al., 2004) and subsequent development of diabetes mellitus (Linne, 2004), an increased risk of hypertensive disorders and pre-eclampsia (Castro and Avina, 2002, Linne, 2004), and thromboembolic complications (Castro and Avina, 2002).

In their latest report CEMACH summarises the risks related to obesity in pregnancy for the mother as being maternal death or severe morbidity, cardiac disease, spontaneous 1st trimester and recurrent miscarriage, pre-eclampsia, gestational diabetes, thromboembolism, post caesarean wound infection, infection from other causes, postpartum haemorrhage and low breast feeding rates (Lewis, 2007). The report shows that obese pregnant women with a BMI>30kg/m^2 are more likely to die in pregnancy, and CEMACH recommends that obese women should be assisted with weight loss prior to conception or receiving any form of assisted reproductive technologies, and should receive pre-pregnancy counselling and advice (Lewis, 2007). The majority of direct and overall deaths were reported in overweight or obese women (BMI>25kg/m^2). Thromboembolism was the leading direct cause of death, and 65% of deaths from thromboembolism were in overweight or obese women. Women were also overweight or obese in 69% of cardiac deaths and 73% of deaths from sepsis (Table 7).

Table 7 CEMACH 2007 Cause of Death by BMI

Numbers of maternal deaths from *Direct* and *Indirect* causes by BMI and percentages overweight or obese; United Kingdom: 2003-05.

	BMI						Total with BMI 25 or over	Total number with known BMI	Not stated or recorded
	Less than 20	20-24	25-29	30-34	35-39	40-60			
	n	n	n	n	n	n	n (%)	n (%)	
Direct									
Thromboembolism	3	8	6	6	2	6	20 *(65)*	**31** *(100)*	10
Pre-clampsia / eclampsia	1	8	6	0	1	2	9 *(50)*	**18** *(100)*	1
Haemorrhage	2	6	2	3	2	0	7 *(47)*	**15** *(100)*	2
AFE	2	6	4	0	2	0	6 *(43)*	**14** *(100)*	3
Early pregnancy	0	4	0	1	1	0	2 *(33)*	**6** *(100)*	8
Sepsis	1	2	5	2	0	1	8 *(73)*	**11** *(100)*	7
Anaesthetic	0	2	0	0	1	1	2 *(50)*	**4** *(100)*	2
All *Direct*	9	36	23	12	9	10	54 *(55)*	99 *(100)*	33
Indirect									
Cardiac	4	9	14	6	4	5	29 *(69)*	**42** *(100)*	6
Other Indirect	8	35	12	10	4	1	27 *(39)*	**70** *(100)*	17
Psychiatric	3	4	4	0	0	2	6 *(46)*	**13** *(100)*	5
Malignancies	2	2	2	0	0	1	3 *(43)*	**7** *(100)*	3
All *Indirect*	17	50	32	16	8	9	65 *(49)*	132 *(100)*	31
All	26	86	55	28	17	19	119 (52)	231 *(100)*	64

(Lewis, 2007)

1.2.6 Psychosocial Implications

Obesity has an impact on the psychological health of the mother as well as the biomedical risks identified in Section 1.2.5. There is an inherent social stigma associated with being obese, with many societies displaying negative attitudes and discrimination towards obese individuals (Reilly and McDowell, 2003, Brown et al., 2006), and this could potentially be heightened with increased interest by the media. The ‘Choosing Health: Making Healthy Choices Easier’ white paper identifies that media coverage of obesity has increased dramatically in recent years (Department of Health, 2004a), which could have acted as a mechanism for validating the social acceptability of obesity related stigma. There appears to be a stronger relationship with social stigma and overweight among women compared with men, where women are more likely to perceive themselves as fat compared to men, and being overweight is perceived as a more negative experience for women (Roehling, 1999, Wiles, 1994). This incurs a greater level of social stigma due to the societal disapproval of fatness among women and the pressure on women to conform to cultural notions of attractiveness (Wiles, 1994). The disapproval of obesity among women is manifested in society by the attribution of negative labels based on women's body size, exclusion from full participation in society, and is particularly evident in discrimination in the labour market (Roehling, 1999, Wiles, 1994).

The psychological impact of obesity and reproduction can be seen in the family planning stages, throughout the pregnancy and the postnatal period. The incidence of PCOS and infertility is associated with being overweight and obese, and it appears to be on the increase as there is an increasing proportion of overweight and obese women attending for In-Vitro Fertilisation (IVF) (Norman and Clark, 1998). Although infertility has a biomedical relationship with obesity, it also has a psychological impact on women who are unable to conceive, and with the majority of centres only offering NHS funded fertility treatment for women with a BMI $<35kg/m^2$ (Farquar, 2007), this is likely to add to the distress of infertility in the obese woman. The association between obesity and deprivation described in Section 1.2.3 could also indicate an increase in the psychological distress for women with a low socio-economic status who are unable to afford private healthcare for fertility treatment, and are subsequently unable to conceive due to their BMI status, subsequently widening the health inequality gap.

The psychological impact of obesity in pregnancy is relatively unexplored. Zahorick and Webber (2000) discuss how pregnancy represents the biggest change in a woman's body since puberty, and how adjusting to a post-pregnancy body shape may be even more difficult than coping with the changes of pregnancy (Zahorick and Webber, 2000). The difference between races and cultures in relation to changing body image during pregnancy is also reported, with differences between white and African American women's stomach awareness throughout pregnancy and in the postnatal period, and differences between feelings of body distortion throughout pregnancy (Harris, 1979). Morin found that African American women had some positive attitudes towards their body image 24-48 hours postpartum, although they perceived that they occupied more space than they did in reality (Morin et al., 2002).

Although there are psychological issues with women and their changing body shapes and body image, pregnancy is a time in a woman's life when society appears to be more accepting of women's increased body size. Qualitative research exploring the differences in pre-pregnancy and pregnancy feelings towards body weight in obese women highlights how the social pressure to conform appears to take priority over the health benefits of weight loss (Wiles, 1994). The most frequent reasons for feeling dissatisfied with pre-pregnancy weight were buying and wearing clothes, personal appearance, taking part in sport and social activities, and comments from family members and others leading to a desire for weight loss to please them, whereas health was not discussed by any of the women participating in the study (Wiles, 1994). In contrast to the pre-pregnancy feeling of dissatisfaction with their body weight, the majority of the women in the study reported feeling better about their weight during pregnancy and commented on the greater social acceptability of fatness during pregnancy, and this gave rise to a liberation from some of the self imposed sanctions they faced prior to pregnancy (Wiles, 1994). Despite this being the majority opinion, there were women in the study who were wary of feeling more socially acceptable. For these women the primary reason for this wariness of social acceptability during the transition to pregnancy related to the gestational weight gain and the impact this would have on the re-instigated social undesirability following pregnancy; the secondary reason related to comments and advice given by medical professionals (Wiles, 1994).

The relationship between the medical profession and psychosocial issues relating to obesity in pregnancy has also been raised by HCPs caring for obese women in pregnancy. They noted issues relating to patient dignity, embarrassment, and feelings of victimisation when HCPs raise the issue of obesity with mothers (Heslehurst et al., 2007b). This study reported an apparent lack of awareness of the impact of being obese in pregnancy among women, and HCPs have stated that women often have no perception of being obese themselves, possibly due to the normalisation of overweight and obesity among their peers (Heslehurst et al., 2007b). The normalisation of being overweight has been reported in a study that compared the changing perceptions of being overweight in the UK over an 8 year period which found that with a positive trend in obesity, there was a negative trend in the recognition of being overweight among the population with a reduction in perception of 6% and this was most prevalent among women, who were 1.33 times less likely to perceive themselves as being overweight compared to men (95% CI 1.26, 1.40) (Johnson et al., 2008).

HCPs have also described how the biomedical links with maternal obesity can also have a psychological impact on the mothers. This primarily relates to ultrasound scans and not being able to physically detect the foetus due to the obstructing fat mass when women are obese, which has a biomedical implication for the foetus as the scan cannot detect what it is supposed to, but also has consequences for the parents who can't see the picture of their baby (Heslehurst et al., 2007b). The findings of this study also highlight the frustration of HCPs in maternity units when it came to offering support and services to mothers who are obese, as it was felt to be a public health issue. They perceived that there was little that could be done in terms of weight reduction during pregnancy as this is not clinically recommended, and that any weight loss interventions need to be carried out before conception rather that during pregnancy (Heslehurst et al., 2007b). It was felt that all that could be done during the pregnancy was to manage the care of the mother as safely as possible, but the difficulty in conveying the message of the potential adverse health implications of being obese when pregnant was also expressed. HCPs found it difficult to get a balance of information about the potential risks, the requirement of additional procedures and more intensive monitoring, and the reduced choice for the mothers in their care plans such as midwifery-led care and mode of delivery, without causing additional upset and stress to the mothers when they are already considered to have high risk pregnancies (Heslehurst et al., 2007b). The potential for having a negative impact on the psychological wellbeing of the mothers by drawing attention to their weight is supported by Wiles (1994), who found that comments and advice given by the medical profession about weight were perceived by women as being insulting or derogatory, with implications that they were not aware of their weight problem or hadn't been doing anything about it (Wiles, 1994). The findings of these two studies highlight the same anxieties between HCPs and women about addressing the issue of obesity in pregnancy and the negative impact this can have on the psychological health of the mother, whereas there are differences in opinions about women's realisation of being overweight.

1.2.7 Health Risks to the Child

The CEMACH report (2007) summarises the risks relating to obesity in pregnancy for the child as being stillbirth and neonatal death, congenital anomalies, and prematurity. In 2005 mothers were obese in 22.9% of all late foetal loss, 30.4% of stillbirths, and 30.6% of neonatal deaths (Confidential Enquiry into Maternal and Child Health, 2007). Published research supports the findings of the CEMACH report with the association between increased risk of late foetal loss (Lashen et al., 2004), stillbirth (Cnattingius and Lambe, 2002), and congenital anomalies in offspring of obese mothers, including spina bifida, heart defects, anorectal atresia, hypospadias, limb reduction defects, diaphragmatic hernia, and omphalocele (Waller et al., 2007). An explanation for the link with increased stillbirths and late foetal loss could be due to the potential to misdiagnose conditions in utero when the mother is obese leading to the appropriate measures not being taken during delivery, such as macrosomia or growth restriction, and not detecting foetal distress or being able to accurately monitor the foetal heart rate during labour due to difficulties in ultrasound scans, monitoring, and detecting the foetus (Heslehurst et al., 2007b). The difficulties in ultrasound scans being able to detect the foetus when the mother is obese could also help to explain the increased prevalence of congenital anomalies, through reduced detection rates and undiagnosed disease in utero. There may also be a relationship with obesity resulting in insufficient protective effect of folate (Hotzel, 1986). Lower levels of circulating nutrients, including erythrocyte folate, have also been found in obese women (Werler et al., 1996).

There are also increased complications throughout the delivery when the mother is obese which pose risk to the health of the baby. There is an increased risk of macrosomia and shoulder dystocia during labour, the need for more frequent induced and operative deliveries due to foetal distress (Andreasen et al., 2004, Morin, 1998), and increased requirement for neonatal intensive care for the newborn (Callaway et al., 2006, Usher Kiran et al., 2005, Kumari, 2001).

1.2.7.1 The Development of Obesity in the Offspring

In addition to the impact maternal obesity has on the immediate health status of the newborn infant, there is also a link with the long term development of obesity in the offspring. It is well recognised that children who are obese are likely to have obese parents (Parsons et al., 1999, Patrick and Nicklas, 2005), and although there is no consensus on the causal relationship between parental and childhood obesity there is evidence of a combined endogenous and exogenous relationship which cannot be viewed in isolation.

There is an argument in life course research that adult health and inequalities can be influenced by the intra-uterine environment (Barker, 1998), and there is a significant relationship between obese mothers, macrosomia, and the subsequent development of childhood and adult obesity in the offspring (Curhan et al., 1996b, Curhan et al., 1996a, Larsen et al., 1990, Whitaker et al., 1998, Power et al., 2003). A systematic review of the childhood predictors of adult obesity showed that maternal obesity and weight gain during pregnancy are related to higher BMI in childhood, and subsequent obesity in adulthood (Parsons et al., 1999).

When looking at maternal obesity as an independent risk factor for the development of childhood obesity in the offspring, the morbidities that often co-exist with obesity must also be considered. When women are obese there is an increased risk that they may also have type I diabetes or impaired glucose tolerance (IGT), and an increased risk of developing gestational diabetes mellitus (GDM) during pregnancy (Pettigrew and Hamilton-Fairley, 1997). Life course studies show that women who have diabetes during pregnancy persistently have obese offspring, and this is independent of genetic factors suggesting that the intra uterine environment is altered in a diabetic pregnancy (Breidahl, 1996, Pettitt et al., 1993, Plaguemann et al., 1997, Rodrigues et al., 1998, Silverman et al., 1991, Whitaker et al., 1998).

The exact mechanisms as to why these endogenous factors appear to generate the development of obesity in the offspring are unknown; however there are multiple theories relating to the effects of the intra uterine environment. These theories refer to the effects of placental pathology, and maternal and foetal nutrition. One mechanism is thought to be an alteration in the intra uterine environment affecting the transfer of metabolic substrate to the foetus, potentially impeding development of the structure and function of foetal organs involved in energy metabolism (Whitaker et al., 1998). Excessive weight gain during pregnancy is also thought to cause foetal hyperinsulinism, which may ‘malprogramme’ the foetal hypothalamus, pancreatic beta cells, and adipocytes, predisposing the infants to obesity (Dorner and Plagemann, 1994). Pederson's model theorises that the metabolic alterations in utero when the mother is diabetic are due to increased glucose and amino acids in the blood having a similar affect to when the mother is obese, causing foetal pancreatic beta cell hyperplasia, hyperglycaemia, and hyperinsulinaemia (Whitaker et al., 1998). The diminished insulin secretion and increased insulin resistance is theorised to lead to obesity in adulthood, and the effects of the intrauterine environment on the development of insulin receptors and stimulation of beta cells, or leptin production, may also contribute towards obesity development.

The adipocyte number hypothesis refers to an increased transfer of fat fuels to the foetus when the mother is obese, or an elevation of triglycerides due to GDM, affecting the fat cell size and number in the foetus which potentially has long-term implications for obesity predisposition. The foetal over-nutrition hypothesis relates to the persistence of fat rather than muscle in offspring of mothers who are obese or develop GDM during the pregnancy (Poston and Taylor, 2007). This is potentially due to the high maternal glucose, free fatty acid, and amino acid plasma concentrations resulting in over-nutrition of the foetus which may permanently change the appetite control, neuroendocrine functioning, or energy metabolism in the developing foetus, leading to obesity in later life (Lawlor and Chaturvedi, 2006). Lawlor and Chaturvedi (2006) discuss how maternal obesity may be the prime factor in foetal over-nutrition due to the high plasma concentrations of glucose and free fatty acids, and the relationship with glucose intolerance and insulin resistance.

1.2.8 NHS Maternity Service Implications

In addition to the increased health risks associated with obesity in women who become pregnant, there is also a demand for additional care and resource from health service providers. However there has been limited research addressing this factor as a measured outcome, internationally or in the UK. One reason why the impact of maternal obesity on maternity services may not have been studied thoroughly could be the difficulty in quantifying many of the factors. Qualitative research by Heslehurst et al (2007b) discusses the impact of obesity in pregnancy on the NHS maternity services as described by HCPs caring for women during their pregnancy. The objective of this study was to gain a detailed understanding of HCPs perceptions of the impact maternal obesity has on maternity services in their day to day care. The study used semi-structured interviews and focus groups in 16 maternity units in the North East of England, and involved a total of 37 HCPs who care for obese women in pregnancy. Five dominant themes around the impact of obesity on pregnancy were identified, and these included issues with booking appointments, equipment, care requirements, complications and restrictions, and current and future management of care.

The location of the booking appointment was raised as an issue, whereby the location had a direct influence on whether height and weight were measured or self reported. The general consensus was that if the booking appointments took place in an NHS location then the recorded height and weight measurements were more likely to be measured, whereas home bookings tended to rely on self reported measures due to a lack of equipment for community midwives. The location of the booking appointment was also considered to influence the response to sensitive questions, which includes questions about weight when the mothers are obese. The theme of having the appropriate equipment for obese mothers was raised throughout all interviews, where specific issues related to equipment to safely manage the care of obese mothers, such as equipment which has a maximum weight load or expansion, and equipment for surgical deliveries. There was a lack of appropriate equipment with major cost implications identified, such as the need for stronger delivery beds, and this issue was raised in a number of maternity units where there was an absence of equipment for safe delivery of the mothers routinely available.

"The theatre table can hold up to 27 stones. Occasionally the woman has had to have surgery on the general bed as opposed to the theatre bed, and there have been instances where this is not enough and the women have had to go to main theatre for surgery."

(Midwife, Maternity Unit 16)

The knock on effect of not having suitable equipment routinely available in the maternity units was discussed in relation to the impact this has on other departments' resources and waiting lists.

"The lack of an operating table large enough for elective caesareans means that these women are booked in on the gynae theatre list which disrupts the list and has implications on the waiting times for the women who need surgery for gynae problems, this happens approximately twice a month. The gynae theatre table is also required when an emergency caesarean is required which disrupts the theatre list and impacts on the waiting times as well."

(Head of Midwifery, Maternity unit 14)

There were other examples of additional equipment requirements that were less expensive but that could have significant cumulative costs, such as chairs, couches, wheelchairs, longer needles for spinal anaesthesia, and equipment to hold the fat out of the way during caesarean deliveries.

The care requirements for obese women were discussed in relation to routine additional care required, and it was evident that the level of high dependency care that was deemed to be required was not being met in a number of maternity units due to capacity issues. For example, all maternity units had a routine referral pathway for high dependency care, especially in the case of consultant led care. However the BMI cut off points for referral varied between maternity units from a BMI of 30-50kg/m^2, with some maternity units having to increase the BMI cut off points due to the case load being too great to sustain. The requirement for multidisciplinary care when mothers were obese was also discussed, and it was established that dietetic and physiotherapy support was often not available in the maternity units.

Additional routine care also included glucose tolerance tests (GTTs) due to the increased risk of developing diabetes during the pregnancy, and the provision of additional scans due to difficulties in detecting the foetus, determining the foetal size and presentation. There is also risk of misdiagnosing conditions, thus leading to unnecessary interventions, or to staff not detecting conditions due to suboptimal monitoring procedures. Examples given were misdiagnosing high blood pressure due to blood pressure cuffs being too tight, not detecting macrosomia or foetal growth restriction due to the difficulties in determining foetal size, and needing to use alternative monitoring methods such as foetal scalp electrodes as the foetal heart rate could not be detected using the normal methods during delivery.

"The excess layers of fat also make it more difficult to palpate to determine foetal lie when the mother is obese, and there are difficulties when doing ultrasound scans and listening to the foetal heart. During labour it is more difficult to pick up the contractions and foetal heart rate, and this can lead to misinterpretation of what is being picked up, which determines the outcome. For example the labour might be misinterpreted as being abnormal which could lead to an unnecessary change in the plan of action, caesarean etc."

(Clinical Midwifery Manager, Maternity Unit 6)

The complications and restrictions addressed by the HCPs included an increased risk of developing co-morbidities such as pressure sores, deep vein thrombosis, incontinence, diabetes, pre-eclampsia, and wound infections. There were also practical issues of accessing body sites for administration of treatment such as joints, bones and peritoneum for physiotherapy treatment. There is also increased difficulty in siting and administering analgesia, leading to the necessity for a general anaesthetic which poses a greater risk to obese women. In addition to the health related complications and restrictions, there is also a reduction for the mothers in terms of patient choice when they are obese in pregnancy. For example the removal of the choice for midwifery-led and community care; restrictions in birth choice given the clinical contra-indications to pool births and women were discouraged from home births due to the risks involved; limited choice for pain relief due to the difficulties in siting and administering epidurals; and women also tended to require more support for breastfeeding when they were obese (Heslehurst et al., 2007b).

The theme of current and future management of care included discussions around patient information and advice. HCPs felt that diet and weight gain advice was currently undertaken on an ad hoc basis and in an inconsistent way. No maternity units had any policy or guidance on weight gain recommendations and advice to give to women, and the dietary advice tended to be based on the "do's and don'ts" relating to healthy and safe eating during pregnancy and was generic to all women regardless of BMI (Heslehurst et al., 2007b). Suggestions for the management of maternal obesity included improved links with dietetic departments, and weight management groups for pregnant women led by HCPs, but it was acknowledged that resource issues might make this difficult to achieve. Preconception community interventions were also considered to be important, as weight loss during pregnancy could not be advised.

"The referrals we get tend to come from the combined clinic, women with impaired glucose tolerance. I think it would be very valuable to do it [set up a referral service for women based on their BMI] because often you find they are more motivated when they're pregnant, and also to ensure you pick them up post delivery. With the impaired glucose tolerance ones we do but there are other women who may have equal weight problems but they are not referred through because they don't meet the criteria"

(Dietitian, Confirmatory Focus Group)

"They [public health interventions] *focus on obesity, the bit that's missing is 'do you realise your baby is at risk if you become pregnant?' that bit doesn't seem to be there. They can get that from the midwives when they come in but it doesn't seem to be out there beforehand, apart from those who maybe have a co morbidity and go to say the preconception clinics for diabetes"*

(Head of Midwifery, Confirmatory Focus Group)

The authors conclude that the views of HCPs caring for obese women during pregnancy indicate major implications for service delivery, relating to resources and cost, clinical complications and their impact on the health of the mother and her baby, restrictions in care options for the mother, and difficulties faced when trying to carry out certain procedures (Heslehurst et al., 2007b). There was also a view from some HCPs that maternal obesity was a public health issue that wasn't addressed in the public health arena, and there was a general concern over the lack of national guidance on which to base local policy for the care of obese women in pregnancy.

A number of the issues identified in the qualitative research have been highlighted by other authors. Ramsey et al (2006) discuss the technical problems in managing obese mothers during pregnancy and these include some of the non-quantifiable issues identified by Heslehurst et al (2007b), such as the issues around the difficulties in performing ultrasound, the size of the blood pressure cuffs, issues around foetal monitoring, problems encountered with surgical deliveries and equipment, implications of regional and general anaesthesia, and wound infections. In addition to these similar findings, the authors also identified the issue of women having reduced awareness of foetal movements when they are obese which was not identified as an issue by Heslehurst et al (2007b).

The impact of overweight and obesity on healthcare cost has been studied in France, where the prenatal care cost was found to be 5.4-16.2 fold higher in overweight and obese women with a BMI of 25 to <35kg/m^2 compared with the prenatal care cost of women with an ideal BMI (18-24.9kg/m^2) (Galtier-Dereure et al., 1995, Galtier-Dereure et al., 2000). When both pre and postnatal care was considered, this cost was seen to rise further in women with a BMI>29kg/m^2 due to an increased duration of day and night hospitalisation (an average of 4.43 days more than women with an ideal BMI) (Galtier-Dereure et al., 2000). The percentage of infants requiring admission to neonatal intensive care was also 3.5 times higher in mothers who were obese, which has major cost implications to health services (Galtier-Dereure et al., 2000). Chu et al (2008) report similar findings in terms of length of hospitalisation, with significantly increasing length of stay with increasing levels of obesity compared to women with an ideal BMI. This study found the mean length of stay to increase from 3.6 days for an ideal BMI, to 3.7 days for overweight, 4.0 days for moderately obese, 4.1 days for severely obese, and 4.4 days for morbidly obese women.

One drawback of the cost studies by Galtier-Dereure et al (1995, 2000) is that they only address cost in terms of inpatient and outpatient hospitalisation in obstetric and surgical units, whereas there are other influences on the cost of care when the mothers are obese. However, Chu et al (2008) also identify additional resource implications in their study when women had a raised BMI following adjustment for maternal age, ethnic group, education and parity, with a significant increase in the requirement for more prenatal foetal tests, obstetric ultrasonography examinations, medications dispensed from the outpatient pharmacy, telephone calls to the department of obstetrics and gynaecology, and prenatal visits with physicians, while there were significantly fewer prenatal visits with nurse practitioners and physician assistants (Table 8).

Table 8 Number of Prenatal Tests, Medications, and Visits with Health Care Providers According to Maternal BMI and Presence or Absence of a High-Risk Condition

Variable	Underweight, BMI <18.5 (N=259)	Normal, BMI 18.5–24.9 (N=6091)	Overweight, BMI 25.0–29.9 (N=3634)	Obese, BMI 30.0–34.9 (N=1848)	Very Obese, BMI 35.0–39.9 (N=918)	Extremely Obese, BMI ≥40.0 (N=692)
				number		
Fetal tests						
All pregnancies	1.3±0.3	1.6±0.1	1.8±0.1	2.1±0.1†	2.8±0.2†	3.8±0.2†
With high-risk condition	2.6±1.2	3.5±0.3	3.9±0.3	3.9±0.4	5.4±0.4†	6.4±0.4†
Without high-risk condition	1.3±0.2	1.3±0.1	1.3±0.1	1.4±0.1	1.4±0.1	1.7±0.2
Obstetrical ultrasonographic examinations						
All pregnancies	3.5±0.4	3.7±0.1	3.9±0.2	4.4±0.2†	5.4±0.2†	7.5±0.2†
With high-risk condition	6.2±1.7	6.6±0.5	7.0±0.5	7.1±0.5	9.2±0.6†	11.0±0.6†
Without high-risk condition	3.3±0.3	3.3±0.1	3.3±0.1	3.3±0.2	3.4±0.2	4.7±0.3†
Physician visits						
All pregnancies	4.3±0.3	4.4±0.1	4.6±0.1	4.8±0.1†	5.4±0.2†	6.0±0.2†
With high-risk condition	5.1±1.1	5.6±0.3	5.9±0.3	5.9±0.3	6.6±0.4†	7.6±0.4†
Without high-risk condition	4.3±0.3	4.2±0.1	4.4±0.1	4.4±0.2	4.8±0.2†	4.9±0.2†
Visits with nurse practitioner or physician assistant						
All pregnancies	5.0±0.3	4.9±0.1	4.8±0.1	4.6±0.1	4.5±0.2†	3.9±0.2†
With high-risk condition	3.9±0.9	4.1±0.2	4.1±0.2	3.6±0.2	3.6±0.3	3.2±0.3†
Without high-risk condition	5.1±0.3	5.0±0.1	4.9±0.1	4.9±0.2	4.9±0.2	4.3±0.2†
Medications dispensed from outpatient pharmacy‡						
All pregnancies	3.6±0.4	3.6±0.1	4.1±0.2†	4.9±0.2†	6.3±0.2†	7.7±0.3†
With high-risk condition	4.7±2.0	5.6±0.5	6.4±0.5	7.0±0.6†	9.9±0.6†	10.8±0.6†
Without high-risk condition	3.5±0.3	3.4±0.1	3.6±0.2	4.1±0.2†	4.5±0.2†	5.1±0.3†
Telephone calls to obstetrician-gynecologist						
All pregnancies	5.0±0.3	4.8±0.1	5.2±0.1†	5.4±0.1†	6.5±0.2†	7.0±0.2†
With high-risk condition	8.5±1.3	7.0±0.4	7.6±0.4	7.4±0.4	9.5±0.4†	9.5±0.4†
Without high-risk condition	4.7±0.3	4.5±0.1	4.6±0.1	4.7±0.1	5.1±0.2†	5.3±0.2†

* Plus–minus values are means ±SE. Means were adjusted for maternal age, race or ethnic group, education, and parity. Prenatal refers to the interval between the start of pregnancy and admission to the hospital for delivery. High-risk conditions during pregnancy were preexisting diabetes mellitus, gestational diabetes mellitus, and hypertensive disorders, as reported on the electronic medical record or the birth certificate.
† $P<0.05$ for the comparison with women of normal weight.
‡ For women in all categories of body-mass index, the most commonly dispensed medications were antibiotics, narcotics, antiemetics, antidepressants, antiasthmatics, and cough-and-cold preparations. The single exception was insulin, which was the second most frequently used medication among very obese and extremely obese women but was not commonly used by women in other categories.

(Chu et al., 2008)

Ramsay et al (2006) also discuss the implications of maternal obesity on maternity services, and highlight ways in which obesity can raise the management costs of pregnancy owing to the increased risk of admission to hospital for complications; increased use of ultrasonography and operator time for difficult anomaly scans and foetal assessment; increased risk of operative delivery and postpartum complications, such as infection, haemorrhage, and venous thromboembolism; and increased risk of neonatal admission (Ramsay et al., 2006).

1.2.9 Maternal Obesity, Clinical Guidelines and Recommendations

Previously obesity in pregnancy was absent from any of the NICE clinical guidelines, with the only reference to obesity being that women with a BMI>35kg/m^2 may require care outside the routine antenatal guidance and are not suitable for midwifery led care (National Institute for Health and Clinical Excellence, 2003), which was supported by the CEMACH recommendations that the care of women with a BMI>35kg/m^2 should be *"shared with an obstetrician and* [the mother] *advised to deliver in a consultant led obstetric unit"* as they are at a higher risk of developing problems (Confidential Enquiry into Maternal and Child Health, 2004). More recently however, NICE has incorporated obesity into their clinical guidelines for antenatal care (National Institute for Health and Clinical Excellence, 2008a), diabetes in pregnancy (National Institute for Health and Clinical Excellence, 2008b), and intrapartum care (National Institute for Health and Clinical Excellence, 2007). Overall these updated guidelines consider obese women to be among the high risk groups that require additional screening, intervention or monitoring.

The guidelines for antenatal care highlight that all women should have their height and weight measured at booking (ideally within 10 weeks of conception) and their BMI calculated (National Institute for Health and Clinical Excellence, 2008a). The guidelines also state that repeated weighing during pregnancy should be confined to circumstances in which clinical management is likely to be influenced. The NICE also identify that the booking BMI should be utilised indicate additional routine monitoring of women if the BMI>30kg/m^2. The additional monitoring should incorporate enquiry to ensure women are taking the specified daily dose of vitamin D supplement (10 micrograms), to ensure women undergo screening for gestational diabetes, and to identify that these women are high risk for developing pre-eclampsia (National

Institute for Health and Clinical Excellence, 2008a). A booking BMI>35kg/m^2 should indicate that an individual assessment is required when planning the place of birth, and that women should be advised to have a planned delivery in an obstetric unit due to the increased intrapartum risk and postpartum haemorrhage risk (National Institute for Health and Clinical Excellence, 2007).

The NICE diabetes in pregnancy guidelines replicate the antenatal clinical guidelines for screening for gestational diabetes in women with a booking BMI>30kg/m^2, and also state that women who have diabetes and are planning to become pregnant with a BMI>27kg/m^2 should be offered advice on how to lose weight in line with the NICE Obesity clinical guideline 43 (National Institute for Health and Clinical Excellence, 2006), and that women with gestational diabetes who have a pre-pregnancy BMI>27kg/m^2 should be advised to restrict calorie intake to 25kcal/kg/day or less, and to take moderate exercise of at least 30 minutes daily (National Institute for Health and Clinical Excellence, 2008b).

The antenatal care guidelines also include new guidance on clinical examination of pregnant women. These advise that obese women should be informed of the limitations of routine ultrasound screening and that detection rates vary depending on the woman’s BMI among other factors, and that when it is not possible to measure nuchal translucency owing to a raised BMI that women should be offered serum screening between 15 to 20 weeks (National Institute for Health and Clinical Excellence, 2008a). However these additional guidelines on clinical examination do not indicate the measure of obesity at which the detection rates deteriorate.

Despite the incorporation of obesity into the NICE clinical guidelines for pregnancy they are not comprehensive for obesity and the antenatal care guideline continues to include the statement that women with a BMI>30kg/m^2 at the first contact usually require care in addition to that detailed in the guideline (National Institute for Health and Clinical Excellence, 2008a). However the new programme of the NICE public health intervention guidance (18th wave) includes proposals for intervention guidance on the prevention of excessive weight gain in pregnancy (National Institute for Health and Clinical Excellence, 2008e) and effective weight maintenance following childbirth (National Institute for Health and Clinical Excellence, 2008c) due to be published in

2010. In addition to the planned NICE guidance, the CEMACH are developing national standards of care and service provision for women with obesity and their babies (Confidential Enquiry into Maternal and Child Health, 2008). The standards are due to be published in 2010, and encompass the preconception period, the pregnancy, and the postnatal period.

The importance of the requirement for more comprehensive clinical guidelines for the care of obese women in pregnancy is described in sections 1.2.5 and 1.2.7, and relates to the immediate health risks to the mother and infant. The CEMACH report has made specific recommendations for the management of thromboembolism, which is the leading cause of maternal death, including an urgent requirement for a guideline for obese pregnant women with a BMI>35kg/m^2 (Appendix 1). The CEMACH report also addresses the issue of anaesthesia and obesity, and highlights that obesity presents many challenges which should be addressed by evidence based clinical guidelines. The report also describes some learning points to note for obesity and anaesthesia (Appendix 2).

A number of the issues identified among the various NICE clinical guidelines and the CEMACH recommendations are supported by the Royal College of Obstetricians and Gynaecologists (RCOG). The RCOG Obesity and Reproductive Health consensus views (Royal College of Obstetricians and Gynaecologists, 2007) state that:

1. Maternal weight and height should be measured at the booking visit in all women and throughout pregnancy in women who are obese. Inter-pregnancy weight change should also be recorded.
2. Women with severe obesity (BMI>35 kg/m^2) plus one additional risk factor for hypertensive disease should be prescribed aspirin 75 mg/day from 12 weeks.
3. Pre-pregnancy counselling for women who are severely obese (BMI>35kg/m^2) in sub fertility, recurrent miscarriage and diabetic clinics:
    a) Consider high-dose folic acid (5 mg/day)
    b) Discuss the importance of healthy diet and exercise in pregnancy and the need to avoid excessive weight gain; consider referral to a dietitian and screening for diabetes.

4. Early booking visit to plan pregnancy management for all women who are obese:
    a) Consider low-dose aspirin (75 mg/day) in the presence of additional clinical risk factors (other than obesity) for pre-eclampsia
    b) Consider antenatal thromboprophylaxis in the presence of additional clinical risk factors for venous thromboembolic (VTE) disease.
5. A detailed anomaly scan and serum screening for congenital anormaly should be recommended in all women who are obese.
6. Glucose tolerance testing at 28 weeks of gestation, with the potential for repeating in later pregnancy, should be considered in all women who are obese.

(Royal College of Obstetricians and Gynaecologists, 2007)

In addition to the pregnancy consensus views, the clinical views state that women who are obese and attending for reproductive health care should have access to a referral pathway to appropriate HCPs for supporting and adopting a healthy lifestyle, that women should be referred to a nutritionist in cases where clinicians lack the knowledge and/or time to provide adequate counselling, that disordered eating and eating disorder psychopathology should be assessed and specific psychological input offered, that all women planning a pregnancy should be encouraged to maintain a BMI in the range 20-25kg/m^2, and that women with a BMI>30kg/m^2 should be advised to reduce weight to a BMI<30kg/m^2 before receiving assisted reproductive technology therapy/ovulation induction (Royal College of Obstetricians and Gynaecologists, 2007).

1.3 Mixed Methods Research

The integration of qualitative and quantitative methodology for a single programme of research is referred to as mixed methods research, and is common in health services research (O'Cathain et al., 2008) The underlying logic is that neither line of enquiry alone is sufficient to answer a research question in enough detail whereas mixing methods yields a more complete analysis, and studies become more robust (Creswell et al., 2004). Mixed methods strategies may be utilised in one or more phases of the research process, including the design, data collection, interpretation, and contextualisation of data (Brannen, 2005). Triangulation is often used as a method of utilising different data sources, methods, investigators, and theories to provide corroborating evidence to address research questions (Cresswell, 1998).

There are a variety of ways in which qualitative and quantitative methods can be mixed, and the methods utilised in research are dependent on the objectives of the research question. For example Teddlie and Yu (2007) describe typologies of mixed methods sampling as being:

- basic mixed methods sampling - utilising a combination of qualitative and quantitative methodologies to complement one another;
- sequential mixed methods sampling - the results from the first study inform the methodology for the subsequent sampling using either qualitative methods to inform quantitative methods or quantitative methods to inform qualitative methods;
- concurrent mixed methods sampling – the independent sampling of qualitative and quantitative strands but data collection is carried out simultaneously, or a single sample is generated to collect data for both the quantitative and qualitative strands;
- multilevel mixed methods sampling –research examining organisations in which different units of analysis are nested within one another;
- sampling using multiple mixed methods sampling strategies – combinations of the above.

(Teddlie and Yu, 2007)

There are both benefits and disbenefits in carrying out mixed methods research. The benefits relate to the completeness of the data collected, with exploratory and inductive qualitative research yielding much richer data than quantitative methods could, while confirmatory and deductive quantitative methods provide more rigorous numerical data. However the epistemological differences between quantitative and qualitative research have led to critics believing that the two cannot be combined. Brannen (2005) discusses how qualitative and quantitative research involves fundamentally different paradigms on which epistemological assumptions, theoretical approaches and methods are based. Also, quantitative and qualitative researchers often hold different epistemological assumptions and belong to different research cultures (Brannen, 1995, Devine and Heath, 1999). For example qualitative researchers become part of the experience which they are studying in order to gain a greater understanding, adopting flexibility in data collection as knowledge emerges, whereas quantitative researchers utilise predefined questioning and fixed measurements in their methodology. Therefore the transferability of researcher skills between the two theoretical and methodological approaches must be questioned. However Brannen also argues that the common distinction between qualitative and quantitative methods are over simplified, and that the association of qualitative research with an inductive logic of enquiry, and quantitative research with hypothetic deduction can often be reversed in practice as both may employ both forms of logic (Brannen, 1995).

The epistemological and theoretical issues of mixing methods are considered by some to be most evident in the context of justification; when the data are analysed and interpreted (Brannen, 1995). Utilising different methodologies in the form of triangulation to investigate a phenomenon from different viewpoints may lead to researchers assuming that the data may corroborate each other. However there are number of possible outcomes, including:

- Corroboration: The same results are derived from both qualitative and quantitative methods.
- Elaboration: The qualitative data analysis exemplifies how the quantitative findings apply in particular cases.
- Complementarity: The quantitative and qualitative results differ, but together they generate insights.
- Contradiction: Where qualitative data and quantitative findings conflict.

(Brannen, 1995)

Devine and Heath (1999) discuss how the virtues of combining methods have become widely accepted; however little attention is paid to making sense of contradictory findings that may result from combining methodologies. The authors question the action that should be taken when qualitative and quantitative findings challenge each other; should one data source be discarded in favour of the other, or how can the researcher reconcile the contradictor findings? Therefore mixing methods requires researchers to consider how they would deal with the issues that may arise from integrating data, and whether or not one data source should take priority over the other (Devine and Heath, 1999), thus requiring researchers to question the hierarchy of evidence which supports the dominance of quantitative research over qualitative.

There are also criticisms around the degree to which mixed methods researchers genuinely integrate their findings throughout the analysis, interpretation, and write up of their research (Bryman, 2007). This criticism relates to whether the components of the investigation are related or whether they are largely independent of each other, and whether the end product is a sum of the independent qualitative and quantitative parts. Bryman (2007) discusses the published mixed methods research and suggests that researchers do not always bring together their findings, and that the qualitative and quantitative components are treated as separate domains. Although reasons for this may include that there were never any intentions for the findings to be integrated in this way, such as when projects are designed with the qualitative and quantitative components to address distinct parts of the research question and therefore the integration during analysis is not paramount to the design (Bryman, 2007).

In addition to the theoretical criticisms of carrying out mixed methods, there are practical constraints such as funding and available financial resources, the social organisation of the research team, and political orientations (Brannen, 1995). Bryman (2007) identified several barriers to the integration of mixed methods encountered in the course of researchers' study. Bryman (2007) concludes that more focus is required on the writing up of qualitative and quantitative research, and specifically the ways in which findings can be integrated. Bryman (2007) also identifies a level of uncertainty among researchers about what it means to integrate findings, and that an absence of exemplars and guidelines in the writing up process means that this exercise becomes increasingly difficult. However Bryman (2007) also warns that the integration of findings might not be appropriate in all cases of mixed methods research.

A mixed methods programme of research will be used to answer the aims described in section 1.1. The mixed methods will utilise survey research, quantitative epidemiology, quantitative systematic review with meta-analysis, and qualitative interviews and focus groups. The use of different types of research methodologies will be carried out independently throughout most of the programme of work. The aim is for the results to complement one another, and to place the independent studies in context with the overall question being posed at the point of discussion. This will be carried out with the exception of the sequential nature of a quantitative survey being required in order to inform the methodology for the quantitative research to address aims 1 and 2 of the programme of work.

1.4 Literature Review Summary

The literature review has highlighted the lack of epidemiological data relating to maternal obesity on a national level in the UK, although data from two cities have reported rising incidence of obesity in the pregnancy population within Scotland and Wales.

The relationship between health inequalities and obesity in the general population relates to socio-economic status, ethnicity, and employment, with pregnancy and the time between pregnancies being shown to be a significant life event for the development of obesity in women. These factors have been explored to some extent in published literature; however there is no current evidence regarding the women who are most at risk of being obese in pregnancy. Pregnancy has also been identified as a critical life stage where the success of interventions may be more likely, and the relationship between maternal obesity, health risks, and the development of obesity in the offspring makes pregnancy a critical time for intervention for the immediate and long term health of the mother, and for the health of her baby, and could potentially have an impact on the health of future generations.

In addition to the health implications of maternal obesity, HCPs have described an impact on NHS maternity services and frustration about the lack of national guidelines for tackling the issue. There is also an issue around addressing obesity with pregnant women, and there appear to be communication issues between HCPs and women when attempting to discuss the implications of obesity in pregnancy.

The following chapters aim to address some of the gaps in the evidence base. The areas to be addressed include identifying epidemiology and health inequalities associated with maternal obesity. The chapters will also describe the impact of obesity on maternity services, and current maternal obesity services in the North East of England. The successes and barriers in implementing maternal obesity services will be discussed, as well as where HCPs feel services need to be developed in order to be effective in addressing the issue.

Chapter Two

Pilot Study to Identify Trends in Maternal BMI Incidence and the Demographic Predictors of Maternal Obesity

The results of this pilot study have been published in the BJOG: An International Journal of Obstetrics and Gynaecology (Appendix p3).

2.1 Objective

The objective of this chapter is to pilot the methodology to be used for the nationally representative study in England, which will identify trends in maternal obesity incidence rates and demographic predictors of maternal obesity. This chapter will describe in detail the methodology used for data collection, coding, and analysis, and will discuss the results found in the pilot maternity unit in context with the England population.

2.2 Methods

2.2.1 Data Collection

Data have been prospectively collected and electronically recorded in a large maternity unit in Middlesbrough since 1990. Maternal height and weight is recorded at the initial booking appointment from a direct measurement by midwives at General Practitioner (GP) practice bookings, with only a small proportion of self reported measurements from home booking appointments (approximately 5%, personal communication, Dr Helen Simpson, Consultant Obstetrician). The data were examined for all booking appointments between January 1st 1990 and December 31st 2004.

2.2.2 Exclusion Criteria

As pregnancy naturally incurs weight gain there was a potential to classify women as being overweight (or obese) due to their pregnancy related weight gain, and that this would not be representative of the mother's weight status at conception. It was therefore necessary to eliminate any potential false positives of maternal overweight by excluding women who had their booking appointment (and therefore their weight measured) at a late stage in their pregnancy.

There is a lack of up to date research relating to patterns of gestational weight gain. Carmichael et al 1997 identified the distribution of weight gain per trimester, split by BMI group, in 4,218 women who had singleton deliveries between 1980 and 1990 in California, United States, with good pregnancy outcomes[4]. They concluded that the pattern of weight gain was highly variable, even in this group of women that were considered to have been low risk due to the nature of the pregnancy outcomes. The results of this study are highlighted in Table 9 showing the mean ($\bar{x}$) total weight gain for trimester one per BMI group, and the $\bar{x}$ kg/week weight gain for trimesters two and three per BMI group.

Table 9 Distribution of Weight Gain by Trimester in Women with Good Pregnancy Outcomes

TABLE 1—Distribution of First-Trimester Weight Gain and Second- and Third-Trimester Rates of Gain in Women with Good Pregnancy Outcomes

	Percentile of Weight Gain					
	10th	25th	50th	75th	90th	Mean ± SD
First trimester, kg						
Underweight	−1.81	−0.14	1.92	3.78	5.77	1.92 ± 3.06
Normal weight	−2.21	−0.09	2.20	4.37	6.59	2.19 ± 3.47
Overweight	−2.91	−0.59	2.38	4.63	7.04	2.16 ± 3.95
Obese	−3.08	−0.86	1.17	3.89	7.22	1.65 ± 3.94
Second trimester, kg/wk						
Underweight	0.33	0.44	0.56	0.69	0.82	0.57 ± 0.20
Normal weight	0.31	0.44	0.56	0.71	0.85	0.58 ± 0.22
Overweight	0.21	0.36	0.49	0.65	0.83	0.51 ± 0.24
Obese	0.06	0.24	0.42	0.56	0.78	0.41 ± 0.27
Third trimester, kg/wk						
Underweight	0.26	0.36	0.47	0.60	0.71	0.48 ± 0.19
Normal weight	0.26	0.37	0.50	0.64	0.77	0.51 ± 0.21
Overweight	0.21	0.34	0.47	0.63	0.77	0.49 ± 0.22
Obese	0.19	0.31	0.43	0.64	0.80	0.47 ± 0.24

Note. To calculate the distribution of first-trimester rate of gain (kg/wk), divide the values in the table by 13 weeks. To calculate the distribution of total gain (kg) in the second and third trimesters, multiply the values in the table by 13 weeks.

(Carmichael et al., 1997)

[4] Where a good pregnancy outcome is considered to be a vaginal, term (37 or more completed weeks gestation) delivery of a live infant of average size for gestational age, to a mother without diabetes or hypertension (Carmichael et al., 1997).

Using the data provided by Carmichael et al (1997) further calculations[5] show a weighted $\bar{x}$ gestational weight gain of 0.16 kg/week (Standard Deviation (SD) 0.26), and 2.09 kg (SD 3.41) total gain in the 1st trimester, 0.57 kg/week (SD 0.25), and 7.36kg (SD 2.83) total gain in the 2nd trimester, and 0.50 kg/week (SD 0.21), and 6.48kg (SD 2.68) total gain in the 3rd trimester (Table 10).

Table 10 Weighted Mean Weight Gains (Per Week and Total) by Trimester

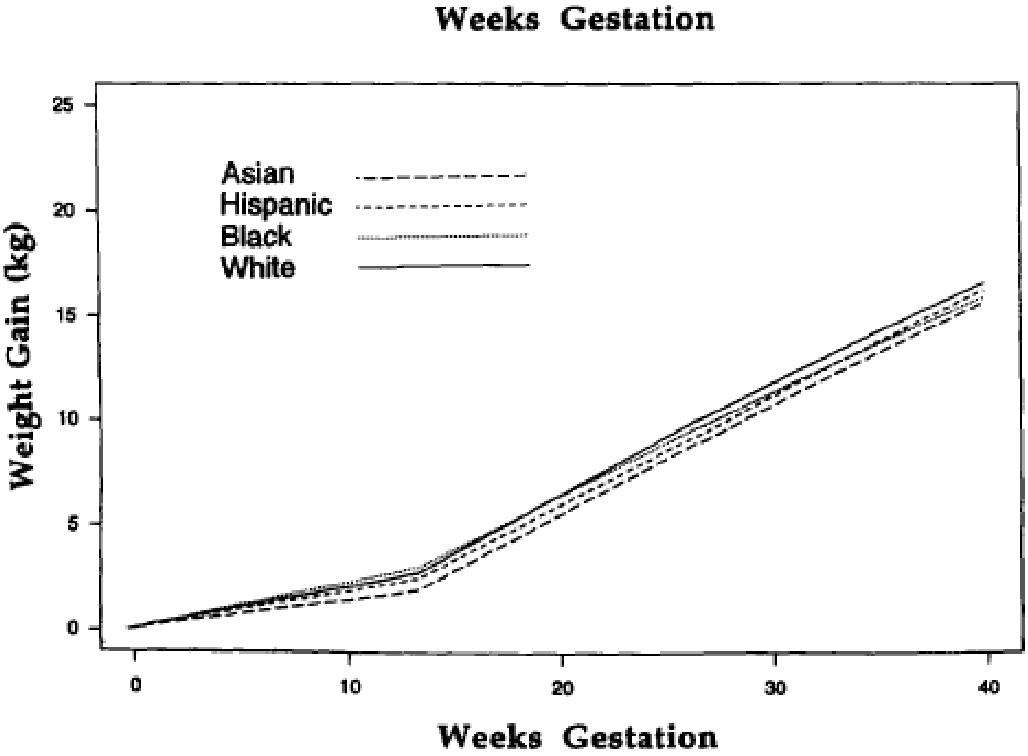
Mean Weight Gain (Kg/Week) per Trimester							
		Trimester 1		Trimester 2		Trimester 3	
BMI Group	n	Mean	SD	Mean	SD	Mean	SD
Underweight	1219	0.14	0.24	0.57	0.20	0.48	0.19
Ideal weight	2593	0.17	0.27	0.58	0.22	0.51	0.21
Overweight	221	0.17	0.30	0.51	0.24	0.49	0.22
Obese	173	0.13	0.30	0.41	0.70	0.47	0.24
Overall	4206	0.16	0.26	0.57	0.25	0.50	0.21

Mean Total Weight Gain (Kg) per Trimester							
		Trimester 1		Trimester 2		Trimester 3	
BMI Group	n	Mean	SD	Mean	SD	Mean	SD
Underweight	1219	1.92	3.06	7.41	2.60	6.24	2.47
Ideal weight	2593	2.19	3.47	7.54	2.86	6.63	2.73
Overweight	221	2.16	3.95	6.63	3.12	6.37	2.86
Obese	173	1.65	3.94	5.33	3.51	6.11	3.12
Overall	4206	2.09	3.41	7.36	2.83	6.48	2.68

Using the same initial cohort as Carmichael et al (1997) without excluding women based on good pregnancy outcome, Abrams et al (1995) found the mean weight gain was slowest in the 1st trimester, and approximately constant over the 2nd and 3rd trimesters with a slight drop in the rate of weight gain present in the 3rd trimester (Figure 10). The $\bar{x}$ weekly rate of weight gain was 0.17kg (SD 0.27) in the 1st trimester (n=7,587), 0.56kg (SD 0.24) in the 2nd trimester (n=8,000), and 0.52kg (SD 0.23) in the 3rd trimester (n=10,052).

[5] Using the formulae: weighted mean = $\sum (n) \bar{x} / \sum n$ and weighted mean SD = $\sqrt{((\sum n(SD^2) / \sum n)}$

Figure 10 Weight Gain by Gestation Based on Piecewise Fitted Regression Lines



(Abrams et al., 1995)

Based on the 50th centile data from a prospective cross sectional study in Switzerland from 1996 to 2000 (Ochsenbein-Kolble et al 2004, Table 11) the weight gain per week pattern for each trimester is comparable to previous data in terms of the 1st trimester weight gain being substantially slower than the 2nd and 3rd trimesters (using 13 week cut off for trimesters as per Carmichael et al 1997 and Abrams et al 1995). However in this study the trend does not slow down from the 2nd to 3rd trimester as Carmichael et al (1997) and Abrams et al (1995) showed. The $\bar{x}$ weight gain in this study was 0.15kg/week (SD 0.22), and 2.0kg (SD 2.9) total gain in trimester one, 0.45kg/week[6] and 5.9kg total gain in trimester two, and 0.55kg/week and 7.1kg total gain in the 3rd trimester, with a central tendency for weight gain at 16 weeks being 2.9kg. This weight gain pattern for each trimester has also been noted in developing countries. Despite having a substantially lower total weight gain throughout pregnancy, an Indonesian cohort of women prospectively observed from 1996 to 1998 showed a slower 1st trimester rate of weight gain in comparison to the

[6] The SD's for trimesters two and three can not be calculated based on the data presented in the paper, however based on the SD from trimester one it would be approximately 3kg.

2nd and 3rd trimesters, and a drop in rate of weight gain in the 3rd trimester; 0.07kg/week (SD 0.26) in the 1st trimester, 0.33kg/week (SD 0.22) in the 2nd trimester, and 0.26kg/week (SD 0.20) in the 3rd trimester (Winkvist et al., 2002).

Table 11 Estimated Centiles and SD for Weight Gain and BMI by Gestational Week

Table 2
Caucasians (N = 3242)

GW	N	Weight gain								BMI (kg m^{-2})			
		c5		c50		c95		S.D.		c5	c50	c95	S.D.
		(kg)	(lb)	(kg)	(lb)	(kg)	(lb)	(kg)	(lb)				
5	24	−2.3	−5.1	0.8	1.8	3.8	8.4	1.8	4.0	18.3	22.9	31.1	3.5
6	93	−2.3	−5.1	0.9	2.0	4.2	9.3	2.0	4.4	18.4	23.0	31.3	3.6
7	161	−2.4	−5.3	1.0	2.2	4.5	9.9	2.1	4.6	18.4	23.1	31.5	3.6
8	160	−2.5	−5.5	1.2	2.6	4.9	10.8	2.2	4.9	18.5	23.3	31.7	3.6
9	145	−2.5	−5.5	1.3	2.9	5.2	11.5	2.3	5.1	18.6	23.4	31.9	3.7
10	127	−2.6	−5.7	1.5	3.3	5.6	12.3	2.5	5.5	18.7	23.5	32.1	3.7
11	98	−2.6	−5.7	1.6	3.5	6.0	13.2	2.6	5.7	18.8	23.6	32.3	3.7
12	128	−2.6	−5.7	1.8	4.0	6.4	14.1	2.7	6.0	18.9	23.7	32.5	3.7
13	105	−2.6	−5.7	2.0	4.4	6.8	15.0	2.9	6.4	19.0	23.9	32.7	3.8
14	93	−2.6	−5.7	2.3	5.1	7.3	16.1	3.0	6.6	19.1	24.0	32.9	3.8
15	60	−2.5	−5.5	2.6	5.7	7.8	17.2	3.1	6.8	19.2	24.2	33.1	3.8
16	55	−2.3	−5.1	2.9	6.4	8.3	18.3	3.2	7.1	19.3	24.3	33.3	3.9
17	51	−2.2	−4.9	3.3	7.3	8.9	19.6	3.3	7.3	19.4	24.5	33.5	3.9
18	44	−2.0	−4.4	3.7	8.2	9.5	20.9	3.5	7.7	19.6	24.6	33.8	3.9
19	39	−1.7	−3.7	4.2	9.3	10.2	22.5	3.6	7.9	19.7	24.8	34.0	3.9
20	48	−1.4	−3.1	4.7	10.4	10.9	24.0	3.7	8.2	19.8	24.9	34.2	4.0
21	44	−1.1	−2.4	5.2	11.5	11.7	25.8	3.9	8.6	19.9	25.1	34.4	4.0
22	44	−0.8	−1.8	5.7	12.6	12.4	27.3	4.0	8.8	20.1	25.3	34.6	4.0
23	30	−0.5	−1.1	6.2	13.7	13.2	29.1	4.1	9.0	20.2	25.4	34.8	4.0
24	31	−0.1	−0.2	6.8	15.0	13.9	30.6	4.2	9.3	20.4	25.6	35.0	4.0
25	31	0.1	0.2	7.3	16.1	14.7	32.4	4.4	9.7	20.5	25.8	35.2	4.1
26	34	0.5	1.1	7.9	17.4	15.5	34.2	4.5	9.9	20.7	26.0	35.4	4.1
27	48	0.9	2.0	8.5	18.7	16.2	35.7	4.6	10.1	20.8	26.1	35.6	4.1
28	46	1.3	2.9	9.0	19.8	17.0	37.5	4.7	10.4	21.0	26.3	35.8	4.1
29	43	1.6	3.5	9.6	21.2	17.7	39.0	4.8	10.6	21.2	26.5	36.0	4.1
30	45	2.0	4.4	10.2	22.5	18.5	40.8	4.9	10.8	21.3	26.7	36.1	4.1
31	44	2.4	5.3	10.7	23.6	19.2	42.3	5.1	11.2	21.5	26.9	36.3	4.1
32	75	2.8	6.2	11.3	24.9	19.9	43.9	5.2	11.5	21.7	27.0	36.4	4.1
33	65	3.2	7.1	11.8	26.0	20.7	45.6	5.3	11.7	21.9	27.2	36.5	4.1
34	85	3.6	7.9	12.4	27.3	21.4	47.2	5.4	11.9	22.0	27.4	36.7	4.1
35	181	3.9	8.6	12.9	28.4	22.1	48.7	5.5	12.1	22.2	27.6	36.8	4.1
36	201	4.3	9.5	13.4	29.5	22.8	50.3	5.6	12.3	22.4	27.7	36.9	4.0
37	181	4.7	10.4	14.0	30.9	23.5	51.8	5.7	12.6	22.6	27.9	36.9	4.0
38	132	5.0	11.0	14.5	32.0	24.1	53.1	5.7	12.6	22.7	28.0	37.0	4.0
39	201	5.4	11.9	15.0	33.1	24.8	54.7	5.8	12.8	22.9	28.2	37.1	4.0
40	239	5.7	12.6	15.5	34.2	25.4	56.0	5.9	13.0	23.0	28.3	37.2	4.0
41	11	6.1	13.4	16.0	35.3	26.1	57.5	6.0	13.2	23.2	28.4	37.2	3.9
42	24	6.5	14.3	16.5	36.4	26.8	59.1	6.1	13.4	23.3	28.6	37.3	3.9

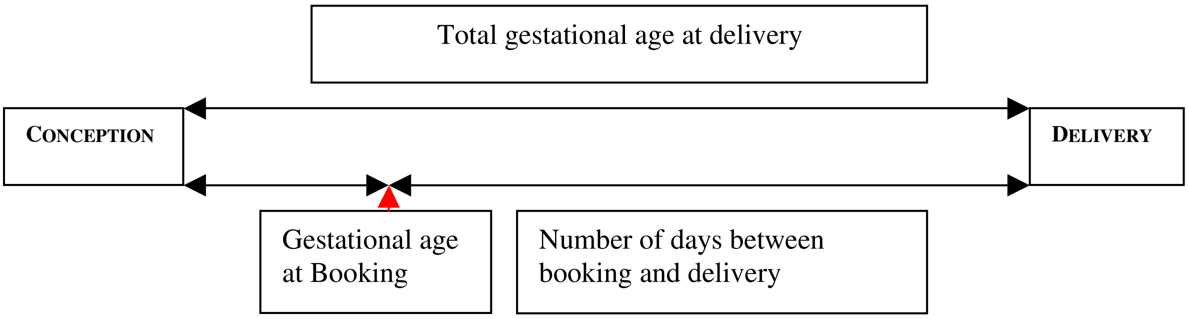
Weight gain and BMI: estimated centiles and S.D. per gestation week.

(Ochsenbein-Kolble et al., 2004)

Based on the published data highlighting minimal weight gain in the 1st trimester it was deemed appropriate to include all women with a booking data of at least up to the end of the 1st trimester. However, there is a possibility that only including women who booked in their 1st trimester could potentially exclude a large proportion of obese women who booked late due to the association between irregular menstruation and obesity (Lake et al., 1997, Linne, 2004). Also slight changes in weight status may not be as noticeable to obese women as Table 10 shows that the obese group of women gained weight at a slower rate than the non obese groups. Therefore confirmation of the pregnancy may be at a later stage in the pregnancy for these women.

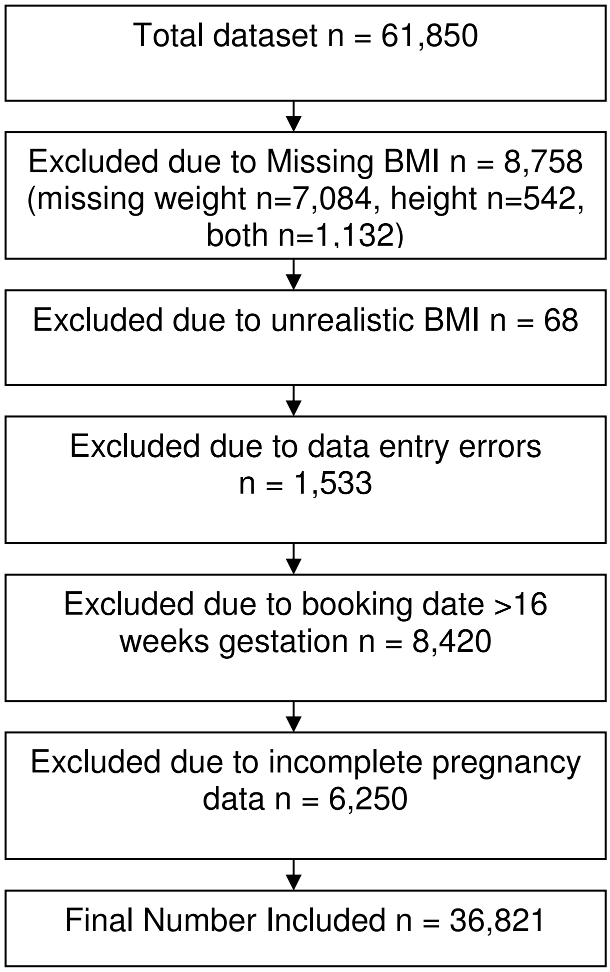
In order to minimise selection bias based on the limited available evidence, a cut off of 16 weeks gestation at booking was used. The gestational age at booking is not routinely recorded electronically in this maternity unit; therefore it was calculated by subtracting the number of days between booking and delivery from the gestational age at delivery (Figure 11).

Figure 11 Model for Calculating Gestational Age at Booking



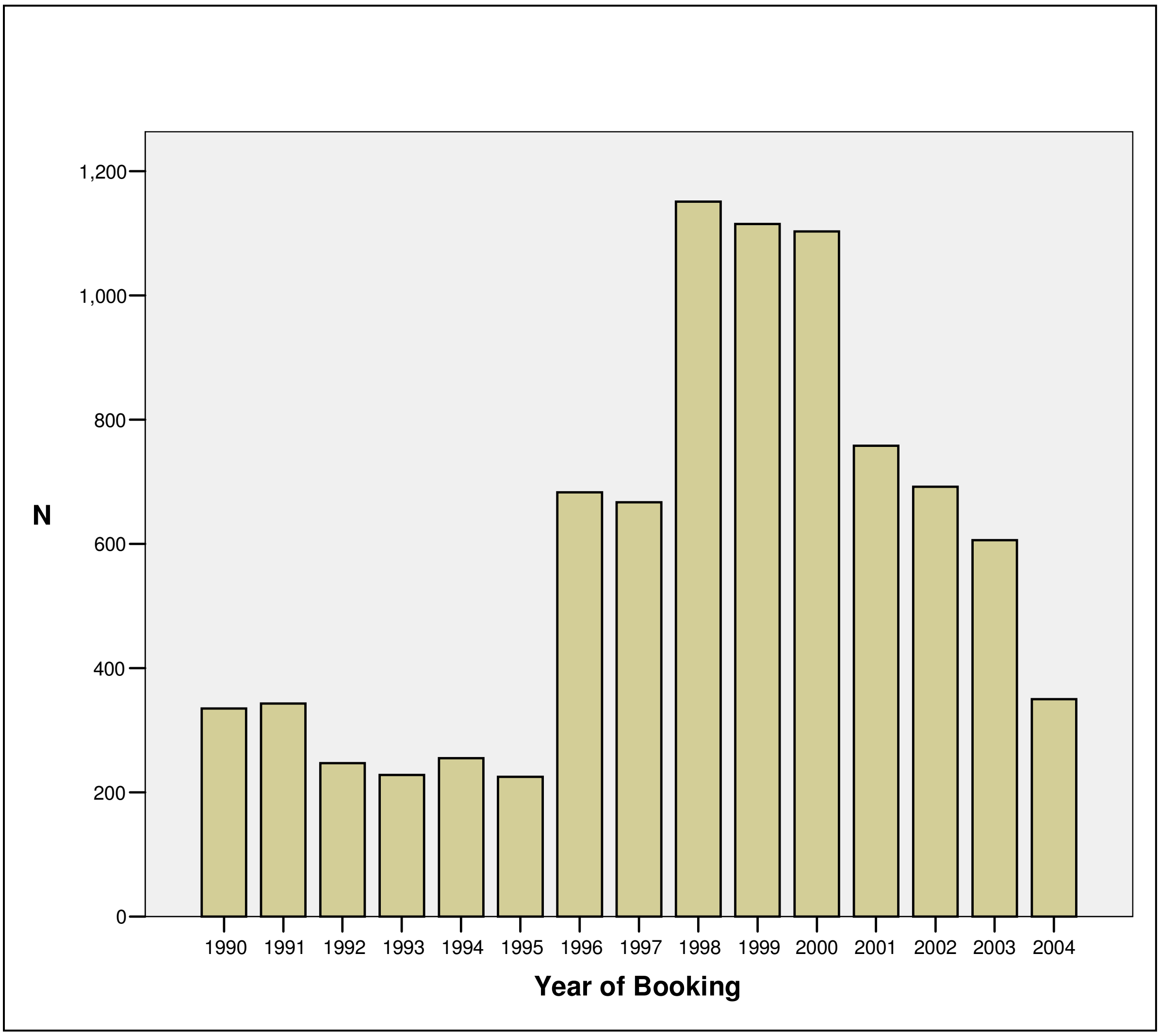
Ultrasound scans to estimate the gestational age of the foetus have been carried out for all women since 2000; pre 2000 the foetal dating estimate was based on last menstrual period dates only, so there may be some cases where the dating is less accurate in this group. If there is a discrepancy between the dating scan and the last menstrual period date then the scan date is always used at the maternity unit. Data were retrieved for 61,850 subjects. Exclusions were made (Figure 12) for: missing BMI data, data entry errors (including an unrealistic BMI [lower limit <11kg/m^2 n=210 (Henry, 1990), upper limit group outliers range 98-119,350kg/m^2 n=77] and errors in date records), booking date after 16 weeks gestation, and missing gestational age (due to incomplete data or incomplete pregnancies). In total 36,821 women remained for the analysis.

Figure 12 Women Excluded from the Incidence Analysis



Due to the high proportion of excluded women in this study additional analysis was carried on the excluded population and is discussed in section 3.3.4. The systematic exclusion of any specific groups of women should be limited (although section 3.3.4 discusses issues relating to ethnic group). The maternity unit has bariatric equipment therefore they have the capacity to measure the weight of women regardless of their BMI status. Previous research has indicated that HCPs find it difficult to broach the subject of obesity with women in pregnancy without causing unnecessary psychological distress (Heslehurst et al., 2007b); therefore this could potentially have an impact on the systematic weighing of obese women in pregnancy. Anecdotally there has been more stringent measurement of BMI by staff in the maternity unit since 2001 (personal communication, Dr. Helen Simpson, Consultant Obstetrician). This is due to the 2001 CEMACH report emphasising the need to use BMI as a risk assessment for thrombosis post delivery (Confidential Enquiry into Maternal Deaths, 2001), and this was further emphasised in the 2004 CEMACH report (Confidential Enquiry into Maternal and Child Health, 2004). Figure 13 shows that there was a rise in missing BMI data from 1990 and this peaked in 1998, with a steady decline in missing BMI data from 2000 to 2004. This suggests that the anecdotal reports of increased rigour in measurement of BMI are correct and there is therefore a potential for a higher level of accuracy in the representation of BMI status following 2001.

Figure 13 Year of Booking for Women Excluded due to Missing BMI Data



2.2.3 Data Coding

Initial exploration of the BMI data found that the distribution was positively skewed rather than being normally distributed. Three methods were used to transform the data in an attempt to establish a normal distribution; taking the logarithm of the BMI, taking the square root of the BMI, and using the reciprocal of the BMI. The transformed data continued to show skewed BMI data (Figures 14-17), and all observed distributions were significantly different to the expected values if normally distributed (with p<0.05).

Figure 14 Normality Test for Raw BMI Data: Kolmogorov-Smirnov Test p=.000

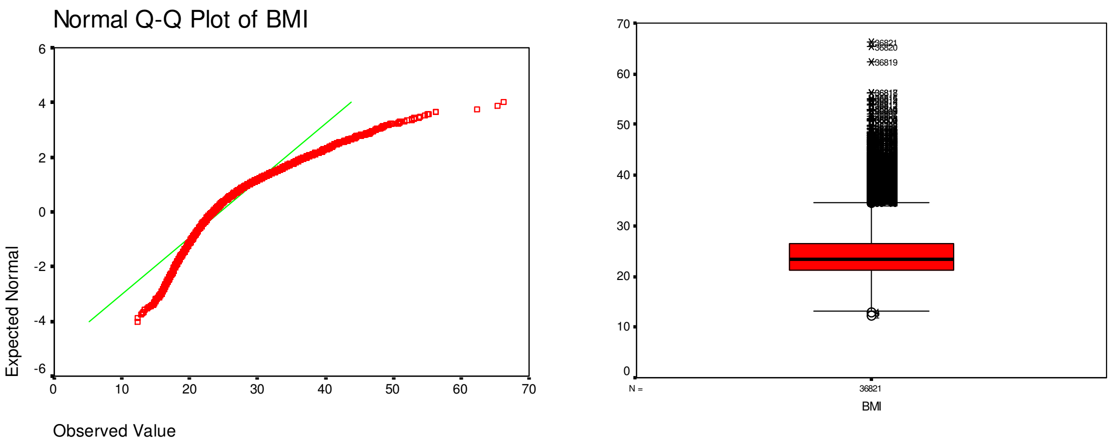


Figure 15 Normality Test for LogBMI Data: Kolmogorov-Smirnov Test p=.000

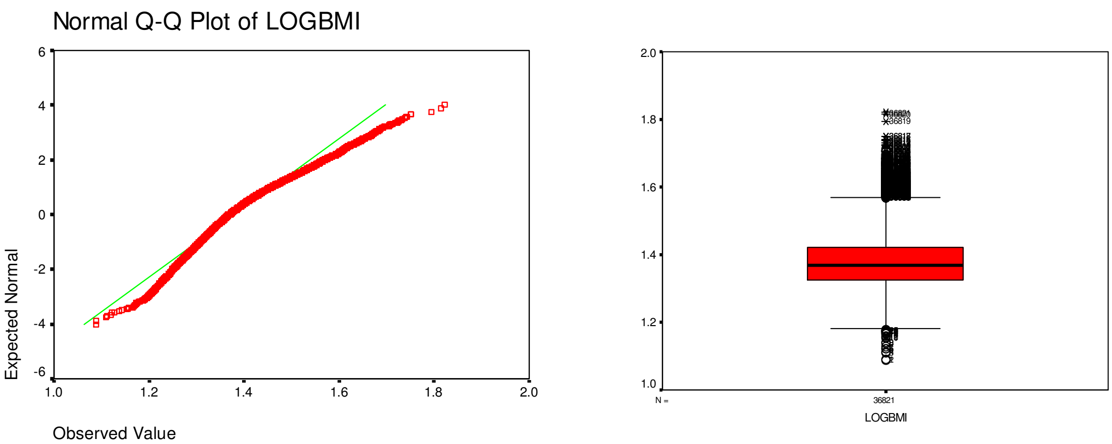


Figure16. Normality Test for Square Root BMI Data: Kolmogorov-Smirnov Test p=.000

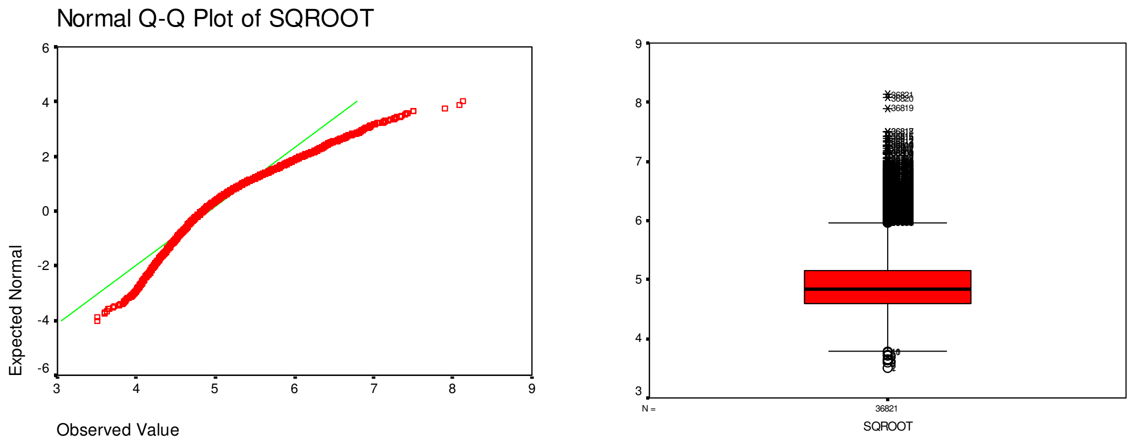
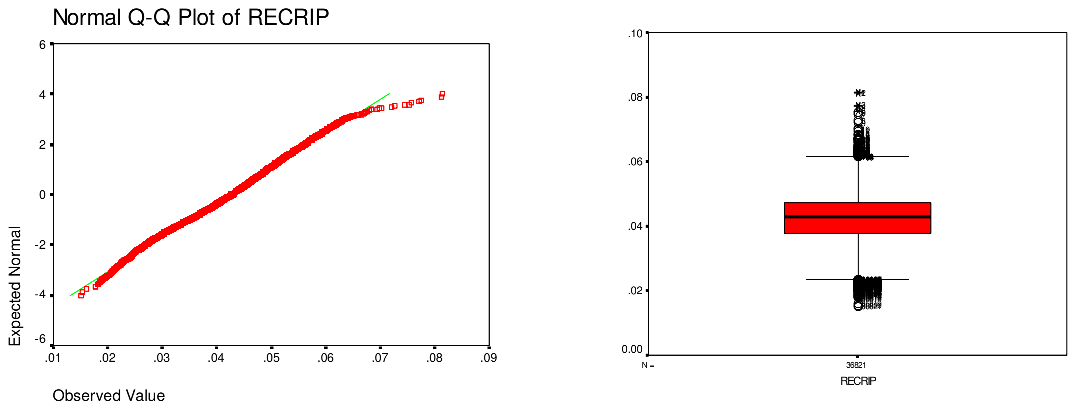


Figure 17 Normality Test for Reciprocal BMI Data: Kolmogorov-Smirnov Test p=.000



As the dependent variable was not normally distributed, the continuous BMI data could not be used in any tests that have a requirement of normal distribution. Chi-squared and logistic regression analyses do not require normal distribution or continuous data, therefore the included study population were categorised based on their BMI at booking: lean (BMI <18.5kg/m^2), ideal (BMI 18.5–24.9kg/m^2), overweight (25-29.9kg/m^2), and obese (BMI>30kg/m^2).

Maternal age and parity were analysed as continuous data; the remaining data were categorical. The data for maternal ethnic group, marital status, and employment were categorised in a way that would allow comparison to the national census data.

Ethnic group included:

- White (where data provided included Caucasian, White, or other European)
- Mixed race (where data provided included mixed descent)
- Asian/Asian British (where data provided included Pakistani, Indian, Bangladeshi, or Other Asian)
- Black/Black British (where data provided included African or Black)
- Chinese/other (where data provided included Chinese or other unspecified)
- Not known (where the data provided stated not known or was missing)

Marital status included:

- Married
- Separated, divorced, widowed
- Single (where data provided included single supported and unsupported)
- Unknown (where data provided included marital status unknown or missing data)

Employment status included:

- Paid employment (where data provided included a paid occupation)
- No paid employment (where data provided included housewife, unemployed, voluntary worker, sickness benefits)
- Education or Training (where data provided included college or university student, schoolchild, Youth Training Scheme or equivalent)
- Unknown (where data provided included either unknown occupation or missing data)

The reference data for the level of deprivation was taken from the Index of Multiple Deprivation (IMD) for England (Index of Multiple Deprivation, 2000). The deprivation scores were assigned in quintiles split into five groups of equal proportion where 1=most deprived, and 5= least deprived.

2.2.4 Data Analysis

Chi-squared test for association (χ^2) was used to identify any significant differences between the included and excluded populations, and the England census and IMD data were used to compare all predictor variables for women of childbearing age in Middlesbrough and England, to place the findings from this study into context with the national population.

2.2.4.1 Trends in Maternal BMI over Time

The trends in incidence over time were calculated using the chi-squared test for trend (χ^2_1) for each BMI group (ideal v non-ideal, obese v non-obese etc). Linear and nonlinear regression analysis identified the most appropriate model for these incidence trends and to predict future rates of maternal BMI. The analysis of incidence of maternal obesity over time was carried out using SPSS (version 13). The χ^2 was used to test the null hypothesis (H_0):

H_0= the incidence of maternal obesity has not changed with time

The χ^2 calculated if there was a significant statistical difference between the expected and observed results; where the expected results are in equal proportions for the variables entered, and a probability (p) value of <0.05 was considered significant. The χ^2 test was valid as at least 80% of the expected frequencies exceeded five. As the χ^2 does not account for the natural order of the predictor variable and does not examine the relationship between intervals (Bland, 1996) it only represents the significance in the observed and expected values being different and it does not represent the significance of changes in proportions of BMI categories over time (i.e. the association does not represent the trend between 1990 and 1991, 1991 and 1992 etc). The χ^2_1 was therefore used for the proportion of obese mothers per year, to see if any associated difference in observed versus expected distribution of BMI was related to an increase in the obesity category over time. As SPSS does not have a function for the χ^2_1 this was manually calculated in excel using the formula:

$$\chi^2_1 = \frac{n\left(\sum y_i x_i - \frac{(\sum y_i)(\sum x_i)}{n}\right)^2}{\left(\sum x_i - \frac{(\sum x_i)^2}{n}\right)\left(\sum y_i^2 - \frac{(\sum y_i)^2}{n}\right)}$$

(Bland, 1996)

2.2.4.2 Demographic Predictors of Maternal Obesity

Multivariate logistic regression analysis and odds ratios (OR) were used to examine predictors of BMI category at the start of pregnancy. The statistical analyses were performed using SPSS (version 13).

The independent relationship between the demographic predictor variables and BMI category was established using χ^2, and showed all variables to have an independent association with BMI. As χ^2 can only ascertain if there is a significant association between the variables being analysed, the strength of the association between the independent demographic variable and the dependent BMI variable was calculated using logistic regression.

Prior to deriving the final regression model the data were screened for multicollinearity using linear regression diagnostics. Multicollinearity exists when there is a strong correlation between two or more predictors in a regression model, and high levels of collinearity increase the probability that a strong predictor of the dependent variable (BMI category) will be found non significant and rejected from the model (Field, 2000). Therefore if any of the independent variables had a strong association with each other, this could potentially bias the results of regression analysis (and the regression model would need to be adapted accordingly).

Multicollinearity tests for all independent variables used the linear regression test for multicollinearity, as the logistic regression function in SPSS does not have the facility to carry out collinearity analysis despite the test being a requirement of this model (Field, 2000). As linear regression does not allow for categorical data, the categorical variables (ethnic group, employment, marital status, and quintiles) had to be adapted using dummy codes (Appendix 3). For example, instead of the maternal employment variable being one categorical variable with 4 possible responses: 1. unknown employment status, 2. no paid employment, 3. education/training, and 4. paid employment; the variables were recoded with yes/no responses: paid employment (yes/no), unpaid employment (yes/no), education/training (yes/no), where a no response to all 3 meant a yes response to the remaining variable by default (unknown employment status).

The indication that a variable has a strong linear association (collinearity) with other variables, is when the Variable Inflation Factor (VIF) ≥10 (Appendix 4), the Condition Index (C.I.) is >30 and the Variance Proportion (VP) is >50% in 2 or more cases ((Fry, 1993) & (Belsley et al., 1980) cited in (Batterham et al., 1997)) (Appendix 5). In the case of these indications in this study, further investigations of collinearity were carried out using a correlation index (Pearsons r) to identify which variables had a high correlation (>0.8, see Appendix 6). All independent variables had a significant independent association with BMI category and no collinearity, and therefore were included in the final logistic regression model.

2.3 Clinical Governance

2.3.1 Ethical Approval

Central Office for Research Ethics Approval (COREC) forms were submitted to the University of Teesside School of Health and Social Care Research Ethics Committee and South Tees NHS Trust Local Research Ethics Committee (LREC) (Appendix 7). Ethical approval was granted by the University of Teesside School of Health and Social Care Research Ethics Committee on the 25/05/2005 (Appendix 8) and by the LREC on the 30/06/2005 (Appendix 9).

2.3.2 Research and Development Approval

Research and development (R&D) approval was granted from the South Tees NHS Trust R&D committee on 07/09/2005 (Appendix 10).

2.4 Results

This study population mainly consisted of White women residing in the most deprived quintile 1. There were significant differences between the BMI groups for all characteristics with the exception of height (Table 12).

Table 12 Pilot Study Population Characteristics

	All (n = 36 821)	Lean (n = 1576)	Ideal (n = 22 247)	Overweight (n = 8616)	Obese (n = 3922)	P
Maternal BMI, mean (SD)	24.2 (4.5)	17.5 (0.8)	22 (1.7)	27 (1.4)	33.7 (3.5)	<0.01
Maternal weight in kg, mean (SD)	63.2 (12.7)	47.4 (4.5)	58.6 (6.4)	71.4 (7)	77.9 (23.8)	<0.01
Maternal height in m, mean (SD)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	NS
Maternal age at delivery, mean (SD)	27.1 (5.8)	24 (5.4)	26.8 (5.7)	27.9 (5.7)	28.1 (5.5)	<0.01
Parity, mean (SD)	1.1 (1.1)	1.0 (1.0)	1.0 (1.0)	1.2 (1.1)	1.4 (1.2)	<0.01
Deprivation quintile, *n* (%)						<0.01
Most deprived 1	19 174 (54.6)	1039 (5.4)	11 293 (58.9)	4474 (23.3)	2368 (12.4)	
2	6386 (18.2)	220 (3.4)	3923 (61.4)	1557 (24.4)	686 (10.7)	
3	3944 (11.2)	104 (2.6)	2511 (63.7)	962 (24.4)	367 (9.3)	
4	3717 (10.6)	101 (2.7)	2426 (65.3)	903 (24.3)	287 (7.7)	
Least deprived 5	1922 (5.5)	59 (3.1)	1270 (66.1)	459 (23.9)	134 (7)	
Ethnic group, *n* (%)						<0.01
Caucasian	33 420 (91.9)	1356 (4.1)	20 501 (61.3)	7939 (23.8)	3624 (10.8)	
Mixed race	187 (0.5)	11 (5.9)	121 (64.7)	34 (18.2)	21 (11.2)	
Asian/Asian British	1486 (4.1)	148 (10)	850 (57.2)	347 (23.4)	141 (9.5)	
Black/Black British	77 (0.2)	1 (1.3)	46 (59.7)	22 (28.6)	8 (10.4)	
Chinese/other ethnic group	133 (0.4)	14 (10.5)	91 (68.4)	19 (14.3)	9 (6.8)	
Not known	1058 (2.9)	46 (4.3)	638 (60.3)	255 (24.1)	119 (11.2)	
Employment status, *n* (%)						<0.01
Paid employment	19 942 (54.8)	522 (33.1)	12 456 (56)	4903 (56.9)	2061 (52.5)	
No paid employment	15497 (42.6)	981 (62.2)	9162 (41.2)	3547 (41.2)	1807 (46.1)	
Education/training	620 (1.7)	47 (3)	448 (2)	99 (1.1)	26 (0.7)	
Not known	302 (0.8)	26 (1.6)	181 (0.8)	67 (0.8)	28 (0.7)	
Marital status, *n* (%)						<0.01
Married	19 298 (53.1)	592 (3.1)	11 663 (60.4)	4890 (25.3)	2153 (11.2)	
Single	15433 (42.4)	931 (6)	9591 (62.1)	3314 (21.5)	1597 (10.3)	
Separated/divorced/widowed	1113 (3.1)	29 (2.6)	667 (59.9)	284 (25.5)	133 (11.9)	
Not known	517 (1.4)	24 (4.6)	326 (63.1)	128 (24.8)	39 (7.5)	

NS, not significant.

2.4.1 Middlesbrough and England Population

Middlesbrough contains some of the most deprived parts of England, with nearly 60% of the population living in one of the 10% most deprived wards in England (Department of the Environment Transport and the Regions (DETR), 2000). As there are no national statistics on maternal BMI status at the start of pregnancy, the population of women of childbearing age in Middlesbrough was compared with the population of women of childbearing age in England. The national census data (Census, 2001) and the IMD data (Index of Multiple Deprivation, 2000) were used to place the results from this study into a more national context; the results are shown in Table 13.

Table 13 Characteristics of Women of Childbearing Age in Middlesbrough and England

	Proportion in Middlesbrough (95% CI)	Proportion in England
Ethnicity (women aged 15–44)*		
White	0.929 (0.926, 0.932)	0.884****
Mixed	0.010 (0.009, 0.011)	0.014****
Asian or Asian British	0.053 (0.050, 0.055)	0.056****
Black or Black British	0.004 (0.003, 0.005)	0.032****
Chinese/other ethnic group	0.005 (0.004, 0.006)	0.014****
Employment status (women aged 16–44)*		
Paid employment	0.520 (0.515, 0.526)	0.628****
No paid employment	0.327 (0.322, 0.333)	0.241****
Education/training	0.152 (0.148, 0.157)	0.131****
Number of dependent children 0–18 years (women aged <24–49)*,**		
0	0.231 (0.225, 0.237)	0.297****
1	0.319 (0.313, 0.326)	0.277****
2	0.296 (0.290, 0.302)	0.292
3 or more	0.153 (0.149, 0.158)	0.134****
Deprivation quintile (women aged 15–44)***		
Most deprived 1	0.622 (0.616, 0.627)	0.215****
2	0.100 (0.097, 0.103)	0.210****
3	0.122 (0.118, 0.126)	0.199****
4	0.139 (0.135, 0.143)	0.190****
Least deprived 5	0.017 (0.016, 0.019)	0.185****
Marital status (women aged 16–44)*		
Single	0.528 (0.522, 0.533)	0.482****
Married	0.351 (0.345, 0.356)	0.405****
Separated, divorced or widowed	0.122 (0.118, 0.126)	0.113****

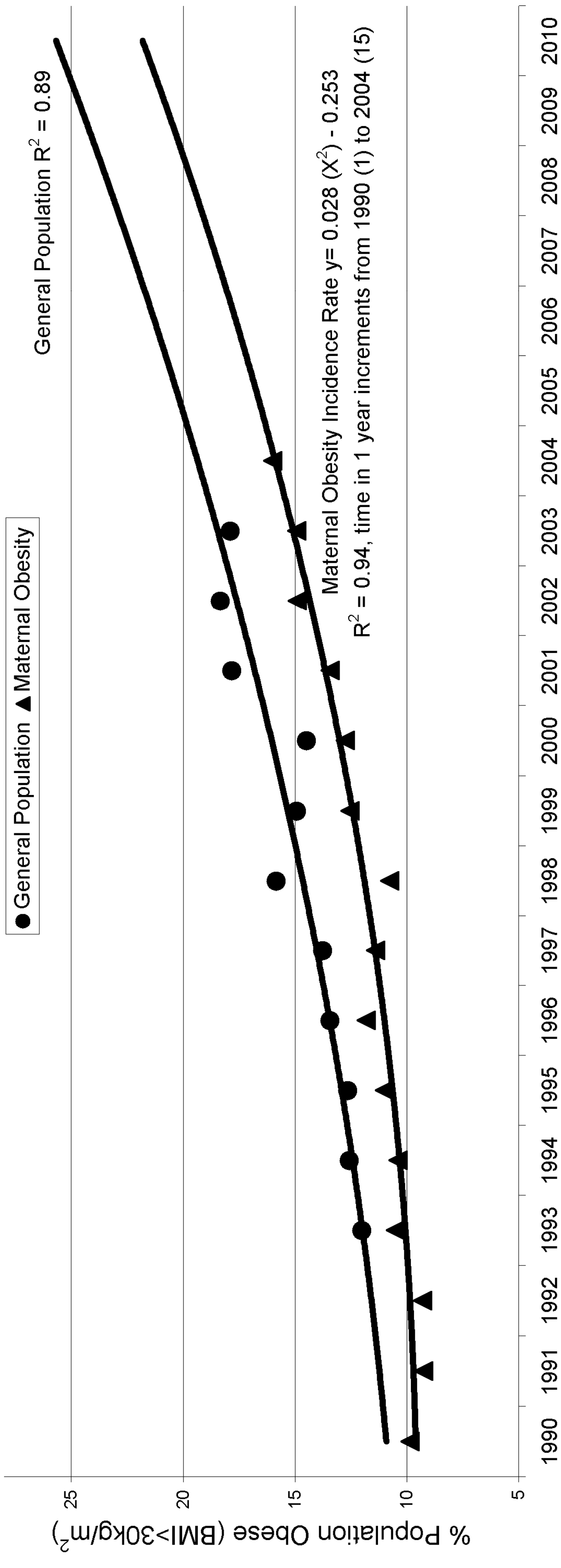
*Census data.
**Number of dependent children used in place of parity.
***IMD data.
****England and Middlesbrough populations significantly different $P < 0.05$.

Confidence Interval (CI) analysis showed that women of childbearing age in Middlesbrough are more likely to be residing in areas of most deprivation (quintile 1, 62.2% versus 21.5% in England, p<0.05), whereas the proportion residing in quintile 5 is significantly lower in Middlesbrough (1.7% versus 18.5% in England, p<0.05). The Middlesbrough population also has a significantly higher than average proportion of White ethnic group, and lower proportions of the remaining ethnic groups (although the difference between Asian groups is only 0.3%), more likely to be unemployed or in education, to have 3 or more dependent children, and to not be married.

2.4.2 Trends in Maternal BMI over Time

The crude trends for incidence of maternal BMI are illustrated in Figure 18.

Figure 18 Trends in Incidence of Maternal Obesity and the Prevalence of Obesity in Women of Childbearing Age (16–44 years) in England's General Population**



% Study Population Lean BMI = 3.8% in 1990, 4.0% in 2004*
% Study Population Ideal BMI = 64.8% in 1990, 54.8% in 2004, projected 47% in 2010
% Study Population Overweight BMI = 21.5% in 1990, 25.3% in 2004*
% Study Population Obese BMI = 9.9% in 1990, 16.0% in 2004, projected 22% in 2010

* Can not extrapolate this data for projected incidence rates: Significant fit for linear model, however R2=0.4 for both BMI categories, therefore not a strong relationship
^ General Population Data Source, Health Survey for England Data 1993-2003, http://www.dh.gov.uk/assetRoot/04/09/89/15/04098915.xls

The rates were not adjusted for change in maternal age over time as the $\bar{x}$ age of the samples varied less than one year over the 15-year period (minimum 26.49, SD 5.16; maximum 27.30, SD 6.05). The gestational age at booking also remained relatively constant over time with a difference of approximately two weeks between the minimum and maximum $\bar{x}$ booking gestational age (minimum 11.16, SD 5.22, maximum 13.31, SD 6.01).

Over the 15-year period there has been a significant decrease in the incidence of women in the ideal BMI group from 64.8% in 1990 to 54.7% in 2004 (χ^2 159.13, df=1, p<0.001). Conversely there is a significant increase in the incidence of women in the overweight BMI group (21.5% to 25.3%, χ^2 19.01, df=1, p<0.001), and obesity in the study population has risen from 9.9% in 1990 to 16.0% in 2004 (χ^2 141.36, df=1, p<0.001).

The regression analysis showed that obesity incidence is best explained by a quadratic model: Incidence = a + b*(x^2) (where x is the time point in years; 1=1990 and 15=2004), with the linear term of the second order polynomial making no contribution to the model fit. This model indicates that the rate of maternal obesity is accelerating over time. If the trend that has been shown in the 15 year period is assumed to continue increasing at the same rate, then the predicted incidence of obesity in this study population will be 22% by the year 2010. This prediction is based on an assumption that the trend remains constant and does not account for saturation of high risk groups, specifically socio-economic deprivation, which would cause the accelerating rate to slow down and eventually level off at some point in the future.

The increasing incidence of maternal obesity is accelerating over time at a similar rate to that of obesity in all women of childbearing age in the general population in England, although the incidence of maternal obesity lags behind that of the general population (Figure 18).

2.4.3 Demographic Predictors of Maternal Obesity

All variables had an independent association with BMI category and no multicollinearity therefore all were included in the final regression model (Table 14). The subjects in the ideal BMI category were used as the reference group[7].

Table 14 Adjusted Logistic Regression for Demographic Predictors of Maternal BMI Group

	Lean versus ideal BMI, OR (95% CI)	Overweight versus ideal BMI, OR (95% CI)	Obese versus ideal BMI, OR (95% CI)
Maternal age	0.95 (0.94, 0.96)***	1.03 (1.03, 1.04)***	1.04 (1.04, 1.05)***
Parity	0.99 (0.93, 1.07)	1.10 (1.06, 1.13)***	1.17 (1.13, 1.22)***
Deprivation quintile			
Least deprived 5	Baseline data		
4	0.82 (0.56, 1.20)	1.05 (0.91, 1.22)	1.13 (0.89, 1.44)
3	0.76 (0.52, 1.11)	1.12 (0.97, 1.29)	1.39 (1.10, 1.75)**
2	0.80 (0.56, 1.13)	1.18 (1.03, 1.35)**	1.79 (1.44, 2.23)***
Most deprived 1	0.95 (0.68, 1.32)	1.33 (1.16, 1.51)***	2.42 (1.96, 2.98)***
Unknown quintile	0.86 (0.56, 1.33)	1.00 (0.83, 1.21)	1.14 (0.84, 1.56)
Ethnic group			
Caucasian	Baseline data		
Mixed race	0.84 (0.36, 1.93)	0.83 (0.55, 1.27)	0.86 (0.49, 1.53)
Asian/Asian British	2.34 (1.85, 2.96)***	1.04 (0.90, 1.20)	0.83 (0.68, 1.01)
Black/Black British	0.00	1.27 (0.71, 2.26)	1.08 (0.49, 2.39)
Chinese/other	2.57 (1.31, 5.03)**	0.45 (0.26, 0.79)**	0.55 (0.27, 1.16)
Ethnic group unknown	1.16 (0.80, 1.69)	0.99 (0.83, 1.18)	1.08 (0.85, 1.36)
Employment status			
Paid employment	Baseline data		
No paid employment	1.92 (1.66, 2.23)***	1.00 (0.94, 1.07)	1.08 (0.99, 1.18)
Education or training	1.53 (1.06, 2.22)**	0.72 (0.56, 0.93)**	0.53 (0.34, 0.83)**
Employment unknown	2.77 (1.58, 4.84)***	1.31 (0.94, 1.82)	1.16 (0.72, 1.86)
Marital status			
Married	Baseline data		
Single	1.34 (1.15, 1.56)***	0.93 (0.87, 1.00)**	0.94 (0.86, 1.03)
Separated, divorced, widowed	1.01 (0.68, 1.49)	0.87 (0.75, 1.01)	0.74 (0.61, 0.91)***
Marital status unknown	1.23 (0.77, 1.96)	1.01 (0.80, 1.27)	0.67 (0.46, 0.98)**

*Variable(s): deprivation, age, ethnic group, parity, employment, marital status.
**$P < 0.05$.
***$P < 0.01$.

The variables included in the logistic regression model were individually both independent predictor variables and potential confounding variables to one another, which were therefore adjusted for. For example deprivation score as an independent variable was analysed following adjustment for all additional variables included in the

[7] The results for ethnic group used the White population as the baseline for comparison as this was the majority group (91.7% of the total cohort). The employment status and deprivation categories used paid employment and residing in the least deprived quintile (5) as baselines for comparison as they were considered to be the best social circumstance when considering health inequality issues. Being in the married group was arbitrarily chosen as the comparison group for the marital status category.

model (shown in Table 14), and it was also considered to be a confounding variable in the analysis of the remaining variables and was therefore adjusted for in subsequent analysis of the remaining independent variables (age, parity, ethnic group, marital status, and employment).

Following adjustment the subjects in the obese group were significantly older, more parous, and residing in the more deprived quintile areas 1 to 3; this was more pronounced in the most deprived quintile 1, where women were almost two and a half times more likely to be obese at the start of pregnancy than those women living in the least deprived quintile 5. For women who were separated, divorced, widowed, or participating in education, there was significant reduction in the incidence of maternal obesity. Ethnicity was not found to have a significant association with maternal obesity, although interpretation of this data is limited due to the small sample size representing the non-White populations.

The overweight group had a significant association with residing in the two lowest quintile areas, being slightly older and slightly more parous, and less likely to be single or in education. The lean group were significantly younger, single, in education, and not in paid employment.

2.4.4 Excluded Population

There were statistically significant differences between the included and excluded groups for all variables except parity, where both groups had a $\bar{x}$ parity of 1 ($p=0.46$). There was a difference in the $\bar{x}$ age of 0.86 years ($p<0.001$), although this is not of clinical significance. χ^2 analyses showed that there was a significant association between ethnic group and exclusion; proportionally more White women were included (60.5%), while more Black (63.5%) and Asian (53.0%) women were excluded. The average inclusion rate relating to deprivation was 59.6%; however this relationship was not evenly distributed across all quintiles with the least deprived having an inclusion rate above average (63.1%), whereas the most deprived was the only quintile that had an inclusion rate below average (57.7%). As there is a potential association with these factors and inequality, the high exclusion rate of certain groups was further investigated. χ^2 analysis showed missing BMI data to explain the relationship with certain groups: White ethnic group, and quintiles 2 to 4. A gestational age at booking of more than 16 weeks was the leading explanation for exclusion of all other ethnic groups, not being in paid employment, and being in the least or most deprived quintiles (1 and 5).

2.5 Discussion

This study has confirmed that the incidence of maternal obesity is rising in this study population at a rate similar to that of all women of childbearing age in the general population, although the incidence of maternal obesity lags behind that of the general population. The relationship between obesity and fertility is well documented (Clark et al., 1995, Wang et al., 2002), and it is likely that this lag effect is primarily due to physiological factors which hinder fertility.

The results of this study show that the increasing incidence of maternal obesity is accelerating; however there is a potential that this is underestimated. Women whose pregnancies were incomplete were excluded from the study population, and the relationship with obesity, miscarriage, and late foetal death (Lashen et al., 2004) could potentially have resulted in the exclusion of a significant proportion of the obese women. The exclusion of women who presented after 16 weeks gestation could also have added to the underestimation of maternal obesity due to the association with irregular menstruation (Lake et al., 1997), (Linne, 2004). Also since slight changes in weight status may not be as noticeable in obese women, confirmation of the pregnancy may be later in this category. There is also evidence to show that self reported weight is underestimated and height overestimated (Engstrom et al., 2003), therefore this could have led to a further underestimation of the overweight or obese BMI groups in this study. However the majority of bookings use measured weights and heights and there has been no change in the location of booking appointments over the 15-year period studied, making the variation in self reported heights and weights over time limited due to this factor.

The HC reports that an increased prevalence of obesity in the general population is associated with health inequalities and deprivation (House of Commons Health Committee, 2004), which fully supports the findings of this study in relation to maternal obesity. There is also an association with prevalence of obesity in women in the general population and increasing age (Department of Health, 2004b). The relationship with incidence of maternal obesity and increasing age following adjustment for all other confounders was highly significant in this study; however the relationship showed only a slight increase. The relationship with increasing age and obesity in women in the general population is most significant following menopause (Department of Health, 2004b). Therefore the magnitude of this significant relationship is not going to be reflected in the women in this study population, and the high significance of the slight increase in OR is realistic for the age group in this study population.

The results of this study show increasing parity to be a predictor of maternal obesity. Published evidence supports this, as the time period during and between pregnancies is shown to be a critical period in the development of obesity (Gore et al., 2003), (Siega-Riz et al., 2004), (Gunderson and Abrams, 2000). Women in education had a highly significant reduced OR of being obese at the start of pregnancy. The mothers who are in education are more likely to be a younger group, and the significant relationship with increasing age and obesity makes the younger group less likely to be in the obese category; however there was no collinearity between the age and education variables. Also, age as a confounder had been accounted for in the regression model; therefore this cannot explain the inverse phenomenon between this group of mothers and obesity. As this research was looking at independent demographic predictors to identify health inequalities that may have a relationship with maternal BMI status, lifestyle factors were not taken into consideration and this may have influenced the inverse relationship with obesity and mothers being in education.

There was no significant association between any of the ethnic minority groups and maternal obesity. Although the number of women from ethnic minority groups in this study population was relatively low, there were a significantly increased proportion of women excluded from ethnic minority groups, particularly in the Asian and Black ethnic groups. One explanation why proportionately more women from some ethnic groups had late booking appointments could be related to inequalities in access to services. This is supported by evidence such as that published in the House of

Commons HC report '*Inequalities in Access to Maternity Services'* (House of Commons Health Committee, 2003).

There are certain limitations when trying to quantify health inequality issues, as there is a great deal of speculation when it comes to defining data such as deprivation. The traditional categorisation of socio-economic status is outdated as it is reliant upon the occupation of the male in a household, which is unlikely to be an adequate representation in the modern day, particularly in populations that have a higher proportion of single mothers. Deprivation has been numerically categorised for the purposes of this research using area of residence as an indicator of deprivation based on the IMD, which uses postcodes to calculate deprivation based on the area's level of income deprivation, employment deprivation, health deprivation and disability, education, skills and training deprivation, barriers to housing and services, living environment deprivation, and crime. Although there is the argument that someone living in an area of deprivation is not necessarily themselves deprived, and also that the boundaries of areas of deprivation change with time making it difficult to attribute a deprivation score to one postcode over any length of time, it was still considered to be a more accurate indicator of deprivation than the household male occupation.

The results of this study should be comparable to other populations in England where women of childbearing age are mainly White (with Asian being the highest proportion of ethnic minority groups), have a higher than average level of deprivation, unemployment, and single mothers. The rise in maternal BMI over time in this study population is highly significant, with proportions of maternal obesity accelerating at a rate far greater than any other BMI status. The trends in incidence for the data predict that the proportion of mothers who are obese at the start of pregnancy could potentially have increased from 10% in 1990 to 22% by 2010 assuming that the trend continues, and that the proportion of mothers in the ideal BMI category could potentially have reduced from 65% in 1990 to 47% by 2010. Maternal BMI status is also shown to relate to health inequalities, particularly for women who live in the areas of the most deprivation who are almost two and a half times more likely to be obese at the start of pregnancy than women who live in areas of least deprivation. There are also potentially issues relating to inequalities within ethnic groups and access to maternity services, which is supported by published evidence. The results from this study indicate serious implications both in terms of public health and service delivery.

Chapter Three
National Survey of Data Collection in Maternity Units in England, and Sampling for the National Epidemiological Study

3.1 Objective

The objective of this chapter was to establish the current level of electronic data collection in maternity units in England, specifically relating to anthropometric data. The survey was required to identify which maternity units could potentially participate in a nationally representative study in England relating to maternal obesity incidence and demographic predictors of women most at risk of being obese in pregnancy. This chapter describes the survey development and methodology, the response to the survey and the level of electronic data collection in England, and the sampling and research governance procedure for the multi-centre national study.

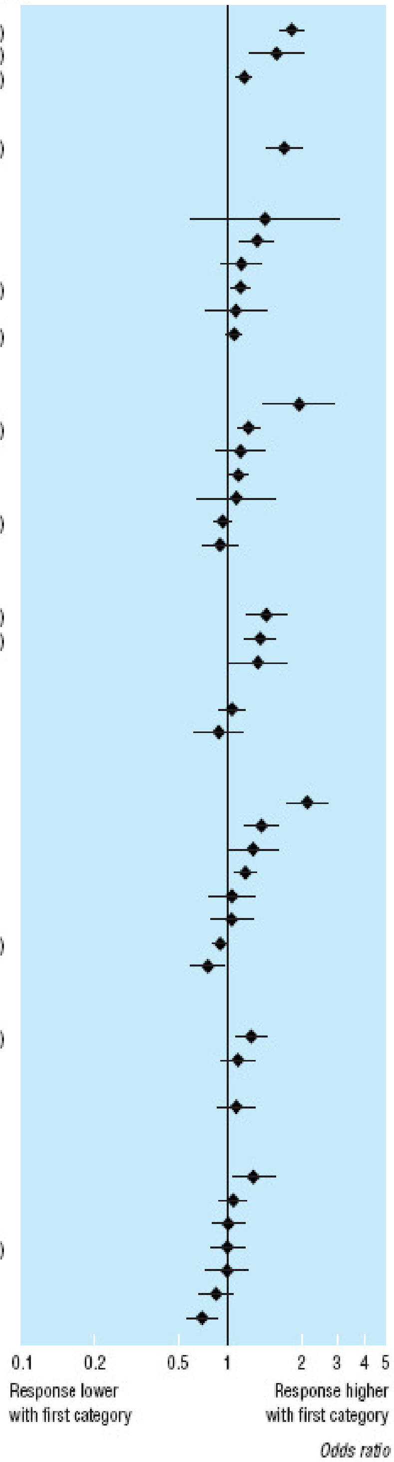
3.2 Background to the Tailored Design Method for Survey Design

The survey was designed in accordance with the principles of the Tailored Design Method (DM) which is an updated version of the Total DM established in the 1970s (Dillman, 2007). The Total DM was based on the social exchange theory of human behaviour, and the reasons why people do or do not respond to surveys being reflective of the perceived benefits and costs to the individual (Dillman, 1978). The conclusion was that there were certain key methodological aspects of survey design that were found to increase response rates to postal questionnaires, such as repeat mail outs with additional copies of the questionnaire, personalised with names and addresses, printed questionnaires, and real signatures. Although the Total DM was pivotal in the use of mail surveys and increased response rate in studies, it was flawed due to the rigid methodological stance that the same methodology was appropriate in all types of survey. Also due to rapidly changing technologies over the decades the method of increasing response rates also needed to be adapted in order that the perceived benefit of response by the individual was not outweighed by the perceived cost of completing the questionnaire. These societal developments led to the development of the Tailored DM, where increasing response is not emphatically related to following the rigid key methodology of Total DM, but rather that the development of survey procedures should create respondent trust, perceptions of increased reward and reduced costs for being a respondent, taking into account the features of the survey situation, and where the goal is to reduce survey error (Dillman, 2007). One form of Tailored DM is the increased use of mixed-mode survey design, in which there is more than one format for reaching individuals and more than one format for response, with the benefit of this being that it allows for different methodologies to complement one another when there may be weaknesses in either (Dillman, 2007). This is especially important in light of the rapid changes in technology since the 1970s, where more households and businesses have access to the internet, email accounts, and mobile phones, and with the environmental responsibilities of reducing the use of paper when not necessary.

Two systematic reviews have identified the methodologies shown to increase the response rate to postal surveys. The first review included 292 randomised control trials (RCTs), including 258,315 participants in 75 strategies to improve the response to postal questionnaire (Edwards et al., 2002). The meta-analysis highlighted numerous factors that have increased response rates in postal surveys (Figure 19). The most successful factor was found to be the addition of financial incentives; however a non-monetary incentive was still found to have a higher response rate than no incentive. Shorter questionnaires were found to be returned more frequently, the use of coloured ink and personalisation of the survey were found to be significant in improving response rates. Recorded delivery was found to be the most successful form of delivery, although providing a stamped return envelope and first class outward mail were also found to be significant. Pre-contacting the participants and following up non-responders, especially with postal follow up and re-sending the questionnaire were found to be the most successful form of contact. The more interesting the content of the questionnaire, the greater the response rate was found to be. Having a user friendly approach, including only factual questions rather than attitudinal questions, having the more relevant questions first and the more general questions last, and not including sensitive questions were all significantly found to increase the response. Finally, having university sponsorship, having to give an explanation for non participation, and not being given an option to opt out were found to significantly increase the response rate.

Figure 19 Meta-Analyses for the Effects on Questionnaire Response of 40 Strategies where Combined Trials Included Over 1,000 Participants

Strategy	No of trials (No of participants)	Odds ratio (95% CI)	P value for heterogeneity
Incentives			
Monetary incentive *v* no incentive	49 (46 474)	2.02 (1.79 to 2.27)	<0.00001
Incentive with questionnaire *v* incentive on return	10 (13 713)	1.71 (1.29 to 2.26)	<0.00001
Non-monetary incentive *v* no incentive	45 (44 708)	1.19 (1.11 to 1.28)	<0.00001
Length			
Shorter *v* longer questionnaire	40 (40 669)	1.86 (1.55 to 2.24)	<0.00001
Appearance			
Brown envelope *v* white	2 (5311)	1.52 (0.67 to 3.44)	<0.00001
Coloured ink *v* standard	1 (3540)	1.39 (1.16 to 1.67)	
Folder or booklet *v* stapled pages	2 (1845)	1.17 (0.94 to 1.45)	
More personalised *v* less personalised	38 (39 210)	1.16 (1.06 to 1.28)	<0.00001
Identifying feature on return *v* none	7 (4014)	1.08 (0.78 to 1.51)	<0.001
Coloured questionnaire *v* white	8 (14 797)	1.06 (0.99 to 1.14)	
Delivery			
Recorded delivery *v* standard	6 (2127)	2.21 (1.51 to 3.25)	<0.01
Stamped returned envelope *v* business reply or franked	14 (38 259)	1.26 (1.13 to 1.41)	<0.00001
Questionnaire sent to work address *v* home address	2 (1140)	1.16 (0.89 to 1.52)	
First class outward mailing *v* other class	1 (7370)	1.12 (1.02 to 1.23)	
Pre-paid return envelope *v* not pre-paid	4 (4094)	1.09 (0.71 to 1.68)	<0.00001
Stamped outward envelope *v* franked	6 (13 964)	0.95 (0.88 to 1.03)	
Commemorative stamp *v* ordinary stamp	4 (5238)	0.92 (0.78 to 1.09)	
Contact			
Precontact *v* no precontact	28 (28 793)	1.54 (1.24 to 1.92)	<0.00001
Follow up *v* no follow up	12 (16 740)	1.44 (1.22 to 1.70)	<0.0001
Postal follow up including questionnaire *v* postal follow up excluding questionnaire	6 (6310)	1.41 (1.02 to 1.94)	<0.00001
Mention of follow up contact *v* none	6 (6553)	1.04 (0.91 to 1.18)	
Precontact by telephone *v* post	2 (1375)	0.90 (0.70 to 1.16)	
Content			
More interesting *v* less interesting questionnaire	2 (2151)	2.44 (1.99 to 3.01)	
User friendly questionnaire *v* standard	1 (3540)	1.46 (1.21 to 1.75)	
Factual questions only *v* factual and attitudinal	1 (1280)	1.34 (1.01 to 1.77)	
More relevant questions first *v* other items first	1 (5817)	1.23 (1.10 to 1.37)	
Demographic items first *v* other items first	2 (1040)	1.04 (0.81 to 1.34)	
"Don't know" boxes included *v* not included	1 (1360)	1.03 (0.82 to 1.29)	
Sensitive question included *v* no sensitive question	6 (19 851)	0.92 (0.87 to 0.98)	
Most general question first *v* last	1 (2000)	0.80 (0.67 to 0.96)	
Origin			
University sponsorship or as source *v* other organisation	13 (20 428)	1.31 (1.11 to 1.54)	<0.00001
Sent by more senior or well known person *v* less senior or less well known	4 (2584)	1.13 (0.95 to 1.35)	
Ethnically unidentifiable/white name *v* other name	2 (1800)	1.11 (0.91 to 1.36)	
Communication			
Explanation for not participating requested *v* not requested	1 (1240)	1.32 (1.05 to 1.66)	
Appeal stresses benefit to respondent *v* other	6 (9332)	1.06 (0.92 to 1.22)	
Appeal stresses benefit to sponsor *v* other	7 (9708)	1.01 (0.86 to 1.19)	<0.05
Appeal stresses benefit to society *v* other	8 (10 088)	1.00 (0.84 to 1.20)	<0.01
Response deadline given *v* no deadline	4 (4340)	1.00 (0.84 to 1.20)	<0.05
Instructions given *v* not given	1 (2000)	0.89 (0.74 to 1.06)	
Choice to opt out from study given *v* none	3 (3045)	0.76 (0.65 to 0.89)	



(Edwards et al., 2002)

An updated Cochrane review identified consistencies with these factors that promoted the increased response to postal questionnaires in 372 RCTs incorporating 98 strategies (Edwards et al., 2007). Non-monetary incentives compared to no incentives were found to increase the odds for return of the questionnaires by over a 10th, as did the personalisation of the questionnaires. Short questionnaires had odds ¾ higher than when using longer questionnaires, using coloured ink increased the response by $^{2}/_{5}$, follow up of non-responders, resending the questionnaire, and having the easiest questions first increased the odds by ½. Questions of specific interest to the participants more than doubled the response, utilising factual questions rather than attitudinal questions increased the response by ⅓, and there was increased response when the questionnaire was sent from a university. In addition to the previous findings, using brown coloured envelopes was found to increase the response by ⅓, whereas although there was an increased odds of 1.52 shown previously, this was not found to be significant (95% CI 0.67, 3.44) (Edwards et al., 2002). When incentives were offered on the first mailing the odds of returning the questionnaires were increased by more than a 10th, and reduced odds of ⅔ was found when open ended questions were utilised rather than closed questions.

3.3 Materials and Methods

3.3.1 Survey Design

The design for the national survey utilised the Tailored DM, specifically relating to mixed-mode design and the factors found in the systematic reviews to be successful at increasing the response of postal surveys.

A list of all maternity units in England was obtained from the Birth Choice UK website (http://www.birthchoiceuk.com/)[8]. The name of the maternity unit, address, contact number, whether it was midwifery led, consultant led, or GP led, and the average number of births per year were identified for all non private health care providers on the list, and a database was created. The database included 151 maternity units that were consultant led, 33 combined consultant and midwife led units, 54 midwife led

[8] This source of information was provided by the Department of Health as the best source for a full list of maternity units in England (Appendix 11)

units, and five GP led units. Each maternity unit was contacted to establish the name, position, direct address, email address, and telephone number where possible for the current head of midwifery, and clinical director or lead consultant obstetrician in order to obtain the details for personalisation of the questionnaires.

A cover letter was designed to accompany the questionnaire in the first mail out which was personally addressed to the head of midwifery, lead consultant obstetrician/clinical director for maternity services (Appendix 12). The letter was designed to be short (not to exceed one page), utilise colour, outline the importance of the survey in terms of identifying current known trends of maternal obesity in Middlesbrough, and identifying the importance of knowing this on a national scale. Why the survey should be of interest to them was outlined as this being the first step towards a national level study that they could potentially be involved in. My contact details were included in the covering letter; however the letter was signed by more senior members of the research team.

3.3.1.1 The Questionnaire Design

The questionnaire was designed to be no more than one page, including details on the return of the questionnaire, closed, factual questions, utilised colour, and showed where the survey originated from (the University of Teesside and NEPHO) (Figure 20). The Tailored DM of mixed-mode survey design was applied to the development of the questionnaire, where an online version of the cover letter and questionnaire were developed[9] and could be accessed via the web address http://www.nepho.org.uk/maternityquestionnaire/. This alternate method for completing the questionnaire was developed due to the nature of the survey relating to IT systems in maternity units. It was anticipated that the heads of midwifery and clinical directors would potentially delegate the task of completing the questionnaire to the member of staff responsible for managing a database, and therefore they might prefer an online version of the questionnaire and consider this to involve less effort.

[9] The online survey was developed by Richard Dean, Web Developer at the NEPHO

Figure 20 The Questionnaire for the National Survey of Maternity Units

nepho
NORTH EAST PUBLIC HEALTH OBSERVATORY

UNIVERSITY OF TEESSIDE
SCHOOL OF HEALTH & SOCIAL CARE

Obesity in Pregnancy Questionnaire

Maternity Unit: ______________________

NHS Trust: ______________________

Contact Name: ______________________

Position: ______________________

Contact Number: ______________________

Contact Email: ______________________

Q1. Does your maternity unit routinely collect information electronically? Yes / No

(If "Yes" please continue, if "No" then no further details required)

Q2. What year did you commence collecting electronic data? __________

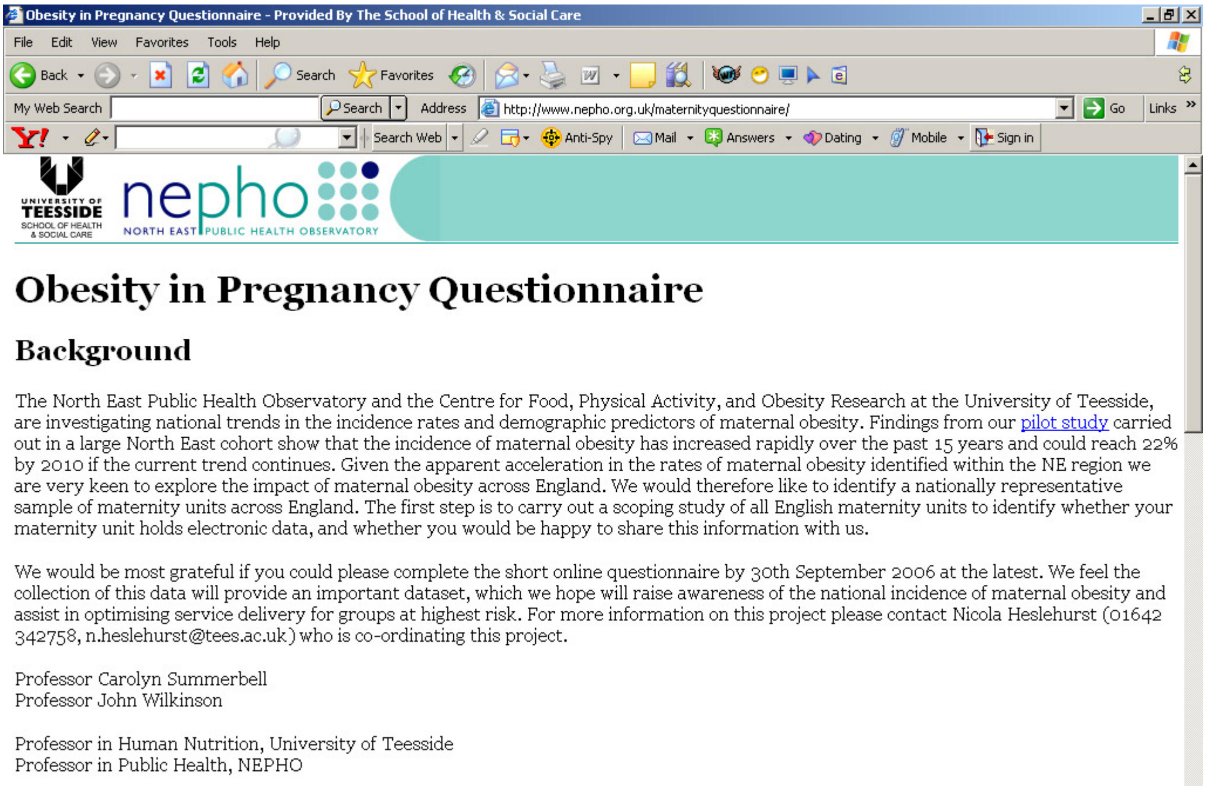
Q3. Do you electronically record the following information for women in your maternity unit?

Data Item	Routinely Collected Electronically?	Measurement of Data (SR – Self Reported, M – Measured)	Year Commenced Data Collection IF Different From Above
Mother's height	Yes / No	SR / M	
Mother's weight at booking	Yes / No	SR / M	
Mother's BMI at booking	Yes / No	SR / M	
Date of booking appointment	Yes / No		
Stage of pregnancy (booking)	Yes / No		
Date of delivery	Yes / No		
Gestational age at delivery	Yes / No		
Mother's age or DOB	Yes / No		
Mother's ethnic group	Yes / No		
Mother's marital status	Yes / No		
Mother's employment status	Yes / No		
Parity	Yes / No		
Postcode	Yes / No		

Thank you for your time in completing this survey. Please return by 30th September 2006 in the SAE/fax/online submission to:
Nicola Heslehurst
The Centre for Food, Physical Activity, & Obesity Research
School of Health and Social Care
University of Teesside
Middlesbrough
TS1 3BA
Fax: 01642 342770
Online Submission: http://www.nepho.org.uk/maternityquestionnaire/
For further information please ring 01642 342758 or email n.heslehurst@tees.ac.uk

Mixed-mode has been criticised for potentially leading to different responses due to the differing formats (Edwards et al., 2007), therefore it was important that the online version of the survey represented the same layout and format as the paper based survey. The online version included the cover letter at the top of the page, with the University of Teesside and NEPHO logo's, and the questionnaire in the same layout and format as the paper based survey (Figure 21). The online version of the questionnaire also included validation checks to prompt the respondent to complete any data fields with missing information, where the fields had a red "please check" prompt when they were empty and these changed to a green "OK" field when information was entered. A second validation check for reducing errors in completing the survey was to remove the option for completing questions 2 and 3 if the answer to question 1 was checked as "no" (Figure 22).

Figure 21 The Online Survey



Obesity in Pregnancy Questionnaire

Background

The North East Public Health Observatory and the Centre for Food, Physical Activity, and Obesity Research at the University of Teesside, are investigating national trends in the incidence rates and demographic predictors of maternal obesity. Findings from our pilot study carried out in a large North East cohort show that the incidence of maternal obesity has increased rapidly over the past 15 years and could reach 22% by 2010 if the current trend continues. Given the apparent acceleration in the rates of maternal obesity identified within the NE region we are very keen to explore the impact of maternal obesity across England. We would therefore like to identify a nationally representative sample of maternity units across England. The first step is to carry out a scoping study of all English maternity units to identify whether your maternity unit holds electronic data, and whether you would be happy to share this information with us.

We would be most grateful if you could please complete the short online questionnaire by 30th September 2006 at the latest. We feel the collection of this data will provide an important dataset, which we hope will raise awareness of the national incidence of maternal obesity and assist in optimising service delivery for groups at highest risk. For more information on this project please contact Nicola Heslehurst (01642 342758, n.heslehurst@tees.ac.uk) who is co-ordinating this project.

Professor Carolyn Summerbell
Professor John Wilkinson

Professor in Human Nutrition, University of Teesside
Professor in Public Health, NEPHO

Figure 21 continued. The Online Survey

Questionnaire

Please complete the contact details below. Once you've completed the questionnaire, click the 'save' button at the bottom of the form.

Maternity Unit		Please check
NHS Trust		Please check
Contact Name		Please check
Position		Please check
Contact Number		Please check
Contact Email		Please check

Q1. Does your matenity unit routinely collect information electronically? ◉ Yes ○ No

(If "Yes" please continue, if "No" then no further details are required)

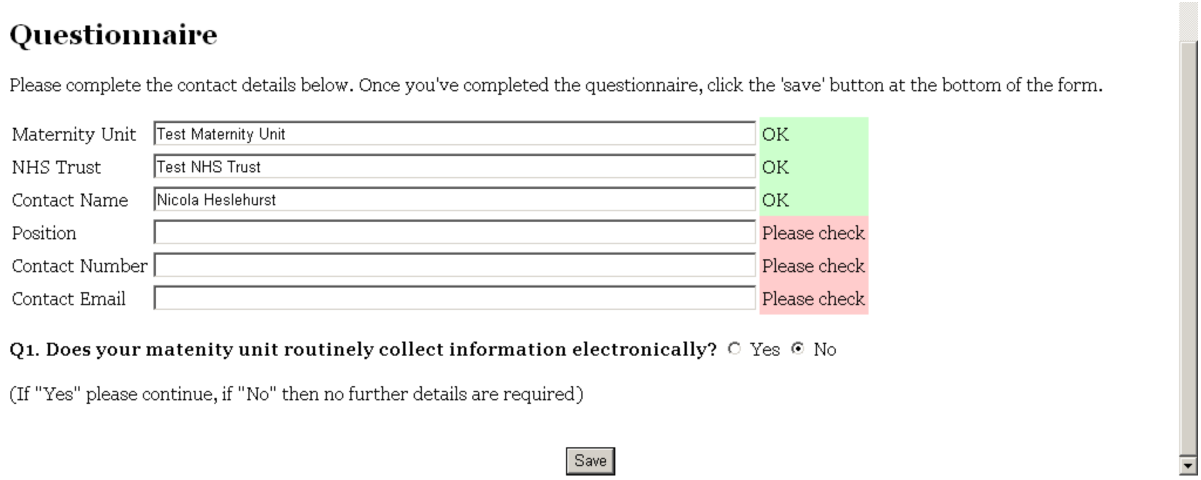
Q2. What year did you commence collecting electronic data? Please check

Q3. Do you electronically record the following information for women in your maternity unit?

Data Item	Routinely Collected Electronically?	Measurement of Data SR - Self Reported M -Measured	Year Commenced Data Collection *IF Different From Above*
Mother's height	○ Yes ○ No	○ SR ○ M	
Mother's weight at booking	○ Yes ○ No	○ SR ○ M	
Mother's BMI at booking	○ Yes ○ No	○ SR ○ M	
Date of booking appointment	○ Yes ○ No	-	
Stage of pregnancy (booking)	○ Yes ○ No	-	
Date of delivery	○ Yes ○ No	-	
Gestational age at delivery	○ Yes ○ No	-	
Mother's age or DOB	○ Yes ○ No	-	
Mother's ethnic group	○ Yes ○ No	-	
Mother's marital status	○ Yes ○ No	-	
Mother's employment status	○ Yes ○ No	-	
Parity	○ Yes ○ No	-	
Postcode	○ Yes ○ No	-	

Save

Figure 22 Validation Checks for the Online Survey


Questionnaire

Please complete the contact details below. Once you've completed the questionnaire, click the 'save' button at the bottom of the form.

Maternity Unit	Test Maternity Unit	OK
NHS Trust	Test NHS Trust	OK
Contact Name	Nicola Heslehurst	OK
Position		Please check
Contact Number		Please check
Contact Email		Please check

Q1. Does your matenity unit routinely collect information electronically? Yes No

(If "Yes" please continue, if "No" then no further details are required)

Save

3.3.1.2 Survey Distribution

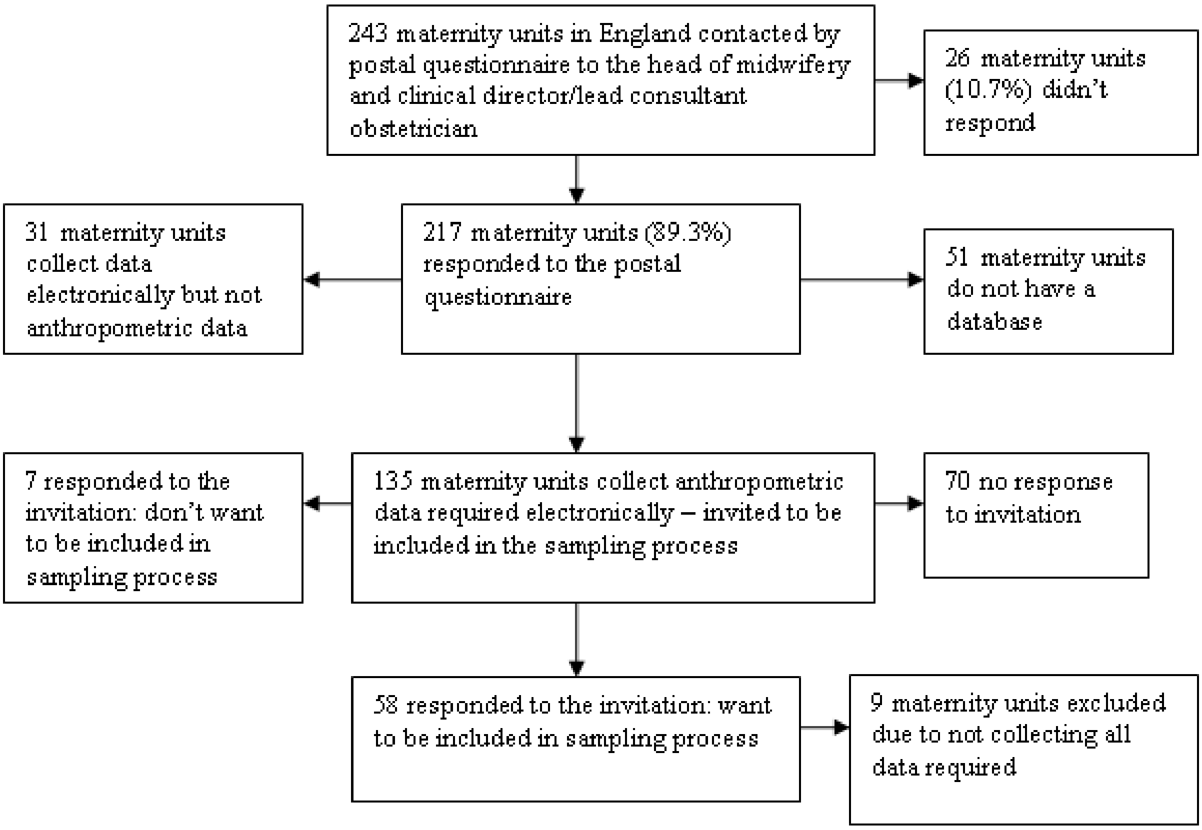
The initial cover letter explaining the study was sent to all established contacts in August 2006 along with a copy of the questionnaire, and a pre-paid return envelope. The initial cover letter and the questionnaire had instructions for completing and returning the questionnaire, where the options of method for return were using the pre-paid return envelope, fax, or to complete the online version of the questionnaire. A deadline for returning the questionnaire was set for 30th September 2006.

A follow up letter to any non-responders was designed utilising the same format and structure as the initial letter for consistency and familiarity to the participants (Appendix 13). The follow up letters to non-responders were sent in October to the same members of staff in the maternity units, and included another copy of the questionnaire and another pre-paid return envelope. Where staff had been willing to provide their email addresses in the initial pre-contact then emails to the non-responders were also sent as another way of potentially reaching participants if the weakness in the postal method for these non-responders was the nature of the paper based survey.

3.4 Response to the Survey

A total of 243 maternity units were contacted. The response from the initial mail out was 75.3% (n=183 maternity units returned the questionnaire). The overall response was 89.3% (n=217 maternity units) returning the questionnaire following the mail out to non-responders (Figure 23).

Figure 23 Response to the Survey



Twenty six maternity units did not respond following the reminder letter and revised deadline (10.7%). The responding maternity units were evenly distributed geographically when compared to the distribution of all maternity units in England (Figures 24-26).

Figure 24 Geographical Distribution of all Maternity Units in England (n=243)

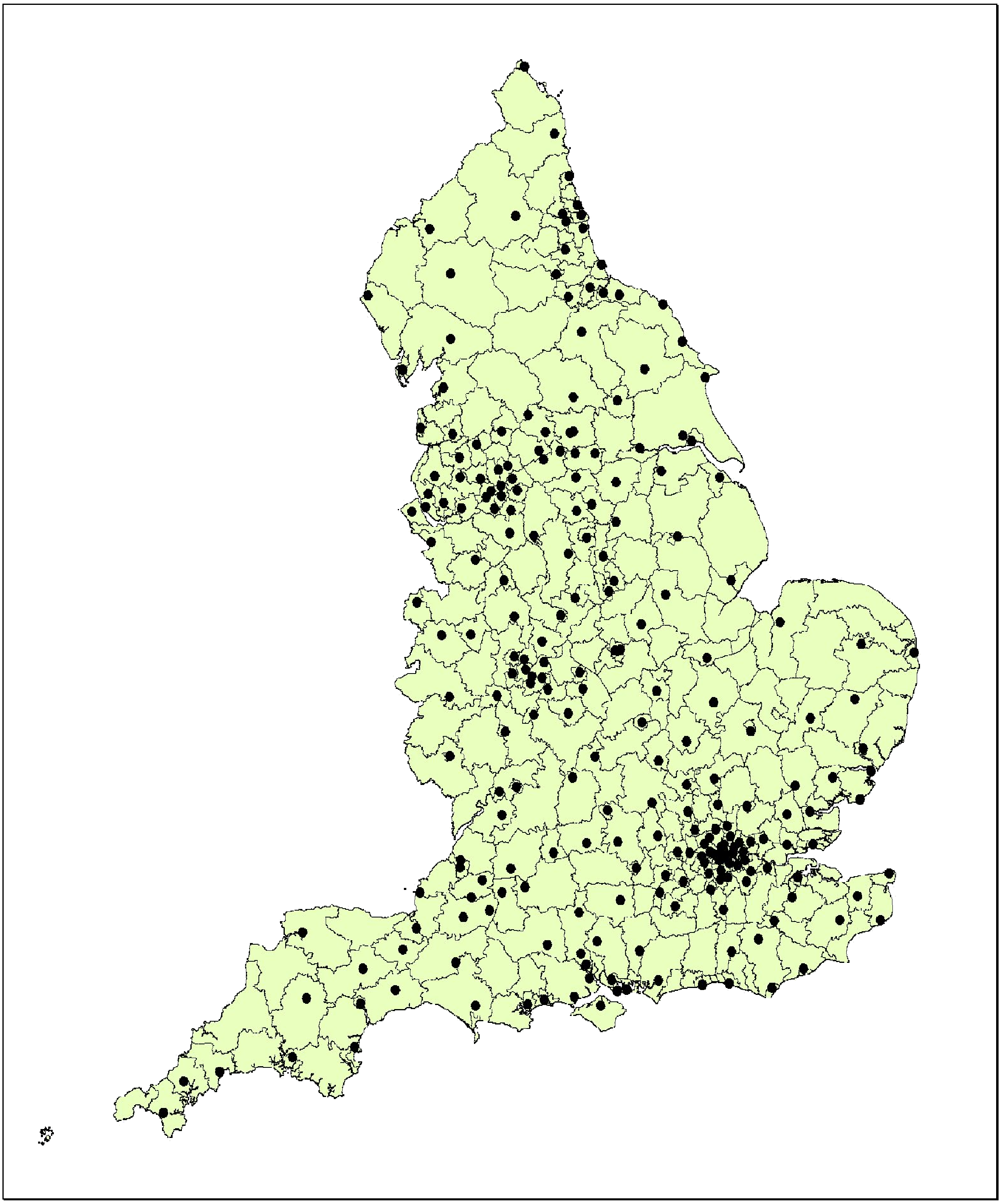


Figure 25 Geographical Distribution of Responding Maternity Units in England (n=217)

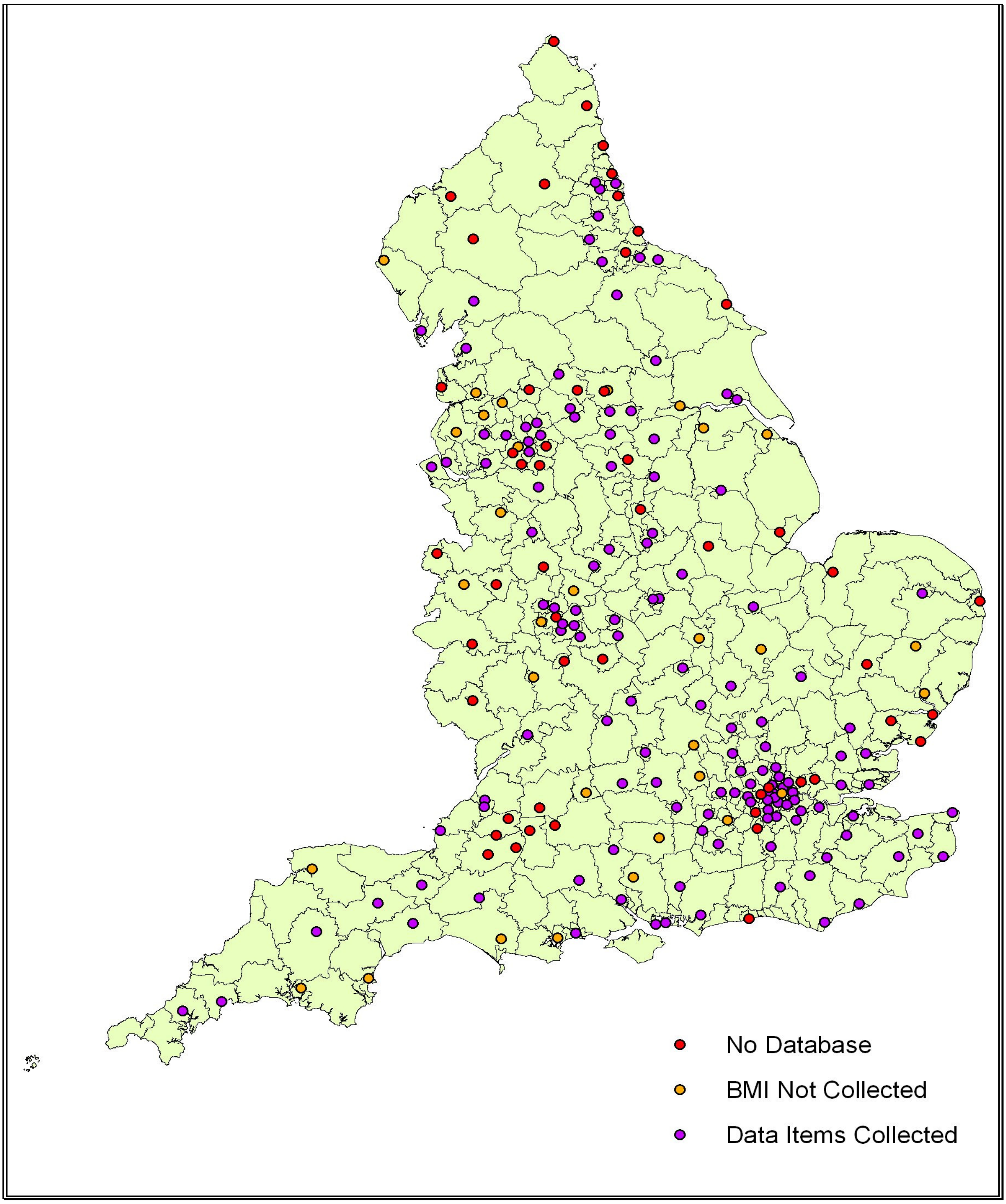
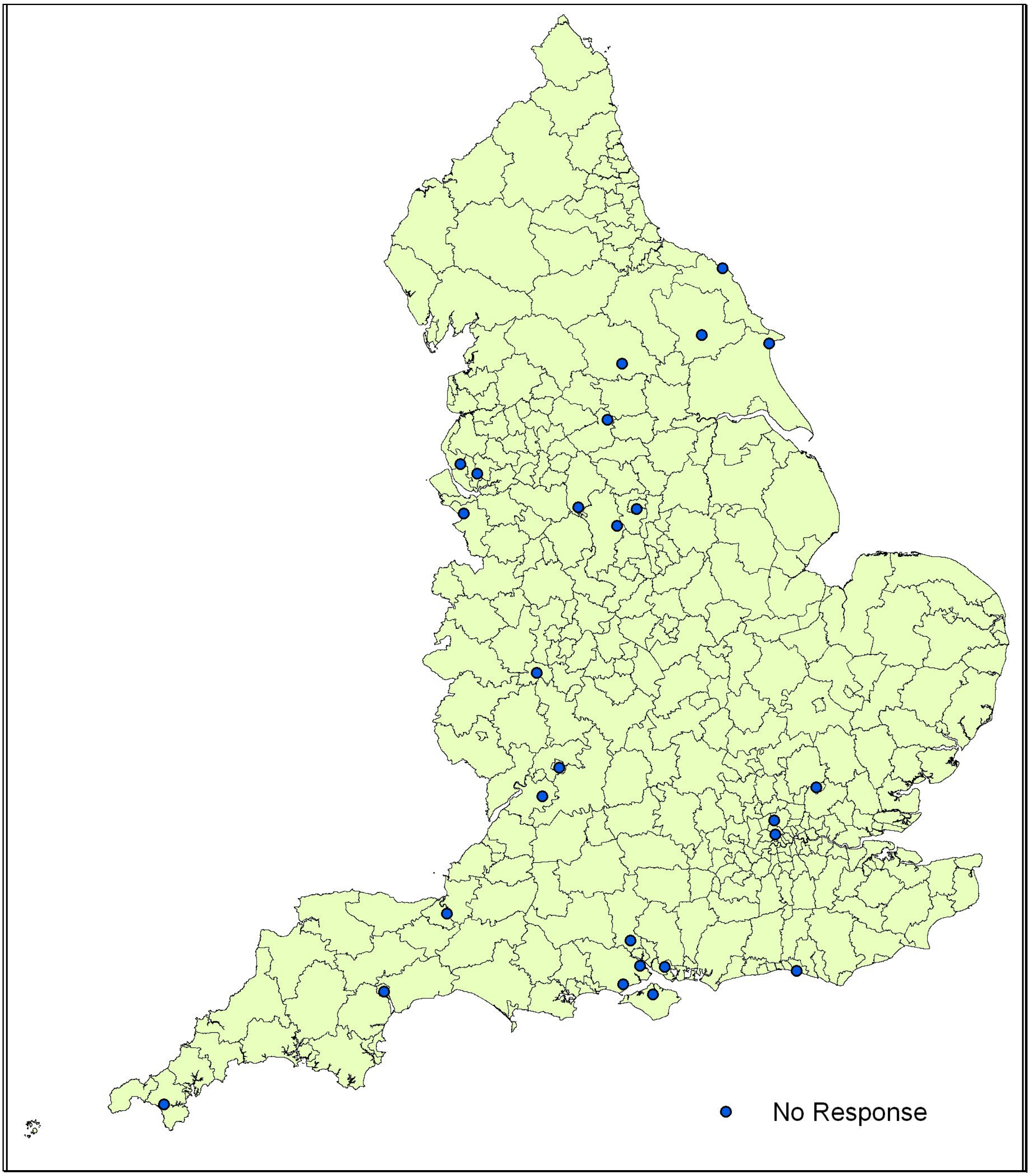


Figure 26 Geographical Distribution of Non-Responding Maternity Units in England (n=26)



3.4.1 Data Collection Practice

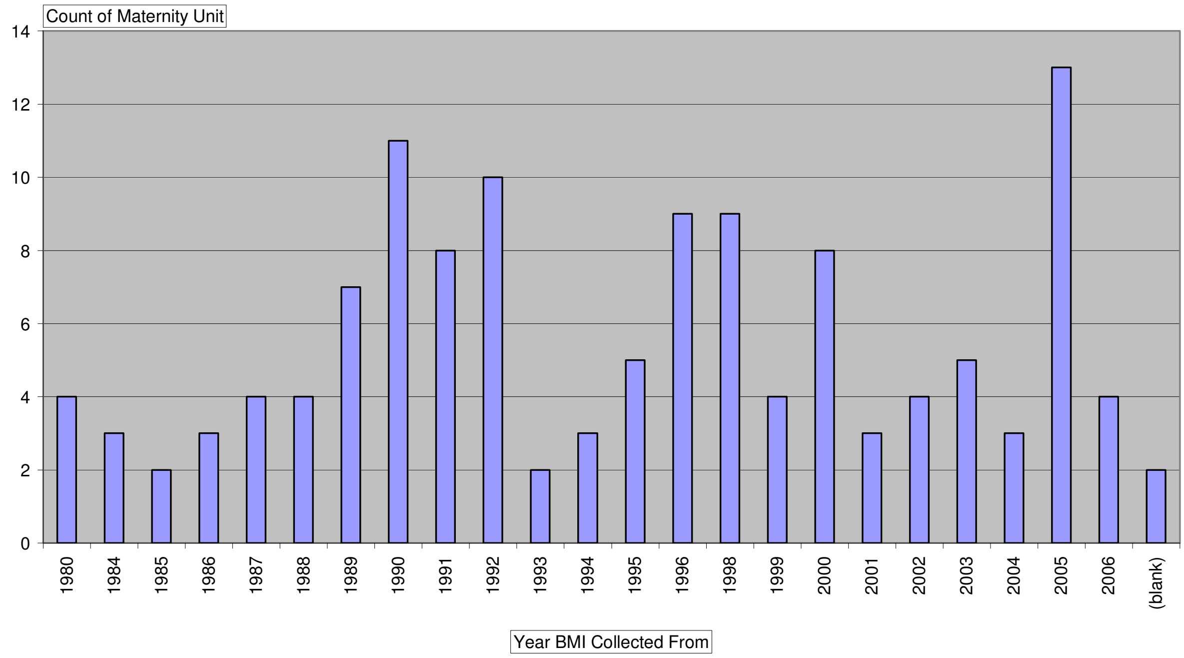
Of the 217 maternity units that responded to the survey, 51 did not have a database for routine electronic data collection, whereas 166 use a database for routine electronic data collection (Figure 23). Of the 166 maternity units that routinely collected electronic data only 135 collected anthropometric data electronically, either by recording both the height and weight, and/or BMI. The survey identified that the data collection practice for the supplementary demographic variables required for the national study varied among the 135 maternity units that did record anthropometric data electronically, with employment status being the variable least collected (Table 15). The level of incomplete information due to the questionnaire not being fully completed was only 0.46% with eight instances of missing information out of a possible 1755 (i.e. 135 maternity units and 13 questions per maternity unit).

The time periods over which anthropometric data has routinely been collected in the maternity units varies from 1980 to 2006 (Figure 27), with two maternity units not including any year for data collection commencement in the returned questionnaire.

Table 15 Results of the Questionnaire for the Maternity Units that Collect Anthropometric Data Electronically

	Data Item Collected			
	Yes	No	Not reported	Total
Height	128	7	0	135
Weight	128	7	0	135
BMI	110	24	1	135
Booking Date	132	1	2	135
Stage of Pregnancy at Booking	123	11	1	135
Delivery Date	134	0	1	135
Gestational Age at Delivery	131	3	1	135
Maternal Age	135	0	0	135
Ethnic Group	133	2	0	135
Marital Status	130	5	0	135
Employment Status	114	19	2	135
Parity	135	0	0	135
Postcode	134	1	0	135

Figure 27 Year Maternity Units Commenced Electronic Anthropometric Data Collection



3.5 Sampling for the National Study

The 135 maternity units that collect anthropometric data electronically were sent a letter in December 2006 outlining the planned national study to identify trends in rates of BMI groups in pregnancy and at risk groups in the population. The letter asked them if they would be interested in participating in the national study, where if they indicated they would like to participate then, subject to research governance approval, they would be included in the sampling process (Appendix 14). A reminder letter was sent to all non-responders one week following the deadline in January 2007.

There were 65 responding maternity units and 70 that did not respond to the invitation following the reminder letter to non-responders. Of the 65 maternity units that did respond to the invitation, 58 maternity units wanted to participate, and nine replied stating they did not want to participate.

Letters were sent to all maternity units in England that responded to the initial questionnaire and were not one of the 58 maternity units that wanted to participate, thanking them for their participation in the audit and stating that they were not going to be included in the final sampling process (Appendix 15).

3.5.1 The Final Sample for Research Governance Application

The sampling frame included the 135 maternity units that collect anthropometric data electronically, with 58 of those maternity units consenting in principle to provide data for the study. Nine of the 58 maternity units reported that they did not routinely collect all of the demographic data required for the analysis of at risk groups of women, and they were therefore excluded.

Preliminary analysis was carried out to compare the characteristics of the England population with the characteristics of the 49 maternity units that reported to collect all of the required data electronically. This involved using the national census and IMD data for the demographics being analysed, the information provided on the Birthchoice UK website regarding the type and size of maternity unit, and the geographical location of the maternity units. This preliminary analysis identified that the demographic characteristics of women of childbearing age in England (defined as 16-44 year old women) was largely comparable to the population of women of childbearing age in the local authority catchment area for the maternity units included in the sample (Table 16). The comparability of the populations was evident in most demographic categories with the exception of ethnic group and deprivation, where the study sample of maternity units included a higher proportion of ethnic minority groups compared with the England data, and a more even distribution of deprivation status than the England data, which shows a lower proportion of women living in the most deprived quintile. This phenomenon was considered to be an advantage in the sample selection, as the pilot study showed that there was a relationship with deprivation and Black and Asian women being excluded due to late booking, therefore over-sampling these population demographics could result in a more nationally representative sample of ethnic group and deprivation status.

Table 16 Population Demographics of the Maternity Units: Study Sample and England

	Study Sample	England
MARITAL STATUS*		
% Single	47.1	45.3
% Married	41.2	43.1
% Seperated,Divorced,Widowed	11.7	11.6
EMPLOYMENT*		
% Paid Employment	62.7	64.9
% No Paid Employment	24.1	23.2
% Education / Training	13.2	11.8
ETHNIC GROUP*		
% White	89.5	92.7
% Asian	2.7	1.8
% Black	5.0	3.4
% Mixed	1.4	1.0
% Chinese / Other	1.4	1.1
DEPENDENT CHILDREN*		
% 0 Dependent Children	29.8	30.0
% 1 Dependent Child	28.0	27.2
% 2 Dependent Children	28.7	29.8
% 3 or More Dependent Children	13.5	13.0
DEPRIVATION**		
% Quintile 1 (Most Deprived)	22.7	14.7
% Quintile 2	20.3	18.9
% Quintile 3	18.6	21.2
% Quintile 4	17.1	22.7
% Quintile 5 (Least Deprived)	21.2	22.5
* Based on National Census Data for Local Authority of Maternity Units		
** Based on the Index of Multiple Deprivation for the Local Authority of Maternity Units		

There was a fairly even distribution of type and size of maternity unit (Tables 17 and 18). However there were no GP led maternity units included in the study sample as none of the GP units that responded had a database or used routine electronic data collection. The size of the maternity unit was based on the number of births per year, where a small maternity unit has <1000 births per year, a medium sized maternity unit has between 1000-3000 births per year, and a large maternity unit has >3000 births per year (Birthchoice UK).

Table 17 Type of Maternity Units: Study Sample Compared to England

	Study Sample	England
TYPE OF UNIT	%	%
Consultant & Midwifery Led Unit	13.3	13.6
Consultant Led Unit	68.9	62.1
Midwifery Led Unit	17.8	22.2
GP Led Unit	0.0	2.1

Table 18 Size of Maternity Units: Study Sample Compared to England

	Study Sample	England
SIZE OF UNIT	%	%
Large	42.2	39.5
Medium	40.0	37.0
Small	17.8	23.5

In terms of geographical distribution, the proportions of maternity units included in the study sample were not closely representative of the distribution of maternity units in England within specified Government Office Regions (GOR) (Table 19).

Table 19 Geographical Representation of the Maternity Units: Study Sample Compared to England

	Study Sample	England
GOR	%	%
East Midlands	2.2	6.6
East of England	4.4	10.3
London	13.3	12.8
North East	11.1	6.6
North West	11.1	13.2
South East	40.0	17.7
South West	6.7	12.8
West Midlands	4.4	9.9
Yorkshire and the Humber	6.7	10.3

The North East and South East GORs were over represented in the study sample, with under-representation for the East Midlands, East of England, South West, West Midlands and Yorkshire and Humber. The differences in the representation for the different GORs was largely due to the constraints of whether the maternity units used routine electronic data collection; however there is a possibility of bias in the over-representation of the North East maternity units due to a number of factors. Firstly the location of the research collaboration conducting the research is in the

North East of England, with established contact between the maternity units and the University of Teesside, the NEPHO, and the Regional Maternity Survey Office (RMSO) in Newcastle which may have encouraged an over-representation of these maternity units to respond to the invitation to be involved in the study. In addition to this, the same research team had previously carried out qualitative research with all maternity units in the North East region which involved face-to-face contact with many of the heads of midwifery and consultant obstetricians that were invited to participate, further establishing these links (Heslehurst et al., 2007b). However, despite the differences in the geographical distribution among the study sample and England GORs, there was representation of each GOR in the study sample, which was considered to be sufficient.

3.6 Research Governance

Research Governance requirements for conducting this multi-centre study included an ethics application to a multi-centre research ethics committee (MREC), and R&D applications to all NHS Trusts for the maternity units included in the sample.

3.6.1 Ethical Approval

NHS National Research Ethics Service (NRES) applications for the MREC application were submitted to the University of Teesside School of Health and Social Care ethics committee in October 2006, pending the list of maternity units to be included in the final sample. Ethical approval was granted from this committee on 28/02/2007 (Appendix 16).

The MREC application was subsequently submitted to the Sunderland MREC in April 2007 including the list of maternity units that had agreed to participate in principle (Appendix 17). A favourable ethical opinion was granted from this committee on 22/05/2007 (Appendix 18). The MREC committee ethical review of research sites considered that this application was site specific assessment exempt and therefore no additional LRECs would need to be informed of this study or any additional approval sought.

3.6.2 R&D Approval

The R&D approval process involved submitting R&D applications to all NHS Trusts where the maternity units had agreed in principle to participate. This involved 49 maternity units belonging to 32 NHS Trusts. Standard R&D application packs were prepared (Appendix 19), including:

- A standard covering letter
- The site specific information form for the relevant R&D committee
- Sections A&B of the ethics form and accompanying documents submitted to the ethics committee, including:
    - The MREC provisionally approved subject to amendment letter dated 08/05/2007
    - The cover letter to the MREC
    - The University of Teesside School of Health and Social Care Ethical Approval letter
    - Research protocol
    - A copy of the questionnaire sent out in the national survey
    - The coding to be used in the data analysis
    - Curriculum vitae for the chief investigator and the principle investigator
    - The University of Teesside indemnity cover letter
    - Copies of the ethical approval letters from the pilot study
- Correspondence to MREC following the provisional approval subject to amendment
- Final approval letter from MREC
- Other R&D associated documentation, including:
    - A sponsor letter from the University of Teesside
    - A letter confirming funding was being provided for the research by the University of Teesside
    - A letter of peer review from the School of Health & Social Care Research Degrees Committee confirming that the study has been reviewed as being at a PhD level

A list of the R&D contacts in each NHS Trust was accessed via the NHS R&D forum website (http://www.rdforum.nhs.uk/) and all NHS Trusts were contacted in advance of submitting the application to establish if there was any additional paperwork required for that NHS Trust. This resulted in two NHS Trusts declaring that as this was an off site study with no patient contact they considered this to be an audit and therefore they were happy to allow the study to commence without submitting the documentation; however a copy of the protocol and ethical approval letter was sent to them before receiving written confirmation that they were happy for the study to go ahead. The remaining 30 NHS Trusts that did require R&D applications had varying levels of information requirements (Table 20).

Table 20 R&D Requirements for Submission of an Application

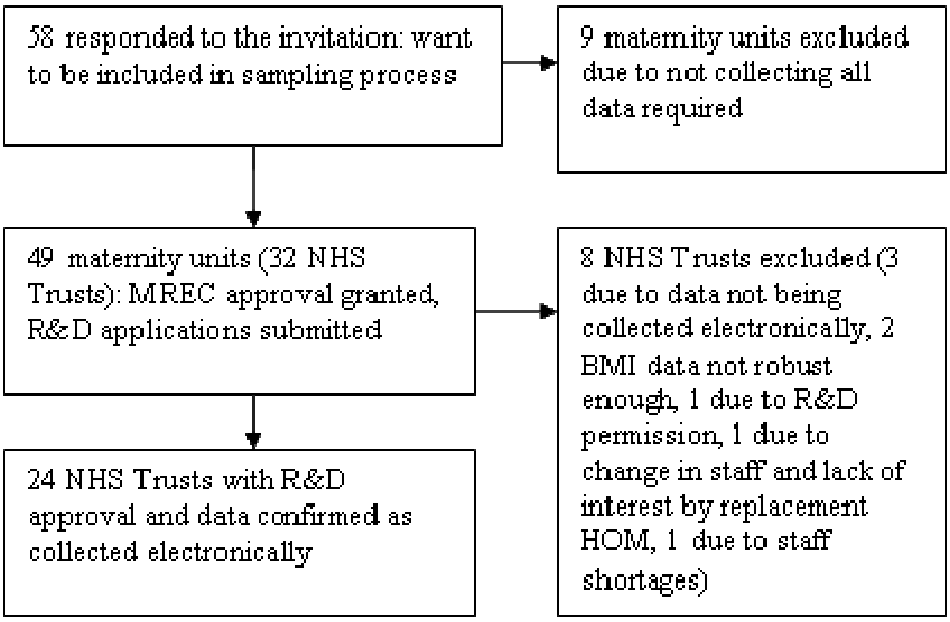
Additional Forms Required	n
Caldecott Form	1
Copy of the response to the Invitation to Participate	1
Data Protection	3
Details of implications to the Trust	1
Financial compliance	1
Funding form	2
Peer review	5
Permission to proceed with study form	1
Principle investigator agreement	1
Project registration form	3
R&D checklist	5
Signed CVs of all co-applicants and local collaborator	1
Sponsor form	9
Who would host the overall study	1
Total	35

Ten of the NHS Trusts did not require any additional information to be sent with the application, and there were 35 additional documents required for the remaining 20 NHS Trusts. Nine had a separate sponsor form to be completed even though there was a sponsor letter included in the standard pack, and five required some form of peer review to be completed, whether that was a form or a report. However, when I explained that the study was a multi-disciplinary study across three agencies

(University of Teesside, NEPHO, and the RMSO), that it had been through a research degrees committee and two ethics committees, the pilot study had been approved by two ethics committees and an R&D committee, and had been published in a high impact peer reviewed journal (evidence of all of these factors included in the application pack), none of the R&D committee contacts felt it was appropriate to ask for the additional peer review information and agreed that the documents provided would suffice.

The R&D application process commenced in May 2007 following receipt of the MREC approval letter, and R&D approval was granted for all but one NHS Trust by April 2008. The one NHS Trust where R&D approval was not obtained was due to the local collaborator at the site leaving before the R&D process was complete and the replacement head of midwifery (HOM) was not interested in participating, therefore the application was not signed off and this site was excluded (Figure 28).

Figure 28 Final sampling and Research Governance



A further seven NHS Trusts were excluded following R&D approval. The reasons for exclusion included NHS Trusts not actually collecting the required data that they thought was being collected electronically; the data not being in an accessible format for exporting from the database; because of staff shortages; another local collaborator having left the site following R&D approval and the new HOM not being interested in participating; and the BMI data not being recorded robustly enough in the database. With reference to the last point, one NHS Trust sent a summary which showed how frequently the BMI was recorded on the database across two maternity units within their Trust (Table 21), where the BMI was only recorded in 0.1% of bookings in 2007, and 0.5% of bookings between 2004-2006.

Table 21 BMI Records in One NHS Trust Excluded from the Study Sample

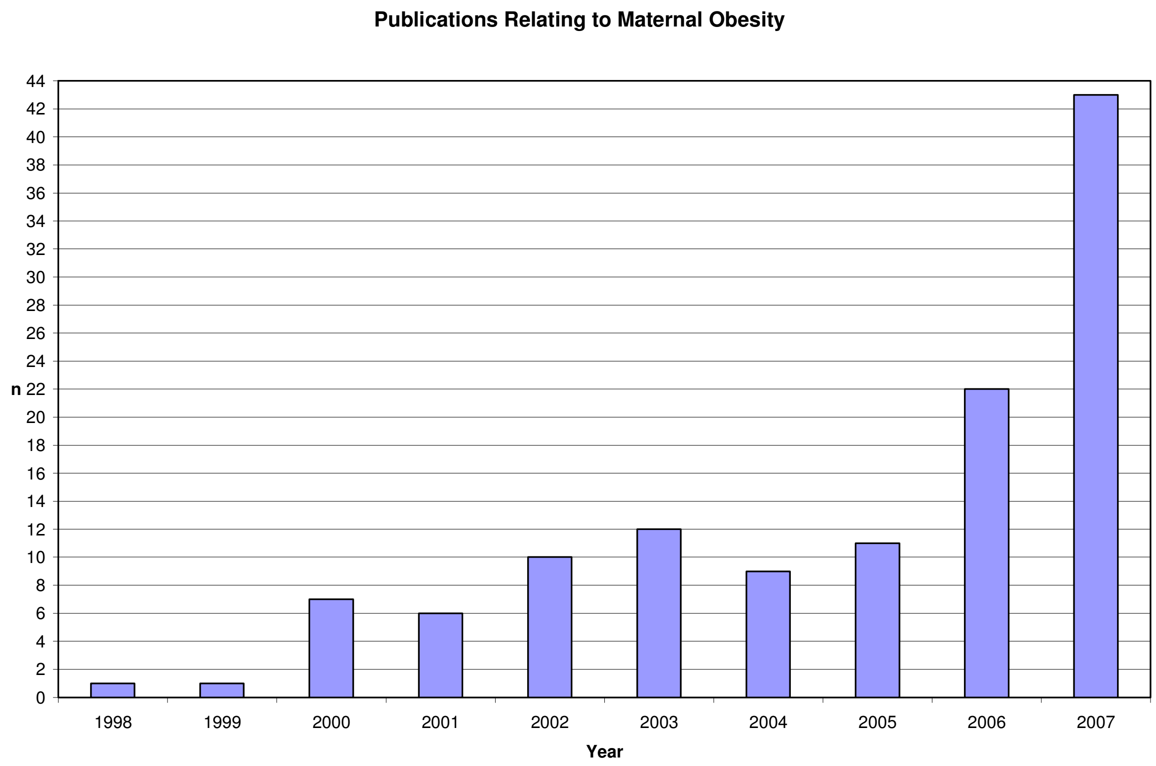
2007	Site 1	Site 2
Bookings	6252	5367
Height Only	59	7
Weight Only	1	7
Height and Weight	3	7

2004, 2005, 2006	Site 1	Site 2
Bookings	18500	15000
Height and Weight	10	213

3.7 Discussion

The response to the postal survey was high, with the Total DM consistently averaging a 70% response rate (Dillman, 2007); the overall response for the survey was 89%. A similarly high response rate was seen in a postal survey carried out in 1997 to identify the issues around data collection in NHS maternity units with an 81% response rate (Kenney and Macfarlane, 1999). This high level of response could be due to a number of factors. Firstly the Tailored DM was adopted with the mixed-mode design giving the respondents the opportunity of returning the questionnaire via an electronic format, and the evidence base for increasing response was reviewed in the development of the questionnaire. In addition to the design of the survey, the interest in maternal obesity could be particularly high among the respondents as previous research has highlighted maternal obesity as being an important issue for practice among midwives and obstetricians (Heslehurst et al., 2007b). There has also been a dramatic increase in publications relating to maternal obesity over the past ten years. Figure 29 shows the history of journal publications relating to maternal obesity when searches were carried out in Medline and Cinahl using the key search terms “maternal obesity” or “obes* pregnan*” in the titles of publications. The increase from one publication in 1998 to 43 publications in 2007 highlights the growing interest in the topic among researchers, and this could potentially have had some impact on the response rate among HCPs working in the field.

Figure 29 Publication History of Maternal Obesity Research over Ten Years (1998-2007)



Despite the high response rate among the survey respondents, there was a fairly low response when the invitation to participate in the study was sent out, with only 48% responding to the invitation to participate, and 43% wanting to participate. The issue of collating maternity data on a national level has been reported elsewhere, where although it is acknowledged that there is a high level of data collected in maternity services locally, the availability of nationally comparable data is low for a number of reasons: the low priority for NHS Trusts to contribute to national level data (Smith, 1998); the variations in the way data are recorded with computerised records only being available in 63% of maternity units in England (Kenney and Macfarlane, 1999); the requirement for the Department of Health to receive data in a standardised format via the Patient Administration System (PAS) whereas only 10% of maternity systems could transfer their data to PAS; the variations in the definitions used for different data items across NHS Trusts (Steer, 2002); and inadequacies in data collection practice (Macfarlane, 1998). Although the reasoning behind the low priority for contribution to nationally representative data may no longer be the case due to the collation of datasets on various maternal and child health issues through the CEMACH, it could have been a contributing factor in this study with respect to the low response in willingness to participate. The issues with inadequacy of data collection may have been another contributing factor where NHS Trusts have the capacity to record BMI electronically, but in practice do not do so to an acceptable level, as highlighted by two NHS Trusts in this survey when preliminary exploration of the data required was carried out.

The differences between NHS Trust practices were also seen with the research governance requirements for the multi-centre study. Despite the successful and streamlined ethical approval experience for this multi-centre study, others have experienced a more complex ethical approval process. The differences in legislation between England and Scotland have made it difficult to cross geographical boundaries when conducting multi-centre research, and research of routinely collected data, is often “re-badged” as audit to avoid the ethical approval procedure (Warlow, 2004). The complexity of the NHS ethics application form has been criticised for being too lengthy and ill suited to many types of research such as epidemiology, analysis of routinely collected data and qualitative research (Jamrozik, 2004), with true ethical questions being few and far between, and the form serving more as an obstruction to research and a waste of resources that could have been put to better use elsewhere (Wald, 2004).

The extremes in variation between the R&D processes across different NHS Trusts in England have also been experienced by others. The Research Governance Framework (RGF) was established in 2001 and updated in 2005 to “ensure the public have confidence in, and benefit from, quality research in health and social care” (Department of Health, 2005b). Despite the RGF being well recognised as necessary among researchers, having strengthened the procedures for protection of patients and improved strategies for the monitoring and management of projects (Byrne et al., 2005), the implementation of the RGF within NHS Trusts has been criticised for involving complex bureaucracy for approval of research projects (Hill et al., 2005). The main issues identified with gaining R&D approval in multi-centre studies are that it is extremely time consuming, which excessively utilises staff resources, there are differences in the requirements between NHS Trusts due to a lack of a national governing body, therefore making the process decentralised with unclear accountability (Al-Shahi Salmon et al., 2007), making the differences in organisation and practices being contrary to the Department of Health recommendations (Hill et al., 2005). The familiarity of NHS Trusts with the research governance procedures documented is also varied. Some NHS Trusts have full awareness and the authority for approval being passed to a committee, while others have little awareness and give immediate verbal approval for research to commence (Elwyn et al., 2005), which is reflective of the findings of this study.

The timescales for gaining R&D approval for this multi-centre study were varied, from immediate approval for one site to 12 months for another, and this variability in timescale is apparent across numerous published studies. Byrne et al (2005) reported a timescale of six months between submission of the first application and receiving the final honorary contract, with the time for processing honorary contracts varying from two to 16 weeks, and the time from R&D meetings to receiving the letters of approval ranging between three to 14 weeks. Hill et al (2005) experienced a 12 month timescale for completion of the research governance procedure, with an average of five months per NHS Trust, Galbraith and Hill (2006) had 11 weeks added to their process due to issues within one NHS Trust, and Elwyn (2005) calculated that 150 days were required for research governance, including both ethics and R&D approval, with a median of 61 days and a maximum of 103 days for the R&D aspect alone. Kielmann et al (2007) had approval from 82% of applications at six months following the initial application, and due to time constraints had to commence the study without chasing up the outstanding applications, potentially causing damage to the design of the study due to administrative delays. The authors also discuss the impact of research governance on the project, stating that the serious delays to the project threatened staff morale, adversely impacted on the timescale for data analysis, reviewing the literature, and preparing for subsequent parts of the study (Kielmann et al., 2007).

Several publications consider the bureaucracy of the research governance process to be potentially harmful to the conduct of research by discouraging good quality multi-centre research from being carried out due to the time constraints. The delays in the administrative process are considered to be unethical to the conduct of the research due to poor organisational processes and inflexibility for different types of projects, with committees indiscriminately applying the same review process to all types of studies, despite the stringent research governance procedures being developed in response to medicinal investigational products, and therefore not being appropriate to apply to all research applications (Al-Shahi Salmon et al., 2007, Hill et al., 2005, Kielmann et al., 2007). Kielmann et al (2007) reported that the research governance administration utilised 318 staff hours, despite it being a low risk study involving only a telephone call with health service managers. The cited delays in obtaining R&D approval largely relate to the duplication of workload, such as obtaining honorary contracts, occupational health checks, proof of immunisations, and criminal records bureau checks for each NHS Trust even though there would be no patient contact, and the requests from some NHS Trusts for further information, including forms specific to the individual site that were required to process the application requesting the same information that had been provided in another format in the application pack (Galbraith and Hawley, 2006, Hill et al., 2005, Kielmann et al., 2007). One study identified that the duplication of work for a non-invasive study required the application to be approved by six committees and more than 60 people who read over 2000 pages of documents (Byrne et al., 2005). Therefore the authors identified that the duplication of workload does not end with the researchers and their duplication of applications and information, but also once the application is submitted, the duplication of workload among the various committees then continues. Kielmann et al (2007) suggest that the system should evolve to incorporate a lead R&D committee for multi-centre studies to classify projects as high, medium or low risk according to agreed criteria, as has been the case with the MRECs, and this would seem to be a sensible step forward in terms of reducing the duplication of workload, the inconsistencies between R&D committees and to help reduce the time taken to gain approval for multi-centre studies.

Chapter Four
National Study to Identify Trends in Maternal BMI Incidence and the Demographic Predictors of Maternal Obesity in England

4.1 Objective

This chapter describes the creation of a nationally representative dataset based on the pilot study described in chapter 2, including data from the NHS Trusts in England with the required electronic data and R&D approval as described in chapter 3. This chapter will discuss the differences in the methodology used in this study compared to the pilot study, trends in BMI groups over time on a national and regional level, demographic predictors of those women most at risk of being obese in pregnancy, and any potential health inequality issues with regard to access to maternity services.

4.2 Methods

4.2.1 Data Collection

Instructions on the data requirements and secure data transfer were posted to all NHS Trusts recruited into the final sample. The instructions were based on a generic letter outlining the specific data items required, the time range they were required for, and the contact details for data transfer (Appendix 20). This letter was adapted when necessary for any NHS Trusts where the R&D committees had outlined specific requirements for the transfer of the data, such as sending the postcode data through separately to be merged at a later date for increased data security. The data was required for all complete years of electronic data collection within the maternity units from January to December, based on the date of delivery, and including 2007. The data required for inclusion in the study included:

- Mother’s height
- Mother’s weight at booking
- Mother’s BMI at booking (if BMI was not available then both height and weight at booking needed to be provided to allow for calculation of the booking BMI)
- Mother’s age
- Mother’s ethnic group

- Mother's marital status
- Mother's employment status
- Parity
- Postcode during pregnancy
- Date of booking appointment
- Stage of pregnancy at booking
- Date of delivery
- Gestational age at delivery (if stage of pregnancy at booking was not available then date of delivery, date of booking, and gestational age at delivery needed to be provided to calculate stage of pregnancy at booking)

The deadline for the data to be transferred was the 28th February 2008, and a secure email address with unlimited storage capacity was created for the data transfer (NMOS@tees.ac.uk). All the emailed data was sent in password protected files with the password sent to an alternate email address (n.heslehurst@tees.ac.uk). Those NHS Trusts that required the data to be encrypted sent the data through a secure courier on a password protected disk. The final dataset was received on the 11th April 2008.

4.2.2 Data Coding

The data provided by the maternity units were not coded uniformly at source and required recoding to make the data comparable across NHS Trusts. The deprivation data were coded as per the pilot study using the postcode to map to the IMD (Index of Multiple Deprivation, 2007) [10] which combines weighted domain scores, using the following weights:

- Income (22.5%)
- Employment (22.5%)
- Health Deprivation and Disability (13.5%)
- Education, Skills and Training (13.5%)
- Barriers to Housing and Services (9.3%)
- Crime (9.3%)
- Living Environment (9.3%)

[10] Previously 2000 Indices of Multiple Deprivation were used

The IMD rank of deprivation at Lower Super Output Area (LSOA) in England was used, where each LSOA has a population range of 1,000-3,000 with an average of 1,500 people. The rank of deprivation ranges from 1 (most deprived) to 32,482 (least deprived), and quintiles for the study group were defined in equal proportions where the most deprived quintile 1 ranged from 1-6,496, quintile 2 from 6,497-12,993, quintile 3 from 12,994-19,489, quintile 4 from 19,490-25,986, and the least deprived quintile 5 from 25,987-32,482.

The ethnic group data were also coded as per the pilot study, using the national census groups White, Asian or Asian British, Black or Black British, Mixed, and Chinese or Other Ethnic Group. As the majority of the ethnic group data were provided in detail the ethnic subgroups could also be coded and therefore additional categories were coded as per the census subgroups:

- White:
  - British, Irish, Other White
- Asian:
  - Bangladeshi, Pakistani, Indian, Other Asian
- Black:
  - African, Caribbean, Other Black
- Mixed:
  - White and Asian, White and Black African, White and Black Caribbean, Other Mixed
- Chinese or Other:
  - Chinese, Other Ethnic Group

The employment data were coded based on whether the women were economically active as defined by the national census data, with subgroups for those who were not economically active. The economically active groups were '*employed*' (including full time, part time, self employed, in vocational training and voluntary workers), and '*higher education*' (including anyone in university or college education aged 18 years or above). The economically inactive groups were '*not employed*' (including anyone unemployed[11] or registered as medically unfit for work), '*housewife or carer*', and '*school or education under 18 years*'.

It was not possible to collate and code the marital status data for this study due to the differences in the coding used in the raw data throughout the maternity units. There are two national census tables that the data could have been coded to represent, referring to marital status (Table KS004) and living arrangements (Table KS003) (Appendix 21); however neither of these tables could have successfully categorised all of the data as it had been presented due to the differences between the coding of the co-habiting or single status of the woman. The pilot study did not differentiate between someone who was single or co-habiting due to being reliant upon the raw data provided, and this was felt to be a weakness in the interpretation of the results. The KS003 categories (living in a couple or not living in a couple) would have addressed the issue of the interpretation of the results as the factor trying to be measured was an indicator of relationship support during the pregnancy. However a number of maternity units did not differentiate between single and co-habiting and therefore this could not be achieved using the data provided and this demographic was excluded from the analysis due to the possibility of misrepresenting the question being asked.

4.2.3 Exclusion Criteria

The exclusion criteria were largely representative of those followed in the pilot study (Chapter 2, Section 2.2.2, Pages 41-49). Data were excluded when the BMI was missing, or it was not possible to calculate the BMI due to missing height or weight data; when the gestational age at booking could not be calculated due to data entry errors in the dates provided making the difference between booking and delivery dates a negative value; and unrealistic BMIs using the lower limit cut point (Henry, 1990) as per the pilot study. Additional exclusion criteria used in the national study were: an upper BMI limit, the booking gestational cut off, and unrealistic gestational age at booking.

[11] This is not in keeping with the Census data where unemployed is considered economically active, however for the purposes of this study the current economic activity rather than potential economic activity was considered to be important due to the employment coding reflecting the situation at the time of pregnancy.

4.3.2.1 Exclusion Criteria for the Upper BMI Limit

Unlike the lower BMI limit there is no published evidence for a realistic upper BMI limit and therefore this had to be determined in order to exclude any false positives of morbid obesity. The data in the pilot study had very distinct outliers (BMI 98-119,350 kg/m^2). However there was not such a distinction in the pattern of BMI in the collated data for the national dataset (see Figure 30 for overall distribution, and Figure 31 for right tail of the distribution). Due to the absence of obvious outliers in the dataset the upper BMI limit could not be data driven alone. An unrealistic upper BMI limit of 80kg/m^2 was defined using a combination of the data trends (the right tail of the distribution appeared to level off at around this BMI value with a fluctuating increase at a BMI of over 100 kg/m^2), and anecdotal reports from midwives and obstetricians about their experiences of the extremes of BMI they had encountered in clinical practice made this a realistic upper BMI limit.

Figure 30 Overall Distribution of BMI before Exclusions

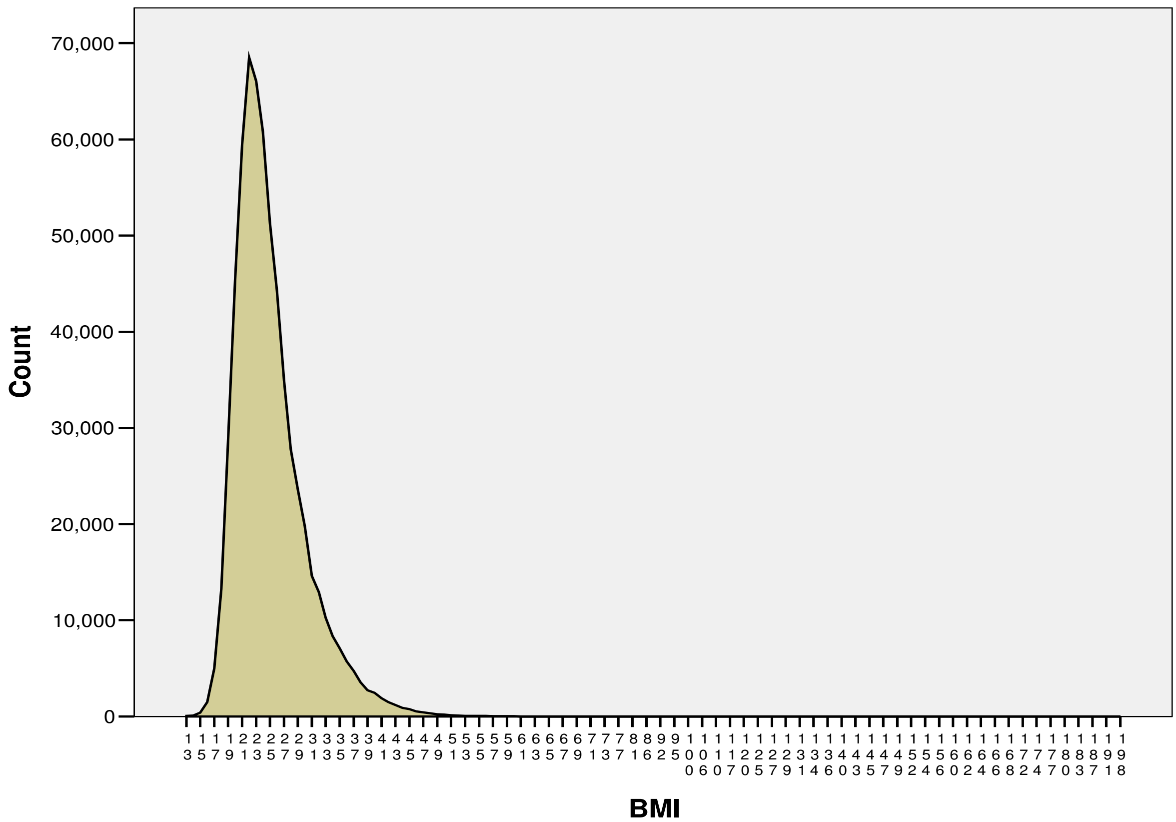
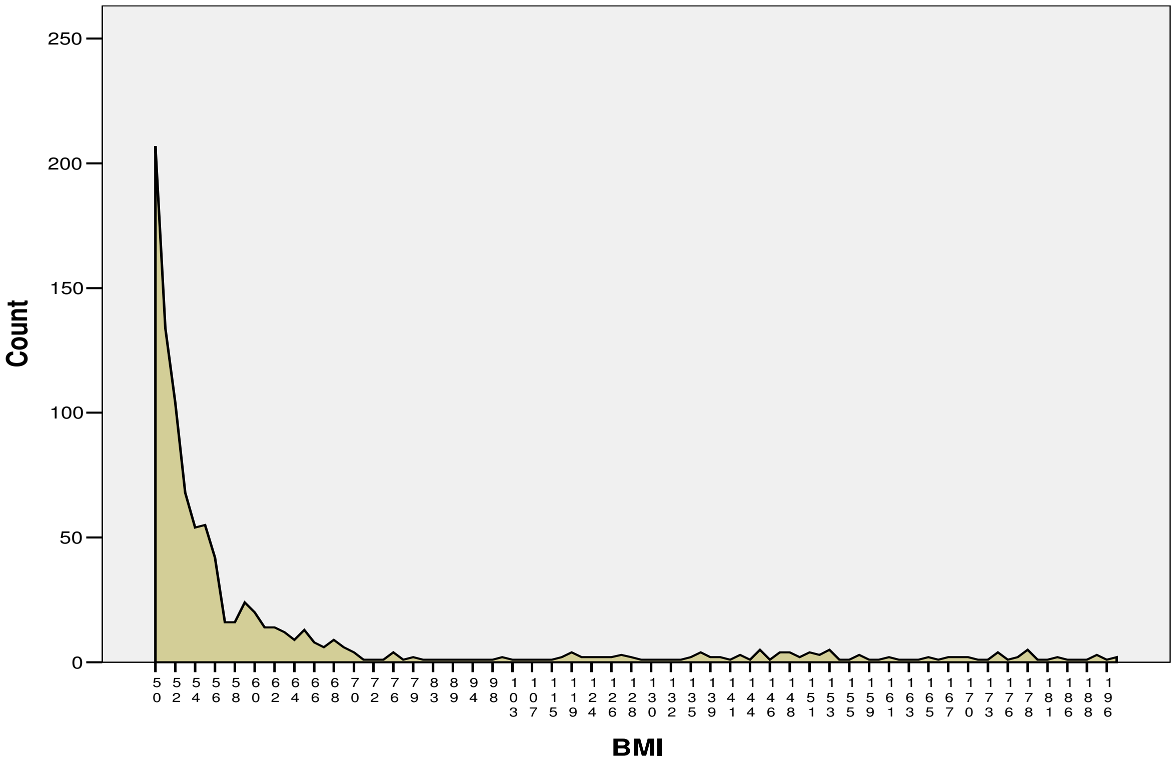


Figure 31 Right Tail of the BMI Distribution before Exclusions



4.3.2.2 Gestational Age at Booking

The pilot study included a booking gestation cut off of 16 weeks to allow the data to reflect the BMI at the start of pregnancy rather than a BMI that had increased due to weight gain during pregnancy. Published data support the view that weight gain during the first 16 weeks of pregnancy should be closely representative of the 1st trimester BMI (discussed in Chapter 2, Section 2.2.2, Pages 41-46).

However, the results of the pilot study showed a lag effect between the incidence of obesity in the pregnant population when compared to the prevalence of obesity in women of childbearing age in the general population (Chapter 2, Figure 18, Page 57). The discussion of the pilot study reasoned that this lag effect may have been a product of potentially excluding some of the obese obstetric population using the 16 week cut off, as the obese population may have been late bookers due to irregular menstrual cycles and changes in body shape/weight not being as noticeable in the early stages of pregnancy, and therefore women may not have identified the pregnancy until a later stage.

As obese women were the priority group for this study it was not considered to be acceptable to potentially exclude data due to late booking, therefore the potential for adjustments for changes in BMI due to late booking gestational age was investigated. The aim of this analysis was to identify if it was statistically acceptable to include adjusted BMIs without positively skewing the data towards increased proportions of obese women in the study population. The adjustments were based on the weekly BMI measures from 5 to 42 weeks gestation as discussed in Chapter 2 (Table 11, Page 45). Table 22 shows the weekly change in BMI from the 1st trimester based on data for the 5th, 50th, and 95th centiles, based on calculations from data provided by Ochsenbein-Kolble et al (2004).

The changes in BMI were subtracted from the booking BMI for all late bookers (women who booked after their 1st trimester; more than 13 weeks). The subtractions were based on the gestational week at booking and the BMI group they were classified as at booking (the subtractions for underweight women were the change in BMI at the 5th centile (c5), for ideal or overweight women the BMI change at the 50th centile (c50)[12], and for obese women the change in BMI at the 95th centile (c95)[13]). Where the adjustments for BMI in late bookers resulted in a change in BMI category, the groups were redefined based on the adjusted BMI data to be reflective of the 1st trimester.

CI analysis was performed to compare the proportions of BMI groups for all 1st trimester bookers (n=355,645), those women who booked in trimester one or two (n=583,579), and all data (n=619,420) (Table 23). The comparison of women who booked in the first two trimesters was carried out to see if the margin of error increased as the gestational age at booking increased.

[12] An additional centile for overweight could not be included as calculations based on the 50th centile data and the SD showed that it was not normally distributed

[13] Additional centiles for extremes of obesity could not be calculated as the paper excluded obesity outliers

Table 22 BMI Change from 1st Trimester with Increasing Gestational Age

		To subtract from booking BMI for:						
Gestational Week	n	BMI c5	Underweight	BMI c50	Ideal or Overweight	BMI c95	Obese	S.D.
5	24	18.3		22.9		31.1		3.5
6	93	18.4		23		31.3		3.6
7	161	18.4		23.1		31.5		3.6
8	160	18.5		23.3		31.7		3.6
9	145	18.6		23.4		31.9		3.7
10	127	18.7		23.5		32.1		3.7
11	98	18.8		23.6		32.3		3.7
12	128	18.9		23.7		32.5		3.7
13	105	19		23.9		32.7		3.8
14	93	19.1	0.1	24	0.1	32.9	0.2	3.8
15	60	19.2	0.2	24.2	0.3	33.1	0.4	3.8
16	55	19.3	0.3	24.3	0.4	33.3	0.6	3.9
17	51	19.4	0.4	24.5	0.6	33.5	0.8	3.9
18	44	19.6	0.6	24.6	0.7	33.8	1.1	3.9
19	39	19.7	0.7	24.8	0.9	34	1.3	3.9
20	48	19.8	0.8	24.9	1	34.2	1.5	4
21	44	19.9	0.9	25.1	1.2	34.4	1.7	4
22	44	20.1	1.1	25.3	1.4	34.6	1.9	4
23	30	20.2	1.2	25.4	1.5	34.8	2.1	4
24	31	20.4	1.4	25.6	1.7	35	2.3	4
25	31	20.5	1.5	25.8	1.9	35.2	2.5	4.1
26	34	20.7	1.7	26	2.1	35.4	2.7	4.1
27	48	20.8	1.8	26.1	2.2	35.6	2.9	4.1
28	46	21	2.0	26.3	2.4	35.8	3.1	4.1
29	43	21.2	2.2	26.5	2.6	36	3.3	4.1
30	45	21.3	2.3	26.7	2.8	36.1	3.4	4.1
31	44	21.5	2.5	26.9	3	36.3	3.6	4.1
32	75	21.7	2.7	27	3.1	36.4	3.7	4.1
33	65	21.9	2.9	27.2	3.3	36.5	3.8	4.1
34	85	22	3.0	27.4	3.5	36.7	4	4.1
35	181	22.2	3.2	27.6	3.7	36.8	4.1	4.1
36	201	22.4	3.4	27.7	3.8	36.9	4.2	4
37	181	22.6	3.6	27.9	4	36.9	4.2	4
38	132	22.7	3.7	28	4.1	37	4.3	4
39	201	22.9	3.9	28.2	4.3	37.1	4.4	4
40	239	23	4.0	28.3	4.4	37.2	4.5	4
41	11	23.2	4.2	28.4	4.5	37.2	4.5	3.9
42	24	23.3	4.3	28.6	4.7	37.3	4.6	3.9

(Calculated from data provided by Ochsenbein-Kolble et al., 2004)

Table 23 Proportion of Women in Different BMI Groups Using 1st Trimester Data and Adjusted BMI Data for Late Bookers

BMI distribution for 1st trimester bookers using raw data

	Frequency	Percent	Lower CI	Upper CI
Ideal	202434	56.9	56.7	57.1
Obese	50862	14.3	14.2	14.4
Overweight	90431	25.4	25.3	25.5
Underweight	11918	3.4	3.3	3.4
Total	355645	100.0		

BMI distribution for 1st and 2nd trimester bookers using the Adjusted BMI data

	Frequency	Percent	Within CI's?	Difference from closest CI
Ideal	334429	57.3	no	0.2
Obese	78729	13.5	no	-0.7
Overweight	147080	25.2	no	-0.1
Underweight	23341	4.0	no	0.6
Total	583579	100.0		0.1

BMI distribution for all data regardless of booking date using the Adjusted BMI data

	Frequency	Percent	Within CI's?	Difference from closest CI
Ideal	353327	57.0	yes	0.0
Obese	81401	13.1	no	-1.0
Overweight	153574	24.8	no	-0.5
Underweight	31118	5.0	no	1.6
Total	619420	100.0		0.1

The CI analysis showed that there were marginal differences between the proportions of women in the different BMI groups when comparing the 1st trimester bookers with the data from all women including late bookers. There was an average difference of 0.1% from the nearest 95% CI when looking at the proportions of women in each BMI group for the 1st and 2nd trimester bookers and the all data. The statistical significance in the CI analysis is unlikely to have any clinical significance due to the marginal differences in proportions, and although the CIs did not overlap in most cases this is likely to be due to the large sample size making the CIs narrow rather than having clinical relevance to the proportions. In addition to this, the adjusted data incurred a positive bias towards increased proportions of women in the underweight group and decreased the proportion of women in the overweight and obese groups. Overall it was considered to be statistically acceptable to use the adjusted BMI data. Additional exclusions were required based on the lower BMI cut off as the subtraction of BMI had reduced some of the data to below the realistic limit.

4.3.2.3 Exclusion Criteria for an Unrealistic Gestational Age at Booking

As the pilot study excluded all booking gestations over 16 weeks, the upper limit for a realistic booking gestation had not previously been considered, whereas using adjusted BMIs in this study meant that this data were not being excluded based on any other factor. Realistically a woman can present and be booked at the onset of labour. The criterion for unrealistic gestational age at booking was decided upon using a combination of clinical guidelines, expertise from clinical practice, and the usual onset of labour timescale. The NICE induction of labour clinical guidelines state that women usually spontaneously go into labour by 42 weeks, and that women should be informed about the risks of prolonged gestational periods and given the options of induction of labour at 41-42 weeks (National Institute for Health and Clinical Excellence, 2008d). However, women are entitled to refuse induction of labour and anecdotal experience of obstetricians and midwives identifies that a small number of women can be overdue by a number of weeks, therefore a gestational age of 44 weeks was considered to be the uppermost cut off point to be realistic.

4.2.4 Data Analysis

4.2.4.1 Trends in Maternal BMI over Time

The data analysis for trends in BMI groups over time was replicated as per the pilot study (Chapter 2, Section 2.2.4.1, Pages 52-53), using χ^2 to identify if there was a significant relationship between the expected and observed values for BMI and year, and χ^2_1 to see if there was a significant trend in the change in proportions of BMI groups over time. The data did not require adjustments for age as there was only two years difference between the highest and lowest $\bar{x}$ age for each year ($\bar{x}$ age 27-29 years, SD 5-6, Table 24), which is unlikely to have any clinical significance.

Table 24 Mean Age by Year

		Age	
		Mean	Standard Deviation
Year	1989	28	5
	1990	28	5
	1991	27	5
	1992	27	5
	1993	28	5
	1994	28	5
	1995	28	5
	1996	28	6
	1997	28	6
	1998	28	6
	1999	29	6
	2000	29	6
	2001	29	6
	2002	29	6
	2003	29	6
	2004	29	6
	2005	29	6
	2006	29	6
	2007	29	6

There were some differences in the ethnic group data. The first six years (1989 – 1994) had a high proportion of missing ethnic group data, whereas from 1995 onwards the data was fairly consistent in overall proportions and trends. The proportion of White women was approximately between 70-80% year on year, with the exception of 2000 where it drops to 61%. The proportion of Asian or Asian British women was between 6-13%. There was also a gradual increase in the proportions of women in the remaining ethnic groups over time, with Mixed ethnic group increasing by approximately 1% (from 0.4 to 1.5%), Chinese or Other ethnic group increasing by approximately 1.5% (from 1.3 to 2.6%), and Black or Black British increasing by approximately 4% (from 1.2 to 4.9%) (Appendix 22). Due to the high proportions of missing ethnic group data in the years prior to 1995, and the unknown distribution in the proportions of BMI groups within these years, the data could not be adjusted for ethnic group differences.

4.2.4.2 Geographical Distribution of Obesity

The datasets were grouped into geographical region using the Ordinance Survey GOR boundaries. The current trends in BMI groups for each region were calculated using the data for 2007 to identify any regional variation in proportions of maternal obesity (with the exception of the two NHS Trusts that could not provide 2007 data and therefore 2006 data were used). Only data from the most recent year were used to analyse the current geographical trends due to the changing proportions of BMI over time, therefore using data for all the years included in the dataset would not necessarily represent the current trends. Statistical significance in the distribution of BMI Groups was analysed using the χ^2.

4.2.4.3 Demographic Predictors of Maternal Obesity

The data analysis for the demographics of women at risk of being in different BMI groups in their 1st trimester was carried out as per the pilot study (Chapter 2, Section 2.2.4.2, Page 53-54). All predictor variables were tested for an independent association with BMI group using the χ^2 (Appendix 23). The data were coded into dummy variables (Appendix 24) and multicollinearity tests were carried out using linear regression diagnostics to test for VIF, C.I., and VP[14], and Pearson's r correlation tests. No multicollinearity was present between the predictor variables (Appendix 25) and therefore all predictor variables were included in the final regression model. The logistic regression analysis was carried out using the overall ethnic group data, and further analysis was carried out using the ethnic subgroups. The analysis was also carried out for obesity including all data where the BMI>30kg/m^2, and for the obesity subgroups of moderate (30.0-34.9 kg/m^2), severe (35.0-39.9 kg/m^2), morbid (40.0-49.9 kg/m^2), and super morbid (>50.0 kg/m^2) obesity.

4.3 Results

Data were provided for 738,307 women in total (Appendix 26). Following exclusions, 619,323 cases remained. The characteristics of the included population are described in Table 25.

[14] Multicollinearity is deemed to be present when the VIF ≥10, the C.I. >30 and the VP >50% in two or more cases.

Table 25 Characteristics of the Included Population

	Total (n= 619,323)		Underweight BMI (kg/m^2) >18.5 (n= 31,021)		Ideal BMI (kg/m^2) 18.5-24.9 (n= 353,327)		Overweight BMI (kg/m^2) 25-29.9 (n= 153,574)		Obese BMI (kg/m^2) >30 (n= 81,401)		Moderately Obese BMI (kg/m^2) 30-34.9 (n= 53,563)		Severely Obese BMI (kg/m^2) 35-39.9 (n= 19,213)		Morbidly Obese BMI (kg/m^2) 40-49.9 (n= 7,969)		Super Morbidly Obese BMI (kg/m^2) >50 (n= 656)	
Age (mean, SD)	28.7	6	26.3	6.1	28.6	6.0	29.3	5.8	29.3	5.8	29.2	6	29.3	5.7	29.5	5.6	30.2	5.9
Parity (mean, SD)	1.1	1	1.0	1.2	1.0	1.2	1.2	1.3	1.4	1.4	1.3	1	1.4	1.4	1.5	1.4	1.5	1.5
Ethnic Group Code (n, %)																		
White	447423	83.2	20651	4.6	254883	57.0	110566	24.7	61323	13.7	39627	8.9	14814	3.3	6363	1.4	519	0.1
Asian or Asian British	50738	9.4	4181	8.2	28320	55.8	12967	25.6	5270	10.4	3905	7.7	1043	2.1	300	0.6	22	0.0
Black or Black British	22525	4.2	977	4.3	9639	42.8	7273	32.3	4636	20.6	3121	13.9	1048	4.7	434	1.9	33	0.1
Mixed	5962	1.1	430	7.2	3376	56.6	1400	23.5	756	12.7	491	8.2	178	3.0	74	1.2	13	0.2
Chinese or Other Ethnic Group	11394	2.1	1046	9.2	7144	62.7	2334	20.5	870	7.6	639	5.6	145	1.3	76	0.7	10	0.1
Employment Code* (n, %)																		
Employed	262504	42.4	10035	3.8	149861	57.1	67400	25.7	35208	13.4	23315	8.9	8288	3.2	3356	1.3	249	0.1
Not Employed	44411	7.2	3549	8.0	25034	56.4	9747	21.9	6081	13.7	3887	8.8	1486	3.3	644	1.5	64	0.1
Higher Education	8042	1.3	539	6.7	4654	57.9	1876	23.3	973	12.1	666	8.3	220	2.7	80	1.0	7	0.1
School Age/Education Under 18 yrs	5087	0.8	635	12.5	3563	70.0	665	13.1	224	4.4	160	3.1	50	1.0	13	0.3	1	0.0
Housewife/Carer	92892	15.0	5773	6.2	49790	53.6	23205	25.0	14124	15.2	9017	9.7	3421	3.7	1554	1.7	132	0.1
IMD Quintile (n, %)																		
1 Most Deprived	136368	22.9	8204	6.0	71171	52.2	34604	25.4	22389	16.4	14262	10.5	5539	4.1	2371	1.7	217	0.2
2	119606	20.1	6373	5.3	64566	54.0	30821	25.8	17846	14.9	11391	9.5	4379	3.7	1922	1.6	154	0.1
3	110026	18.5	5249	4.8	62419	56.7	27715	25.2	14643	13.3	9813	8.9	3364	3.1	1362	1.2	104	0.1
4	104074	17.5	4578	4.4	62030	59.6	25548	24.5	11918	11.5	8006	7.7	2721	2.6	1098	1.1	93	0.1
5 Least Deprived	125450	21.1	5381	4.3	78077	62.2	29511	23.5	12481	9.9	8613	6.9	2728	2.2	1064	0.8	76	0.1
Gestation Week (mean, SD)	14.0	6.4	19.3	10.3	14.0	6.1	13.6	5.8	13.1	5.5	13.2	6	13.0	5.5	12.8	5.4	13.0	6.4
Late Booking >13 weeks (n, %)																		
No	355618	57.4	11861	38.2	202467	57.3	90414	58.9	50876	62.5	33138	61.9	12136	63.2	5174	64.9	428	65.2
Yes	263705	42.6	19160	61.8	150860	42.7	63160	41.1	30525	37.5	20425	38.1	7077	36.8	2795	35.1	228	34.8

*Employment data not provided by 3 maternity units

The population was predominantly white (83%), with an average age of 29 years, a parity of 1 and there was an even distribution across the deprivation quintiles. The mean gestational age at booking was 14 weeks; however the majority of the population were early bookers (booked in the 1st trimester) (57.4%). It was hypothesised in the discussion of the pilot study (and discussed in the methodology for this study) that there was a potential for the more obese women to be late bookers, whereas the data actually shows an inverse relationship with obesity and late booking, where the highest proportion of late bookers were in the underweight BMI group (61.8%), and the proportion of late bookers decreased as the level of overweight and obesity rose (34.8% in the super morbidly obese BMI group).

The characteristics of the study population were compared with the characteristics of women of childbearing age in the general population using CI analysis of valid proportions (proportions excluding missing data) (Table 26).

Table 26. Comparison of the Study Population and the General Population of Women of Childbearing Age in England

	Proportion in Study Population (95% CI)	Proportion in England
Ethnicity (women aged 15-44)*		
White	83.2 (83.1, 83.3)	88.4
Mixed	1.1 (1.1, 1.2)	1.4
Asian or Asian British	9.4 (9.3, 9.5)	5.6
Black or Black British	4.2 (4.1, 4.3)	3.2
Chinese/Other Ethnic Group	2.1 (2.1, 2.1)	1.4
Employment Status (women aged 16-44)*		
Paid Employment	63.6 (63.5, 63.7)	62.8
No Paid Employment	33.3 (33.2, 33.4)	24.1
Education	3.2 (3.1, 3.3)	13.1
Number of dependent children 0-18 years (women aged <24-49)* #		
0	37.5 (37.4, 37.6)	29.7
1	37.5 (37.4, 37.6)	27.7
2	17.8 (17.7, 17.9)	29.2
3 or more	7.2 (7.1, 7.3)	13.4
Deprivation Quintile (women aged 15-44)^		
Most Deprived 1	22.9 (22.8, 23.0)	21.5
2	20.1 (20.0, 20.2)	21.0
3	18.5 (18.4, 18.6)	19.9
4	17.5 (17.4, 17.6)	19.0
Least Deprived 5	21.1 (21.0, 21.2)	18.5

* Calculated from the 2001 Census data (Census, 2001)
# Number of dependent children used in place of parity
^ Calculated from the 2007 IMD data (Index of Multiple Deprivation, 2007)

The study population had significantly fewer white women included than the general population, and significantly more women from ethnic minority groups, particularly Asian, fewer women in education, more women not in paid employment, more women who have no children or one child, and fewer women who have three or more children. The deprivation distribution is well represented. Again the CIs are small due to the large sample size, and therefore statistical significance is not necessarily clinically significant. In addition to this the IMD and census data of women of childbearing age is not necessarily representative of the obstetric population, and therefore can only be used as an approximation based on the only available national level data for these characteristics.

As the pilot study identified an issue with the high exclusion rate of women from ethnic minority groups, particularly Asian and Black women, and the low inclusion of any ethnic group other than White, the high proportional inclusion of women from Asian and Black ethnic groups was considered to be a positive factor in the population characteristics of the overall sample. The difference between the proportions of women in education was anticipated to be higher in the study group due to the census data only including women over the age of 16, whereas the study group included adolescent pregnancies; however an inverse relationship was found. This difference could potentially be due to more women being in higher education in the general population than in the population of pregnant women in this study, whereas it is possible that those women who do not progress into higher education may be more likely to start a family at a younger age, thus resulting in this inverse relationship.

4.3.1 Trends in Maternal BMI over Time

There was a significant relationship with BMI group and year (χ^2 4158.5, p=0.000, Appendix 23.1), and there was a significant trend in the proportion of women in each BMI group over time (Table 27).

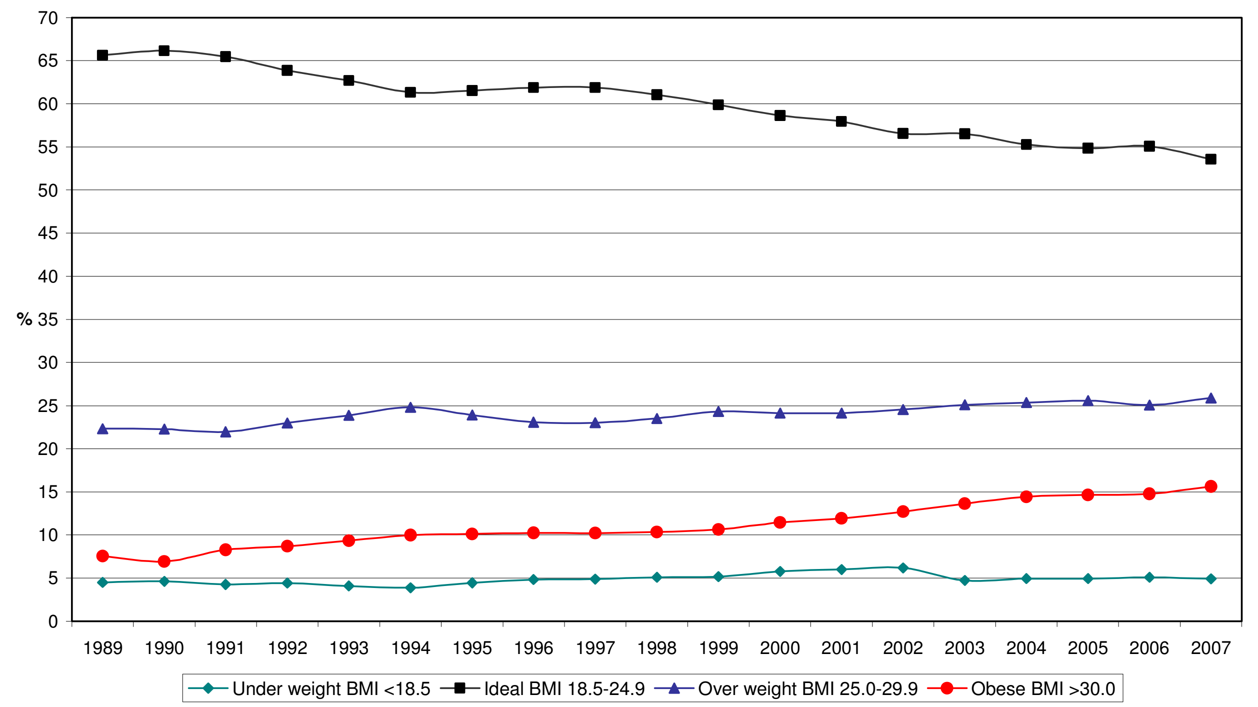
Table 27. Distribution of Women in BMI Groups by Year and CHI Squared Test for Trend

Year	Maternity Units (n)	Sample (n)	Percent							
			Underweight BMI (kg/m^2) <18.5	Ideal BMI (kg/m^2) 18.5-24.9	Overweight BMI (kg/m^2) 25.0-29.9	Obese BMI (kg/m^2) >30.0	Moderately Obese BMI (kg/m^2) 30.0-34.9	Severely Obese BMI (kg/m^2) 35.0-39.9	Morbidly Obese BMI (kg/m^2) 40.0-49.9	Super Morbidly Obese BMI (kg/m^2) >50.0
1989	1	3773	4.51	65.62	22.32	7.55	5.65	1.43	0.42	0.05
1990	2	6092	4.63	66.15	22.28	6.94	5.11	1.46	0.34	0.03
1991	4	13029	4.27	65.48	21.97	8.29	5.74	1.99	0.51	0.05
1992	4	12687	4.43	63.86	23.01	8.70	6.19	1.79	0.66	0.06
1993	5	15775	4.10	62.70	23.87	9.33	6.61	1.94	0.75	0.03
1994	5	15664	3.88	61.33	24.80	10.00	6.93	2.32	0.74	0.01
1995	6	16160	4.44	61.53	23.90	10.12	6.92	2.33	0.79	0.07
1996	6	16371	4.83	61.87	23.07	10.24	6.98	2.25	0.98	0.04
1997	6	16580	4.89	61.87	23.03	10.22	6.89	2.49	0.79	0.04
1998	6	16359	5.09	61.06	23.52	10.34	7.00	2.34	0.96	0.05
1999	6	16253	5.17	59.88	24.32	10.64	7.27	2.41	0.87	0.09
2000	14	24964	5.76	58.65	24.13	11.46	7.72	2.71	0.97	0.07
2001	15	28356	6.01	57.93	24.14	11.92	7.95	2.76	1.15	0.06
2002	17	35311	6.18	56.55	24.56	12.71	8.42	3.01	1.21	0.07
2003	21	54040	4.74	56.53	25.09	13.64	9.10	3.07	1.38	0.10
2004	24	65601	4.94	55.27	25.34	14.44	9.33	3.47	1.52	0.12
2005	26	77169	4.94	54.83	25.59	14.64	9.48	3.55	1.48	0.13
2006	29	86628	5.09	55.06	25.07	14.77	9.55	3.50	1.58	0.14
2007	32	98511	4.93	53.58	25.88	15.61	10.01	3.81	1.61	0.18
Total	34	619323	5.01	57.05	24.80	13.14	8.65	3.10	1.29	0.11
CHI Squared Test for Trend			33.4	2698.4	252.0	2721.4	118.0	18.6	90.0	39.9
p value (1 d.f)			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

There has been a significant increase over time in the proportion of women who are obese, and this has doubled from 8% to 16% over the 19 years studied (χ^2_1 = 2721.4, p<0.001, 1d.f), whilst there has been a decrease of 12% from 66% in 1989 to 54% in 2007 in the ideal BMI group (χ^2_1 = 2698.4, p<0.001, 1d.f). The trends in incidence of maternal BMI group are illustrated in Figure 32 (see Appendix 27 for χ^2_1 calculations).

Although the χ^2_1 for underweight was significant (χ^2_1 = 33.4, p<0.001, 1d.f), the proportion of women in that group has fluctuated over time with a minimum of 3.9% in 1994 and a maximum of 6.2% in 2002, but overall it has remained at around 5%. There was also a significant trend in the incidence of overweight with a gradual increase of 4%, from 22% in 1989 to 26% in 2007 (χ^2_1 = 252.0, p<0.001, 1d.f).

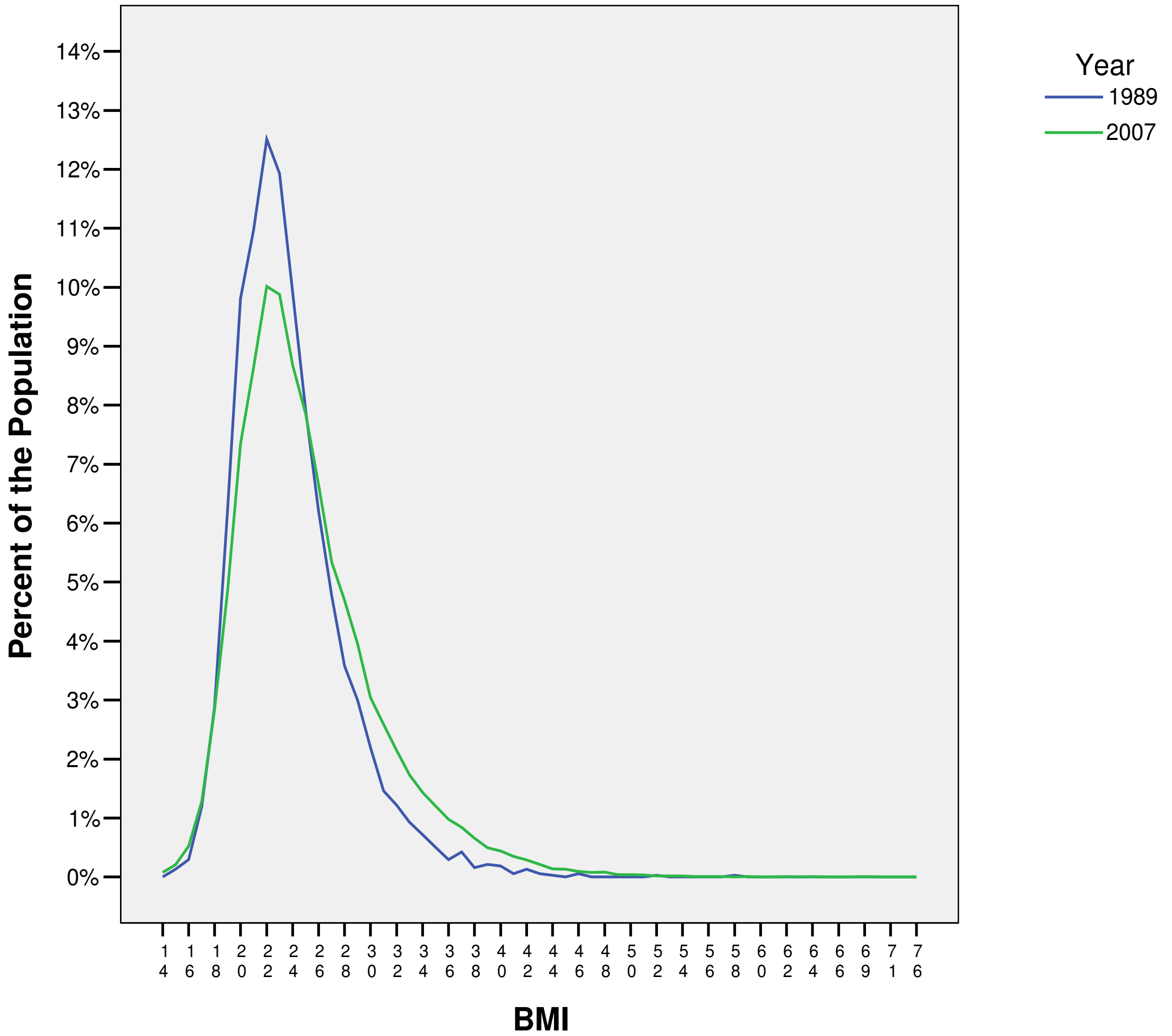
Figure 32. Trends in the Proportion of Women in BMI Groups in their 1st Trimester, Including 619,323 Women over a 19-year Time Period



% Study Population Underweight: 4.5% in 1989, 4.9% in 2007
% Study Population Ideal: 65.6% in 1989, 53.6% in 2007
% Study Population Overweight: 22.3% in 1989, 25.9% in 2007
% Study Population Obese: 7.6% in 1989, 15.6% in 2007

The pregnancy population change in BMI over time between the start and end years of the study is shown in Figure 33, and this illustrates a substantial drop in the ideal BMI range, and a population shift to the right with increasing levels of obesity.

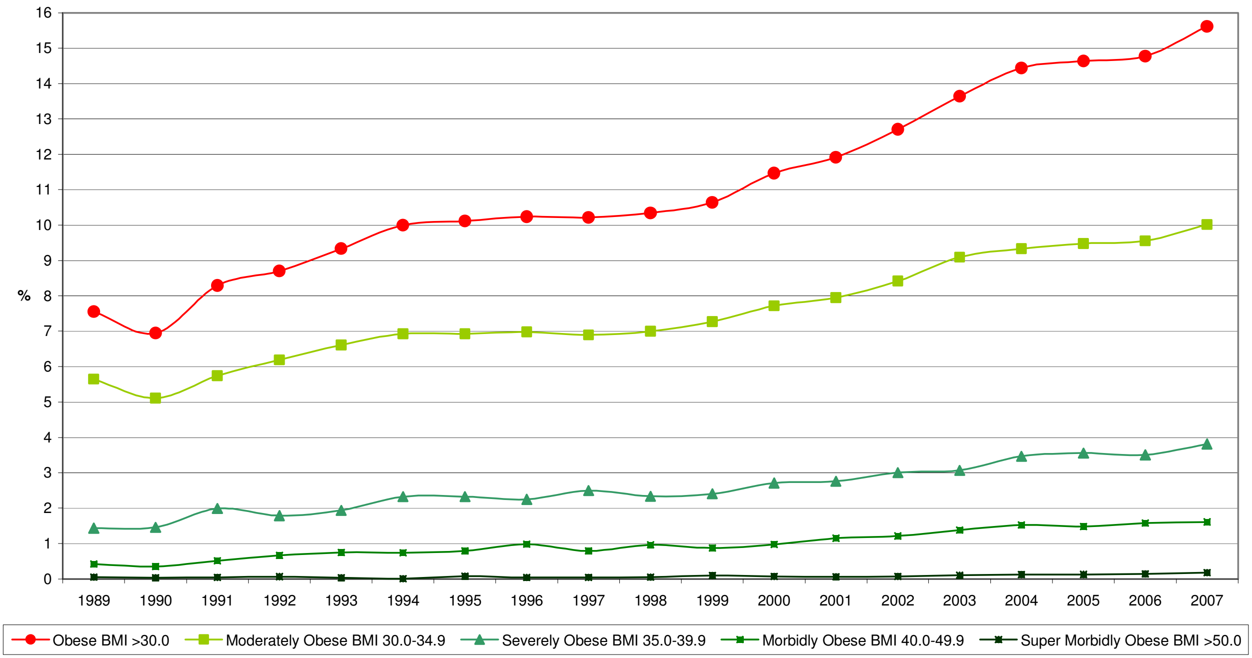
Figure 33. Pregnancy Population Change in BMI between 1989 and 2007



The χ^2_1 also showed a significant trend over time for the obesity subgroups illustrated in Figure 34. The majority of the obese population in this study are moderately obese and there has been a 4.3% increase in the proportion of women in this group in the 1st trimester, from 5.7% in 1989 to 10% in 2007 ($\chi^2_1 = 118.0$, $p<0.001$, 1d.f). The increase in the remaining subgroups is proportionately lower and decreases as the severity of obesity increases, with 2.4% in the severely obese group ($\chi^2_1 = 18.6$, $p<0.001$, 1d.f), 1.2% in the morbidly obese group ($\chi^2_1 = 90.0$, $p<0.001$, 1d.f), and

0.2% in the super morbidly obese group ($\chi^2_1 = 39.9$, $p<0.001$, 1d.f). However, when comparing the ratio of the increase from 1989 to 2007 the relationship is seen to be increasing at the most rapid rate within the morbidly obese group; moderately obese 1.75, severely obese 2.71, morbidly obese 4.0, super morbidly obese 3.6.

Figure 34. Trends in the Proportion of Women in the Obesity BMI Subgroups in their 1st Trimester, Including 81,401 Women over a 19-year Time Period



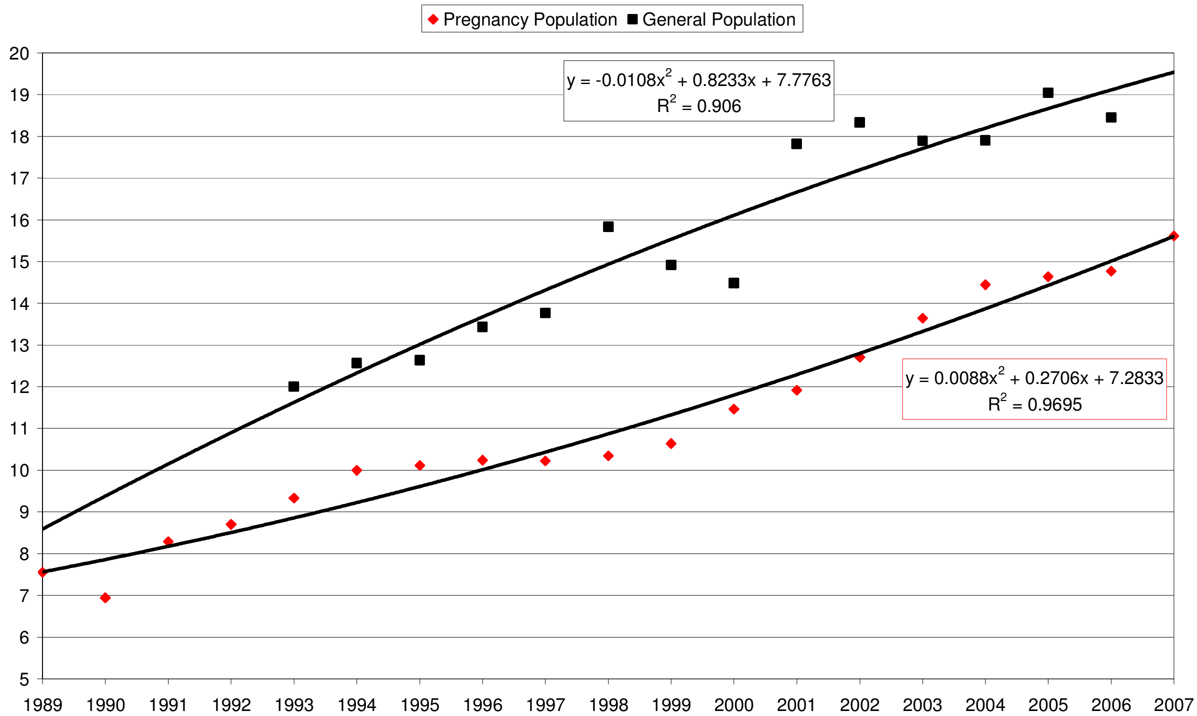
Total Obese: 7.6% in 1989, 15.6% in 2007, CHI Squared test for trend = 2721.4, p<0.001 (1d.f)

Moderately Obese: 5.7% in 1989, 10.0% in 2007
Severely Obese: 1.4% in 1989, 3.8% in 2007
Morbidly Obese: 0.4% in 1989, 1.6% in 2007
Super Morbidly Obese: 0.05% in 1989, 0.18% in 2007

4.3.1.1 Trends in Maternal Obesity Compared to Trends in the General Population of Women of Childbearing Age

The pilot study identified that the increasing incidence of maternal obesity was accelerating over time at a similar rate to that of obesity in women of childbearing age in the general population in England, although the incidence of maternal obesity lagged behind that of the general population. The trends for this study are compared with women of childbearing age using the most recent HSE data (Figure 35).

Figure 35. Trends in Incidence of Maternal Obesity and the Prevalence of Obesity in Women of Childbearing Age (16–44 years) in England's General Population*



*Genereal Population data Source, Health Survey for England 2006 (http://www.ic.nhs.uk/webfiles/publications/HSE06/ADULT%20TREND%20TABLES%202006.xls)

Trend lines were modelled for the data as a time series (with time points from 1-19 being the equivalent of 1989-2007). The obese pregnancy population shows a good fit with a correlation co-efficient value (R^2) of 0.9695. There are however, some slight residual data points. The data shows an almost linear increase in the incidence of maternal obesity between 1989 and 1994 and this appears to plateau to approximately 10% between 1995 and 1999, with an almost linear increase again in the remaining years resulting in a shallow S shaped trend over time. Although these residuals are slight and the R^2 value is high the trend could exist due to selection bias incurred as a result of the data representing a different number of maternity units across the years being studied. The data from 1989 to 1994 represents an increasing number of maternity units in the dataset from one to five, 1995 to 1999 represents the same six maternity units with no additional maternity units' data being included until 2000 when there is a sudden increase to 14 maternity units which steadily increases to 32 maternity units in 2007. Therefore selection bias could help to explain this phenomenon as the data that appears to plateau at 10% represents a static population, with the accuracy of the trend increasing post 2000 where the inclusion of maternity units more than doubles, making the study population demographics more nationally representative.

The pilot study identified similar trends between the pregnancy population and women of childbearing age in the general population, although the trend line for women of childbearing age was reported as being exponential in the pilot study. The addition of subsequent years data to the HSE identified a best fit that indicates the increasing prevalence of obesity in this population may be slowing down (R^2=0.906). In saying this however, both linear and exponential trend lines also have a good fit (R^2=0.902 and 0.904 respectively). Therefore without data for the earlier years for comparison, the true trend is unknown for the general population. Despite the difficulties in identifying the trend for the general population of women of childbearing age, the lag effect between the two populations remains, as with the pilot study.

4.3.2 Geographical Distribution of Maternal Obesity

The NHS Trusts that provided data included representation of all GORs with the exception of the East Midlands region (Table 28). One NHS Trust in the East Midlands was included in the sampling process (Chapter 3, Table 19); however this NHS Trust did not provide any data as it did not record BMI robustly enough to participate (Chapter 3, Table 21).

Table 28. GOR Representation[15]

Government Office Code	Governement Office Region	Number of NHS Trusts
A	NORTH EAST	3
B	NORTH WEST	3
D	YORKSHIRE AND THE HUMBER	3
E	EAST MIDLANDS	0
F	WEST MIDLANDS	1
G	EAST OF ENGLAND	1
H	LONDON	4
J	SOUTH EAST	8
K	SOUTH WEST	2
	Total	25

[15] The number of NHS Trusts is more than 24 as one NHS Trust overlaps two GORs

The data for 2007 (and 2006 for two NHS Trusts not able to provide data for 2007) analysed by geographical region showed a significant relationship with BMI group and GOR (χ^2 = 826.2, p<0.001, 21 d.f., Appendix 23.2). Women living in the West Midlands were most likely to be obese or overweight in pregnancy, while those living in London were most likely to be underweight, and women in the South East were most likely to have an ideal BMI in pregnancy (Table 29).

Table 29. The Proportion of Women in BMI Groups in their 1st Trimester by GOR

	BMI Group							
	Underweight		Ideal		Overweight		Obese	
	n	%	n	%	n	%	n	%
North East	507	5.1%	5167	51.7%	2589	25.9%	1732	17.3%
North West	751	4.7%	8348	52.5%	4315	27.1%	2491	15.7%
Yorkshire and The Humb	436	3.8%	5881	50.8%	3149	27.2%	2105	18.2%
West Midlands	127	2.0%	2953	46.5%	1905	30.0%	1372	21.6%
East of England	155	4.7%	1808	55.1%	798	24.3%	518	15.8%
London	810	6.4%	6972	55.0%	3212	25.3%	1685	13.3%
South East	2120	5.4%	22298	56.6%	9532	24.2%	5424	13.8%
South West	370	4.8%	4231	54.6%	1939	25.0%	1211	15.6%

Analysis of the obesity subgroups identified that women in the West Midlands remained the most likely to be moderately, severely and morbidly obese, and the super morbidly obese women were most likely to live in both the West Midlands and the North East (Table 30), and these results remained significant (χ^2 = 49, p<0.001, 21 d.f).

Table 30. The Proportion of Women in the Obesity BMI Subgroups in their 1st Trimester by GOR

	BMI Subgroup							
	Moderately Obese		Severely Obese		Morbidly Obese		Super Morbidly Obese	
	n	%	n	%	n	%	n	%
North East	1077	10.8%	429	4.3%	199	2.0%	27	.27%
North West	1652	10.4%	614	3.9%	215	1.4%	10	.06%
Yorkshire and The Humber	1338	11.6%	507	4.4%	231	2.0%	29	.25%
West Midlands	863	13.6%	350	5.5%	142	2.2%	17	.27%
East of England	315	9.6%	138	4.2%	58	1.8%	7	.21%
London	1081	8.5%	401	3.2%	179	1.4%	24	.19%
South East	3541	9.0%	1284	3.3%	551	1.4%	48	.12%
South West	767	9.9%	293	3.8%	126	1.6%	25	.32%

Some caution should be noted with the West Midlands results as there was only one NHS Trust included in the sample for this region; however the sample size is substantial for deliveries in 2007 (n=6,357). Again, when interpreting the super morbidly obese group the small sample size should be noted. However, the North East GOR includes three NHS Trusts with a sample size of approximately 10,000 which is again a substantial population size for one year of deliveries.

The incidence of obesity in pregnancy for the GORs were compared with the obesity prevalence in the general population of women using the 2006 HSE data (The Information Centre, 2008a). The comparison shows overall lower rates of obesity in the pregnancy population than in the general population of women for all regions, with a difference of 7.4% in the overall proportion for England, and ranging from a minimum difference of 5.8% to a maximum of 10.7% for the individual GORs (Table 31). The lower rate of obesity in the pregnancy population compared to the general population in this study is similar to the pilot study findings (Chapter 2, Figure 18).

Table 31. Comparison of the GOR Obesity Rates for the General Population of Women and the Pregnancy Population

GOR Code	Name	Women in the General Population	Pregnant Women	Difference in Proportion
		HSE 2006	2007*	
		%	%	%
	ENGLAND	23.0	15.6	7.4
A	North East	28.0	17.3	10.7
B	North West	22.0	15.7	6.3
D	Yorkshire & the Humber	24.0	18.2	5.8
E	East Midlands	27.0	no data	no data
F	West Midlands	29.0	21.6	7.4
G	East	24.0	15.8	8.2
H	London	20.0	13.3	6.7
J	South East	24.0	13.8	10.2
K	South West	23.0	15.6	7.4

*2006 for 2 NHS Trusts

The GOR league table for obesity also shows a different regional pattern of obesity in pregnancy when compared to the general population, although the West Midlands and the North East regions are in the top three for both populations (Table 32).

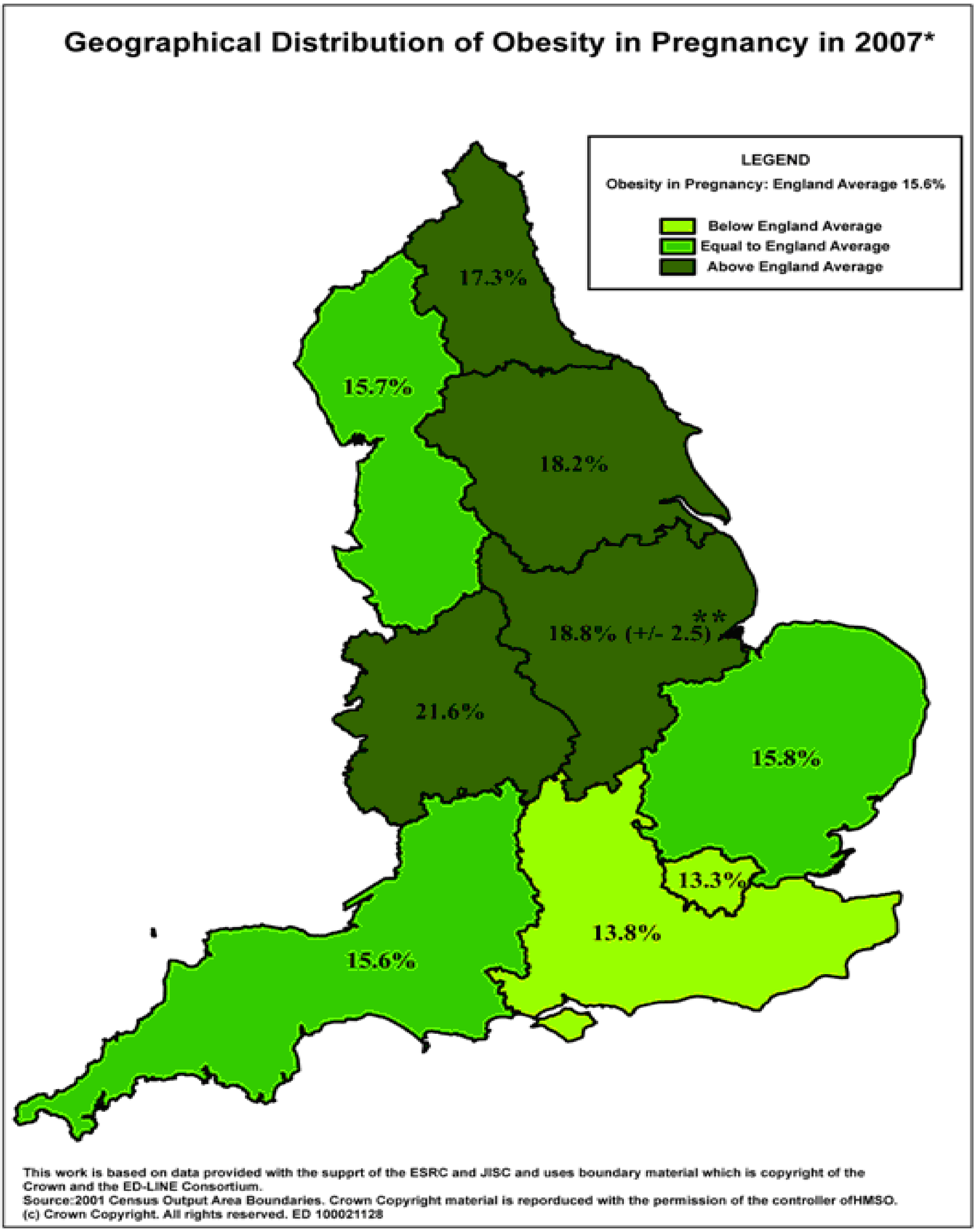
Table 32. League Table for GOR Obesity Rates for the General Population of Women and the Pregnancy Population

Obesity in Women in The General Population: 2006			Obesity in Pregnancy: 2007*		
1	West Midlands	29	1	West Midlands	21.6
2	North East	28	2	Yorkshire & the Humber	18.2
3	East Midlands	27	3	North East	17.3
4	Yorkshire and the Humber	24	4	East	15.8
4	East	24	5	North West	15.7
4	South East	24	6	South West	15.6
5	South West	23	7	South East	13.8
6	North West	22	8	London	13.3
7	London	20		East Midlands	no data

*2006 for 2 NHS Trusts

The East Midlands is the third most obese region for women in the general population, and HSE data shows that it has previously been the region with the highest prevalence of obesity in women (Department of Health, 2004b). However, due to the missing data in the pregnancy population, the two populations cannot be directly compared. Based on the East Midlands general population data, the minimum and maximum differences between the pregnancy and general populations, it is anticipated that the average proportion of obese pregnant women in this GOR would range between 16.3% to 21.2%, with a mean of 18.8%, placing it among the top four obese regions in the pregnancy population. Figure 36 illustrates the GORs with higher than average, lower than average and equal to average incidence of maternal obesity.

Figure 36. Map of Geographical Distribution of Obesity in England using GOR Boundaries[16]



* Including data from 32 maternity units for 2007 deliveries, and 2 maternity units for 2006 deliveries where 2007 data was not available
**No data provided for East Midlands. The proportion was modelled based on the HSE 2006 data for women and GOR, and the differences in proportions for all other GORs pregnancy data compared to the HSE data

[16] The map was produced by Marianne Law at the North East Public Health Observatory

4.3.3 Demographic Predictors of Maternal Obesity

All variables had an independent association with BMI category and no multicollinearity, therefore all were included in the final regression model. The ideal BMI category was used as the reference group, and the white population were the baseline for comparison of ethnic group as this was the majority population (83.2%). Paid employment and residing in the least deprived quintile (5) were used as the reference groups for employment and deprivation, as they were considered to be the most advantageous social circumstance. The adjusted results of the logistic regression analysis using the overall ethnic group categories are shown in Table 33, and the ethnic subgroups in Table 34.

The results show a significant increase in the odds of being overweight or obese with increasing parity, and this trend is seen to rise with increasing levels of obesity up to the point of being super morbidly obese at which point there is no significance. Increasing age also has a relationship with overweight and obesity which remains significant throughout the obesity subgroups, with the most significant relationship with super morbidly obese women (OR 1.07, 95% CI 1.05, 1.09). In contrast with the pilot study however, there is also a significant increased odds of women being older in the underweight group of 1.06 (95% CI 1.06, 1.06) whereas there was a significant inverse relationship with underweight in the pilot study (OR 0.95, 95% CI 0.94, 0.96) (Chapter 2, Table 14).

Overall women who were underweight, overweight, or obese were more likely to be employed (than unemployed, housewives or carers, or in education). This relationship did not remain significant when looking at the subgroups of obesity, where there was an increased odds of women being a housewife or carer if they were morbidly obese (OR 1.09, 95% CI 1.02, 1.17) or super morbidly obese (OR 1.40, 95% CI 1.10, 1.78), and increased odds of being unemployed in women who were super morbidly obese (OR 1.50, 95% CI 1.12, 2.02).

Table 33 Adjusted Regression Analysis for Predictor Variables: Overall Ethnic Group

	Underweight			Overweight			Obese		
	(BMI <18.5kg/m^2)			(BMI 25.0-29.9kg/m^2)			(BMI >30.0kg/m^2)		
	OR	95% C.I.		OR	95% C.I.		OR	95% C.I.	
		Lower	Upper		Lower	Upper		Lower	Upper
Parity	0.99	0.97	1.00	1.09	1.09	1.10	1.17	1.16	1.18
Age	1.06	1.06	1.06	1.02	1.02	1.02	1.02	1.02	1.02
Employed	Reference Group								
Not Employed	0.63	0.60	0.66	0.84	0.82	0.87	0.91	0.88	0.94
Housewife/Carer	0.68	0.65	0.71	0.90	0.88	0.91	0.94	0.92	0.97
Higher Education	0.80	0.72	0.88	0.85	0.80	0.90	0.77	0.71	0.83
School Age/Education Under 18 Years	0.78	0.71	0.86	0.51	0.47	0.56	0.31	0.27	0.36
IMD Quintile 5 (Least Deprived)	Reference Group								
IMD Quintile 4	1.06	1.00	1.11	1.15	1.12	1.18	1.25	1.21	1.30
IMD Quintile 3	1.08	1.03	1.14	1.25	1.22	1.28	1.57	1.51	1.62
IMD Quintile 2	1.07	1.01	1.13	1.39	1.35	1.43	1.97	1.90	2.03
IMD Quintile 1 (Most Deprived)	1.11	1.05	1.17	1.45	1.41	1.49	2.20	2.13	2.28
White	Reference Group								
Asian or Asian British	0.65	0.62	0.68	1.01	0.98	1.04	0.63	0.60	0.66
Black or Black British	0.86	0.78	0.94	1.71	1.64	1.78	1.78	1.70	1.87
Mixed	0.66	0.59	0.75	0.95	0.88	1.03	0.82	0.74	0.90
Chinese or Other Ethnic Group	0.51	0.47	0.56	0.74	0.69	0.79	0.49	0.45	0.54

Table 34 Adjusted Regression Analysis for Predictor Variables: Overall Ethnic Group and Obesity Subgroups

	Moderately Obese			Severely Obese			Morbidly Obese			Super Morbidly Obese		
	(BMI 30.0-34.9kg/m^2)			(BMI 35.0-39.9kg/m^2)			(BMI 40.0-49.9kg/m^2)			(BMI >50.0kg/m^2)		
	OR	95% C.I.		OR	95% C.I.		OR	95% C.I.		OR	95% C.I.	
		Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
Parity	1.16	1.15	1.18	1.18	1.16	1.19	1.19	1.16	1.21	1.07	0.99	1.16
Age	1.02	1.01	1.02	1.02	1.02	1.03	1.03	1.03	1.04	1.07	1.05	1.09
Employed	Reference Group											
Not Employed	0.88	0.85	0.92	0.93	0.87	0.99	1.02	0.93	1.11	1.50	1.12	2.02
Housewife/Carer	0.91	0.88	0.94	0.96	0.92	1.01	1.09	1.02	1.17	1.40	1.10	1.78
Higher Education	0.77	0.71	0.85	0.75	0.65	0.87	0.71	0.56	0.90	0.97	0.45	2.08
School Age/Education Under 18 Y	0.33	0.28	0.39	0.28	0.20	0.38	0.20	0.11	0.36	0.34	0.05	2.43
IMD Quintile 5 (Least Deprived)	Reference Group											
IMD Quintile 4	1.21	1.16	1.26	1.35	1.26	1.45	1.38	1.24	1.54	1.79	1.18	2.73
IMD Quintile 3	1.50	1.44	1.56	1.69	1.58	1.81	1.77	1.59	1.97	2.40	1.61	3.59
IMD Quintile 2	1.76	1.69	1.83	2.36	2.21	2.52	2.63	2.38	2.91	3.59	2.44	5.30
IMD Quintile 1 (Most Deprived)	1.96	1.88	2.03	2.71	2.54	2.89	2.97	2.69	3.29	4.69	3.20	6.87
White	Reference Group											
Asian or Asian British	0.76	0.72	0.79	0.49	0.45	0.54	0.30	0.26	0.35	0.27	0.15	0.48
Black or Black British	1.95	1.85	2.06	1.60	1.47	1.74	1.51	1.34	1.72	1.45	0.96	2.18
Mixed	0.85	0.76	0.96	0.77	0.64	0.93	0.73	0.55	0.97	1.05	0.47	2.37
Chinese or Other Ethnic Group	0.58	0.52	0.64	0.31	0.25	0.39	0.43	0.32	0.57	0.67	0.32	1.43

There were increased odds of women living in the more deprived quintiles throughout all BMI groups when compared with women of an ideal BMI. The relationship with residing in the more deprived areas and obesity is similar to the pilot study, where there was an odds of 2.42 (95% CI 1.96, 2.98) for women living in the most deprived quintile compared with the least deprived quintile, and the current study shows an increased odds of 2.20 (95% CI 2.13, 2.28) for obese women residing in the most deprived quintile. When the subgroups of obesity were explored the relationship with deprivation was seen to increase as the level of obesity increased, with odds of 1.96 (95% CI 1.88, 2.03) for moderately obese, to 4.69 (95% CI 3.20, 6.87) for super morbidly obese women.

There was a significantly reduced odds of women from any of the ethnic groups being underweight compared to white women (Table 33). However, after analysis of the ethnic subgroups, this result was no longer significant for women who were Black African, Black Caribbean, mixed race White and Black African, and Mixed Race White and Black Caribbean (Table 35). The ethnic group Black/Black British was the only ethnic group to have increased odds of overweight (OR 1.71, 95% CI 1.64, 1.78) and obesity (OR 1.78, 95% CI 1.70, 1.87) (Table 33). However, this relationship decreased with increasing levels of obesity, from 1.95 for moderately obese, 1.60 for severely obese, 1.51 for morbidly obese, and the relationship was no longer significant in the super morbidly obese group (Table 34).

The relationship with obesity and ethnic group remained the same when exploring the ethnic subgroups, with Black African, Black Caribbean, and Black Other being the only groups to have a significant increased odds of being obese (BMI>30kg/m^2) (Table 35). This significant relationship was also seen with the obesity subgroups where only Black African, Black Caribbean and Black Other were significantly more likely to be in the moderately and severely obese groups (Table 36). The relationship with obesity subgroups and the Black or Black British ethnic subgroups was not significant for Black African women in the morbidly obese group but remained for Black Caribbean and Black Other, and was not significant for any of the Black or Black British ethnic subgroups in the super morbidly obese BMI group (Table 36).

Table 35 Adjusted Regression Analysis for Ethnic Group Subgroups*

	Underweight (BMI <18.5)			Overweight (BMI 25.0-29.9)			Obese (BMI >30.0)		
	OR	95% C.I.		OR	95% C.I.		OR	95% C.I.	
		Lower	Upper		Lower	Upper		Lower	Upper
White British	Reference Group								
White Irish	0.83	0.64	1.08	0.92	0.81	1.05	0.78	0.65	0.92
Other White	0.70	0.65	0.76	0.81	0.77	0.84	0.60	0.56	0.64
Bangladeshi	0.55	0.50	0.60	0.94	0.88	1.00	0.36	0.32	0.40
Pakistani	0.82	0.76	0.89	1.15	1.10	1.21	0.81	0.77	0.86
Indian	0.56	0.51	0.62	0.86	0.81	0.92	0.52	0.48	0.57
Other Asian	0.52	0.46	0.59	0.91	0.84	0.98	0.61	0.54	0.68
Black African	0.90	0.80	1.01	1.78	1.70	1.88	1.71	1.61	1.81
Black Caribbean	0.86	0.72	1.03	1.55	1.44	1.68	1.83	1.68	2.00
Black Other	0.57	0.45	0.72	1.52	1.33	1.72	1.78	1.54	2.05
White and Asian	0.63	0.46	0.86	0.86	0.70	1.04	0.64	0.49	0.84
White and Black African	1.02	0.63	1.66	1.45	1.17	1.79	1.13	0.87	1.48
White and Black Caribbean	1.12	0.82	1.53	0.87	0.74	1.04	0.92	0.75	1.13
Other Mixed	0.53	0.45	0.61	0.91	0.82	1.01	0.74	0.64	0.85
Chinese	0.35	0.29	0.41	0.39	0.32	0.46	0.11	0.08	0.17
Other Ethnic Group	0.55	0.50	0.61	0.82	0.77	0.88	0.57	0.52	0.63

***Following adjustment for Age, Parity, Employment, and Deprivation**

Table 36 Adjusted Regression Analysis for Ethnic Group Subgroups* and Obesity Subgroups

	Moderately Obese (BMI 30.0-34.9)			Severely Obese (BMI 35.0-39.9)			Morbidly Obese (BMI 40.0-49.9)			Super Morbidly Obese (BMI >50.0)		
	OR	95% C.I.		OR	95% C.I.		OR	95% C.I.		OR	95% C.I.	
		Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
White British	Reference Group											
White Irish	0.81	0.66	1.00	0.76	0.54	1.06	0.46	0.25	0.87	2.84	1.17	6.91
Other White	0.62	0.58	0.67	0.55	0.49	0.63	0.56	0.46	0.67	0.73	0.41	1.31
Bangladeshi	0.49	0.44	0.55	0.18	0.13	0.23	0.12	0.07	0.19	0.16	0.04	0.64
Pakistani	0.96	0.90	1.02	0.70	0.63	0.78	0.44	0.36	0.53	0.14	0.04	0.43
Indian	0.63	0.57	0.70	0.37	0.30	0.45	0.25	0.17	0.36	0.54	0.22	1.32
Other Asian	0.71	0.62	0.81	0.54	0.43	0.67	0.24	0.14	0.40	0.55	0.18	1.71
Black African	1.94	1.82	2.07	1.51	1.37	1.68	1.12	0.95	1.33	1.31	0.79	2.19
Black Caribbean	1.90	1.72	2.11	1.70	1.46	1.98	2.02	1.65	2.48	1.58	0.74	3.37
Black Other	1.78	1.50	2.10	1.54	1.20	1.99	2.39	1.77	3.24	1.77	0.56	5.54
White and Asian	0.71	0.52	0.97	0.64	0.39	1.06	0.27	0.09	0.84	No Data		
White and Black African	1.29	0.95	1.75	0.78	0.45	1.38	0.83	0.37	1.87	4.51	1.43	14.26
White and Black Caribbean	0.83	0.65	1.08	1.01	0.71	1.45	1.28	0.80	2.06	0.85	0.12	6.10
Other Mixed	0.79	0.67	0.93	0.68	0.52	0.89	0.60	0.39	0.93	0.66	0.16	2.67
Chinese	0.12	0.07	0.20	0.04	0.01	0.15	0.26	0.12	0.59	No Data		
Other Ethnic Group	0.67	0.60	0.75	0.37	0.30	0.47	0.45	0.33	0.61	0.83	0.39	1.77

***Following adjustment for Age, Parity, Employment, and Deprivation**

Interestingly, the Mixed White and Black African ethnic subgroup was the only other group to show a positive relationship with obesity, and this was only present for the super morbidly obese group where the odds were 4.51 (Table 36). This result should be interpreted with caution, as the associated CI was broad (95% CI 1.43, 14.26), the number of cases is relatively low for the ethnic group Mixed White and Black African (n = 725 out of 5,962 for Mixed ethnic group), and the total number for this ethnic group within the super morbidly obese group is also low (n = 5 out of 597 women in the super morbidly obese subgroup).

4.3.4 Comparison of Included and Excluded Groups

There were 118,984 cases excluded from the study sample (16.1%). Some individual cases had multiple exclusion reasons; however the overall leading reason for exclusion was not being able to calculate the BMI (88.9%) (Appendix 28). Additional exclusion reasons were not being able to calculate the gestational age at booking (13.6%), having an unrealistic BMI at the lower limit (0.5%), having an unrealistic BMI at the upper limit (0.3%), and finally having an unrealistic BMI at the lower limit following the BMI adjustments for late bookers (0.1%). There were no differences in the $\bar{x}$ maternal age and parity between the included and excluded groups (Table 37), with a $\bar{x}$ maternal age of 29 (SD 6) and a $\bar{x}$ parity of one (SD 1).

There were some differences in the proportions of the remaining variables in the included and excluded groups (Table 37), and χ^2 showed that there was a significant association between the expected and observed values for all of the variables (Appendix 29). However, the statistical significance shown between the included and excluded groups is unlikely to have any clinical significance due to the marginal differences in proportions between the two groups, with a minimum difference of 0% for quintile 2, and a maximum difference of 4.9% for White ethnic group (Table 38).

Table 37. Comparison of the Included and Excluded Groups

		Included or Excluded			
		Excluded		Included	
		Mean* and n^	Standard Deviation* and %^	Mean* and n^	Standard Deviation* and %^
Parity*		1	1	1	1
Age*		29	6	29	6
Ethnic Group^	Asian or Asian British	7265	6.1%	50738	8.2%
	Black or Black British	5569	4.7%	22525	3.6%
	Chinese or Other Ethnic Group	2780	2.3%	11394	1.8%
	Mixed	1101	.9%	5962	1.0%
	White	80134	67.3%	447423	72.2%
Employment^	Employed	45385	38.1%	262504	42.4%
	Higher Education	1212	1.0%	8042	1.3%
	Housewife/Carer	17199	14.5%	92892	15.0%
	Not Employed	6989	5.9%	44411	7.2%
	School Age/Education Under 18 yrs	1216	1.0%	5087	.8%
IMD Quintile^	1 Most Deprived	23442	20.6%	136368	22.9%
	2	22793	20.0%	119606	20.1%
	3	21112	18.6%	110026	18.5%
	4	20568	18.1%	104074	17.5%
	5 Least Deprived	25836	22.7%	125450	21.1%

Table 38. Differences Between the Proportions of Variables in the Included and Excluded Groups

	Excluded		**Included**		**Difference in %**
	Count	**%**	**Count**	**%**	
Ethnic Group Code					
Asian or Asian British	7265	6.1	50738	8.2	2.1
Black or Black British	5569	4.7	22525	3.6	-1.0
Chinese or Other Ethnic Group	2780	2.3	11394	1.8	-0.5
Mixed	1101	0.9	5962	1.0	0.0
White	80134	67.3	447423	72.2	4.9
Employment Code					
Employed	45385	38.1	262504	42.4	4.2
Higher Education	1212	1.0	8042	1.3	0.3
Housewife/Carer	17199	14.5	92892	15.0	0.5
Not Employed	6989	5.9	44411	7.2	1.3
School Age/Education Under 18 yrs	1216	1.0	5087	0.8	-0.2
IMD Quintile					
1 Most Deprived	23442	20.6	136368	22.9	2.3
2	22793	20.0	119606	20.1	0.0
3	21112	18.6	110026	18.5	-0.1
4	20568	18.1	104074	17.5	-0.6
5 Least Deprived	25836	22.7	125450	21.1	-1.6

4.3.5 Comparison of 1st Trimester and Late Bookers

The pilot study identified an issue with a significant proportion of women from Black and Asian ethnic groups in Middlesbrough being excluded due to a late gestational age at booking when compared with White women, potentially reflecting an inequality in access to maternity services (Chapter 2, Page 60). As there were no exclusions based on late gestational age at booking in this study due to adjustments being made to the booking BMI instead, additional analysis of the differences between 1st trimester bookers and later bookers was carried out (Table 39).

Table 39. Characteristics of 1st Trimester Bookers Compared to Late Bookers

		Late Booking (>13 weeks)			
		1st Trimester Bookers		Late Bookers	
		Mean* and n^	Standard Deviation * and %^	Mean* and n^	Standard Deviation * and %^
Parity*		1	1	1	1
Age*		29	6	28	6
Ethnic Group^	Asian or Asian British	21064	41.5%	29674	58.5%
	Black or Black British	7571	33.6%	14954	66.4%
	Chinese or Other Ethnic Group	5441	47.8%	5953	52.2%
	Mixed	3174	53.2%	2788	46.8%
	White	278162	62.2%	169261	37.8%
Employment^	Employed	167695	63.9%	94809	36.1%
	Higher Education	3845	47.8%	4197	52.2%
	Housewife/Carer	49211	53.0%	43681	47.0%
	Not Employed	23864	53.7%	20547	46.3%
	School Age/Education Under 18 yrs	2387	46.9%	2700	53.1%
IMD Quintile^	1 Most Deprived	71490	52.4%	64878	47.6%
	2	65643	54.9%	53963	45.1%
	3	65787	59.8%	44239	40.2%
	4	65854	63.3%	38220	36.7%
	5 Least Deprived	79019	63.0%	46431	37.0%

The analysis showed that there was no difference in $\bar{x}$ parity between the early and late bookers, and there was a $\bar{x}$ difference in age of one year, which is unlikely to have any clinical significance. There were however, significant differences in the expected and observed proportions for all remaining variables (Appendix 30). Due to the large differences in the proportions of the variables between the 1st trimester and late bookers (Table 40), there may be some health inequality issues relating to the stage in pregnancy that women commence with routine antenatal care.

Table 40. Differences Between the Proportions of Variables in the Early and Late Booking Groups

	1st Trimester		Late Bookers		Difference in %
	Count	%	Count	%	
Ethnic Group Code					
Asian or Asian British	21064	41.5	29674	58.5	17.0
Black or Black British	7571	33.6	14954	66.4	32.8
Chinese or Other Ethnic Group	5441	47.8	5953	52.2	4.5
Mixed	3174	53.2	2788	46.8	-6.5
White	278162	62.2	169261	37.8	-24.3
Employment Code					
Employed	167695	63.9	94809	36.1	-27.8
Higher Education	3845	47.8	4197	52.2	4.4
Housewife/Carer	49211	53.0	43681	47.0	-6.0
Not Employed	23864	53.7	20547	46.3	-7.5
School Age/Education Under 18 yrs	2387	46.9	2700	53.1	6.2
IMD Quintile					
1 Most Deprived	71490	52.4	64878	47.6	-4.8
2	65643	54.9	53963	45.1	-9.8
3	65787	59.8	44239	40.2	-19.6
4	65854	63.3	38220	36.7	-26.6
5 Least Deprived	79019	63.0	46431	37.0	-26.0

A similar trend to the pilot study was identified with regard to ethnic group and gestation at booking, where proportionately more White women were early bookers within the 1st trimester (62.2% compared with 37.8% late bookers), while significantly fewer Asian and Black women were 1st trimester bookers (41.5% compared with 58.5% late bookers for Asian women, and 33.6% compared with 66.4% late bookers for Black women), suggesting that Black and Asian women access maternity services later than white women. There was a slight increase in late bookers in the Chinese or Other ethnic group, and a slight reduced proportion of Mixed ethnic group were late bookers; however with a difference of 4.5% (Chinese or Other) and 6.5% (Mixed) this is unlikely to have much clinical impact.

Despite all women being more likely to be 1st trimester bookers rather than late bookers regardless of the deprivation quintile in which they reside, there is a gradual increase in the proportion of women who are late bookers the more deprived the area of residence, where approximately a third of women from the least deprived quintile were late bookers (37%) compared with almost half of all women living in the most deprived quintile (48%), suggesting that women from lower socio-economic groups access services later than those from higher socio-economic groups.

The majority of women were more likely to be early bookers than late bookers in the employment groups with the exception of those in education. The clinical significance of this relationship is again likely to be low in this group due to the differences between the proportions of early and late bookers being relatively low (4.4% for higher education and 6.2% for school age).

4.4 Discussion

The results of this study have shown that obesity in pregnancy is increasing with time; women who reside in the most deprived areas, and Black women are most at risk of maternal obesity. There is a relationship with increasing parity and increasing maternal age. Super morbidly obese women are most likely to be unemployed during pregnancy. In addition to these findings there are also issues with access to maternity services for women who are Black or Asian, and those who live in the more deprived areas.

The increasing rates of obesity, and decreasing rates of women in the ideal BMI group over time, is reflective of the pilot study findings, although the actual proportions vary, with the final year included in the pilot study showing an incidence of 16% in the obese group, and the same year in this study (2004) showing a lower proportion of 14%. This difference in proportion between the England and Middlesbrough populations is not surprising, and it would be expected that Middlesbrough would have a maternal obesity rate above the average due to its high rank of deprivation.

The implication of the changes in the proportions of women who are obese and those with an ideal BMI is seen with the additional numbers of women who are considered to be high risk and require additional care and support during pregnancy. If the proportion of women in the obese group had remained constant over the 19 year time period, then this would have meant that out of the 106,911 women who delivered at the 24 NHS Trusts in this study in 2007[17], 8,125 would have been obese, whereas the increase in obesity proportion from 7.6% in 1989 to 15.6% in 2007 meant that an additional 8,533 women required high dependency care. With NICE guidance and CEMACH recommending that women with a BMI>30kg/m^2 should have consultant care rather than midwifery led care, this places a massive burden on maternity unit resources. If this increase in proportion is considered at a national level[18] then the change in the proportion of women who are obese more than doubles from 45,064 to 92,501 women. Thus approximately 47,500 additional women require high dependency care in England every year as a result of the change in BMI over time.

Using the same data source for the average number of births per year in England, the small proportional increases in the obesity subgroups have considerable implications for maternity services. The increase in the proportion of moderately obese women by 4.3% over the 19 years results in approximately an additional 25,500 women per year in England being in this BMI category, the 2.4% increase in the severely obese group results in an additional 14,000 women, the 1.2% increase in the morbidly obese group results in an additional 7,000 women, and the 0.2% increase in the super morbidly obese group results in an additional 1,000 women each year.

Both the pilot study and this study found that there was a lag effect between obesity in pregnant women and obesity in women of childbearing age in the general population, and multiple theories on what may have caused this were put forward in the pilot study discussions. The primary hypothesised theory related to physiological factors that affect women when they are obese and which may hinder fertility. In addition to this there was potentially an underestimation of obesity in the obstetric population due to the exclusion of women who did not complete their pregnancies potentially excluding a substantial proportion of obese women due to the relationship with miscarriage. There could also have been further exclusion of obese women who

[17] 2006 for 2 NHS Trusts
[18] Using the sum of the average number of births per year for all 243 maternity units in England from the birthchoice.uk website then the average number of births per year in England is 592,960

were late bookers. This is due to irregular menstrual cycles associated with obesity, and changes in weight and body shape potentially not being as noticeable in the obese population in the early stages of pregnancy, therefore the pregnancies potentially were not being detected until a later stage (Chapter 2, Pages 45-46).

This study could not address the issue of incomplete pregnancies as data on completed pregnancies were required to calculate the gestational age at booking in a number of NHS Trusts. Therefore the data requested for this study was based on all completed pregnancies within the maternity units rather than all pregnant women. This limitation means that the results of this study could potentially still be an underestimation of maternal obesity rates, especially in light of the latest CEMACH report on perinatal mortality where mothers were obese in 22.9% of all late foetal loss, and 30.4% of stillbirths (Confidential Enquiry into Maternal and Child Health, 2007).

The issue relating to the exclusion of late bookings was addressed in this study by adjusting the reported BMI to be reflective of the 1st trimester BMI based on standardised published changes in BMI per week of gestation (Ochsenbein-Kolble et al., 2004). However there are limitations in applying these adjustments to the data. First, the data used was average population level data, and this was being applied at individual level to the dataset in this study, whereas the variance between individuals is not necessarily the same as the variance at population level, and therefore there will be a certain amount of prediction error in the adjusted BMI data. To assess the extent of this prediction error the adjusted data were compared with the 1st trimester data and the differences in the proportions of women across the BMI groups was marginal, with a positive bias towards increasing the proportion of underweight women rather than increasing the proportion of overweight and obese women.

The population data used by Ochsenbein-Kolbe et al (2004) was also cross sectional, and therefore did not follow the same cohort of women throughout the pregnancy. Although the total sample was fairly large with 3,432 women included, there were differences in the sample size at each gestational week, with some weeks including a large sample of women, particularly at the start and end of the pregnancy (as would be expected as most women have contact with their health care providers at these stages of pregnancy and therefore it would be easier to take height and weight measurements during these contacts), whereas a smaller sample of women were included in the middle weeks of pregnancy (with a range of 30-93 women included in the weeks between 14 and 34). The implications of this are that the reliability of the BMI data for adjustment is likely to vary depending on the gestational week and the sample size included. However there were no obvious outliers in the trend of change in BMI, with the increase in BMI over time remaining fairly linear.

The dataset used by Ochsenbein-Kolble et al (2004) also had the outliers removed to make it normally distributed, therefore excluding the extremes of underweight and obesity that were ± 4 S.D from the mean. The changes in BMI patterns over the gestational weeks for these extreme groups are likely to be different to the changes in those within the normal distribution, with published data showing that the more obese the pregnant woman, the less weight they gain during pregnancy (Bergmann et al., 1997). The potential bias incurred from this adjustment is towards reducing the proportion of women in the morbidly obese groups by subtracting too much from their BMI. In addition to this, the gestational age included in the Ochsenbein-Kolble et al (2004) dataset only went up to 42 weeks, whereas the data included in this study included gestational periods up to 44 weeks, therefore the BMI increase at 42 weeks was used for adjustment of all women who were 43 and 44 weeks. Any additional increase in BMI at this late stage of pregnancy is unlikely to be significant as evidence shows that the lowest rates of weight gain are in the earliest and latest weeks of pregnancy (Amorim et al., 2008, Dawes and Grudzinskas, 1991, Institute of Medicine, 1990).

The adjustments for BMI were based on White ethnic group data, whereas the dataset in this study included women from other ethnic groups. Ochsenbein-Kolble et al (2004) analysed data for Black and Asian women, and concluded that the white population data was representative of the Black population and could be used directly for this ethnic group, whereas for Asian women an additional 1.5kg/m^2 should be added to the weekly gain. However as the data were being used to calculate the difference in BMI gain from week 13 onwards to adjust the late booking data back to the 1st trimester BMI, this would have involved adding 1.5kg/m^2 to week

13, and 1.5kg/m^2 to all remaining weeks data which would cancel out any differences. Therefore the data had been confirmed for appropriate use for Black, and Asian women. In the absence of any published data for Mixed and Chinese ethnic groups, this data were applied to all ethnic groups.

Despite the limitations in using the Ochsenbein-Kolble et al (2004) data for adjusting the raw BMI data provided by the maternity units, it was considered overall to be an appropriate method of ensuring that the late booking data could be included to address the issue in the pilot study of excluding late bookers and thus potentially excluding a substantial proportion of the obese population. It was also felt that including some adjustment for the BMI of late bookers would ensure that the proportion of women who are obese at the start of pregnancy was not over emphasised, as late booking BMI could not be representative of the start of pregnancy BMI due to the weight gain incurred in pregnancy (Amorim et al., 2008).

Despite making the adjustments for the stage of pregnancy at the booking appointment based on the hypothesis put forward in the pilot study relating to the late bookers being potentially more likely to be the obese population, additional analysis of the differences in the maternal characteristics of early and late bookers found an inverse relationship with this hypothesis, where the underweight group were the most likely to be late bookers and this relationship decreased as the level of obesity increased, to super-morbidly obese women being the least likely to be late bookers. Theories as to why this inverse relationship may exist could be due to the relationship with obesity and diabetes, as the risk of developing diabetes increases with obesity. NICE recommends that women with diabetes should attend clinics for preconceptual care (National Institute for Health and Clinical Excellence, 2008b), and women with diabetes are encouraged to book early in their pregnancy, therefore this could explain why the relationship with obesity and early booking exists despite the issues with irregular menstrual cycles and changes in weight and body shape not being as noticeable in obese women. In addition to this, the relationship with underweight women and late bookers could be due to age. Although the results found a difference in mean age between 1st trimester and late bookers of only one year, which was unlikely to have any clinical significance, there were proportionately more school age/in education under 18 years in the late booking group than the 1st

trimester bookers (53% compared with 47%), and there is a possibility that this group of adolescent mothers accessed maternity services later due to a denial of being pregnant or trying to conceal the pregnancy. In addition to this, there is the possibility that mothers with substance abuse are more likely to be underweight, and potentially they are more likely to not engage in services as early or to miss scheduled appointments (personal communication, Dr Helen Simpson, Consultant Obstetrician), and this could account for the phenomenon identified in the results. Further research into the reasons behind underweight women accessing services at a later date than other women is required in order to address the issue in clinical practice.

There were also differences in the number of maternity units that provided data for each year, and this was dependent on how long they had been collecting data electronically. There was no single year where all 34 maternity units had provided data, as two maternity units had changed their database systems in 2007 and could not retrieve the data from these for that year. There are two main issues with the differences in the number of maternity units that provided data for each year. The first issue relates to precision error, where the earlier years that have smaller sample sizes may incur less precision in their results for BMI distribution than the larger sample sizes for later years (resulting in greater CI's). However, the smallest sample size in 1989 which included only one maternity unit has a population of 3,773, which is a large sample size and there should be fairly high precision in this data. The second issue relates to selection bias, where the earlier years with less maternity units included may have a higher or lower probability of having an obese population. The results section for this study described how the years prior to 1995 had fewer maternity units included, smaller sample sizes, and higher proportions of missing data for certain variables, particularly ethnic group, therefore the pre 1995 data were further explored.

In the first instance the average proportions of the different BMI groups for the pre 1995 maternity units were compared with the total dataset to identify whether these particular maternity units had a higher or lower trend for obesity (Table 41). This analysis identified similar distributions among each of the BMI groups, with a slightly reduced proportion of women who were obese and a slightly increased proportion of women who were in the ideal BMI group when compared with the full dataset.

Table 41. Comparison of the BMI Distribution in the Total Dataset and the Maternity Units Providing Data pre-1995

	%			
	Under weight	**Ideal**	**Over weight**	**Obese**
Total Average[1]	**5.0**	**57.1**	**24.8**	**13.1**
Average for maternity units included in 1989[2]	4.7	60.2	24.8	10.3
Average for maternity units included in 1990[3]	4.9	59.7	24.8	10.7
Average for maternity units included in 1991 and 1992[4]	4.8	59.7	24.1	11.4
Average for maternity units included in 1993 and 1994[5]	4.9	58.9	24.6	11.6

[1] Including all maternity units for all years
[2] Including one maternity unit
[3] Including two maternity units
[4] Including four maternity units
[5] Including five maternity units

As the regression analysis showed that deprivation and Black ethnic group were the highest predictors of obesity, the trends in this data prior to 1995 were also investigated. The years with five or less maternity units included have a high proportion of missing ethnic group data, between 32 and 100% (Appendix 22) and therefore it is impossible to tell if these represent the average for those years. However, looking at the trends in Black ethnic group for the years with lower proportions of missing data (post 1995) the increase of approximately 4% suggests that there is a potential for lower proportions of Black women in the earlier years, which could under estimate the levels of obesity pre-1995, and this would concur with the findings in Table 41 which show a slightly lower than average proportion of obese BMI in the maternity units that provided the pre-1995 data.

The differences in the proportions of women across the deprivation quintiles for the pre-1995 years was also investigated (Table 42). This identified that in 1989 there were no women residing in the most deprived quintile 1; however this is likely to be a result of changing boundaries and postcodes over time in relation to the IMD coding (which utilised 2007 data). The proportion of women residing in the 2nd most deprived quintile in 1989 is more representative of the combined bottom two quintiles for the total dataset, despite remaining a higher overall proportion, and this is represented through all years from 1989-1994. All years also show an under representation of women residing in the least deprived quintile 5. Overall the earlier years represent a higher level of deprivation than the total dataset, which may have led to an over estimation of obesity due to the significant positive relationship with obesity and increasing levels of deprivation. The combination of the higher representation of deprivation in the earlier years, and the potential for lower representation of Black women should balance out any under and over representation issues.

Table 42. Comparison of the Deprivation Distribution in the Total Dataset and the Maternity Units Providing Data pre-1995

	IMD Quintile				
	1	2	3	4	5
	Most Deprived				Least Deprived
1989	.0%	56.5%	13.0%	17.4%	13.0%
1990	12.4%	38.1%	18.4%	13.6%	17.5%
1991	32.1%	22.1%	20.0%	13.7%	12.1%
1992	23.1%	24.1%	21.2%	15.5%	16.1%
1993	26.8%	21.9%	19.6%	14.8%	16.9%
1994	26.4%	22.6%	19.8%	15.0%	16.2%
Total Dataset	22.9%	20.1%	18.5%	17.5%	21.1%

The demographic predictors of being obese in pregnancy highlight health inequalities that largely reflect the pilot study, particularly residing in areas of deprivation, which had the strongest relationship with obesity following adjustment for the other variables. The additional analysis carried out in this study on the obesity subgroups was not carried out in the pilot study, and the results show a striking positive relationship with deprivation and increasing levels of obesity. Although a certain degree of caution must be noted with the super morbidly obese group due to the limited size of this group in comparison to the other groups, overall the sample is large and the population characteristics are representative of women of childbearing age in the general population. Deprivation is known to have a significant relationship with maternal death, where in England women who live in the most deprived areas are five times more likely to die compared with those women living in the least deprived areas (Lewis, 2007), and this finding, in conjunction with the strong links with increasing levels of obesity and deprivation, pose major health inequality issues to women residing in the areas of greatest deprivation in England.

Further inequalities exist with employment and ethnic group. Although analysis of overall obesity (BMI>30kg/m^2) shows that women are significantly less likely to be unemployed than employed, this result masks the relationship with increasing levels of obesity. There is a relationship with women being more likely to be unemployed or housewives/carers as the level of obesity increases, and this finding is supported in the HSE data for women in the general population where obesity was found to be related to unemployment in women following adjustment for confounding variables, with obese women being 33% more likely to be unemployed than non-obese women, and this rose to 55% of severely obese women (Morris, 2004) (discussed in Chapter 1, Section 1.2.3.4). The impact of unemployment in pregnancy is highlighted in the 2007 CEMACH report, which shows that a third of all women who died in pregnancy were either single and unemployed, or were unemployed with an unemployed partner (Lewis, 2007).

The results for ethnic group in the pilot study could not be commented upon due to the low proportion of women from any ethnic group other than White included, whereas this study had an over representation of all ethnic groups other than White when compared to the general population of women of childbearing age. The results show a positive relationship with obesity and women being Black or Black British, which is representative of the relationship with women in the general population where Black African and Black Caribbean women have the highest prevalence of obesity (Department of Health, 2005a). The relationship in this study was especially significant for Black Caribbean women and Black Other when looking at the ethnic group subgroups, and the relationship remained significant with increasing levels of obesity to the point of morbid obesity, whereas with Black African women the relationship was only significant up to the point of severe obesity. This relationship with Black African women and morbid obesity may have been an artefact of the data as the data were coded as Black Other when the country of origin was not defined, therefore there may have been a number of Black African women in the Black Other group where there was a significant association with morbid obesity. These findings reflect the latest CEMACH report on maternal deaths where it was identified that Black African and Black Caribbean women had a higher risk of dying during pregnancy when compared with white women (Lewis, 2007).

Interestingly this study identified a significantly reduced relationship with Asian women and being overweight or obese, and this remained for all obesity subgroups and all Asian ethnic subgroups. As there is an increased relationship with obesity and Asian women in the general population, particularly Pakistani women (Department of Health, 2005a), this finding is unexpected. This inverse relationship with Asian women and obesity may be due to the association between obesity and age in women, where obesity is most raised in post-menopausal women (Department of Health, 2004b). This may be more prominent in Asian women in the general population, making obesity most prevalent in post-menopausal women, and therefore not being reflective of women of childbearing age and the pregnancy population. There could also be physiological implications relating specifically to obese Asian women, resulting in a high proportion of obese Asian women having fertility problems and therefore excluding them from the pregnancy population. There is a relationship with infertility and central adiposity (Hollmann et al., 1997), and the HSE shows that women who are Bangladeshi and Pakistani have the highest risk ratio for having a waist-hip ratio over 0.85 (2.29 and 1.77 respectively when compared to the general population) (The Information Centre, 2006).

The relationship with obesity and increasing age and parity was similar to that observed in the pilot study. These results also reflect the associations found in the general population, where increasing age is linked with increasing levels of obesity (Department of Health, 2004b), and pregnancy is a recognised life event in women in the promotion of obesity (Gore et al., 2003, Siega-Riz et al., 2004, Gunderson and Abrams, 2000), therefore it is logical that there is a relationship with increasing parity.

The pilot study found that there were potential inequalities in access to maternity services for women who were Black and Asian, where there was a proportionately higher exclusion rate of women from these ethnic groups when compared with White women due to late booking. This study compared the characteristics of the early and late bookers and found that a significant relationship remained with women from Black and Asian ethnic groups. In addition to this there was also a relationship with increasing levels of deprivation and increasing proportions of women being late bookers. The House of Commons HC report on 'Inequalities in Access to Maternity Services' highlights that the most disadvantaged and vulnerable women who are most in need of care and support throughout their pregnancy, including women from ethnic minority groups and those women living in poverty, are less likely to receive the same quality of care as other women, and in some cases fail to gain access to services at all (House of Commons Health Committee, 2004). The CEMACH report also has two recommendations for access to care in their top ten key recommendations, with one being that all service providers should ensure their antenatal services are welcoming and accessible for all women, especially those that find it difficult to access maternity care to ensure they can access services at an earlier stage (Lewis, 2007). The second recommendation states that pregnant women who are already 12 weeks or more at the time of referral to maternity services should be seen within two weeks of referral. The rationale for these recommendations are based on the CEMACH report data which shows that of all the women who died in pregnancy, 17% had their antenatal booking appointment after 22 weeks, missed over four routine antenatal visits, did not seek care at all, or actively concealed their pregnancies (Lewis, 2007). In addition to this, some women who were referred by their GP to maternity services within a timely manner did not receive their first appointment until 20 weeks gestation. The CEMACH report also included a breakdown of proportions of women from different ethnic groups who died and were late bookers or received no antenatal care, and this shows that 57% of Black Caribbean women who died during pregnancy were late bookers or did not receive and antenatal care, 40% for Black African, and 25% for Middle Eastern women, compared to 17% for White women. There was also an increasing relationship with mothers dying in pregnancy with increasing deprivation, where women who resided in the areas of most deprivation were five times more likely to die than those women living in areas of least deprivation (RR 5.1, 95%CI 3.2, 8.1).

The relationship between obesity, ethnic group, deprivation, and unemployment indicate significant health inequalities in the demographics of those women most likely to be obese in pregnancy. In addition to this, the relationship between all of these factors, access to maternity services, and risk of maternal death highlights how closely linked the issues surrounding inequalities in pregnant women are.

Chapter Five

Systematic Review of the Impact of Maternal BMI Status on Pregnancy Outcomes with Immediate Short-Term Obstetric Resource Implications

The results of this review have been published as a supplement within an issue in Obesity Reviews (Appendix p4).

This chapter contains the methodology and findings of the systematic review, with details of the search strategy, data extraction and quality assessment tools, sensitivity analysis, characteristics of included studies, quality scores, and raw data from the included studies in Appendices 31-37.

5.1 Objective of the Review

The objective of this systematic review was to identify the immediate impact on obstetric care when women are obese at the start of pregnancy. The findings of this review will help to place maternal obesity in context with the implications of the impact on NHS maternity services.

5.2 Methods

5.2.1 Search Strategy

The electronic databases MEDLINE, CINAHL, the Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, NHS Economic Evaluation Database, and the Midwives Information and Resource Service (MIDIRS) were searched from January 1990 to June 2007. Searches were limited to English language studies in humans. References of all published review articles identified in the search, and all included studies were citation searched for other eligible studies. A search strategy was developed for MEDLINE and adapted for CINAHL (Appendix 31). MIDIRS was searched using their standard search on obesity, and Cochrane was searched using the MeSH facility for pregnancy and obesity, and using the search facility and the following terms: (obes* or overweight) AND (pregnan* or matern*).

5.2.2 Selection of Studies

Titles and abstracts of all studies identified in the search were scanned and full papers of any studies that were associated with maternal obesity were retained for further independent evaluation by two reviewers. Any disagreement on the inclusion of a study was assessed by a third reviewer.

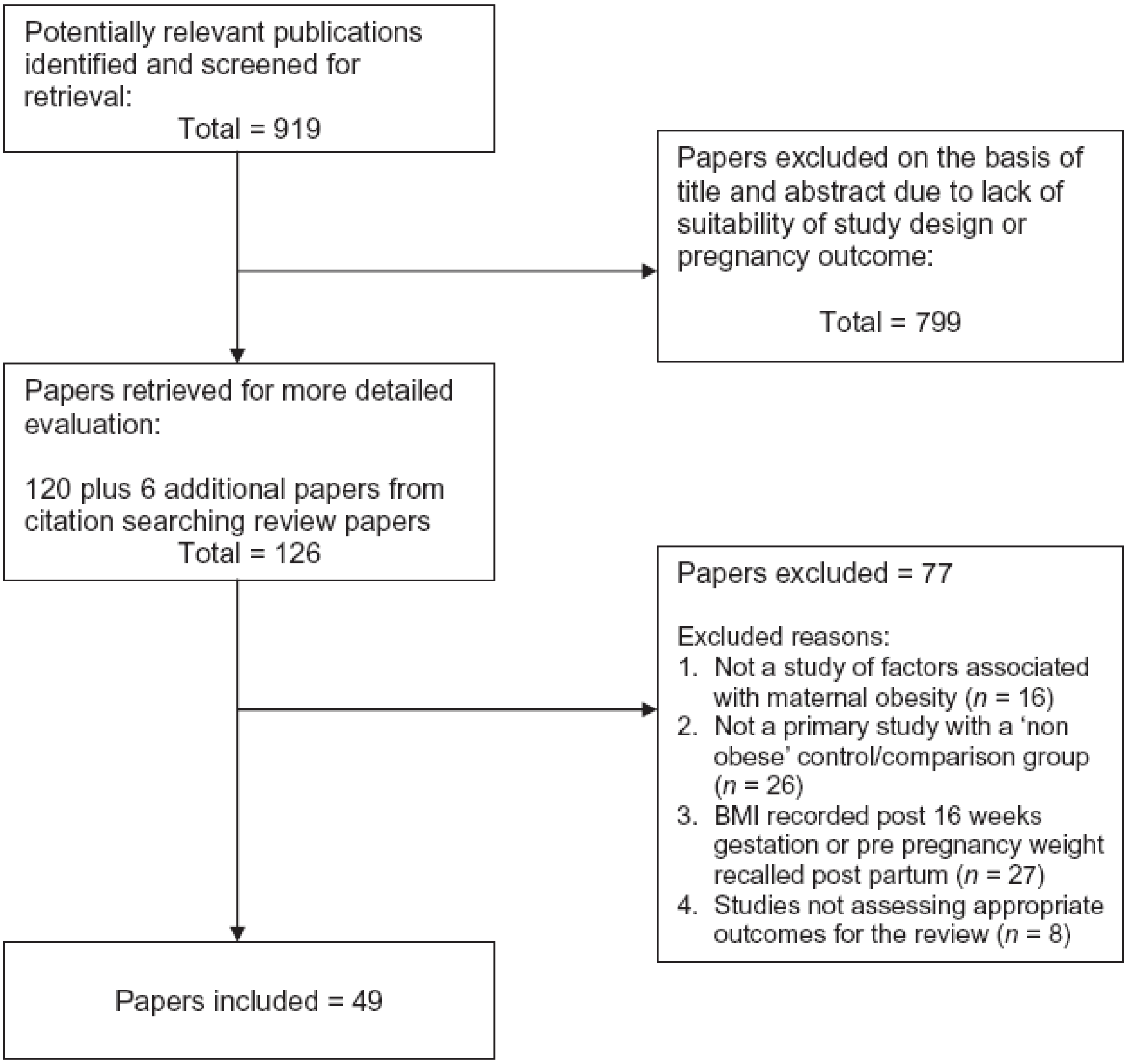
The inclusion criteria for the review were:

- Maternal weight or Body Mass Index (BMI) was recorded prior to 16 weeks gestation
- Measured or self reported weight was recorded at the start of pregnancy (studies were excluded when women were asked to recall their pre-pregnancy weight postnatally)
- There was at least one obese and one comparison group
- Women were followed up for the duration of the pregnancy and delivery
- Studies were included whether women were categorised into groups based on their BMI, other weight for height measure, or weight alone (only studies using BMI were included in the meta-analysis)

The primary outcome measures reviewed were categorised as those with a major direct NHS resource association; secondary outcome measures were those with an indirect resource association. Primary outcome measures included instrumental and caesarean delivery, length of hospital stay, neonatal intensive care, neonatal trauma, maternal haemorrhage, maternal infection, and $3^{rd}/4^{th}$ degree tears.

The searches identified 919 records following deduplication and 799 were excluded based on the titles and abstracts. 120 studies were screened, plus an additional six studies identified through citation searching, of which 77 were excluded (Figure 37). 49 studies were eligible and included in the review.

Figure 37. Quorum Statement Flow Diagram



5.2.3 Data Extraction and Quality Assessment

Included studies were data extracted and quality assessed by two researchers independently, while I carried out data extraction and quality assessment for all studies for consistency. The data extraction utilised the Cochrane data extraction template for cohort studies (The Cochrane Non-randomised Studies Methods Group, 2001) (Appendix 32), and the quality assessment forms were based on the Scottish Intercollegiate Guidelines Network (SIGN) methodology checklist for cohort studies (Scottish Intercollegiate Guidelines Network, 2004) (Appendix 33).

Data extraction included the following items:

1. General Study Information (title, author, year of publication, location and language of study, study name where applicable, dates of enrolment/follow up, outcomes for analysis and criteria for definition of outcomes, definition of maternal obesity used, additional comments).
2. Methodology (prospective/retrospective cohort, number identified/excluded/lost to follow up/included by total cohort, control group, and study group(s), all subjects accounted for, inclusion criteria for control and study groups, method of measurement of maternal obesity and outcome).
3. Subject Characteristics (total cohort characteristics, differences between control group and study group(s) characteristics, significance of difference, summary of group differences).
4. Results (number with and without the outcome in control and study groups, crude and adjusted ORs, relative risk (RR), p value, factors adjusted for).

Studies were quality assessed and given a score of low (-), good (+), or excellent (++) based on internal validity, overall assessment of the study, and description of the study.

5.2.4 Data Analysis

Data were combined for meta-analysis when the following criteria were satisfied in three or more studies:

1. The definition for the outcome data being analysed were sufficiently similar that the clinical service implications could be compared.

2. The definition of maternal body weight status utilised BMI.

3. Where possible, the control group BMI categories were comparable.

Where the data was not presented as an OR it was calculated using the data presented in the paper. The formula for the ORs, standard error (SE), and CI calculations were based on those described by Bland (Bland, 1996)[19], where OR = ad/bc, $SE(\log_e(or)) = \sqrt{(1/a)+(1/b)+(1/c)+(1/d)}$, and presuming the log OR comes from a normal distribution 95% Lower CI = $e^{\log OR-(1.96* SE(\log_e(or)))}$, and the Upper CI = $e^{\log OR+(1.96* SE(\log_e(or)))}$.

A p-value <0.05 was indicative of significant heterogeneity being present. Tests for heterogeneity between combined study results were carried out in STATA (StataCorp LP, 2005) to identify whether the variation between studies was attributable to chance[20]. Results of the meta-analysis are presented as ORs and 95% CI where possible.

5.2.5 Sensitivity Analysis

Sensitivity analysis was carried out in all cases where heterogeneity was present and there were more than three studies included. The sensitivity analysis was based on studies where the results were crude or adjusted, results being split by level of obesity (moderate, severe, or morbid), quality score of the studies, and consistency in BMI cut off used. The sensitivity analyses for those results marked with # in the primary and secondary outcome results Tables 43 and 44 are described in Appendix 34. Sensitivity analysis was also carried out for the remaining results in Tables 43 and 44 where significant heterogeneity was present, there were more than three studies included, and there were grounds to exclude studies based on the criteria described. However the sensitivity analysis did not change the overall result in these instances therefore the whole group results are presented.

[19] Where a= n in study group with a condition, b= n in control group with a condition, c= n in study group without a condition, and d= n in control group without a condition

[20] Where the test for heterogeneity utilised the formula Q = SIGMA_i{ (1/variance_i)*(effect_i - effect_pooled)^2 } where variance_i = ((upper limit - lower limit)/(2*z))^2

5.3 Results

5.3.1 Description of Studies

Study characteristics are described in Appendix 35, and the quality scores and adjustments in Appendix 36.

Included studies were primarily from the USA and Europe; (USA (n=22)[21]; Europe (n=20): four from Finland[22] and Denmark[23], three from the UK[24], Italy[25], and Sweden[26], two from France[27], and one from Austria[28]).

The remaining studies included one from Australia (Callaway et al., 2006), Canada (Kramer et al., 1999), Abu Dhabi (Kumari, 2001), Brazil (Nucci et al., 2001), Thailand (Phithakwatchara and Titapant, 2007), Israel (Sheiner et al., 2004), and Iran (Yekta et al., 2006).

Four of the 49 studies were excluded from the meta-analysis due to BMI not being the measurement of obesity. All studies presented data in ORs, or had data available for the authors to calculate the ORs. The data for the obese BMI groups are shown in Appendices 37.1-37.5.

5.3.2 Primary Outcomes

Most primary outcomes showed increasing odds associated with increasing BMI category (Table 43).

[21] (Abrams and Newman, 1991, Baeten et al., 2001, Bianco et al., 1998, Crane et al., 1997, Dempsey et al., 2005, Doherty et al., 2006, Ehrenberg et al., 2004a, Ehrenberg et al., 2004b, Hellerstedt et al., 1997, Hendler et al., 2005, Hulsey et al., 2005, Johnson et al., 1992, Kaiser and Kirby, 2001, Kugyelka et al., 2004, Lombardi et al., 2005, Naeye, 1990, Ogunyemi et al., 1998, Rosenberg et al., 2003, Shepard et al., 1998, Steinfeld et al., 2000, Vahratian et al., 2004, Weiss et al., 2004)
[22] (Ekblad and Grenman, 1992, Lumme et al., 1995, Ranta et al., 1995, Rantakallio et al., 1995)
[23] (Jensen et al., 2003, Jensen et al., 1999, Olesen et al., 2006, Rode et al., 2005)
[24] (Bergholt et al., 2007, Usher Kiran et al., 2005, Konje et al., 1993)
[25] (Bo et al., 2003, Di Cianni et al., 2003, Mancuso et al., 1991)
[26] (Cedergren, 2004, Cnattingius et al., 1998, Rossner and Ohlin, 1990)
[27] (Galtier-Dereure et al., 1995, Galtier-Dereure et al., 2000)
[28] (Giuliani et al., 2002)

Table 43. Meta Analysis Results: Primary Outcomes

	Underweight vs. ideal BMI	Overweight vs. ideal BMI	Obese vs. ideal BMI	Morbidly obese vs. ideal BMI
	OR (95% CI)			
Labour and delivery				
Total caesarean delivery	0.807 (0.720, 0.903)† $n = 9$	1.483 (1.390, 1.581)† $n = 14$	2.005 (1.872, 2.148)†‡ $n = 16$	1.432 (1.346, 1.524)§ $n = 6$
Elective caesarean delivery	–*	–*	1.240 (0.899, 1.710) $n = 3$	
Emergency caesarean delivery	–*	–*	1.626 (1.396, 1.893)† $n = 6$	
Instrumental delivery	–*	0.773 (0.674, 0.888)† $n = 3$	1.169 (1.130, 1.209)†‡ $n = 4$	
Hospital admission				
Length of hospital stay (mean days)¶	–*	2.563 (2.460, 2.666) $n = 6$	2.706 (2.623, 2.788) $n = 4$	3.279 (3.131, 3.428) $n = 3$
Neonatal intensive care unit use	–*	1.121 (0.979, 1.283) $n = 3$	1.377 (1.157, 1.639) $n = 4$	1.331 (1.175, 1.507) $n = 3$
Mother				
Haemorrhage	0.671 (0.547, 0.822)† $n = 4$	1.420 (1.095, 1.842)† $n = 3$	1.202 (1.163, 1.243)‡ $n = 4$	1.430 (1.328, 1.540)‡ $n = 3$
Infection	–*	–*	3.335 (2.738, 4.062) $n = 6$	

*Data not available for meta-analysis.
†No significant heterogeneity.
‡Results following sensitivity analysis.
§Sensitivity analysis with non-obese comparison group rather than ideal BMI shows no heterogeneity and increases odds to 2.36 (2.03, 2.73).
¶Length of stay compared with women in the ideal BMI category where OR 2.421 (2.407, 2.434).

5.3.2.1 Labour and Delivery Meta-analysis

Labour and delivery primary outcomes included instrumental deliveries and caesarean deliveries.

5.3.2.1.1 Instrumental Delivery

There are increased odds of instrumental delivery in obese women (Figure 38), whereas there appears to be significant reduced odds for instrumental delivery in overweight women when compared with women of an ideal BMI (Figure 39). Meta-analysis could not be carried out for underweight women and instrumental delivery; however there was no significant relationship between these factors in the one study identified (Jensen et al., 1999).

Figure 38. Instrumental Delivery Forest Plot for Obese BMI Compared with Ideal BMI following Sensitivity Analysis Including Adjusted ORs only

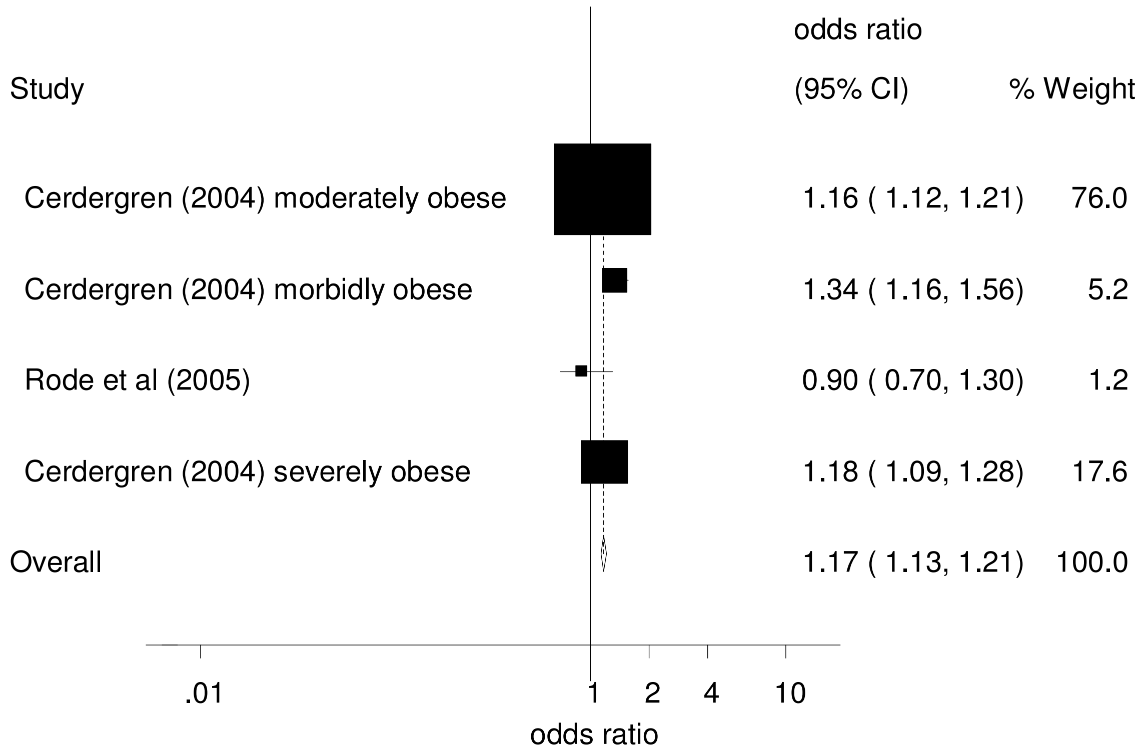
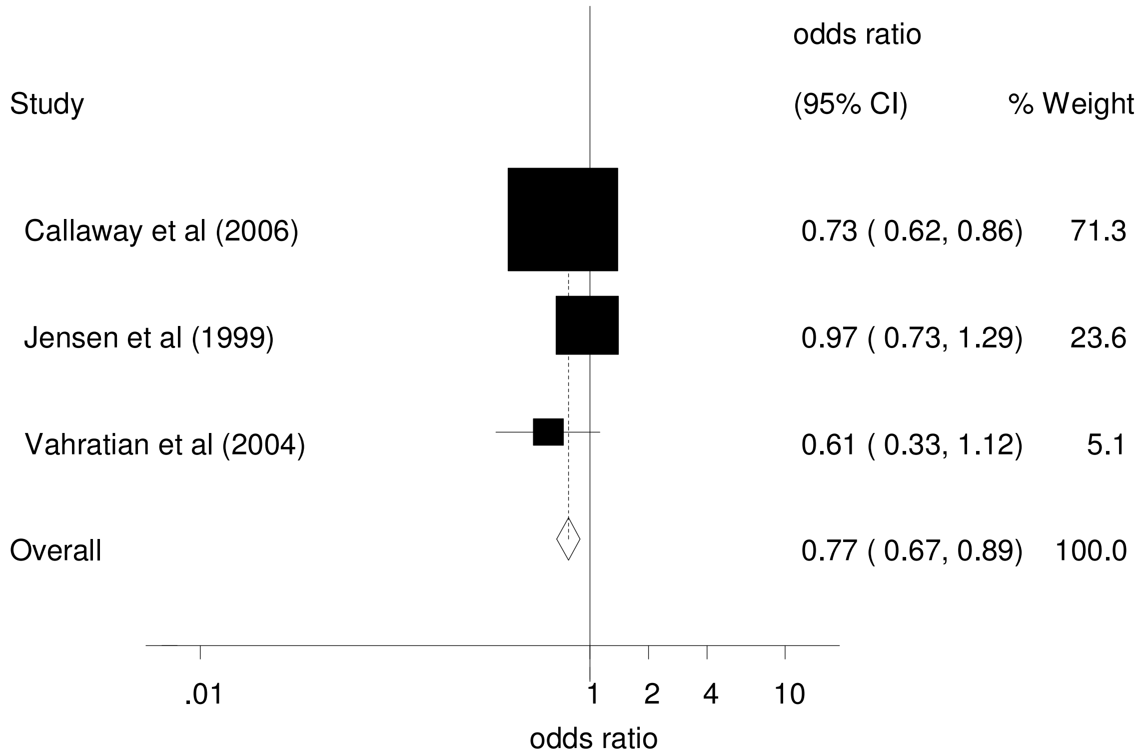


Figure 39. Instrumental Delivery Forest Plot for Overweight BMI Compared with Ideal BMI



5.3.2.1.2 Caesarean Delivery

Being overweight, obese, or morbidly obese shows significant increased odds for overall and emergency caesarean delivery (Figures 40 and 41) but this is not significant for elective caesarean delivery (Figure 42). For the overall caesarean delivery rate (including studies where the definition of emergency or elective caesarean delivery has not been specified) the meta analysed results do not show an exponential trend with increasing obesity. However there are only six studies included in the review that categorise obesity into subgroups that allowed the separate analysis of morbid obesity compared with ideal BMI (Figure 41), whereas 16 studies analysed obesity generically (Figure 40) and this might be masking a true exponential trend. It is worth noting that when studies were meta-analysed comparing morbid obesity to “non obese” rather than ideal BMI group (n=3), the odds of a caesarean delivery being required increased to 2.36 from 1.43 when compared with ideal BMI only. Being underweight showed reduced odds of 0.81 (95% CI 0.72, 0.90) for caesarean delivery.

Figure 40. Overall Caesarean Delivery Forest Plot Including Emergency and Elective Caesarean Delivery for Obese BMI Compared with Ideal BMI following Sensitivity Analysis for Control Group Definition

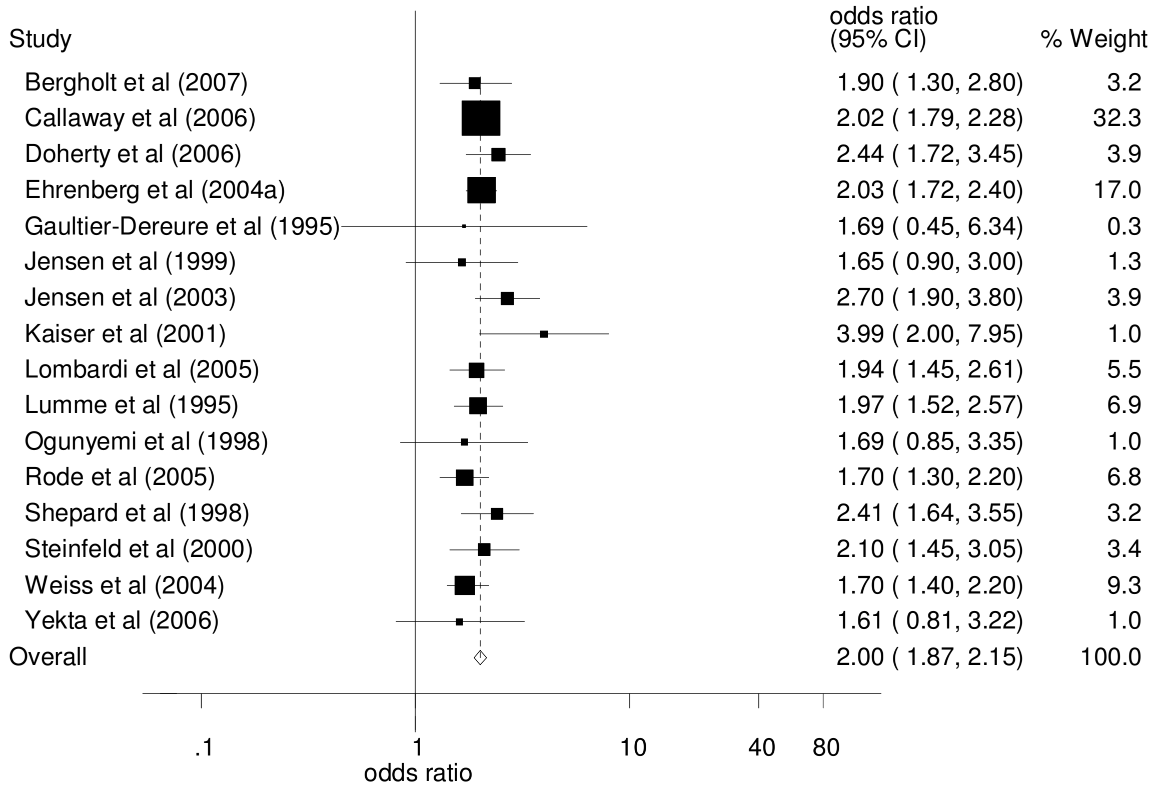


Figure 41. Emergency Caesarean Delivery Forest Plot for Obese BMI Compared with Ideal BMI

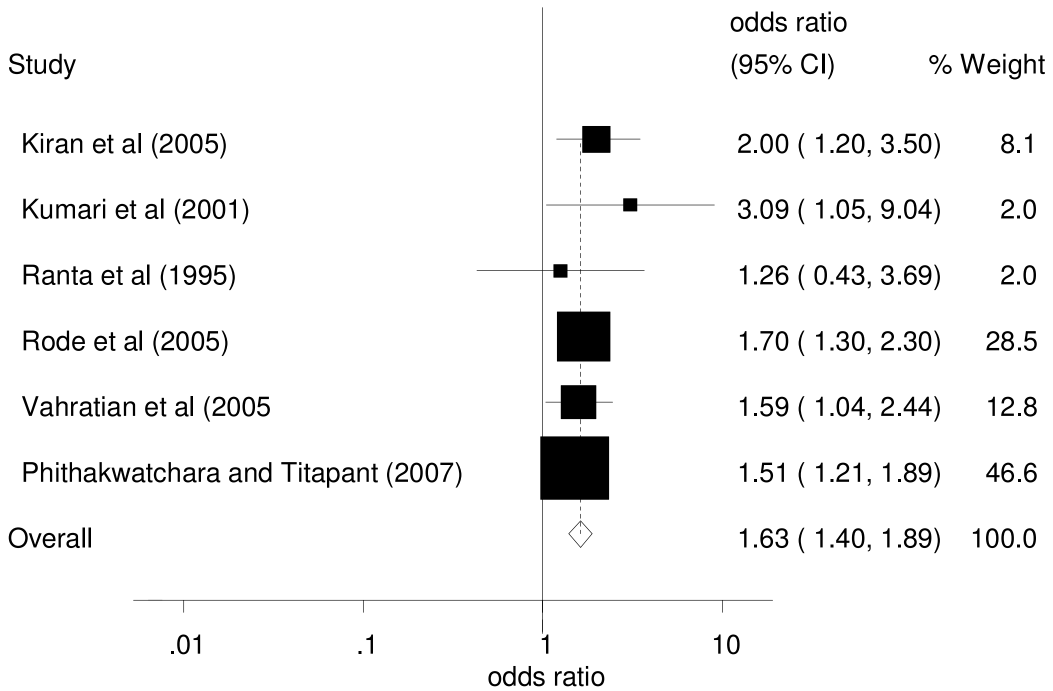
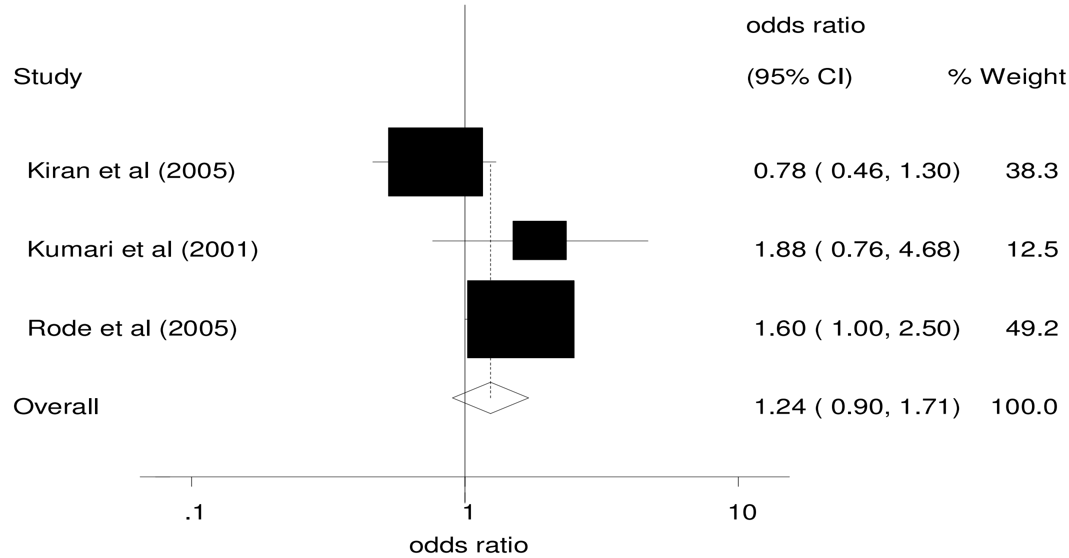


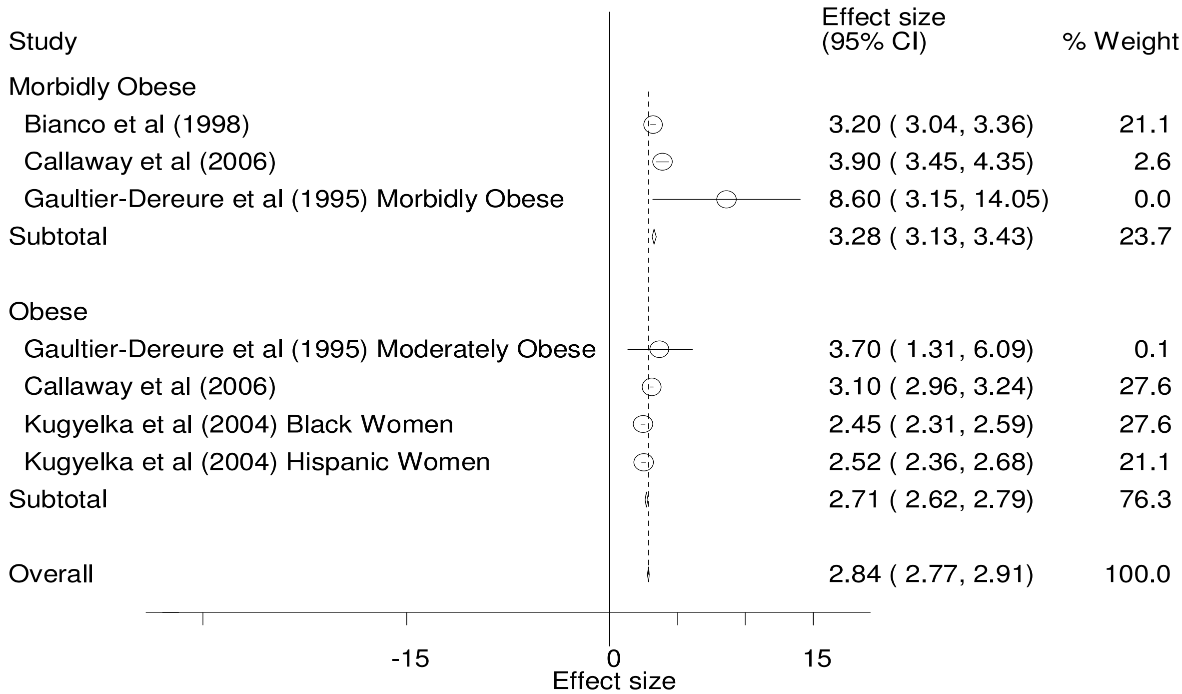
Figure 42. Elective Caesarean Delivery Forest Plot for Obese BMI Compared with Ideal and Non Obese BMI



5.3.2.2 Hospital Admission Meta-analysis

There was a significant gradual increase in mean length of hospital stay as BMI increased, from 2.4 days for ideal BMI to 3.3 days for morbidly obese women (Figure 43).

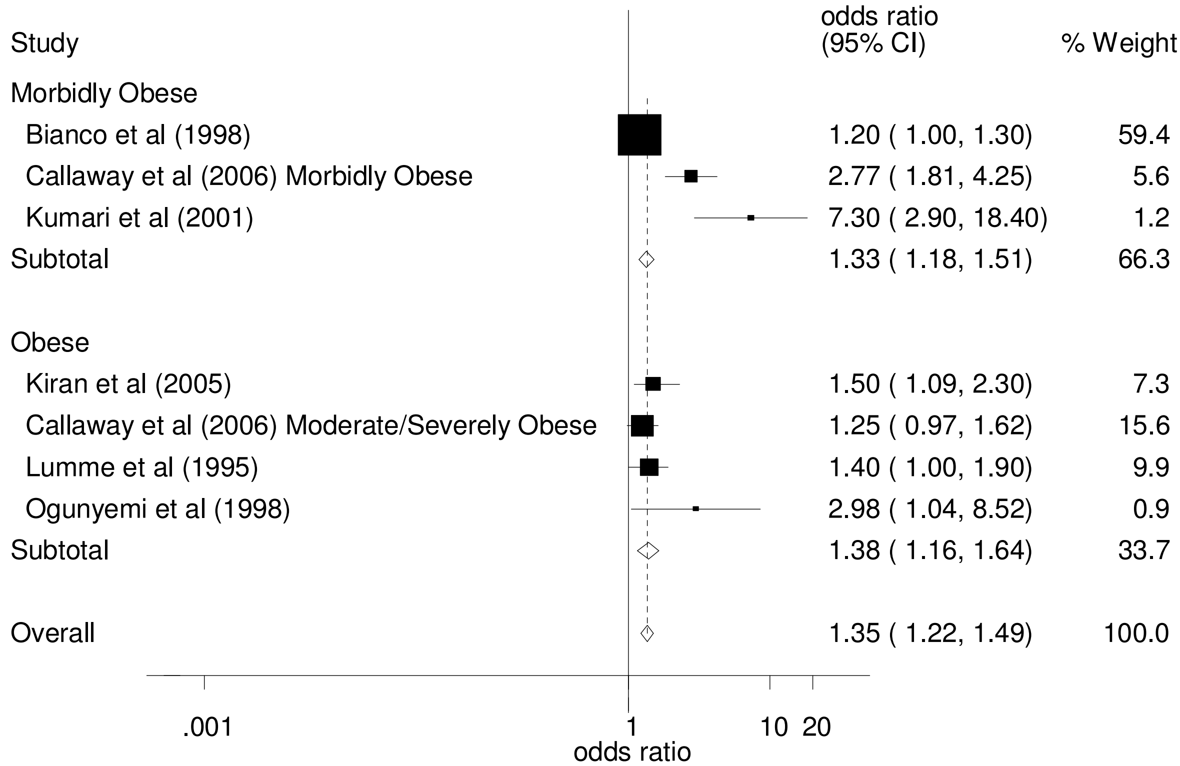
Figure 43. Mean Length of Hospital Stay (days) for Obese and Morbidly Obese BMI Compared with Ideal BMI (Ideal Mean Length of Stay 2.4 days)



The data from individual studies included in the meta-analysis showed an overall length of stay as being between 2-3 days for those women with an ideal BMI, 2-4 days for women who were overweight or obese, and 3-5 days for women who were morbidly obese (Appendix 37.5).

The neonatal requirement for intensive care was not significant for overweight women, but was shown to be increased for both obese and morbidly obese women (Figure 44). Neonatal intensive care requirements for underweight women could not be meta analysed; however two studies found an increased odds of 1.3 (95% CI 1.0, 1.5) (Lumme et al., 1995) and 4.30 (95% CI 1.32, 13.97) (Ogunyemi et al., 1998), when compared to women with an ideal BMI.

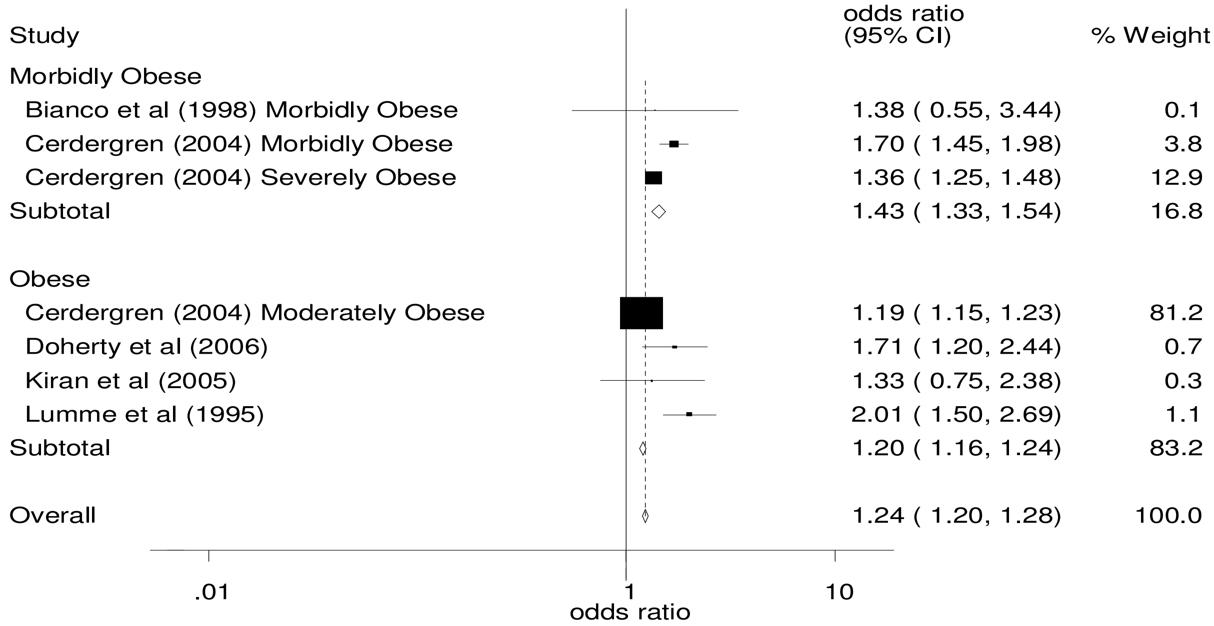
Figure 44. Neonatal Intensive Care Unit Treatment for Obese and Morbidly Obese BMI Compared with Ideal BMI



5.3.2.3 Maternal Complications Meta-analysis

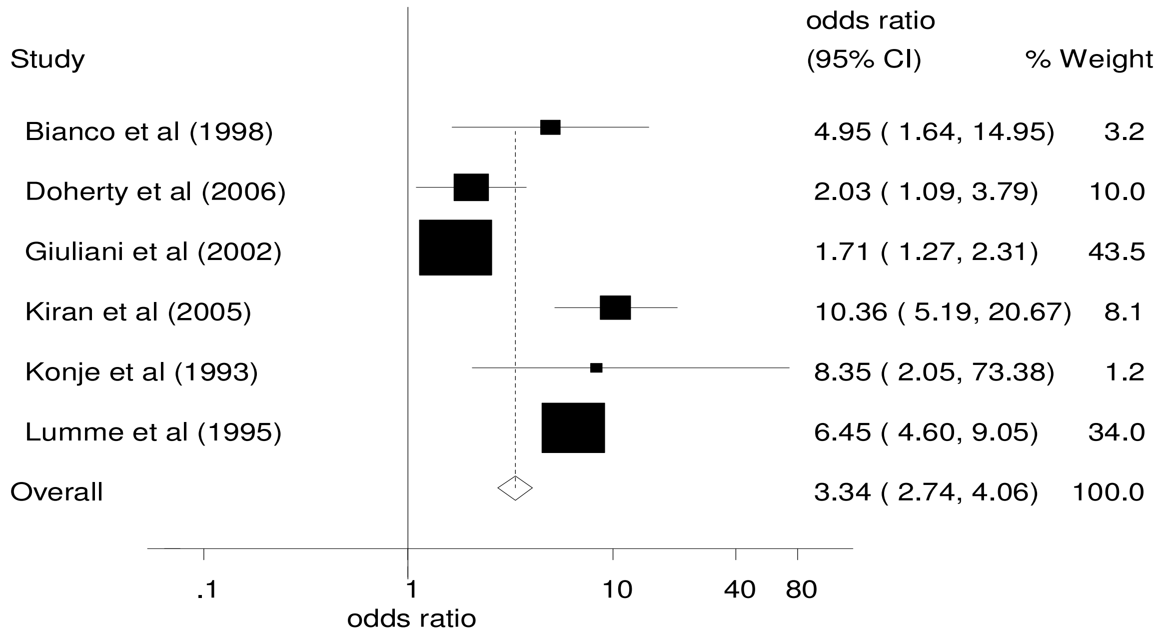
Women who were overweight, obese, and morbidly obese had significantly increased odds of haemorrhage when compared with women with an ideal BMI (Figure 45), whereas being underweight has reduced odds for this outcome.

Figure 45. Maternal Haemorrhage Forest Plot for Obese and Morbidly Obese BMI Compared with Ideal BMI



The rate of infection[29] was significantly higher in obese women with almost a 3 and a half fold increase when compared with women of an ideal BMI (Figure 46).

Figure 46. Maternal Infection for Obese BMI Compared with Ideal BMI



[29] Infection includes wound infection (n=2, abdominal wound (n=1), and combined wound and uterine n=1), and combined wound, urinary tract, perineum, chest, and breast (n=1).

Meta-analysis could not be carried out for under or overweight women and infection; however two studies did not show a significant relationship with either of these BMI groups (Doherty et al., 2006, Giuliani et al., 2002).

5.3.2.4 Maternal Complications Non Meta-analysis

It was not possible to combine studies for 3rd/4th degree tears due to an insufficient number of identified studies. One study showed no significant relationship between anal sphincter laceration and moderate, severe, or morbid obesity when compared with women in the ideal BMI group (Cedergren, 2004), and one study showed no relationship with 3rd/4th degree tears when obese women were compared with non obese women (Usher Kiran et al., 2005).

5.3.2.5 Neonate Non Meta-analysis

It was not possible to combine studies for neonatal birth trauma due to an insufficient number of studies being identified in the search. The studies that were identified showed a significant increase in trauma incidence[30] in obese mothers when compared to non obese (OR 1.50, 95% CI 1.10, 2.10) (Usher Kiran et al., 2005), whereas there was no statistically significant relationship with obesity, overweight or underweight and skull fracture (Naeye, 1990).

5.3.3 Secondary Outcomes

The results of the meta-analysis for the secondary outcomes that may incur an indirect resource implication for maternity services are shown in Table 44.

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[30] Where trauma was defined as cuts, grazes, bruises, fractures, muscle haematomas, dislocation, cephalhaematomas, and nerve palsies

Table 44. Meta Analysis Results: Secondary Outcomes

<table>
<tr><th></th><th>Underweight vs. ideal BMI</th><th>Overweight vs. ideal BMI</th><th>Obese vs. ideal BMI</th><th>Morbidly obese vs. ideal BMI</th></tr>
<tr><th></th><th colspan="4">OR (95% CI)</th></tr>
<tr><td>Birth weight and growth</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Birth weight (mean)§</td><td>3225 (3206, 3243)
n = 4</td><td>3334 (3317, 3351)†‡
n = 3</td><td colspan="2">3429 (3418, 3439)
n = 15</td></tr>
<tr><td>Low birth weight</td><td>1.781 (1.677, 1.891)†
n = 11</td><td>0.933 (0.890, 0.978)
n = 14</td><td>0.841 (0.782, 0.905)
n = 19</td><td>1.113 (0.924, 1.340)
n = 5</td></tr>
<tr><td>High birth weight</td><td>0.522 (0.458, 0.596)
n = 4</td><td>1.308 (1.215, 1.407)†‡
n = 8</td><td colspan="2">2.357 (2.293, 2.422)‡
n = 15</td></tr>
<tr><td>>41/42 weeks</td><td>–*</td><td>1.282 (1.198, 1.372)†
n = 3</td><td>1.370 (1.332, 1.409)†
n = 4</td><td>1.556 (1.479, 1.636)
n = 3</td></tr>
<tr><td><37 weeks</td><td>1.049 (0.871, 1.265)†
n = 3</td><td>1.166 (1.051, 1.293)†
n = 6</td><td>1.226 (1.149, 1.308)†
n = 9</td><td>1.495 (1.409, 1.587)
n = 6</td></tr>
<tr><td><34 weeks</td><td>–*</td><td>–*</td><td colspan="2">0.885 (0.670, 1.169)†
n = 3</td></tr>
<tr><td><32 weeks</td><td>–*</td><td>–*</td><td colspan="2">1.586 (1.467, 1.715)
n = 4</td></tr>
<tr><td>Labour and delivery</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Labour onset induced</td><td>0.728 (0.639, 0.829)‡
n = 4</td><td>1.302 (1.163, 1.458)†‡
n = 3</td><td colspan="2">1.880 (1.844, 1.917)‡
n = 10</td></tr>
<tr><td>Oxytocin</td><td>–*</td><td>–*</td><td colspan="2">1.593 (1.356, 1.872)
n = 3</td></tr>
<tr><td>Epidural</td><td>–*</td><td>–*</td><td colspan="2">1.228 (1.191, 1.266)
n = 5</td></tr>
<tr><td>Vaginal delivery</td><td>–*</td><td>0.777 (0.712, 0.847)
n = 3</td><td colspan="2">0.654 (0.592, 0.722)†‡
n = 4</td></tr>
<tr><td>Failure to progress</td><td>–*</td><td>–*</td><td colspan="2">2.306 (1.871, 2.842)†
n = 4</td></tr>
<tr><td>Placenta abruption</td><td>–*</td><td>–*</td><td colspan="2">0.984 (0.899, 1.078)†
n = 8</td></tr>
<tr><td>Placenta previa</td><td>–*</td><td>–*</td><td colspan="2">0.826 (0.714, 0.955)†
n = 7</td></tr>
<tr><td>Neonate</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Low Apgar score (1 min)</td><td>–*</td><td>–*</td><td colspan="2">1.494 (0.808, 2.763)†‡
n = 3</td></tr>
<tr><td>Low Apgar score (5 min)</td><td>–*</td><td>–*</td><td>1.570 (1.465, 1.682)†
n = 4</td><td>2.095 (1.866, 2.353)
n = 3</td></tr>
<tr><td>Fetal compromise</td><td>–*</td><td>2.062 (1.439, 2.955)†
n = 4</td><td>1.623 (1.545, 1.705)
n = 5</td><td>2.082 (1.924, 2.254)
n = 4</td></tr>
<tr><td>Meconium</td><td>–*</td><td>–*</td><td colspan="2">1.570 (1.422, 1.732)
n = 5</td></tr>
<tr><td>Shoulder dystocia</td><td>–*</td><td>–*</td><td colspan="2">1.042 (0.966, 1.125)
n = 9</td></tr>
<tr><td>Jaundice</td><td>–*</td><td>–*</td><td colspan="2">1.041 (0.933, 1.162)†
n = 4</td></tr>
<tr><td>Mother</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Tears/lacerations</td><td>–*</td><td>–*</td><td colspan="2">1.021 (0.969, 1.076)†
n = 7</td></tr>
</table>

*Data not available for meta-analysis.
†No significant heterogeneity.
‡Results following sensitivity analysis.
§Birth weight (g) compared with women in the ideal BMI category where mean birth weight 3281 (3273, 3288).

5.3.3.1 Birth weight and Growth Meta-analysis

There is a trend for an increasing $\bar{x}$ birth weight and high birth weight with increasing BMI category, and significant reduced odds of high birth weight when mothers are underweight. However there were insufficient studies to analyse high birth weight and morbid obesity separately to that of overall obesity. The trend for low birth weight is significantly higher in underweight women compared with women in the ideal BMI group, with significant reduced odds for women who are overweight and obese. The morbidly obese group shows a slight increase in low birth weight; however this is not significant (OR 1.11, 95% CI 0.92, 1.34).

There is an increasing odds of postdate delivery as the BMI category increases. Meta-analysis could not be carried out for underweight and postdate data; one study showed reduced odds (OR 0.87, 95% CI 0.8, 0.94) (Olesen et al., 2006), whereas another study showed no significant relationship (OR 1.0, 95% CI 0.7, 1.4) (Lumme et al., 1995). Interestingly, in addition to having an increased odds of postdate delivery, there was also an increasing odds of preterm delivery at <37 weeks with increasing BMI category, whereas underweight was not significant. Delivery at <32 weeks (which has the largest impact on service in terms of neonatal care) showed a positive relationship with obesity with an increased rate of over one and a half fold when compared with women in the ideal BMI group. The meta-analysis showed no significance in the results for delivery at 34 weeks for obese women.

5.3.3.2 Labour and Delivery Meta-analysis

There are increased odds for induction of labour in overweight and obese women, and failure to progress with the labour is more than twice as likely in obese women. The odds for requiring oxytocin or epidurals are also increased, and although these outcomes could not be meta analysed by degree of obesity one study shows an apparent increase in the requirement for epidurals with increasing severity of obesity (Cedergren, 2004).

There are significant reduced odds for vaginal delivery in both overweight and obese women. Morbidly obese and underweight BMI groups could not be meta-analysed for this outcome due to limited studies. Two studies identified no significant relationship with underweight (Ekblad and Grenman, 1992, Shepard et al., 1998), whereas one study identified a significant reduced odds for morbid obesity and vaginal delivery (OR 0.52, 95% CI 0.40, 0.67) (Callaway et al., 2006). The meta-analysis also showed significant slightly reduced odds for placenta previa in obese women, but no apparent relationship with placenta abruption.

5.3.3.3 Labour and Delivery Non Meta-analysis

It was not possible to include a number of labour and delivery outcomes in the meta-analysis. One study found a 12 fold significant increase in having difficulty in determining foetal lie in obese women when compared to non obese women (Konje et al., 1993), mal presentation was significant with increased odds of 1.4 (95% CI 1.2, 1.6) in obese women (Sheiner et al., 2004) but this was not significant in overweight women (Vahratian et al., 2004), and incidence of occiput posterior was not found to be significant in obese, overweight, or underweight women (Jensen et al., 1999). Premature rupture of membranes (PROM) was identified to have increased odds of between 1.2 and 1.3 in three studies (Konje et al., 1993, Sheiner et al., 2004, Weiss et al., 2004); however this was only significant in one study with odds of 1.20 (95% CI 1.02, 1.5) (Sheiner et al., 2004).

Failed induction increased from 0% in the ideal BMI group, to 1.7% and 2.5% in overweight and obese mothers respectively (Vahratian et al., 2004). Failed instrumental delivery was significantly higher in obese compared to non obese women in one study (Usher Kiran et al., 2005), whereas another study found no significance in either obese or overweight women when compared to the ideal BMI group (Vahratian et al., 2004). Labour abnormalities[31] were found to be significantly increased in overweight women when compared to underweight women (OR 1.78, 95% CI 1.11, 2.81), but this was not found to be significant in obese women (Johnson et al., 1992). There was an increased odds of labour dystocia and obesity (OR 1.67, 95% CI 1.50, 1.86) (Ehrenberg et al., 2004a), and duration of labour ranged between a mean of 4.7 hours (SD 2.8) (Galtier-Dereure et al., 1995) to 8.1 hours (SD 4.2) (Usher Kiran et al., 2005) for obese women, compared to 5.7 hours

[31] Including prolonged latent phase, protracted active phase, secondary arrest of dilation, arrest of descent, prolonged second stage

(SD 2.9) (Galtier-Dereure et al., 1995) to 7.7 hours (SD 4.0) (Usher Kiran et al., 2005) in non obese women.

Only one study measured pain and obese women were found to have a lower median pain score compared to women with an ideal BMI (9 and 8 respectively). However the proportion of women who reported a high pain score of 7-9 was slightly higher in the obese group (85% versus 83%) (Ranta et al., 1995). There was also increased odds of obese women requiring nitrous oxide (OR 6.43, 95% CI 3.17, 13.04) and pethidine (OR 12.35, 95% CI 3.00, 50.89) for pain relief when compared to women who were not obese (Ranta et al., 1995).

5.3.3.4 Hospital Admission Non Meta-analysis

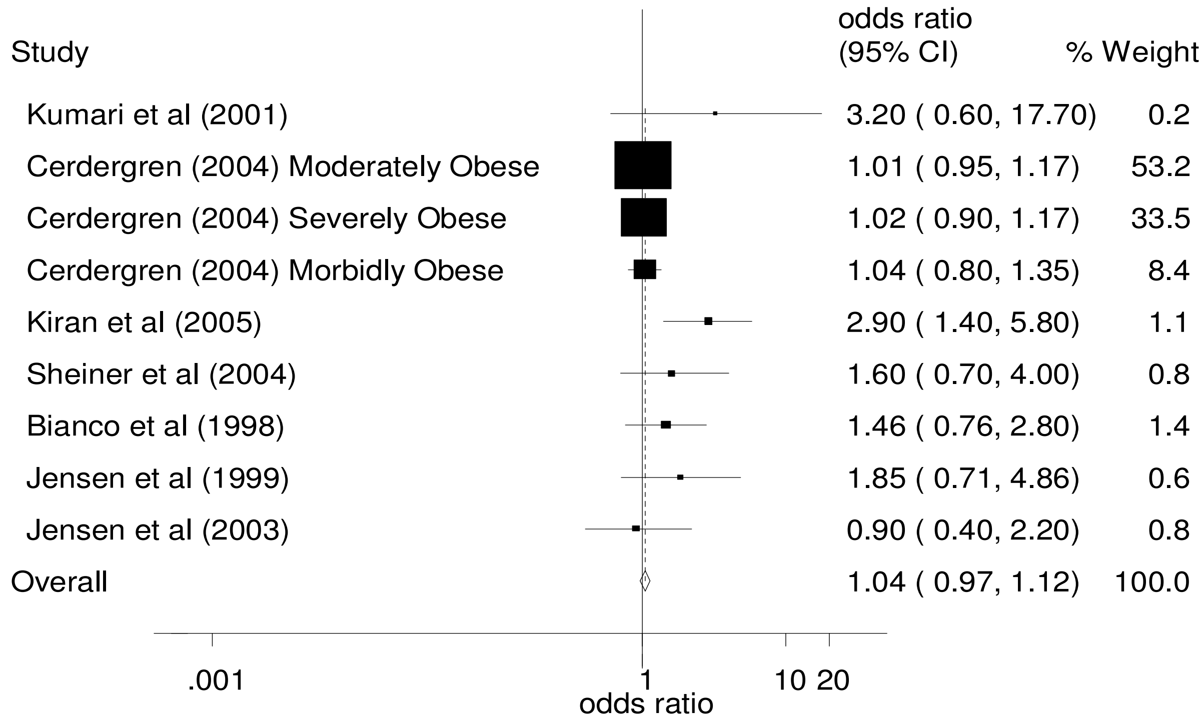
Studies looking at hospitalisation could not be meta-analysed; however most showed an increasing level of hospital contact with obesity and overweight. For moderate obesity and severe or morbid obesity the odds of outpatient hospitalisation were 10.42 (95% CI 3.05, 35.55) and 20.00 (95% CI 5.51, 72.58) respectively when compared with women in the ideal BMI group (Galtier-Dereure et al., 1995). This pattern was reflected in the odds of inpatient hospitalisation being 5.60 (95% CI 1.75, 17.90) for moderate obesity, and 18.51 (95% CI 5.44, 62.99) for severe or morbid obesity, and increased hospitalisation was also shown in the overweight group (OR 6.25, 95% CI 1.92, 20.38 for outpatient, and 4.90, 95% CI 1.63, 14.70 for inpatient hospitalisation). The odds of overall admission to hospital was also increased in obese women when compared to women with an ideal BMI (OR 2.67, 95% CI 2.15, 3.32) but not significant for underweight women (Lumme et al., 1995). Readmission to hospital showed a significant relationship with underweight (OR 3.36, 95% CI 1.84, 6.12) but was not found to be significant for obese or overweight women (Giuliani et al., 2002).

5.3.3.5 Neonate Meta-analysis

There is no significant relationship with apgar score at 1 minute and maternal obesity. However there was a one and a half fold increased odds of having a low apgar score at 5 minutes, and this rose to two fold when the mother is morbidly obese. The relationship between apgar score and underweight could not be meta-analysed; however no apparent significant relationship with apgar score a 1 minute (Lumme et al., 1995) or 5 minutes (Jensen et al., 1999) was found.

There is a significant increase in foetal compromise in the overweight, obese and morbidly obese groups, and there are increased odds of meconium being present when mothers are obese. Foetal compromise in underweight women could not be meta-analysed but was found not to be significant in two studies (Dempsey et al., 2005, Doherty et al., 2006). There doesn't appear to be any significant relationship with shoulder dystocia (Figure 47); however the control groups for this outcome included both ideal and non obese BMI. Following sensitivity analysis including only ideal BMI control groups no significance remained (OR 1.02, 95% CI 0.95, 1.11).

Figure 47. Shoulder Dystocia Forest Plot for Obese BMI Compared with Non Obese



Jaundice in neonates born to obese mothers showed no significance; however the analysis could not be carried out for morbid obesity separately for either jaundice or shoulder dystocia. One study that provided data on morbid obesity showed a significant increase in the odds of jaundice (OR 1.44, 95% CI 1.09, 1.89) (Callaway et al., 2006), but there remained no significance for shoulder dystocia (Cedergren, 2004).

5.3.3.6 Neonate Non Meta-analysis

There were a number of outcomes affecting the neonate that have an impact on resources and could not be meta-analysed. No significant relationship between obesity or overweight and the need for mechanical ventilation was reported (Callaway et al., 2006), whereas there appears to be a significant relationship with obesity and incubator requirement (OR 1.64, 95% CI 1.02, 2.63) (Usher Kiran et al., 2005), respiratory distress (OR 1.71, 95% CI 1.38, 2.11) (Naeye, 1990), and resuscitation (OR 1.75, 95% CI 1.26, 2.43) (Doherty et al., 2006), with similar findings in the overweight BMI group (Doherty et al., 2006, Johnson et al., 1992, Naeye, 1990), but not in the underweight group (Doherty et al., 2006, Naeye, 1990). There is a reported increased odds of foetal heart rate abnormalities in both obese and overweight women (OR 1.33, 95% CI 1.01, 1.67 and 1.38, 95% CI 1.03, 1.85 respectively) (Johnson et al., 1992), and increased tube feeding required (OR 1.51, 95% CI 1.08, 2.10) (Usher Kiran et al., 2005). The incidence of asphyxia was not found to be significantly related to obesity, overweight, or underweight (Jensen et al., 1999, Usher Kiran et al., 2005), obesity and overweight appear not to be related to the incidence of hyperbilirubinaemia (Di Cianni et al., 2003), hypoglycaemia (Jensen et al., 2003), or cord pH<7.2 (Usher Kiran et al., 2005).

5.3.3.7 Maternal Complications Meta-analysis

The primary outcome 3rd/4th degree tears is considered to have a direct NHS resource implication; however this outcome has been combined with the other reported tears (perineal tear/trauma, and vaginal repair) due to insufficient studies being suitable for meta-analysis. There was no significant relationship with tears and lacerations and maternal obesity. It was not possible to meta-analyse the relationship with underweight or overweight and tears. However there was no apparent relationship with overweight and perineal trauma (Doherty et al., 2006, Jensen et al., 1999), whereas underweight had a significantly inverse relationship with perineal trauma in one study (OR 0.70, 95% CI 0.49, 0.99) (Doherty et al., 2006), and another study identified no significant relationship (Jensen et al., 1999).

5.3.3.8 Maternal Complications Non Meta-analysis

The maternal outcomes identified as having resource implications that could not be meta-analysed were retained placenta, evacuation of uterus, thromboembolic events and puerperal complications, and these largely showed no significant relationship with BMI group (Doherty et al., 2006, Giuliani et al., 2002, Jensen et al., 1999, Usher Kiran et al., 2005, Konje et al., 1993, Sheiner et al., 2004). One study did show significantly reduced odds for retained placenta in the underweight group when compared to women in the ideal group (Doherty et al., 2006); however these results are not supported by a second study which identified no significant relationship between these factors (Jensen et al., 1999).

5.4 Discussion

The findings of this systematic review have been split into outcomes which are deemed to have the greatest impact on maternity services in terms of direct resource implications, and those outcomes which have the potential to lead to additional care being required that would also impact on NHS maternity service provision. A number of the outcomes identified as having a significant positive relationship with obesity support the findings of qualitative research carried out with HCPs to identify their views on the impact of obesity on maternity service provision (Heslehurst et al., 2007b).

This review has identified a relationship between obesity and increased demand for deliveries that require additional resources such as instrumental and caesarean deliveries, and an inverse relationship with vaginal delivery. A vaginal delivery is the least costly option when considering the resources required for the NHS in both staffing and length of stay. According to the 2006 Department of Health National Schedule of Reference Costs, the requirement for instrumental and caesarean deliveries increases the cost from £817 for a vaginal delivery without complications, to £1,129 for an assisted delivery and £1,682 for a caesarean delivery (Department of Health, 2006). These costs are seen to rise further to £2,239 and £2,337 when the assisted and caesarean deliveries have complications. The increased rate of caesarean delivery may be attributed to women who are identified as having larger babies prior to the onset of labour. Also those women who may fail to progress in the first or second stages of labour may require an emergency caesarean delivery. Both of these outcomes are shown to be positively associated with maternal obesity in this review. Women who have had previous caesarean deliveries are at increased risk of requiring subsequent caesarean deliveries (Chauhan et al., 2001, Edwards et al., 2003). As obesity in pregnancy is associated with increasing parity in mothers (Heslehurst et al., 2007a), and pregnancy is a factor which promotes obesity due to gestational weight gain and inadequate weight loss between pregnancies (Gore et al., 2003, Gunderson and Abrams, 2000, Siega-Riz et al., 2004), it would be reasonable to presume that increasing rates of repeat caesarean deliveries would be higher in those women who are obese. This is supported by Hibbard et al (2006) where morbid obesity in women who had a previous caesarean delivery was associated with failure of a trial of labour, and increased requirement for caesarean delivery (Hibbard et al., 2006). Failure to progress with labour is also shown in this review to be over two fold higher in obese women, which in addition to a relationship with more frequent caesarean deliveries, demands more intense midwifery care and need for an increased number of epidurals.

The implications of a caesarean delivery in terms of the mother's health when she is obese should be considered. There are greater anaesthetic risks during surgery when obesity is a factor (Dresner, 2007) and there is an increased risk of wound infections following surgery. The three and a half fold relationship with obesity and infections found in this review impacts on resources with the requirement for antibiotics and intravenous infusions, longer length of stay, and potentially debridement for severe wound infections which may require input from a plastic surgeon. The risk of haemorrhage is also shown to be increased in obese mothers, which may require longer hospitalisation, increased drugs, blood transfusion, fluids, and may result in a return to theatre and intensive care treatment.

The potential for the increased risk of caesarean delivery and longer length of stay is associated with a number of the secondary outcomes. In addition to the caesarean risks associated with high birth weight, low birth weight (especially in the case of intra uterine growth restriction (IUGR)), is also an indicator for early caesarean delivery in order to minimise the risk of further restricted foetal growth in utero. Morbid obesity poses a risk for clinicians to fail to diagnose IUGR due to an inability to obtain accurate foetal measurements, which could ultimately result in stillbirth if there is no intervention at an appropriate stage. With high birth weight there are resources that may be required in addition to caesarean delivery, such as repeat growth scans and clinic visits if the foetal measurements are above the cut off for gestational age, and the mothers may require additional tests to exclude diabetes, such as glucose tolerance or fasting glucose tests.

The gestational age at delivery has a potential impact on maternity resources. Postdates tend to have a higher induction rate associated with increased requirement for caesarean delivery and longer hospitalisation. The resource implications for premature deliveries largely relate to neonatal special care or intensive care requirements; especially those deliveries under 32 weeks (where obese mothers have a one and a half fold increased risk). The neonatal risk of having a low apgar score at 5 minutes was shown to rise from over one and a half fold in the overall obese group, to over two fold in the morbidly obese group. The resource implications of having a low apgar score are increased input from paediatric teams, resuscitation, and neonatal care. Additional staff requirements such as medical teams and increased midwifery care are needed for other foetal outcomes such as signs of foetal compromise, which may result in repeat foetal blood sampling if there is an abnormal heart pattern on monitoring, an operative vaginal or caesarean delivery, staff input during delivery and neonatal care requirements. Meconium stain can be a sign of foetal compromise; however it can also be present in the case of postdate babies. If the meconium stain is significant, a paediatrician may be required at the delivery therefore increasing staffing costs. In addition to the financial cost of neonatal intensive care, there is also a shortage of neonatal intensive care beds on a national level (Parmanum et al., 2000) and increased maternal hospitalisation adds to the increased pressure on bed capacity. In addition to the neonatal intensive care requirements, there is generally a longer length of stay when babies are premature. Large tertiary centres that provide care for premature deliveries require the facilities to care for mothers to stay both prenatally and post delivery, and there is a social cost because mother and baby are separated following birth.

In addition to the well documented health implications to the obese mother and her baby, the huge demand on NHS resources as a consequence of this is apparent. The safer childbirth minimum care requirements for service provision (Royal College of Obstetricians and Gynaecologists et al., 1st November 2006) include indicators for increased midwife to mother ratio. These indicators incorporate a number of the risks for obese women identified in this review. The lowest risk categories I and II are deliveries between 37 and 42 weeks, normal birth, no intervention, good birth weight and apgar score, and no epidural, requiring a 1:1 midwife to mother ratio. As the risk categories and midwifery ratios increase, the relationship with obesity and the indicators for increased midwifery care also increase. Category III requires a 1:1.12 ratio and includes induction, foetal monitoring, instrumental delivery, third degree tear and preterm birth, category IV includes the use of epidural and a 1:1.3 ratio, and the highest risk category requiring a 1:1.4 ratio includes emergency caesarean, medical or obstetric complications, and severe pregnancy induced hypertension.

Despite the adverse health implications and additional resource demand, there is an apparent lack of national guidelines for clinical practice, and an absence of public health interventions and research devoted to the public health aspect of obesity in pregnancy. The latest Confidential Enquiry into Maternal and Child Health report recommends that obese women should be considered a high risk group that require preconception counselling and support, especially in the case of assisted reproduction and other fertility treatments, and stresses that guidelines are urgently needed for the management of obese women in pregnancy (Lewis, 2007). This drive to develop clinical guidelines for the management of the obese pregnant woman is vital to help safeguard the health of mothers and their babies, and to develop public health interventions both prior to conception and postnatally to help prevent the rise in maternal obesity. Developing a successful programme of public health interventions would stem rising NHS resource implications, and minimise the risks to both the mother and her baby.

Chapter 6
A Qualitative Study to Investigate the Development of Maternal Obesity Maternity Services in the North East of England

6.1 Objective

The aim of this chapter is to identify any maternity services specific to obesity that are in place throughout the North East of England. The specific objectives are to explore HCPs perceptions of the benefits and disadvantages of maternal obesity specific services, and any barriers encountered or successes in developing maternal obesity specific services, using semi-structured interviews.

Previous research carried out between 2005 and 2006 in all maternity units in the North East of England (n=16) showed that the care requirements for obese pregnant women did not match the current service provision in the maternity units, and across all NHS Trusts there was a distinct absence of any obesity specific maternity services, as well as an absence of guidelines and policy (Heslehurst et al., 2007b). HCPs felt that advice given to women who were obese in pregnancy, particularly relating to weight gain, diet and nutrition, tended to be inconsistent and ad hoc, depending on who was in charge of the care of the women. A few members of staff had indicated that they wanted to develop services for obesity in pregnancy, or were in the early stages of developing obesity specific guidelines or policy (Heslehurst et al., 2007b).

Anecdotally, there has been a drive to develop services and guidelines for women who are obese in pregnancy in the North East since this study was carried out, partly as a result of participating in the study, initiating some maternity units and NHS Trusts in the North East to address the issue. This chapter will describe the qualitative exploration of the developments in services specifically related to maternal obesity, barriers and successes of implementing maternal obesity services within maternity units, and where maternity staff feel maternity services need to be developed in order to address the issue of maternal obesity effectively.

6.2 Methods

6.2.1 Data Collection

The data collection utilised focus groups and one to one interviews to establish any services, guidelines, or protocols that have been developed in North East maternity units, relating to the prevention or management of obesity in pregnancy. The data collection also addressed where HCPs felt maternity services needed to be developed in order to effectively manage the care of obese pregnant women.

Cover letters and information sheets relating to the study were sent to heads of midwifery and clinical directors/lead consultant obstetricians at all eight NHS Trusts in the North East, including 16 maternity units (Appendix 38). The contacts were asked to distribute the information sheets provided among their staff, and they were encouraged to include a variety of HCPs including midwives, obstetricians, dietitians, physiotherapists, diabetes specialists and any other members of staff who have a particular interest in the care of women who are obese in pregnancy. Emphasis was placed on the importance of participating in the study even if the maternity unit had no obesity specific services in place, as it was important to gather information about barriers to implementing services.

Semi-structured interviews and focus groups were carried out in the maternity units that agreed to participate (n=10) which included all NHS Trusts in the North East of England. An appropriate room for interview or focus group was determined by the contact at each hospital. All face to face interviews were carried out in the HCPs place of work, and two telephone interviews were carried out. The decision on whether interviews or focus groups were carried out was dependent on the number of HCPs interested in participating in each maternity unit. The recruitment of participants took place throughout August and September 2008, with the final focus group being carried out on 10/10/2008. The semi-structured interviews and focus groups utilised topics for discussion, with open-ended questions used as prompts for discussion in order to allow the HCPs to identify their own issues within their maternity unit. The topics for discussion all related to the services for maternal obesity, where the definition of services included any intervention, policy, or guideline specific to maternal obesity. The semi-structured interviews followed an interview schedule:

1. The development of services specifically for obese pregnant women
   a) Does your maternity unit have any obesity specific services, where services can include any clinical services, guidelines, or policy?
   b) If yes - can you describe them (for example what BMI must the woman have to be included)
   c) If no – what are the main reasons why there are not any obesity specific services?

2. The benefits of developing maternal obesity specific services
   a) If you have developed obesity specific services what are the benefits of these services, if any?
   b) How do you think they might be improved if necessary?
   c) If you haven't developed any obesity specific services then what do you feel the benefit of developing these services would be, if any?

3. The disadvantages of developing maternal obesity specific services
   a) If you have developed obesity specific services what do feel the disadvantages of these might be, if any?
   b) How do you think the disadvantages might be overcome if necessary?
   c) If you haven't developed any obesity specific services then what do you think the disadvantages of developing these services would be, if any?

4. Any barriers encountered when developing/trying to initiate development of maternal obesity specific services
   a) If you have developed obesity specific services, were any problems encountered during the development of these services? What were they?
   b) Did you overcome the problems encountered? How?
   c) If you have not developed any obesity specific services then have you tried to initiate the development of any services? Did you encounter any problems?
   d) Did you overcome these problems? How?

5. Any successes in the development of maternal obesity specific services
   a) If you have developed any obesity specific services do you feel there have been any areas of particular success?
   b) How do you feel these successes were achieved?
   c) If you haven't developed any obesity specific services then what do you feel would make them successful if you were to develop them?

6. Where do you feel maternal obesity services need to be developed in order to address the issue of maternal obesity?
   a) What do you think needs to be developed further in your maternity unit?
   b) What do you feel your role is in addressing maternal obesity?
   c) In an ideal world how can this issue be tackled?

The interview schedule was used only as a prompt for discussion if required, rather than as a formal process. The questions were not necessarily asked in the same order, as this was dependent on the natural progression of the discussions that took place. When issues were discussed without the need for prompts, then the questions were adapted and asked towards the end of the interviews to ensure continuity of interviews and that all topics for discussion were addressed. All interviews and focus groups were audio recorded, the data were transcribed verbatim, and all transcripts were anonymised. The transcripts were emailed to the interviewee for one to one interviews, and to the main interview participant who had organised the focus groups, to confirm that interviews were accurately represented and to enhance the validity of the data.

6.2.2 Data Analysis

Following validation of the interview transcripts by the interviewees, the transcripts were analysed using the recommendations made by Burnard (1991) for systematic thematic content analysis of semi-structured interviews, which uses category systems and is adapted from the grounded theory approach (Burnard, 1991). Two researchers independently open coded all interview transcripts in order to enhance the validity of the findings and to remove the potential for researcher bias. The open coding was combined to develop category systems and themes from the interview transcripts. The process of developing the category systems was achieved by:

1. Open coding key terms that were emerging whilst reading through the transcripts.
2. Reading through the notes and transcripts and developing lists of headings of themes emerging while taking note of supporting quotes and sections of discussion.
3. Re-reading the transcripts and grouping the headings together under broader categories when themes were similar.
4. Working through the list of categories to remove or collate repetitious headings.
5. Summarising the content of the themes that had emerged.
6. Collating and reading through the supporting sections of transcripts with the summarised themes, to ensure that the interpretation of the data in the analysis represented the raw data in the transcripts.
7. Updating the content of the themes based on any misinterpretation, over emphasis on any particular aspects, and to include any subthemes that had been overlooked in the process of generating the category systems.
8. Agreement by both researchers on the final themes and subthemes.

The final category system produced was agreed by both researchers and accepted as being representative of the data. Copies of the full transcripts were retained for the write up process to ensure that the key themes identified remained in context with the discussion of the findings.

6.3 Clinical Governance

The University of Teesside School of Health and Social Care ethics application forms were completed for this study (Appendix 39), and ethical approval was granted by the ethics committee on 23/07/2008 (Appendix 40).

The protocol for this study was emailed to the NRES queries line and the response stated that NRES considered this study to be a service evaluation, and therefore it was exempt from the NHS ethical approval process (Appendix 41). All R&D committees for the North East NHS Trusts were contacted and verbal confirmation was gained that they were happy for the service evaluation to proceed without an R&D application.

6.4 Results

6.4.1 Study Sample

All eight NHS Trusts in the North East of England agreed to participate in the study. Two NHS Trusts with more than one site for maternity services had differences in the services and guidelines between sites, therefore additional interviews and focus groups were carried out for these NHS Trusts to ensure that issues were identified at individual maternity unit level, as these were likely to differ across the Trust.

Ten maternity units participated in the data collection for this study during September and October 2008; four focus groups, and six one-to-one interviews (four face to face and two telephone interviews) were conducted. There was a range of health care specialties represented across the region including midwifery managers (n=9), trainee clinicians (n=8), consultant obstetricians (n=5), midwives (n=4), dietitians (n=2), and ultrasonographers (n=2). As with the previous study (Heslehurst et al., 2007b), there was a noticeable absence of physiotherapists, despite trying to include them in the study sample.

Following transcription and validation checks by interviewees, no participants requested any changes to the content of the discussions or withdrawal of their interviews, and all were included in the content analysis.

6.4.2 Content Analysis

The content analysis identified four overarching themes, and each theme had numerous subthemes (Appendix 42). The overarching themes included:

1. Maternal Obesity Service Development
2. Psychosocial Issues and Maternal Obesity Services
3. Information, Evidence, and Training
4. Where to go From Here?

6.4.2.1 Theme 1: Maternal Obesity Service Development

The theme of service development included discussions around factors that influence service development, services that maternity units had developed, and the issue of obesity specific antenatal care.

6.4.2.1.1 Factors That Influence Service Development

Safety was discussed by the majority of HCPs, and this was at the forefront of the development of services to address maternal obesity. The mother's safety, and the safety of the baby throughout the pregnancy and delivery was felt to be the main remit of maternity services, and the greatest benefit that could result from developing obesity services.

"…in the hospital I think it's looking at safety for the birth and delivery… …the monitoring of the baby in labour becomes difficult, the safety of the mum and the baby, it's a very high risk situation. I think that we have got a little bit of expertise in looking after obese women but when we have a woman like that we would call in our moving and handling people…"

(Head of Midwifery, Maternity Unit 4)

"It's explaining that if there are problems with the baby in the labour that it's the mum's condition and her care that is paramount, because if there's a problem we've got to make sure that mum's safe irrespective of the condition of the baby… So it's having that discussion that if there was foetal distress in a normal sized woman, because there's minimal associated risks you can get things done quickly, but there's more to take into consideration with large BMI, that might slow things down and if you've got a compromised baby there could be an adverse outcome"

(Head of Midwifery, Maternity Unit 1)

The complications that arise when the mother is obese have led to the need for high dependency care, additional monitoring, the need for more frequent contact, consultant led care, additional risk assessment, mobility, and the need to plan the delivery more thoroughly as emergency situations are more likely to arise.

"It's about planning and tailoring their individual care plan and making sure they can have a safe as possible pregnancy and delivery. It's around mobility afterwards, about prevention of DVT with obese women being more prone. When you're pregnant anyway you're at a higher risk of having a thrombosis, when you add obesity into that that elevates it so it's about looking at appropriate care afterwards as well"

(Head of Midwifery, Maternity Unit 4)

"…those women whose BMI is 35 and above will have serial scans for growth, a glucose tolerance test and anaesthetic referral… where their BMI hits 40 they will specifically have consultant care… There is an anaesthetic clinic that has now been established for women who are deemed to be at high risk so that will include women who have an increased BMI which is over 35, whether or not we've got anything planned for them electively or not they will all be seen within an outpatient setting, and they will be risk assessed… all women who are admitted to the delivery suite, if their BMI is over 35 a further risk assessment is carried out to determine whether any special equipment or any additional measures need to be taken to support the woman during her time in the delivery suite. Whether that's choice of room or whether that's thinking about any particular lifting… any sort of special considerations that we need to make along those lines"

(Head of Midwifery, Maternity Unit 5)

"I have concerns about mobility in labour for the obese woman, because what we've developed for the non obese is trying to get them off the bed and onto birthing balls and be more mobile in labour, but midwives are expressing concerns that the birthing balls wouldn't take the weight of a woman who weighed 120 kilos… That is the challenge, it's keeping the bigger women mobile, that improves their chance of having a normal delivery…"

(Consultant Obstetrician, Maternity Unit 6)

HCPs also discussed what maternal obesity services were trying to achieve. It was felt that this needed to be established before developing services and there was confusion among some HCPs about what they were expecting to achieve other than looking after the immediate safety of the mother and baby.

"In obstetrics we can deal with the consequences of women being overweight and that's what we're gearing up to do, because it is an established risk. So it's worth applying resource to deal with the demonstrable risk. But what I'm less clear about is the… well yes I agree with the health advice and what have you, but if we're starting to talk about putting in resources in, whatever form that is, even using the midwives time, that's fair enough if there's a positive outcome, but is there going to be a positive outcome when you've got someone already with a BMI of 35, what can we achieve in the 6 months?"

(Consultant Obstetrician 1, Maternity Unit 10)

"The whole point of writing a guideline or physically doing something is that you want to improve the outcome… I think it's quantifying what is the ultimate aim for identifying obesity in pregnancy. Is it that we want to influence the information women have which is always great, the right messages about future lifestyles and healthy eating, but in terms if achieving a reduction in maternal morbidity are we really going to achieve that? We're gathering all of these women into the fold and what are we going to do with them? Do we introduce our own exercise programmes with physios? What else can we do other than see them more regularly, ask them 'are you eating well and have you changed your diet, have you done a bit more exercise?' and if they say no what do we then do? I think this is the real dilemma…"

(Hospital Antenatal Manager, Maternity Unit 7)

6.4.2.1.2 Using BMI to Define Service and Access to Services

All maternity units discussed the use of BMI to define services, and to define which women had access to certain services. There was much debate around the appropriate BMI cut off to define which women were considered high or low risk, and to define specific care pathways. Some HCPs felt that there were differences between the NICE guidelines, CEMACH reports, and RCOG recommendations for BMI cut offs, and felt confused over which recommendations to follow. The confusion and debate around the BMI cut offs helped to explain why there were differences in practice between maternity units in the region. Some HCPs felt that the differences in the national recommendations resulted in them defining their own BMI cut offs, and this was based on local audit of their own population and the pregnancy outcomes associated with BMI. Other maternity units based this decision on capacity and the number of obese women that would be referred to a service, and utilised a BMI cut off that their maternity unit could cope with. There were also instances of maternity units increasing the BMI cut off used for some referrals, due to the capacity problems encountered when lower BMI cut offs were implemented into service.

"One of our problems is what is the BMI that we work to? Is it 35 or 40… depending on whether it's the [Tertiary Referral Maternity Unit]*, NICE, or the Royal College… I don't think the guidelines are clear… You see we've got some midwifery led units, and we need to know, what are the risks? Is 30 appropriate for the clinical risk or 35? So that's one of the reasons for auditing it… If we find a significant increase in adverse outcome with a BMI more than 30 we may then say for the midwifery led units that that will be our cut off point"*

(Consultant Obstetrician 1, Maternity Unit 10)

When discussing maternal obesity services some HCPs felt that the issue was not necessarily about what services were implemented for obese women, but more to do with which women were involved in the services based on their BMI, and at which point do they say someone is 'normal' or 'not normal'. There was discussion around the women with a borderline BMI who might be automatically excluded from high or low dependency services, and that some women were being overlooked based on the BMI cut off defined for access to services within maternity units.

"…we've got the referral mechanisms there but it's only for the super morbidly obese women that we've got them there and are able to do it… but it's the capacity issues and again it's the resource so whilst yes we've got a guideline, and we refer women for this, this, this and this, there is a body of women underneath that that we don't have the resource capacity to actually refer on and help"

(Head of Midwifery, Maternity Unit 1)

"…at the moment I would say probably only the higher spectrum of ladies, the ladies with a BMI of over 40 maybe, are probably being addressed. I don't think ladies who are just a little bit over weight… I think it probably doesn't get addressed as much"

(Maternity Outpatient Manager, Maternity Unit 9)

While all maternity units were using some form of BMI cut off as an indicator for referral for high dependency care (whether that was defined as a referral for consultant led care or a more structured pathway), the use of BMI alone as an appropriate measure to define high dependency care was questioned by HCPs. Some HCPs felt that there could be a better system of defining high risk care, and BMI in conjunction with co-morbidities and risk factors was considered by some to be a better indicator of high risk care. One maternity unit acknowledged the link with increased BMI and maternal death as described in the CEMACH reports (Confidential Enquiry into Maternal and Child Health, 2007, Lewis, 2007). However, they felt that they would like to know more information about those women who were obese and had died, whether they had other underlying problems that may have caused the death or was it the BMI alone? Two maternity units discussed how BMI should be used to flag up other issues, and that a holistic view of the woman's general health was required in order to determine if she required high risk care, such as the fitness, height and weight gain, how long the woman had been overweight, was it a lifelong issue or had they put a lot of weight on recently, if so what was the underlying cause of that weight gain? They felt that these were the issues that should be addressed to set criteria for high dependency care, rather than using the booking BMI as a 'one strike' for referral to consultant led care.

"I'm not convinced that we've got the starting point right… I mean we have women here with BMIs of 30… they're 5 foot 1, and by the time they turf up in labour to have their baby they've put 5 stone on. Now that BMI, by then, must be over the top but they fit our criteria to deliver in a low risk unit. We have other women who have a booking BMI of 35 who are tall, not grossly overweight to look at, who put 8 to 10 pound on over their pregnancy, and they're not allowed to deliver here. And in actual fact their BMI will probably be less than the persons BMI who originally booked here… I think we do have to look at obesity in pregnancy, but I don't actually think we're looking at it the right way… I think it shouldn't be one strike…"

(Midwife 1, Maternity Unit 2)

The similarities between the issues in obese and underweight women were raised, and it was discussed how underweight women were not being addressed in the guidelines and recommendations as much as those who are obese. Respondents were concerned that there was the potential for services for underweight women to be overlooked with the current focus on obesity.

“[following discussion about what to call obesity specific services] *the only hiccup with just calling it BMI clinic is are we then going to get the low low low BMI women in, but then do we want to identify with those women as well? There is a lot of focus on obesity at the minute whereas there’s also the other end of the scale isn’t there…”*

(Consultant Obstetrician, Maternity Unit 8)

“Which has been left out of the scope of the NICE guidance as well so, yeah I think that’s the worry isn’t it, that you don’t forget other groups depending on what’s sort of in vogue at this point in time”

(Consultant Midwife, Maternity Unit 8)

Despite the confusion and debate around the appropriate BMI cut off to be used and the use of BMI as an indicator for high dependency care, all maternity units had some services that were based on BMI.

6.4.2.1.3 Services Developed

There was discussion around the services that had been developed and were in place to address maternal obesity, and services that had been planned and were in the early stages of being implemented. The development of working groups or the use of existing working groups to address aspects of maternal obesity was discussed by some HCPs. The existing groups that were being utilised to address some aspects of maternal obesity were an evidence based practice group, bariatric working group, maternity matters group, and a nutritional advisory group.

“The bariatric working group we’ve got within the Trust have an agreement of an assessment that you make with bariatric patents and that’s out there as a guideline. But we’ve yet to formulate and finish off our midwifery guideline on bariatric patients… We also have within the Trust a nutritional advisory group and they do an assessment for all adults who come in about their eating habits. So very much on that line we’ve finally got something that we can do for pregnant women looking at their dietary habits…”

(Head of Midwifery, Maternity Unit 3)

One NHS Trust had developed a steering group for maternal obesity, including representation from community and acute midwives, obstetrics, anaesthetics, dietetics, diabetes, public health, the local PCT, and an academic institution. The group had developed referral pathways between community services, acute services, and public health, throughout pregnancy and postnatally, using defined BMI cut offs.

"We split them into 30-34.9, 35-39.9, and over 40 and we've developed very specific care pathways through the antenatal, the labour and postnatal and into then community care... [The BMIs between 30 and 40] *are going to flow through the normal clinical pathways, if they're 30-34.9 they're very much still community based care, but with access to the additional group exercise, support things afterwards…"*

(Consultant Obstetrician, Maternity Unit 8)

"it's just supplementation, but it can be done in the normal community based settings"

(Consultant Midwife, Maternity Unit 8)

…and then the 35-40 group, a lot of that can still be very normal, very community based, but they have the very clear pathways that they follow through to if they need additional support. The 35-40's will labour on the high dependency side rather than low dependency, because we know that so many of them end up with sections or being transferred, but they can still have low dependency care within the high dependency setting"

(Consultant Obstetrician, Maternity Unit 8)

The maternity units were at various stages in the development and implementation of obesity guidelines for the antenatal and postnatal period, and the potential benefits and disadvantages of having obesity guidelines were discussed.

"The obesity guideline that we have drafted is out in circulation and it's across the Trust… it starts in the antenatal period with the accurate recording of BMI, referral pathways, what needs to be done, growth scans, information to women… We have a Thromboprophylaxis policy in place which links into the raised BMI… It's not up and running in its entirety, but we're almost there. We've got the antenatal going, the intrapartum is in place, and we're talking about long term prophylaxis postnatally. So

there's a lot of work gone into it, and for all we're not at that end where we want to be there's a guideline out there… we've had it out for a couple of years but on the back of new evidence that's coming out, and best practice and recommendations it's been in, out, in, out! So we haven't had a full one until now"

(Head of Midwifery, Maternity Unit 1)

"… the overarching guideline is just formalising it through one single guideline, it is in effect pulling together the various strands which had always been contained in other guidelines, whether it's thromboprophylaxis management, whether it's assessment pre-labour and so on… because assessment pre-labour of women with an increased BMI would have been in one of the antenatal care guidelines, so it's just pulling them all together so you've got an overarching document which sets out the various measures that we will take, and guidance in respect of women with increased BMI"

(Head of Midwifery, Maternity Unit 5)

"[guidelines have] *raised the profile of the risks of the obese pregnant woman among medical staff and the midwifery staff… because before everyone used to just wring their hands and say 'oh gosh she's heavy what are we going to do about it' and we'd tell the anaesthetist and that would be that because that's what we've always done, but now it's a bit more focussed and woman centred and planned compared to how it used to be… it focuses the mind… it is likely to improve practice in the sense of giving everybody a reminder of what the risks are, as a kind of educational thing… and should improve the management of these women so that they don't miss out, because if there's no guideline each woman is treated on an ad hoc basis. The disadvantage is just guidelines, in general people are sick of guidelines and the more guidelines there are the more there are for people to read and be aware of… I don't think there's a specific disadvantage of the obesity guideline, unless women felt labelled and stigmatised but we've got to keep them safe"*

(Consultant Obstetrician, Maternity Unit 6)

All HCPs discussed referral mechanisms that were established, and that they would like to have. There were referral mechanisms and pathways in place for a variety of HCP specialties, mainly including consultant led care, anaesthetics, dietetics, and diabetes services. The potential benefits and disadvantages of the referral mechanisms, specifically to anaesthetists were discussed.

"…with the anaesthetic referral I think that has a huge benefit because the individual woman can be assessed by a consultant anaesthetist, and the plan can be put in the notes and on the file for when she comes in in labour, what the challenges might be for general anaesthetic, what the challenges might be for spinal anaesthetic and what level of seniority will be required for when she is in labour so people can plan in advance and see what's coming… any disadvantages of the anaesthetic referral, it takes up some time from the anaesthetic department's point of view, but on the other hand it saves a lot of time if they've got a plan, whereas if they're just having to fire fight then they'll take more time in the end…"

(Consultant Obstetrician, Maternity Unit 6)

"…the development we've had with the anaesthetist is good because it was quite ad hoc, if they were there in clinic we would phone them, but we now have a set clinic that they dip into, so we've actually set that up and that's quite good… sometimes the ladies have slipped through the net… but that doesn't happen very often now to be honest… the community midwives are much more aware and refer these ladies much quicker so it's very rare now we get a lady with a BMI of 40 who's come in for pre-section clerking that's not been seen by the anaesthetist, I must admit I think we're fairly good on that now"

(Maternity Outpatient Manager, Maternity Unit 9)

There was discussion around having the facility to assess women, and then signpost them into services that had the appropriate expertise to deal with various aspects of care. However, there were issues with HCPs knowing where to signpost women to, and what was available to them.

"…we're beginning to actually realise what's out there so we can actually signpost the women appropriately to the right place because certainly I didn't know what was out there for the postnatal period until we started out so I think that's one of the important bits…"

(Consultant Obstetrician, Maternity Unit 8)

"…although its not part of our core business I think we have got to step outside of the box and think about how perhaps we can work with other organisations to not only signpost women but to have some kind of contribution and input so that we get the best outcomes for women"

(Head of Midwifery, Maternity Unit 5)

"at booking clinic we don't have that much time and very much I feel this is a 'lets do an assessment and then signpost the woman to somewhere else' which can spend that time talking to her and giving her that additional help"

(Head of Midwifery, Maternity Unit 3)

6.4.2.1.4 Resource

The subtheme of resource included discussion from all maternity units around equipment and facilities, time, capacity, and funding. The need for specialist equipment and facilities to care for obese women in pregnancy was discussed as a marker of success and as a barrier. Most maternity units discussed that they had the essential equipment to manage obese pregnant women safely, such as delivery beds and theatre tables. Overall the maternity units felt that they were much better equipped to care for obese pregnant women than they had been at the time of the study three years earlier.

"Not having to move a theatre bed from one theatre to another is a huge thing so having bariatric theatre tables is a massive change. Having the bariatric delivery beds has helped… and obviously, we're quite lucky here, we've got rooms that have showers that you can just kind of wheel in…"

(Head of Midwifery, Maternity Unit 3)

"We've got the new beds and they go up to a high BMI, we've got an operating table that is fit for purpose, and we've got an ultrasound couch that we've had to buy in the antenatal clinic for overweight women, we do have large cuffs on our BP machines, the community midwives have them. But I don't know… I wouldn't like to say I was fully resourced… I don't think we're too bad actually, I think we're quite lucky in having the operating table and couch and things"

(Head of Midwifery, Maternity Unit 4)

The need for further suitable equipment was discussed, such as wheelchairs that could sustain the weight and width of obese pregnant women, examination couches, wider theatre trolleys, birthing balls, and issues with portable scales for community midwives to measure the weight during community booking appointments. One maternity unit had been involved in developing a novel Trust wide 'bariatric box' which included items such as blood pressure cuffs, incontinence pads, and thrombo-embolic deterrent stockings that were suitable for bariatric patients. The concept of the bariatric box was devised due to the difficulties in resourcing bariatric equipment and consumables, and the boxes are held in a central store which can be accessed by all departments in the Trust who pay for a replacement of a box when it is used. The need for more suitable facilities included showers, door widths, and mortuary facilities. One maternity unit had just completed a risk assessment of the maternity unit facilities and equipment in order to identify the shortfalls that needed to be addressed.

"[Named Midwife] *has done quite a lot of work on risk assessing the unit for obesity looking at door widths, chairs, blood pressure cuffs… all the basic stuff in the clinical areas. So I think that's a very recent piece of work that looks like it's been able to very clearly identify the gaps…*

(Consultant Obstetrician, Maternity Unit 8)

Time to address maternal obesity was discussed. The limited time at booking appointments, and the amount of information that was given to women during this contact with the community midwife was raised as being a barrier. Some HCPs questioned the feasibility of being able to give the advice that would make a difference in the limited time available, especially in light of the competing priorities of different initiatives that are required to be discussed during the booking appointment. However, some HCPs felt that there was time to address the issue, and suggested that HCPs needed to look beyond what was discussed at the booking appointment as they had the whole pregnancy to spend time with a woman and discuss the issues. Others felt that the pregnancy was still only a short period of time to address the issue in the bigger picture of the woman's life course, and that although they had a responsibility to do something they were limited in what they could do in this time period.

"If you ask the community midwife what information she's giving them at the beginning of pregnancy, it's about 3 or 4 pages… how practical is it to give the advice that will really make the difference?"

(Consultant Obstetrician 1, Maternity Unit 10)

"…you've got a woman that's pregnant, 9 months you've got her attention… so if you've got somebody who can spend the time properly to sit with her, talk to her and look at her diet, get the things in place for when she's had the baby…"

(Midwife 1, Maternity Unit 2)

"We have to do something for these women or at least provide something that doesn't increase their BMI and stabilises them, and then you know, gives them that follow on support because I'm very much conscious that we only have them for this 8/9 month period"

(Head of Midwifery, Maternity Unit 3)

One HCP discussed the amount of time that they had available to spend with pregnant women, how it was not enough time to motivate them to address their obesity, and that ideally there would be a specialist HCP in place to deal with these issues.

"In terms of services for the women it would be great… to have a counsellor who was prepared to motivate them, you know do motivational interviewing. I went on a course recently about that and I use it occasionally in my clinical practice… if we had the resources to make available a counsellor that women could go to, to help them stay motivated with maintaining their weight… that would be fantastic, but my half an hour in the clinic when I see them maybe twice in their pregnancy is not sufficient"

(Consultant Obstetrician, Maternity Unit 6)

The need for increased contact time with HCPs during pregnancy was also discussed. There was a general consensus that obese women required more frequent appointments, and additional procedures such as growth scans and GTTs. Some maternity units discussed how clinics were 'feeling the strain' of the demand for services, and there were discussions around the BMI cut off points in national guidelines being too low for maternity units to cope with the capacity and the resources required.

"NICE would guide us to screen everybody with a BMI over 30 with a glucose tolerance test, which is fine, but the resource implication is one that we need to get over. We haven't adopted that policy. I've got a meeting with some consultants in a couple of week's time to discuss how we're going to implement NICE in relation to that"

(Head of Midwifery, Maternity Unit 4)

There was discussion with one consultant obstetrician about their preconception clinics and how they felt it would be appropriate for obese women to attend these clinics. However, they were not currently advertising that fact to GPs as there were not enough doctors to run the clinics, or enough clinic space to add additional clinics. The capacities of collaborative resources were discussed as well, such as dietetic and anaesthetic departments.

"There was a capacity issue about the anaesthetists being able to see the women. So we've moved the goalposts, it was over 35 now its not even 40… we tried 40 but there was a lot of the BMIs over 40 still… so I think it's anything 50 and over has a one-to-one [discussion with the anaesthetist]… I think the biggest problem with the referral pathway is the dietetics, whilst we give advice on healthy eating, and what to avoid… once they get to the [BMI] *50 I'm sure there's referral pathways in that we can refer them but it isn't an automatic one, and the capacity issues within the dietetic department, they cannot cope with the ones we would like to see go through the system"*

(Head of Midwifery, Maternity Unit 1)

"[The resource is] *going to be passed on to somebody isn't it? Whether it's my budget or someone else's budget it's going to be passed on them. So there might be a service in Children's Centres now for exercise or nutrition, but if we start sending everybody to them they're going to reach their capacity and need extra resource"*

(Head of Midwifery, Maternity Unit 4)

Overall it was felt that implementing maternal obesity services was a form of service development. There was an agreement that there were limited resources available within the maternity units to address this issue effectively, whether the service development included incorporating additional or specialised clinics, employing a specialist midwife to take on the role of developing the services, or freeing up staff time to develop a business case for funding. It was felt that there was usually a way around the issue of funding but that maternity units had to work out how they needed to prioritise services, justify the additional resources required, and look at models for commissioning services.

"…resources that would be the big stopping block to everything. Then that's trying redesign services then because if you decide that something's more important than where do we redirect the money from to then provide that service"

(Head of Nutrition and Dietetics, Maternity Unit 10)

"I think the barrier's certainly resource but then that's up to heads of service to put a business case together and feel passionate about it enough, then the Trust will give you some money for…you know… forcing money from PCTs because it's a genuine public health issue"

(Head of Midwifery, Maternity Unit 4)

"One of our Sure Start Midwives looked at putting exercise classes in Sure Start because women are going there with their babies, and they've got physio's there doing antenatal so that might be an idea if women are already going there with their babies and their toddlers and they've got childcare whilst they're doing it. But when we approached that it came up against some funding problems… I mean we've got a pregnancy trained physio who wants to do it, we've got a Sure Start Midwife who wants to do it, we have the women attending, and the women themselves have expressed an interest but, the funding issue to put on another class means we have to pay the physio"

(Consultant Obstetrician 3, Maternity Unit 10)

6.4.2.1.5 Specialist Roles and Multidisciplinary Involvement

The need for an identified lead within maternity units was discussed. One maternity unit specified that they didn't feel it was important whether it was a clinician or midwife that took the lead, but the majority discussed how they would like to have a specialist midwife for obesity services. The role of the specialist midwife was discussed. HCPs felt that the specialist midwives role would:

- address gaps in services
- co-ordinate services
- liaise with public health services
- take some of the caseload off the obstetricians
- link between mainstream services and obesity services
- help to establish referral mechanisms
- have dedicated time to address the issues
- involve research

"[Consultant Midwife] *has basically done all of the organisation, putting together of the working groups so it's having an identified lead, whether that's a midwifery side or medical side I don't think that matters, having some dedicated time... ha ha! to do it and then the interested group… if you have people who aren't interested in the group then it's not going to push it forward, if you've got interested individuals who can then go off and complete their tasks because they actually want to make a difference, then you pull that back into the working group and I think that's how we've worked it"*

(Consultant Obstetrician, Maternity Unit 8)

"For me the investment that I think would pay benefit would be to have a consultant midwife because they can take lead, they can work with a public health agenda. The difficulty I've got is that the referral criteria will put pressure on all the consultants and everybody else, and we don't have the capacity… equally as a consultant midwife they should be doing research on it, and I know we've got the history of research in the region, but I think that we should just be looking at that with a focus, but also getting those links into public health"

(Head of Midwifery, Maternity Unit 3)

There was discussion around whether it would be appropriate to segregate the roles of HCPs into specialist roles. Some felt that all midwives and obstetricians needed to be up to speed in dealing with obesity, and creating specialist roles would take away that expertise. However, some discussed how there were already specialist roles for other aspects of pregnancy in both consultant and midwifery practice, and that obesity wasn't any different.

"There would be enough work for every Trust to employ a couple of midwives… really there would, because obesity's greater than smoking and we've got smoking cessation midwives. We have midwives who specialise in drug and alcohol abuse, we have midwives who specialise in diabetes, we have midwives who specialise in smoking cessation, HIV… why haven't we got midwives who specialise in tackling the obesity problem? Why haven't we got that? That's what we need"

(Midwife 1, Maternity Unit 2)

"The disadvantage is that you are then segregating those women out and is that a disadvantage for them. And you're also taking clinical expertise from the general consultant body, but then we're doing that in many other things. We have epilepsy specialists, and diabetic specialists, and HIV, and hepatitis specialists, and haemoglobinopathy specialists, so why shouldn't we have somebody who does obesity?"

(Consultant Obstetrician, Maternity Unit 8)

The need for specialist teams to work together to develop services for maternal obesity was discussed. HCPs felt that the specialist teams should include midwifery, obstetrics, dietetics, physiotherapy, anaesthetics, diabetes services, maternity care support workers, health care assistants, counselling/psychological support, bariatric services, behaviour therapy, cooking skills, money management, and GPs.

"It is on many levels a multidisciplinary issue because I think leaving it up to one service is wrong… because of the fundamental underlying lifestyle issues that are associated with it, it can't be anything else but multidisciplinary. I think it involves GPs, the women, dietitians, midwives, I think it involves you know… the family…"

(Hospital Antenatal Manager, Maternity Unit 7)

"It would be so nice if we've got these ladies if we could refer them directly to a dietitian who could see them while they are pregnant and look at their diets and… not just to say 'you need to do this diet'… it's not just about that it's the other aspects that go with it as well, so its having everything else in the service, the behavioural therapists, somebody to talk about food, even simple things like a lot of ladies don't know how to cook, so it's all very well saying to somebody 'well actually you should be having meat and two veg' they might not be able to cook meat and two veg, and the other thing as well is obviously… is money… sometimes they need help regarding money management"

(Maternity Outpatient Manager, Maternity Unit 9)

There was extensive discussion from all maternity units about the involvement of dietetics in maternity services. Some maternity units had inadequate links with dietetics, were frustrated at the limited access they had to these services, and felt that they needed to offer the women something else as an alternative. However, other maternity units felt they had improved their links with dietetic departments, that dietitians were keen to be involved in maternity services, and there were established referrals pathways and dedicated dietetic clinics for maternal obesity.

"…we had a lady who was really concerned about her weight and we did try and get the dietetics involved… I did a referral but she'd delivered by the time they could see her… that's the only time I've tried to do it if I'm really honest"

(Maternity Outpatient Manager, Maternity Unit 9)

"I think in the past that there's always been a fine balance between how we utilise dietitians in terms of dietary management… in advice and information... We're much better at including the dietitians, so a few years ago I would have said that's more of an issue than it is now…"

(Head of Midwifery, Maternity Unit 5)

There was discussion around the role of the dietitian, with some HCPs feeling that advice needed to be from a specialist, and others felt that a dietitian was only required if the BMI had caused other clinical problems that needed to be addressed, and that with some training midwives could provide nutritional information.

"I'm not a qualified dietitian. I know to give generic advice about diet in pregnancy, what to avoid etc, but looking at what someone eats and why they eat it I feel comes under a dietetic… it's a specialist thing…"

(Hospital Antenatal Manager, Maternity Unit 7)

"I would personally think that there would be other [HCP] *resources available… as long as they refer on to us if there was a specific problem, like the high cholesterol referral… but if it's information to be given out I'm sure that most people could do that, and I think if we accept that most of the population are a heavier population, if the weight hasn't gone on dramatically before pregnancy and they've been used to being that weight before they got pregnant it's not an extra stress on the body, whereas... the teenager age group might be a specific different group where they are still growing and they have their own maternal needs and growing needs as well as the baby needs... So I suppose it's not trying to group every pregnant person in the same group… and it might be that there is a group that we need to see to make sure that they are getting what they need to still be growing while the baby's growing as well, whereas you've got your older mum who has grown fully and then it's the baby needs"*

(Head of Nutrition and Dietetics, Maternity Unit 10)

Dietitians were also unclear about what was expected from them when they were being referred women from maternity services and felt they needed clearer guidelines for weight gain, weight maintenance, and weight loss during pregnancy. They also questioned the limited amount of time that they had available to engage with a woman during pregnancy and develop the rapport required for intervention.

"From my perspective I would like clearer guidelines for referral on to dietetics as to what's expected of me, because by the time that they've booked in and I get the referral then they're nearly half way through so you know, a magic wand I don't have, but what am I expected to do at that stage, and is it appropriate? I think that would be quite nice to have some clear guidelines about that…"

(Head of Nutrition and Dietetics, Maternity Unit 10)

The role of support workers to help midwives address maternal obesity was also discussed, and the potential to incorporate some of the workload into the maternity care assistant's role was considered to be an area for future development.

"…midwives tend to go in for, well technically 28 days but they tend to hand over to the health visitor at 14 days, now we are looking at something with maternity care support workers in the near future, now whether they would have a role in supporting women with a large BMI in the postnatal period, about the mobility, about activity, the public health and the health promotion aspect of it, I don't know, it could be a remit that you could put into it"

(Head of Midwifery, Maternity Unit 1)

6.4.2.1.6 Obesity Specific Antenatal Care

The suggestions for specific services included dedicated clinics, specialised antenatal classes, and specialised physical activity services. Discussion around what a dedicated clinic should incorporate included the need for consultant led clinics, a specialist midwife, dietitian, anaesthetist, and a phlebotomist.

"Things we want to develop are the things that belong to the pathway, so it's a separate clinic for the women with big BMIs of over 40… They need to be consultant led, ideally with a midwife who has an interest… call it a specialty if you like… anaesthetic involvement so they have an anaesthetic review at least once during their pregnancy, probably a dietetic involvement or at least a signposting... So the idea is to see them at booking, do some care pathways, see them at the 20 week anomaly scan and then at 28 and 34 weeks weighing them, looking at their weight gain and then very specifically looking at labour plans, balancing up risks of emergency versus elective sections, looking at whether they're going to need additional equipment prepping in for their labour and delivery and things like that, so it's looking at their pathway through all of those stages"

(Consultant Obstetrician, Maternity Unit 8)

However, there were opposing opinions about the development of obesity specific antenatal services. Some HCPs felt that it was appropriate to have specialist services as it meant that the appropriate professionals were there at a dedicated clinic to see the women, and there would be appropriate timing of assessment, and there was discussion around how this type of service worked for other specialist groups.

"…having discrete distinct services is, in some respects, is not a bad thing because it allows you to have the right professionals there at the right time to do the right thing in terms of supporting a woman…"

(Head of Midwifery, Maternity Unit 5)

"We've got separate clinics for twins and a separate clinic for teenage mums. So it's not as though we'd be taking obesity as one… It's about getting the most appropriate resources into that clinic to help the women… I think the benefits are safety and being able to have the woman give birth and receive her care in the appropriate place. I think that's a huge benefit and if you look at the CEMACH report in maternal deaths, obesity does figure quite high in it, so I don't think we can ignore it"

(Head of Midwifery, Maternity Unit 4)

"Work that we've done, for example, with the epileptics shows that if you have them in a specialist clinic you get much better adherence to the guidelines and hopefully better outcomes than you do if they're in the general clinics, and hopefully the same will be true of obesity ones"

(Consultant Obstetrician, Maternity Unit 8)

Other HCPs felt that obesity services should be kept as a mainstream service, and that care shouldn't be fragmented or segregated off as all staff needed to be familiar with the issues. There was also discussion around whether that would be what women wanted out of a service and whether it would engage women. Some HCPs discussed the need to think carefully about how a clinic like that would be labelled and how you could stigmatise a service if it wasn't thought out properly.

"There's a bit of a stigma coming to an 'obese' clinic isn't there? And I'm not sure that women would want to come when everybody in the waiting room was obese, I don't know, I think a bit of market research might be required there"

(Consultant Obstetrician, Maternity Unit 6)

"It's making it work alongside the mainstream service. If you take it away so much then the staff in the unit here… nobody will see the obesity patient, if you don't see them then you're not familiar with it … what I don't want to do is fragment that woman's care between all of us, and then she's got somebody else who's got records on her, so it's about keeping everybody else informed and keeping it as part of the pathway. Because sometimes if it's a separate pathway it can fragment the service… but bearing in mind that we're still there to provide antenatal care, and intrapartum so it's almost treating it a bit like smoking cessation, 'that's the obesity team but the mainstream care is still provided by us'…"

(Head of Midwifery, Maternity Unit 3)

"In doing something like that you've got to be mindful that you're sending particular messages to women, you may stigmatise a service. And make women feel like they're not equal to other people because you've separated them off… That might be a disadvantage to services users, they may not see that as being attractive … Maybe I'm completely wrong, maybe women would welcome that... this is something to ask service users really. They may feel that its more attractive to have those issues addressed within a mainstream service that is geared up to address it in terms of having the right professionals to call upon as and when required, and therefore they're not singled out as being different"

(Head of Midwifery, Maternity Unit 5)

The size of the maternity unit also needed to be taken into consideration when considering the development of obesity specific services, as the smaller units probably wouldn't be able to justify the cost of this type of service.

"One of the major issues would be the volume, the number of woman coming through that service as opposed to the cost of that service, one may outweigh the other. We've got a relatively small unit, you may argue that given the size it may be difficult to justify and financially support that, so I think its pretty much dependent on the anticipated numbers of women that will be referred into a discreet service and on the relative cost… if you were talking about a lot of women needing to access the service then I think that would justify the need for discrete distinct services..."

(Head of Midwifery, Maternity Unit 5)

6.4.2.1.7 Weight Gain in Pregnancy

The issue of monitoring weight throughout the pregnancy was contentious with much debate throughout the interviews and focus groups. There were differences in opinion and practice between maternity units, between HCPs within maternity units, and with individual HCPs changing their mind about what was the right thing to do throughout the course of the discussions. Discussion took place around how the monitoring of weight change during pregnancy used to be routine practice, 'part and parcel' of maternity care, whereas now monitoring weight is not carried out consistently. Some HCPs felt that if monitoring weight were routine for all women it would normalise it and it would be more accepted. Also, some HCPs discussed how women often asked to be weighed, and that there was no point waiting until they had gained too much weight to address it. Some units routinely monitored the weight of underweight and obese women only, whereas others did not repeat the weight measurement following the booking appointment regardless of the women's BMI.

"Way back we used to weigh every woman at every antenatal clinic, but it's come up in other forums about weighing women… and it's quite difficult because people have got different viewpoints and you're talking about discrimination, rights and all of the psychological barriers that are in place. At one time they used to just queue up and get on the scales, it was part and parcel of the community midwife check, but now it's such a sensitive issue… I think if you weigh women at every visit it would normalise it. There's no point waiting until she's put a couple of stone on and you think perhaps if she's been given some guidance and… I've had women in the past ask me to weigh them 'Can I pop on your scales?' because there are ones that are conscious of wanting to monitor their own weight, and it's their own health you know"

(Midwife Manager Matron 2, Maternity Unit 10)

"…we've talked about actually starting to weigh everybody haven't we, so that we're not just picking up you know, 'you're chunky therefore you're going to be weighed' so it becomes more accepted that everybody gets weighed and therefore you're looking at everybody's weight gain through pregnancy… we're going back twenty years aren't we!"

(Consultant Obstetrician, Maternity Unit 8)

There was discussion around the reasoning behind routine weight monitoring being stopped in clinical practice due to it being a poor screening tool for what was being monitored. Some HCPs felt that routine weighing would not achieve anything and questioned what the measures would be used for, and when would be the best time to take measurements for clinical benefit. Some HCPs felt that the reasons for weighing women had changed over time, and increasing rates of maternal obesity meant that the reasons for monitoring weight gain now would be for the mother's health rather than the baby's health.

" I'm old enough to remember we used to weigh them all and we really couldn't win, if they didn't put on weight we'd be monitoring them for foetal wellbeing, and if they'd put on too much weight that was not right either because of the supposed risk of pre-eclampsia… so when we dropped weighing actually it was appropriate because it was a poor screening tool for what we were using it for. So I would say if we are going to weigh women what are we achieving from it? Fair enough we establish at some stage what the BMI is because we use that as allocating the risk, but doing it all the time, I just think what's the point?"

(Consultant Obstetrician 1, Maternity Unit 10)

"If you're trying to keep your weight stable and you're not pregnant why do we stop when you are pregnant when that risk's a bit higher? And because we've got an increase in weight gain in the population full stop then… I don't know… but I see your point because I think well what are you going to do, but I think it's just for the woman's own health in pregnancy because we're trying to get them to eat healthy, exercise and all that kind of thing in pregnancy, but we don't actually monitor"

(Midwife Manager Matron 2, Maternity Unit 10)

"…we'd be weighing them for different reasons now than we used to, we used to weigh them because we were worried about the baby, and now we would be weighing them because we are worried about them, excessive weight gain rather than insufficient…"

(Consultant Obstetrician, Maternity Unit 6)

There was discussion around what you would tell the women about their change in weight, and there was confusion around the appropriate weight gain advice to be given to women who are obese during pregnancy; what is too little weight gain and what is excessive? There were also differences in practice around the weight gain advice that was given, both between and within maternity units. Excessive weight gain during pregnancy was also identified as a risk factor for the health of the mother and the complications that could arise, and weight gain was considered to be directly linked to the outcome of the pregnancy. The prevention of excessive weight gain was encouraged in some maternity units, as it was acknowledged that this added to the risk of being obese in future pregnancies due to excessive weight gain being particularly difficult to lose between pregnancies.

" I think women should know their weight at the end of pregnancy, because a lot of our women put on 20 to 30 kilos, we're not talking small weight gains, we're talking 30 kilos each pregnancy, so unless they know that and work to get that off they're often pregnant again and 30 kilos heavier than when they started their first pregnancy. And that's not one or two women that's a lot of our women so I think they should know where they're starting from at the end of their pregnancy"

(Consultant Obstetrician 3, Maternity Unit 10)

Some HCPs were advising obese women to stabilise their weight while pregnant, whilst others were giving generic advice to all women about weight gain. There was a difference in opinion about incidental weight loss as a result of a change in diet and lifestyle incorporating general healthy eating during pregnancy. Some HCPs felt this was acceptable as long as the baby was growing, whereas others questioned this rationale given the evidence base that advises against dieting and weight loss in pregnancy. However, guidelines state that HCPs should encourage healthy eating during pregnancy, which for an obese woman could be a complete lifestyle change and may result in weight loss during pregnancy.

"I would like to see some nationally research based evidence that it is actually ok for women to embark on advice that we give, healthy lifestyle, and say that it is absolutely acceptable if they successfully lose weight and eat healthily and be healthy in pregnancy and beyond. That they can still have an actively healthy baby… a lot of these women have a very unbalanced, unhealthy diet, and going healthy will

actually, in the long run, probably make them lose weight in pregnancy, unintentionally"

(Hospital Antenatal Manager, Maternity Unit 7)

6.4.2.2 Theme 2: Psychosocial Issues and Maternal Obesity Services

The theme of psychosocial issues included discussions around HCPs addressing the issue of obesity with pregnant women, issues of maternal acceptance, equality, stigma, engaging women into services, and choice.

6.4.2.2.1 Addressing the Issue

The difficulty in discussing obesity with pregnant women was raised by the majority of HCPs. It was accepted that HCPs have a duty of care to inform women of their increased risk of complications and the potential limitations of care. However the sensitive and emotive nature of the topic made it difficult to get the balance between factual and sensitive information. There was acknowledgement that HCPs need to be truthful and honest, but also that it needed to be dealt with in a sensitive and non-threatening manner, not condemning obese women, and that they needed to encourage women to engage into services. HCPs also discussed their need to have an unbiased attitude as obese women are vulnerable and need support during pregnancy. However they discussed the differences between what HCPs say to women and what women hear, and women were described as often getting angry when the issue was raised, feeling offended, stigmatised, and targeted.

"I think it's often an issue that women themselves don't like to face… we had a complaint, a woman claimed that her daughter had been called fat by the consultant… he actually didn't say she was fat but her BMI was 48, he said she was grossly overweight and it was going to affect her care… I had a discussion with junior medical staff and registrars about how they say to women in the clinic, and we were split whether you tell them they're fat or whether you tell them they're obese. So I think it's often the language that we use with women… the consultant has their perception then… but I don't think women want to hear that"

(Head of Midwifery, Maternity Unit 4)

"It's making it, in a sensitive way and non threatening way, making the patients aware that we're not just saying 'you are over weight' it's the implications that being overweight is going to have on themselves, on the pregnancy, on their life, but it's to be done in a sensitive manner that's not going to frighten the ladies as well, but they need to be aware of the health risks"

(Maternity Outpatient Manager, Maternity Unit 9)

"Sonographers will often say how to diplomatically talk to women about saying 'well actually I can't quite see that, the image is not so good when you've got a little bit of extra body weight' and the women complain, they get very angry and they complain and 'what are you saying, I'm too fat?' but we're being truthful, we're being honest and saying 'there are limitations to what this machine can tell you because of this'…they don't like it… I think that they don't want to hear it, to me it's the same as someone who's got a BMI of 16, who's incredibly thin, who may have an eating disorder, you've got those kind of psychological elements with overweight"

(Hospital Antenatal Manager, Maternity Unit 7)

The difficulty in HCPs establishing rapport with the women was discussed. This was considered to take experience and training to develop the skills to address the situation effectively, and it was suggested that the information given to women when addressing the issue should be given in a positive way that didn't assign blame to the women.

"…knowing how to talk in such a way as not to be offensive, knowing how to get rapport when you're as skinny as a rake yourself and you're talking to someone whose morbidly obese, not to end up going down that dead end conversation 'its alright for you to talk'… it's taken me years of gentle treading, fortunately I can't remember the last time somebody said that to me but it takes effort…"

(Consultant Obstetrician, Maternity Unit 6)

"I suppose if you give information it's got to be more positive information, so saying to the women this is what we do, and look for a positive outcome… if you can just turn it round and say look at it this way then this is what we do and that's going to be fine, so as well it depends which way you give information sometimes as to whether women take it"

(Midwife Sonographer, Maternity Unit 10)

Some HCPs discussed the terminology 'obesity' as being a barrier to addressing the issue for HCPs involved in the care of obese women in pregnancy. Re-badging obesity services was discussed as a method for addressing obesity services in a different way, with suggestions put forward for calling obesity specific clinics 'raised BMI', 'metabolic', or 'barometric' clinics. Other HCPs felt that labelling it differently was just avoiding the issue.

"I guess the other barrier or concern that certainly community midwives have is… is broaching the topic with somebody about their size and simple things like what do you call the obesity clinic, do you call it the obesity clinic? Would you want to come to the obesity clinic? Do you call it the raised BMI clinic? You know, is there a better politically correct way of doing it? And how do you start initiating that discussion, I don't know if you want to call that a barrier but it's… it is a barrier… hopefully a relatively simple barrier to get over but it's a lot of people involved in that"

(Consultant Obstetrician, Maternity Unit 8)

"There's no point using euphemisms really is there? It would just be a euphemism… it would just be pretending not to talk about it when you are talking about it…"

(Consultant Obstetrician, Maternity Unit 6)

Some HCPs felt that if they did address obesity, they didn't know what advice or services they could offer the women once they had done so. It was felt that clearly defined pathways of care were required for women who are obese, otherwise midwives might avoid addressing the issue with women.

"Community midwives find it difficult to raise the issue and then avoid raising the issue because they're not then quite sure what to do with the issue, and that's one of the things we looked at… the pathway that will be very, very clearly defined roles and pathways and services that they can refer women to, because I think it's like with all of these issues, you raise the issue and then what do you do with it?"

(Consultant Midwife, Maternity Unit 8)

There was also discussion around the issue of childhood obesity in the children of obese pregnant women under the care of HCPs and the difficulties HCPs had in addressing that issue. The issue of the role of HCPs and child protection was raised, where the HCPs felt that the child's immediate and future health was at risk and they had a responsibility to discuss the issue with the mother, but how to bring the issue up in a sensitive manner was felt to be difficult.

"…the child was always with her mother when I saw her, and I didn't know quite how to broach it, but she actually turned up once without the child and… the mother had actually brought it up… and I said 'would you like some help with this'… but she brought it up and I must admit I felt very uncomfortable about how do I approach it and I wouldn't have said anything in front of the child, but you do feel that it's like a child protection issue and you wouldn't have any qualms about bringing it up if you thought it was neglect… if the child was being neglected or physically abused… [If the mother hadn't brought it up] *I decided that I would bring it up before she went home... That's the decision we came to for what we had to do for that child"*

(Consultant Obstetrician 3, Maternity Unit 10)

6.4.2.2.2 Acceptance, Equality, and Stigma

The issue of awareness and acceptance included discussion of how women don't like to face up to the fact that they are obese, and that there are psychological relationships between food, body image, self esteem issues, and obesity. There was also discussion around how obesity was becoming so prolific within communities that it was becoming normalised. HCPs felt it was becoming more normal to see obese women in clinics, and also that women didn't realise they were obese.

"Because people don't realise that they've got a large BMI they don't see it as a problem, because they've never had a problem and it's only when they start coming into the NHS, and the first point of call if they haven't had any ill health is having a baby when they become pregnant… yeah there's loads of media attention and loads of press and different things, but until things start happening to them I don't think they realise the impact"

(Head of Midwifery, Maternity Unit 1)

"I used to think booking someone over 100 kilos was quite rare before, but now I think 110 kilos is fairly normal for my clinic, you know, its even in the past sort of 5 years it's changed quite significantly what we sort of see as almost normal… which we shouldn't be seeing it as normal! But we do because you have that cut off of 90 or 100… now 110"

(Consultant Obstetrician 3, Maternity Unit 10)

The issue of women looking after their own health needs was also discussed, and the competing priorities in their lives that mean women often neglect themselves, making pregnancy a good time to intervene.

"…and about raising their self esteem… and that they do look at their own health needs, because then when they're not pregnant the health of their child comes first and I think some women tend to neglect themselves at the cost of other things sort of going on in their life"

(Head of Midwifery, Maternity Unit 4)

The issue of equality was discussed, and HCPs felt it was important to make sure women felt that they were not being treated differently to everyone else. Equipment was discussed in relation to equality and dignity issues, where some maternity units utilised equipment in a way that obese women didn't feel stigmatised.

"what we've tried to do in terms of the operating table that we use, we use for everybody, we don't like kind of roll it in whenever an overweight person comes along"

(Head of Midwifery, Maternity Unit 4)

"If it's flagged up to us then we can do a risk assessment on the lady so that when she does come in she's got a BMI of 55 then we can have the larger beds… if she's having a planned section the larger theatre table and you know things like that, actually having it already organised rather than having it to be done in an emergency situation… I had one lady who came for pre-section clerking who was really concerned that there would be a gown big enough for her… so we made sure that when she came in we'd got an extra large gown, rather than the lady coming in and saying 'oh we've got nothing to fit Mrs So and So' and it must be awful for them to think 'oh my gosh I'm so big I don't fit in and then they're running round when I'm supposed to be going to theatre'. If you can organise it's so much nicer for the ladies, I mean it's such a sensitive subject"

(Maternity Outpatient Manager, Maternity Unit 9)

Socio-economic status issues were also discussed, including the population's perception of the cost of healthy diets. There was also some discussion around developing free or subsidised services.

"They'll say 'oh fruit and veg has gone up by this much… credit crunch… can we afford…', and people on a limited budget will consider things like that [fast food]*… you've got to convince them, it's about the message of it's not going to be more expensive to eat healthy, it's how you're going to put those messages across"*

(Matron, Maternity Unit 6)

The relationship with obesity and society was discussed, and HCPs felt that a cultural change was needed among society. Some HCPs also felt that they had an obligation to raise the expectations of health among of women, and how they were dealing with low aspiration communities.

"I mean you're talking about changing the social culture, you know, lots of heavy drinking and everything, over eating and that's having an impact on our clients that come here. We're just a small group but we are seeing the repercussions…"

(Midwife Manager Matron 2, Maternity Unit 10)

"It's like smoking 'I smoked all the way through my pregnancy and I had a 9 pound baby' there's too much of that about, it hasn't embedded into society yet that there's associated risks, because unless it happens to them it doesn't happen to them, it always happens to someone else…"

(Head of Midwifery, Maternity Unit 1)

HCPs discussed how obesity was viewed negatively in society and by the media. Some HCPs felt that addressing obesity in pregnancy without appropriate support mechanisms and services available could heighten the stigma associated with being obese among pregnant women. This was due to HCPs feeling that they were drawing attention to the problems associated with the woman's obesity, but not being able to offer her any structured support in addressing the issues in a positive way. There was discussion around how the current obesity message needed to change, to be more positive, and to engage the obese population rather than 'condemning' them.

"I think we have to look at how obesity is seen in society as well. People are very self conscious about body image, weight and everything. And here we go right at the beginning of pregnancy we're telling them that it's a problem… I think a lot of the general public think that it's your fault that you're that weight, because it's your choice to eat what goes in your mouth, how you choose to live, how you choose to exercise… a lot of people look at weight and say it's a personal choice, you could do something about that yourself. I think there's an underlying social stigma, so all we've then done is say to this woman because of the choices you've made and because of what [BMI] *you are now… it has made the difference between whether you are low risk care or whether you are now consultant led care"*

(Hospital Antenatal Manager, Maternity Unit 7)

"Nationally there needs to be a public health message with a slightly different slant on it to the one that's going on at the moment. Everybody's very aware because the media's going on about it, about the national obesity epidemic, but it doesn't seem to be in anyway encouraging, it's more critical and it actually reduces people's self esteem to read about it the way it's written, and it isn't engaging the obese population. It's a bit like the smoking messages, it doesn't engage the smoking

population, it engages the anti-smoking population, and the ‘obesity epidemic’ is just a lot of hand wringing and not a lot of motivating”

(Consultant Obstetrician, Maternity Unit 6)

The issue of anxiety and distress for women was also discussed. HCPs felt that women who were obese in pregnancy got distressed about the wellbeing of their baby as they couldn’t feel any foetal movement due to their size, and when scans can’t detect the foetus. There was also discussion around how women might feel they are ‘being pushed to one side’, or ‘herded’, and that no-one has time for them when they are automatically referred for consultant led care. One HCP discussed how it was important to thoroughly address all of the issues during pregnancy, but they felt that they were taking the joy out of pregnancy for some women because of the focus of the messages all relating to the risks.

“…a lot of women say ‘it’s great to be pregnant and then you just tell us about all of these horrendous risks and you make us very sad’, and I think there is an element of that these days, it’s all about risks, and it’s all about screening and abnormalities, and we need to check that your baby’s growing well… we’re really putting a lot of pressure on women to not have any of these problems, when really what they want to do is just enjoy being pregnant. Some would argue that we’re taking the ‘wow’ enjoyment factor out of it so where do you find the balance? I don’t know… but it’s becoming more and more necessary to define the risk to tell women what the risks are, because when something goes wrong they say ‘you didn’t tell me that was a risk’. So you’re very much between a rock and a hard place sometimes and I think obesity is just one more thing on the list”

(Hospital Antenatal Manager, Maternity Unit 7)

6.4.2.2.3 Engaging with Services

There was discussion around how services being developed to address maternal obesity need to engage women, and to be women and baby focused. There were some examples of services offered to obese women in pregnancy that had a low uptake.

"We refer them to a dietitian… but how many women actually decline or don't go to a dietitian, it's high, even when we refer them they don't want to go... we also send them to an anaesthetist and that uptake is quite high, it's in the high 80's. So women have no problems going to speak to another consultant about anaesthetic risks associated with only their BMI, yet they will not go and see a dietitian, we only have 30% uptake of that, it's poor…"

(Hospital Antenatal Manager, Maternity Unit 7)

Being sensitive to the needs of obese women and offering them services that would not make them feel stigmatised were considered to be important aspects when developing services. There was also a need for the services to be flexible, as not all women would feel comfortable accessing the same type of services.

"It's like anyone who's overweight, it just depends on how they view being overweight. Some people will respond to a group and will be quite happy doing that, and might be used to it because that's what they'll be doing in their antenatal groups… and there'll be the ones who prefer a one-to-one because they're embarrassed and there's a stigma about their weight"

(Head of Nutrition and Dietetics, Maternity Unit 10)

Services also need to be developed to reach all the women that need to be reached, and there was discussion around how supplementary services in general only reach the most motivated women who want to do something, and that this isn't necessarily the women that needed to be reached.

"I think health visitors in the other health centres have postnatal support groups for women, but you've got to remember that they're only accessed by the motivated ones anyway, so they've got to be motivated to go to a postnatal support group, discussing their delivery in depth and everything else that's happened and then talk about diet and… so the health visitors have like people coming in, baby massage, diet, dental health and things, but there are only a few motivated people who have the inclination to attend these groups"

(Midwife Manager Matron 2, Maternity Unit 10)

There was discussion around how services need to reflect what women want, and that there was value in identifying what services women want. It was felt that women need to see a perceived benefit to engage with services that address maternal obesity. HCPs were also concerned that if services were not developed appropriately, in a sensitive manner that the women were comfortable with, then there was a potential for women to disengage from services, which could be more detrimental to their health than not addressing the issue of obesity at all.

"So if you're highlighting it and raising it, just because we're sitting in a focus group now and we're talking about raising the big issues in pregnancy, and we've not necessarily thought about giving women anxiety, you know 'oh my gosh they're weighing me this week', because that's what used to happen, they'd be terrified to go, their anxiety levels are risen"

(Midwife Manager Matron 2, Maternity Unit 10)

"…her blood pressure goes up…"

(Midwife Manager Matron 1, Maternity Unit 10)

"…or worse than that they don't come, because they used to fail to attend didn't they, they wouldn't come because they would have to get weighed…"

(Midwife Manager Matron 2, Maternity Unit 10)

"[Following discussion around low uptake of dietetic referrals] *I think a survey of women would be good to do… I think that's more a valuable thing to learn because what is the point in putting services in place if women don't want to access them? Why don't they want to access them? Is it because it's a separate visit? Is it because they feel they're being labelled to go and see a dietitian, would they prefer to see a dietitian in a maternity rather than in a dietetic department? I don't know those things but it's something that we maybe should find out because I don't want to plough time and energy into services that are not being utilised because it's not what they want or not what they feel they need"*

(Hospital Antenatal Manager, Maternity Unit 7)

There was discussion around how 'being pregnant' moved women into a situation where they were a captive audience as they were, mostly, already engaged within a health service in maternity units. HCPs discussed how pregnancy this made pregnancy an ideal time to engage women to address their obesity as they had the support of HCPs through antenatal clinics and other contact time. Pregnancy was also discussed as potentially being the first time women had contact with health services if they had previously not had ill health, and therefore this could be the first opportunity for HCPs to address obesity with these women. HCPs also discussed how pregnant women wanted to know about healthy eating and were often motivated to address their obesity as they wanted a healthy baby, and this was potentially the greatest benefit of addressing the issue perceived by the women.

"…you've got a captive audience if you like when people are pregnant… the majority attend for antenatal care and most women want to do the best for themselves and the baby when they are pregnant so I think it's the key time to… intervene…"

(Head of Midwifery, Maternity Unit 4)

"…fundamentally, pregnancy is a healthy experience and because we have a captive audience, because we have women under our care for 9 months who for the most part haven't got a health issue, then there are opportunities there to work with them and promote healthy lifestyles..."

(Head of Midwifery, Maternity Unit 5)

"Women can find pregnancy as an excuse to eat whatever they want, and if we monitor their weight we can actually advise them. Some people believe that during pregnancy women are more enabled to follow advice because of the outcome"

(Registrar in Obstetrics and Gynaecology 4, Maternity Unit 10)

There was also discussion from some HCPs around the use of social marketing in encouraging women to engage in services, and that there was probably a lot that could be learned from the social marketing evidence base.

"…I began to think about this social marketing approach and I do think that we need to be using those approaches, and finding out what presses the right buttons… this 'me too' project that's very much been based around social marketing, and the fact that women don't want the emphasis… this was particularly in relation to smoking… they want the emphasis on time for themselves and pampering and all those sort of issues, so I'm sure there's loads of lessons we can learn from what's being done from the social marketing approaches already. But I do think that there might be an area where we need to know a little bit more about what do women want, and we don't know really, and a lot of the things we say might put women off totally…"

(Consultant Midwife, Maternity Unit 8)

6.4.2.2.4 Choice

There was discussion around how services to address maternal obesity potentially removed the choice from women about their care. This was due to the limitations in the care they could receive, such as low dependency care and birthing methods. Choice was also discussed in relation to the choice of the pregnant women, and how they may choose not to act upon the advice and services offered to them to address their obesity, and that HCPs could not force them into addressing it. There was also some discussion around the woman's choice of lifestyle, and it was their choice to eat what they wanted to eat.

" At the end of the day it's individual choice, if that woman wants to put a cream cake into her mouth no matter what you tell them they're going to do it …"

(Senior House Officer 1, Maternity Unit 10)

Others felt that utilising the notion of the women's choice to participate could be a way to encourage them to engage in services to address their obesity, rather than the prescriptive method of just referring them into a service.

"I think what we're doing, which is a subtle way in, is giving them support and inviting them in, and giving them a choice and I think there's more chance of getting people to access the services that way"

(Matron, Maternity Unit 6)

Some HCPs felt that services should be available locally whenever possible, as there were issues with travelling time, transport, and access to services when they weren't local. These issues could act as a barrier to women choosing to participate in services offered to address their obesity, and increased utilisation of midwifery led units and community services were suggested as ways of keeping services as local as possible.

"[When discussing the implementation of an intervention] *A lot of our women here don't drive, don't have their own transport, so it would have to be local and obviously with a big area it has to be lots of different places. We couldn't have them all coming to one place when we're a big rural Trust…"*

(Consultant Obstetrician 3, Maternity Unit 10)

"I don't want to go back to where everybody has to come into hospital to receive care… What I would like to see is an obstetric driven guideline for midwives to follow, that obviously they've been involved in producing, so the midwives are very clear about when to signpost them in to obstetric care. Because as more and more maternity units close, women are travelling further to get consultant led care. So if we can develop guidelines that will allow the care to be delivered in the community but always have the input of an obstetrician at appropriate points…"

(Head of Midwifery, Maternity Unit 4)

6.4.2.3 Theme 3: Information, Evidence, and Training

This theme included discussion around the use of information and evidence, the need for education and training, and the level of knowledge among HCPs and women.

6.4.2.3.1 Information

Having evidence based, up to date government information for HCPs to follow was felt to be important, and having a central information source for maternal obesity, for example a website that HCPs could use, was suggested as something that would be useful. Some HCPs felt that having leaflets relating to maternal obesity would also be useful, especially relating to how leaflets could help community midwives with the competing priorities for different initiatives required to be discussed during the booking appointment. Leaflets were also thought to be a good source of information for women so that they had some information that they could take away with them. Some units already had leaflets for women, for example anaesthetic risks relating to maternal obesity, but most maternity units didn't have any sources of written information for women specific to obesity.

"The anaesthetists have a good information leaflet from an anaesthetic point of view that is purely for women with a raised BMI, identifying the risk… something that they can take away with them. We've just developed one that is purely about BMI to give to women, which highlights good diet and exercise and various other things"

(Hospital Antenatal Manager, Maternity Unit 7)

One focus group discussed how women were receptive to information about nutrition during pregnancy, and that they used national sources of information for nutrition in pregnancy which were generic and not BMI specific. However, there were problems with accessing and utilising this information for all women who required it.

"A lot of women are really well motivated and up for advice and, you know the pregnancy family health promotion service was an A4 book that women get in pregnancy about healthy eating, but we don't get enough, so women are kind of deprived of that information, they might miss the boat if we're out of stock…"

(Matron, Maternity Unit 6)

Some HCPs stated that they didn't give any additional advice to women about nutrition when they were obese and they just received the standard information that all women were given, such as the information at booking. Information about nutrition and physical activity was also given to pregnant women in antenatal classes and workshops, and through antenatal education programmes. One maternity unit discussed their specific antenatal services for young mothers which discussed diet and exercise, and how the sponsored classes provided fruit. One maternity unit had developed a nutritional assessment tool, which is a script sheet for midwives to follow and complete at booking. This assessment tool is used to highlight any nutritional issues, so that midwives can signpost women who may need further support into additional services where they can get support from specialists in that area, such as dietetics services.

“So what we’re doing is… ‘How many portions of fruit and veg are eaten a day’ is one question, ‘are they eligible for the Healthy Start’, ‘Have they sought any or been advised to seek help about their weight’, ‘Does the woman have a BMI of over 30 or under 18 (refer to peoples clinic)’. And then we’ve got a checklist of discussions that need to happen which are current recommendations on healthy eating, folic acid, iron and dietary supplements, vitamin D, food safety, current recommendations on alcohol… And then we’ve got ‘Have they referred them to Healthy Start, have they referred them to a consultant clinic, or have they sent them somewhere else’ in the anticipation that there might be somewhere else to send them to!”

(Head of Midwifery, Maternity Unit 3)

The need for information to address the long term health implications of obesity in addition to the short term impact on their pregnancy was also discussed. The increased use of the internet as an alternative source of information to HCPs during pregnancy was considered to be an area that could be developed to provide useful information for women about maternal obesity.

“The internet does provide a lot of information that women probably would traditionally have sought out from professionals in healthcare… Because of course the NICE guidelines have now… the recommended number of antenatal visits is much smaller than it used to be, and they’re not seen as frequently as they used to be, so I think between times what’s happening is women are sourcing any information they want off the internet, so that would probably be potentially a good source of information for people who have problems with obesity”

(Midwife 1, Maternity Unit 2)

6.4.2.3.2 Evidence

The knowledge gap around maternal obesity services was highlighted as an issue. Some maternity units were involved in carrying out their own research, audits, and evaluations to inform service development. There was also discussion around how more research and audit was required in order to address the knowledge gap in the evidence base, and how services that were implemented needed to be evaluated for the same reason.

"The fact that we've got a computer system that will actually pull off some data supporting the figures… so that's a success. We've got the data to collaborate some evidence to support either business cases or the development of future activity. And also to use it as an audit, there's lots of audits being done by various staff members looking at the impact it has on the unit and what we need to do. And some of the audit results have actually influenced what we do with the guidance… but there's more work to be done, I really feel there's an awful lot of work to be done"

(Head of Midwifery, Maternity Unit 1)

"…we will probably need to develop very specific exercise services for those women, but again we don't know quite what works and again there is that issue isn't there about safety and all of those issues but I know there's expertise with people dealing with the non pregnant population so I'm sure with partnership working we could pilot… research perhaps specific areas. I think that whatever we do we need to be really good at evaluating"

(Consultant Midwife, Maternity Unit 8)

"Yes... because there isn't the research out there so I think if you're doing an intervention, which we are, you need to follow up and see what difference it makes because if it makes no difference then we're not doing the right thing are we, and we're not going to know that without actually evaluating and auditing..."

(Consultant Obstetrician, Maternity Unit 8)

The need for data to support requests for funding and partnership working was discussed, and how looking at local maternity data helps to put national guidance into perspective for local services, and health risks for local populations.

"What I've found is… certainly for Primary Care Trusts and other people who are not as aware [of maternal obesity]*, just giving them some statistics about the impact of maternal obesity on pregnancy and pregnancy outcomes, and you see that they just don't know, people don't realise, and I think that's what I've found is very useful… you know you've got your interested people on board anyway, but that's what really*

makes other people sit up and think, the Directors of Public Health etc, when you start to give them that information"

(Consultant Midwife, Maternity Unit 8)

There were some differences in practice across maternity units relating to maternal obesity; however the majority of maternity units were addressing similar issues. When asked about areas of practice in their maternity units that others could learn from, the majority of HCPs discussed how they didn't think that there was anything particularly innovative that their maternity unit was doing that was different to other maternity units in the region. Some HCPs felt that it would be good to have better regional communication and to share practice and learn from each other. Methods suggested for sharing practice included utilising existing regional networks such as midwifery networks, obstetric networks, and guideline networks.

"I think we could learn from others, good practice from other places and I don't know whether we do enough of that and I think that would be… within what resources we've got, I think it would be good to learn from others and maybe some information sharing sessions, or like a newsletter or something would be very useful…

(Matron, Maternity Unit 6)

Yeah so we're not all completely having to re-invent the wheel individually so things that other people have found to be beneficial… the availability of advice and equipment, it would be great to have a central resource wouldn't it, you know, a maternal obesity website…"

(Consultant Obstetrician, Maternity Unit 6)

There was some discussion around how the development of maternal obesity services could learn from other successful pregnancy initiatives, and discussion particularly focused on smoking cessation services. Smoking cessation during pregnancy has involved additional resources, intensive training, it is standardised and included as part of mainstream care, and it has had national strategic steering. HCPs felt that the same level of national involvement and backing would be required to effectively address maternal obesity, and that national public health messages would be required.

"We had a couple of community midwives went off and did some training on smoking cessation and started up some sessions, a few people attended then it dwindled off. Now you've got a national drive, a regional and local drive, you've got PCTs involved, you've got Smoking Cessation Co-ordinators linked to maternity services, there's more of a strategic drive and resource put into it so it's more effective… So that's where the success with smoking's been, you've started off as a local resource that was unsustainable, it wasn't as robust, and it was a poor engagement and the lack of resource, the lack of training… so there's a lot of investment being done from where we first started up to now which really is a huge improvement… I think it needs to be a national focus very much like the smoking cessation one"

(Head of Midwifery, Maternity Unit 1)

The difference between the objectives of maternal obesity initiatives and previous pregnancy initiatives was also discussed. The objective of smoking cessation in pregnancy is to help the mother to stop smoking, whereas with weight management initiatives the objective would be for a lifestyle change which is more complex and potentially a lot more difficult to achieve.

"…some people give up smoking and do really well and its fabulous, we get a lot of good successes with our alcohol and drug taking and things like that, and obesity to us is another one of those hurdles… but people can reduce and stop smoking we can give them patches, we can give them nicotine, with substance and alcohol we can offer them methadone. We can offer them support programmes for obesity, other than obesity support groups that you would find through the dietetic department, what else? That's as much as we can do at the moment"

(Hospital Antenatal Manager, Maternity Unit 7)

The national and strategic issue was further discussed in terms of needing evidence based guidance on what services should be trying to achieve, and how they can be achieved. When discussing how to address the issue, one HCP stated that regionally agreed principles on what was required would be good, but that the solutions to addressing the principles are likely to differ at a local level.

"I think the principles perhaps should be agreed regionally to say… but I feel, these sort of schemes do have a local theme to them don't they? Different localities will probably require different solutions in terms of how you pull these services together, whether it's geography and the proximity of services. For instance, as a hospital we've got close proximity to a leisure centre, its literally across the road, and you know if you can start and think about how we might want to in the future develop relationships with a local centre that provides sort of 'stay fit' facilities, swimming, gym and other sort of sport activities then we've got proximity. It may not be the case somewhere else… it's a local solution but I would suggest that the principles are more of a regional issue because the problems that affect us affect the whole region"

(Head of Midwifery, Maternity Unit 5)

6.4.2.3.3 Education, Training, and Knowledge

The training requirements discussed by the HCPs largely related to how to best approach the issue of obesity with women, particularly referring to the use of appropriate language, and feeling uncomfortable about discussing this issue with their patients. Issues were also raised around lack of knowledge of what to do after the issue of obesity has been initially discussed.

"…I was just talking about how easily offended obese women are if you don't use the right language and how important it is to maintain rapport and how difficult it is… And so that takes training and the experience in maintaining rapport without offending them, and using the right words so as to ensure they know we're on their side not just saying go away you're too heavy. Because it is easy to offend them…"

(Consultant Obstetrician, Maternity Unit 6)

"I think all midwives would need some training the same as we all have some smoking cessation training, but all that's about is about being able to put the person on the right path isn't it? It's about knowing where to get in touch with things and knowing where to send them for support. So all midwives would have to have some training and probably most midwives do know enough about nutrition generally to kind of support them along the way, but you're definitely going to have to have robust training for these specialist teams."

(Midwife 1, Maternity Unit 2)

There were suggestions offered around the types of training that are being planned, and that would or could be useful, such as behavioural change training that could potentially be delivered by dietitians to midwives. It was also suggested that midwives might consider learning how to broach the subject of obesity with women in a sensitive manner from dietitians, although the logistics of finding time for such a training programme was also discussed by some participants, as well as the feasibility and access to training for all midwives. There was some discussion around how training sessions needed to be flexible to address the logistics issue, and how existing meetings could be utilised as training sessions so additional time out of clinical practice wasn't required.

"…we've talked about training and behavioural change, so we're going to set up some training sessions for the community midwives in how to broach the issue, and how to then use it as a behaviour change and a holistic approach [for the woman's overall health] *rather than just than one little area* [obesity]*…"*

(Consultant Obstetrician, Maternity Unit 8)

"When you're talking about training it's time out, and we have a very limited amount of time we can give to training because of capacity, I don't know how feasible training would be… we have a clinical issues session every month with the community midwives… [the dietitians] are going to *come to the November meeting and they'll do a half hour session, so you could call that a training session if you like and that may be the beginning of things to come. We might invite them to a unit meeting and raise their awareness a bit more of the robust systems that we are trying to develop. So I think there are possibly other ways apart from formal training…"*

(Matron, Maternity Unit 6)

There was also discussion around how links with dietetics departments could and should be improved to enhance patient care, and that the dietitians may need some training from the midwifery and obstetric teams about the needs of the mother and the foetus if there weren't any maternity specialist dietitians accessible in the maternity units.

"…in terms of the dietitian they should be the ones who are dealing with obesity in general anyway. I mean yes they may need a little bit of education in terms of the developing… they would need to understand what the baby needs, what the mum needs… so I don't know whether in terms of the dietitian that they would need expertise on the midwifery side… there would probably be a training implication there, but I don't really want to rubbish the dietitians by saying they don't know because I have no idea… and I just think that's actually quite sad that we have an increasing problem with obesity and yet I've never spoken to a dietitian [about it]*"*

(Midwife 1, Maternity Unit 2)

There was a lack of knowledge among HCPs about what public health services were available to women regarding weight management, and there were very few links between the maternity units and public health. However, there was frequent reference made to commercial slimming clubs and a much better knowledge among HCPs of these services than public health.

"I don't know of anything public health wise, that they're doing… that's why we're trying to get the Maternity Matters group together to very much say come to the table, tell us what you're doing, let us work together because some of it is very much, we've got these targets as well but we need to work together to work it all out"

(Head of Midwifery, Maternity Unit 3)

"I think it's linking in with Sure Start programs too… About using the resources that are already there, signposting into clinics, into children's centres and advice on smoking, its all around lifestyle and public health… I think a lot of the services are there, we just have to know how we get women to access them… It's just a matter of finding out where they are..."

(Head of Midwifery, Maternity Unit 4)

"One of the things I saw at the International Conference of Midwives was actually a collaboration between midwives and Slimming World"

(Head of Midwifery, Maternity Unit 3)

There was also discussion about the knowledge and education needs of the women, as HCPs felt that there was a lack of knowledge among women about BMI and about the risks in pregnancy. Discussion around how to address these issues centred on getting the public health message across to the general population during the preconception period, and getting the message included in schools' curriculum and youth groups. Some HCPs felt that it would be appropriate to refer obese women to preconception clinics, but that there were capacity issues. There was also discussion around the use of preconception clinics, how there may not be enough time to do anything very effective in such a short period of time, and that only the motivated women would attend these pre-conception clinics.

"…there was at one time, there was a big push towards preconception, people went along to these clinics before they actually conceived and got advice, but we tend only to see them now when they're already pregnant..."

(Midwife 1, Maternity Unit 2)

"It's too late by the time they come in and they're pregnant because they're already pregnant, and ideally it's the before bit. Whether we do clinics that are preconceptual just for women who wish to lose weight, but if you had a preconception clinic for everyone that you needed to all we would do is preconception clinics, and then that's only really for the women who want to come to them, the women that you want to get to are not the women that come to preconception clinics…"

(Hospital Antenatal Manager, Maternity Unit 7)

6.4.2.4 Theme 4: Where to go From Here?

The theme of where to go from here included discussions around addressing the issue in the long term and looking at the bigger picture, being pro-active and the need to do more, having a holistic approach to addressing maternal obesity, and the need for partnership working.

6.4.2.4.1 Long Term and the Bigger Picture

The potential for long term benefits of addressing maternal obesity were discussed. These included the benefits of weight loss for the mother's general health with the potential for a reduced risk of developing obesity related disease in her later life.

HCPs felt that the improvement in women's general health during pregnancy could result in a long term reduction in cost for the NHS relating to the future healthcare needs of the woman, including the reduction in cost for future pregnancies if weight loss were maintained, especially for first time mothers who were probably going to come back through maternity services. Addressing obesity in pregnancy was also felt to be a good time to 'break the cycle' of obesity and improve the health for the next generation by starting to address the issue at the foetal development stage.

"You've got a health benefit that'll continue into later life, so your public health targets of reducing your cancers, your cardiac disease, all of that, and your diabetes will have a cost impact for the NHS but also the benefits associated with the maternal health. A change in attitude, again, will have an effect on the babies health so again like I've said you're starting with a new generation with an attitude and a mindset and a healthy lifestyle"

(Head of Midwifery, Maternity Unit 4)

It was also acknowledged that to address the issue in a way that would make any difference we needed to look at the bigger picture. Getting children interested in food, looking at the food industry and advertising of food were given as examples, and HCPs felt that maternity services couldn't really make any impact on these wider issues.

"You've still got supermarkets filled with sweets and people with a bit more money that can buy sweets, you know there's… where do you stop? I mean I don't think we could influence that. You can only… you have to enable the women to see what's right for their babies and start off by the women wanting the children to have healthy options and I think that's the only way… because you're never going to stop this, that's always going to be there"

(Midwife 1, Maternity Unit 2)

There was a general consensus that a long term solution was needed to reduce the problem of maternal obesity, and that the benefits of implementing services to address maternal obesity may take some time to be seen. It was felt that maternity HCPs could only have a limited role in reducing maternal obesity rates regardless of changes that were made to practice, as they were only a small part of a long journey for the woman.

"I think what I'd like to say is, I've been sat listening, and I think we've made contributions from all aspects, but I think we're looking at a big plan... a 10 year plan. In our heads, we're trying to do something right now for this pregnant woman in our imagination, and how we can help her… and I think we are probably doing too much, too quick, too soon, and I think we've just got to change the whole of society, this has happened over the last 20 years, and I think we are just a product of that, these women just happen to be pregnant as well as big, and their partners are big aren't they? [General agreement] *So as much as we want be proactive and do things, I think we can chip away but it's bigger than us!"*

(Midwife Manager Matron 2, Maternity Unit 10)

"We're not going to sort the obesity problem overnight, so we can either say well we'll live with it, or we'll say right let's commit ourselves to it properly and we know we're not going to see results for 10 years, but this is what we have to do"

(Midwife 1, Maternity Unit 2)

6.4.2.4.2 Pro-active and the Need to do More

HCPs felt that current maternal obesity services were focussed on treatment rather than prevention, and intrapartum care with a poor pre-conception service. Staff wanted to be pro-active in shaping the services provided, and were actively freeing up their time in order to address the issue in various ways, including joining working groups and being involved in health promotion events. HCPs felt that all of the people involved in caring for obese women in pregnancy needed to have enthusiasm, and to be willing to take on their role in services directed towards maternal obesity. They also felt that willingness and enthusiasm is required from midwives that take on the role of a specialist midwife, and from the multidisciplinary teams involved in the care of obese women in pregnancy. Overall, HCPs thought that maternal obesity was an important issue that they felt passionate about being involved with and wanted to do something about it in clinical practice.

There was acknowledgement among HCPs that there was a lot of work still to be done to address maternal obesity effectively, and that there was a lack evidence about what was effective in the management of maternal obesity. However, they also agreed that they needed to do something and couldn't ignore the problem. There was agreement that whatever was done it needed to be woman focussed and needed to be what was best for the woman. HCPs were very clear about the obstetric needs of the woman. However the gaps in the knowledge about weight management meant that they weren't clear whether what they were doing was enough, what else they needed to do, or where the services needed to go to be improved.

"The gaps that still exist surround the knowledge of what we actually do with somebody in the antenatal period about their weight management, about how often you check it, whether you check it, what you do if they're putting on pounds, do you do weight restriction? Do you put them on a diet? Because that evidence doesn't exist so those are the big gaps"

(Consultant Obstetrician, Maternity Unit 8)

It was felt that there was a huge amount of work to be done in the community setting and with PCTs, and there were some suggestions on what else was required to address the issue of maternal obesity effectively:

- Targeted and specialist services, such as specific antenatal classes.
- Support for women, including peer support groups, psychological support, counselling, behavioural therapy, and clinical support.
- Dietetics, nutrition and healthy eating services.
- Targeted physical activity services, such as improved access to aqua-natal, walking clubs, and exercise facilities.
- More individual care plans for obese women.
- More screening.
- Methods for increasing mobility during labour.
- Forge links with PCTs.
- Additional breastfeeding support.
- Structured postnatal care relating to obesity.

“I do feel that there is a need to have more specific targeting of those women that may benefit more from the opportunity to have some programmed exercise, not only during the pregnancy but also after the pregnancy… You know, at the same time I’m mindful of the fact that providing exercise in these circumstances is not a core service delivery for the NHS, and I think this is where the opportunity to work in partnership with other organisations must come into it”

(Head of Midwifery, Maternity Unit 5)

6.4.2.4.3 Adopting a Holistic Approach

HCPs felt that a ‘whole health’ approach was required in order to address the issue of maternal obesity, and how maternity services should look at it as a ‘wellness model’ in a positive way. Some HCPs discussed how addressing maternal obesity needed to involve thinking outside the box and beyond what was the core service provision.

“I know we’re trying to look at this wellness model rather than just the tip of the iceberg - the women that need the specialist weight management service or the targeted interventions with BMI over 30. I think we’ve got to look at it from a whole population approach as well…”

(Consultant Midwife, Maternity Unit 8)

“…and what we’ve talked about is putting it in a more holistic approach so it’s not just obesity, it’s obesity, smoking, general health so that they’re not just being picked out for this bit and then they’re being picked on for that bit but it’s the whole health which I think is a very good idea”

(Consultant Obstetrician, Maternity Unit 8)

“And having sat on the various steering groups, they all want so much from that contact with the community midwife which puts the community midwives under a huge pressure. But a lot of these agendas are interlinked, and if we can succeed in joining up some of these public health strategies I think we’ll have come a long way”

(Consultant Midwife, Maternity Unit 8)

There was discussion around how the agendas for maternal health were all interlinked (such as smoking, alcohol and obesity) and how maternity services and public health needed to become much better at joining up their thinking on these issues rather than looking at them separately.

"… everybody wants a different part, and really for the frontline practitioner dealing with that woman it all wants to be joined up, and the skills are transferable. I don't know… but we need to get smarter at doing that and I think the penny has finally dropped for us that that's what... well perhaps not so much for us, but from the primary care point of view, that really these services all need to be joined up and you can't look at women in different parts it all has to be done with this holistic view"

(Consultant Midwife, Maternity Unit 8)

Issues around nutrition and physical activity were discussed, and although nutritional advice was routinely given to all women there didn't appear to be anything specific that was routinely given to obese women, other than in the few units that had a process for dietetic referrals.

"I think they need a support group for pregnant women, I mean whether they go into another one afterwards but I think there should be support, nutritional advisory, psychological support as well for pregnant women during these periods, out in the community that they can go and get peer support as well as professional support"

(Head of Midwifery, Maternity Unit 3)

There was discussion around maternity services incorporating physical activity in pregnancy, including aqua-natal, walking groups and yoga. Some maternity units had an aqua-natal service to offer women as standard, and others had issues with staffing of this resource which meant their sessions were not available at the moment. Discussions also took place around participation in physical activity when women were obese, and whether they would want to attend general aqua-natal sessions or whether more targeted sessions would be more appropriate as some obese women may not feel comfortable attending general sessions.

"I think obese women are less likely to become involved in antenatal exercise like the aqua-natal… they're less likely to go to a pool… but that's their lifestyle anyway, just

because they're pregnant doesn't mean they're all going to leap into pools to do aqua-natal exercises"

(Head of Midwifery, Maternity Unit 4)

"I was talking to a woman yesterday about swimming but this woman had put on 5 stone from before her first baby to now, pregnant with her second. She's gone from 8 stone to 13 and was no longer comfortable even getting into a swimming costume"

(Consultant Obstetrician, Maternity Unit 6)

There was discussion around safety issues and physical activity in obese pregnant women. These issues included:

- From what gestational age women should be encouraged to embark on physical activity when they have not previously been active, so as to ensure the safety of the baby.
- The type of physical activity that should be recommended.
- The requirement for more partnership work between maternity and leisure services to ensure the safety of the mother was thoroughly considered.

Another issue raised was that women may presume that exercise in pregnancy was risky, and that this issue may need to be addressed to reassure some women of the safety, to make the prospect of physical activity attractive to women, and that it needed to be flexible to the needs of the woman.

"I would expect that for women who become pregnant who are not regular exercisers they may actually see exercise as being a risk or something that you need to avoid while your pregnant… part of our responsibility, and we could develop through a scheme, is something that would appear attractive and would give women the assurances… You know, if it had that endorsement and the involvement of maternity services… I mean there's no good reason why women shouldn't exercise during pregnancy but there have got to be certain restrictions or limitations to that. And therefore working with a partnership organisation allows the maternity service to help develop that sort of programme"

(Head of Midwifery, Maternity Unit 5)

The continuity of physical activity through pregnancy and into postnatal services was discussed, and this could be achieved by linking services from the pregnancy arena to the non-pregnancy arena, such as aqua-natal and aqua-aerobics. Postnatal physical activity services also needed to be baby friendly and could include swimming sessions with the baby, walking groups for mothers and pushchairs.

"They might have done aqua-natal… go to aqua- aerobics, this is something you can do afterwards… there are things in the baths you can take your baby to, there's things that you can do at sports centres, that kind of activity, walking… Maybe these people who are looking immediately after the postnatal period could look at what channels are available afterwards… it's encouraging them to continue after the initial pregnancy and postnatal period, and equally involves the baby because there was a lot of things that you can do and take your baby with you"

(Head of Midwifery, Maternity Unit 1)

There was discussion around how services to address maternal obesity should be family focussed, involving children, partners and the whole community. Engaging the mother during pregnancy was also discussed as a way to get the whole family engaged in obesity services, as HCPs felt it was usually the mum who shops and cooks, and therefore there was the potential for a greater impact through family involvement. However, there was also discussion around how engaging the mother to make changes that would influence the whole family would be reliant on the mother's self esteem, assertiveness and confidence, and could potentially be an extra pressure on women while they were pregnant.

"…And I don't really see that as just specifically working with the woman, I think that's about families as well, because we know about the trends, and that obesity may spread throughout the family and in terms of healthy eating habits in children… so we know that it's not just about targeting the women but it's about looking to the wider family as well, and having a more family orientated programme..."

(Head of Midwifery, Maternity Unit 5)

"But you can use the mother as a kind of portal into the family because she's probably the one who's doing the cooking, for her to then to try and teach her children to lead a healthy lifestyle so they will then cook… so we'll see it not this generation but maybe the next generation maybe"

(Head of Dietetics and Nutrition, Maternity Unit 10)

"The hope is that whatever you influence the mother, who is usually the predominant shopper and cooker, that they would influence whatever the rest of the family ate, so I think she is a very committed person in terms of what the family eat, what goes into the fridge, what goes in the freezer, what's put on to the table, is very much still influenced from the maternal point of view so I think if we can get the messages there with her then hopefully we can influence the rest of the family but I think the pressure is on them to do that but I think that… I think even a lot of it has to do with their own personal self esteem, self confidence and assertiveness to actually change not only themselves but the rest of their family and that's a big responsibility…"

(Hospital Antenatal Manager, Maternity Unit 7)

6.4.2.4.4 Partnership Working

The need for partnership working was discussed, and HCPs felt that maternity units could not address the issue of maternal obesity alone, and that it required a multi-pronged approach from a number of stakeholders. There was discussion around how to integrate services through partnership working, and how PCTs with obesity strategies can learn from maternity services about the gaps in addressing maternal obesity. HCPs also felt that partnership working with external services not used to dealing with pregnancy, such as leisure facilities, needed to understand the needs of the pregnant woman so that HCPs were not putting the women at risk by referring them into these services. HCPs felt that one major barrier to overcome was getting the issue of maternal obesity on the PCTs agenda. Some HCPs felt that the links between PCTs and maternity services were already in place for other aspects of care but not for obesity. Others discussed how it was important to get the issue on the wider agenda to be able to address it effectively, including regional networks such as the government office's agenda. They also commented that organisations and departments were just starting to think about the whole lifespan, for example dietetics department had not really thought about this aspect of care previously but were now discussing reconfiguring services to address maternal obesity.

“Certainly having looked at other work that’s been done in other units it is very much based on midwifery and obstetrics services, and as we said right from the start we can’t address this issue on our own, so I think that’s probably the thing that we could transfer to other units, is joining that up and getting into the local and regional networks… it becomes part of the bigger agenda rather than being sort of in this silo of midwifery and obstetrics services”

(Consultant Midwife, Maternity Unit 8)

The type of external services that HCPs felt maternity units needed to work with included public health agencies, PCTs, Sure Start, Children’s Centres, leisure centres, commercial organisations and local borough councils, and that there needed to be ‘buy in’ from all of the relevant organisations.

“There are services already being provided by other agencies, whether it’s local borough councils or private facilities, those services are already there, our services are already there in terms of being able to identify women who have an increased BMI who would benefit from exercise. I do think that we could develop and extend that further, to develop an interface with these services, working with them and providing something which is more attractive to women… We have an example in provision of aqua-natal classes, whereby maternity services have worked with the local borough council through their leisure facilities to have that provision in the swimming pools”

(Head of Midwifery, Maternity Unit 5)

The roles of the community services and in particular Children’s Centres were discussed as being important partnerships to forge. Children’s Centres were felt to be a key service to link with for socially vulnerable women as they already include access to allied health professionals including social workers, health visitors, case worker, support groups, link groups, and postnatal services such as ‘bumps to babes’ and breastfeeding support.

"I mean one of the big initiatives out there for sort of socially vulnerable women is children's centres, and we've got seventeen of them now in this area, and they are primarily based with services in the community… Some of them have got health centres, some of them have got GPs attached to them… a lot of them do postnatal support groups, 'bumps to babes' , breastfeeding support groups. They would be an absolutely ideal place to put something into place with a community setting"

(Hospital Antenatal Manager, Maternity Unit 7)

Some HCPs discussed the services that were already available in the community, including weight management groups, and how existing services could potentially be linked into, utilised and developed for the needs of the pregnant and postnatal woman.

"I think that's something we could really look at within the community programmes that are in existence which maybe are for the general population, it might be the 'Lighten Up' programme, it might be an extra one put on for postnatal… it might be that there's a need to have specifics, so it might be if a group of mums have gone through all the antenatal everything together and they get to the end and they want to lose some weight then that is a group that could be set up and their then can carry on that continuity of getting together… if you can encourage the activity then you can help their education around the nutrition side to go with that"

(Head of Nutrition and Dietetics, Maternity Unit 10)

Continuity of care for women was also discussed in relation to the transition of care between pregnancy and postnatal services, particularly the transition of care between the midwife and health visitor. HCPs felt that effective services to address maternal obesity needed to think beyond pregnancy, and should include preconception, antenatal, labour, postnatal, and community services. Services should also be developed with a focus on engaging women, and HCPs felt that engaging women in postnatal services would be more successful if they had already built a relationship with the service and HCPs throughout the pregnancy.

"…but I think it is better if the pregnant lady is used to having that same person they've got that continuity and they got that respect either way for each other, rather than another health professional coming in who's either the goodie or the baddie wagging their finger, you know because somewhere they've been sent to me look at things further and its that… getting that rapport as well before you even start to engage and there isn't time to engage because they're going to be delivering before you actually get through to do anything that we would do in the longer term…"

(Head of Nutrition and Dietetics, Maternity Unit 10)

"The problem with midwives and maternity care assistants is that they have a role that will end, and then it transfers over to the health visitor, so there's got to be that… if things are going to start up then it's got to be transferred across and the health visitors need to get involved in whatever mechanisms after that… it's linking in with that public health agenda isn't it and it's… who the responsibility lies with, yes we could start it off and channel them, then it's the next person who actually takes it on and channels them even further"

(Head of Midwifery, Maternity Unit 4)

6.5 Discussion

The objective of this study was to identify the developments in maternity services specific to obesity throughout the North East of England. The study also explored HCPs perceptions of the benefits and disadvantages of obesity specific services, any barriers encountered or successes in developing services, and to identify where HCPs felt maternity services needed to be developed to effectively address maternal obesity. The strengths of this study are in the regional nature. All regional NHS trusts are included in this study, with more than one maternity unit included where different practice is carried out between maternity units within a trust. This representation includes maternity units with populations of differing socio-demographics, including urban and rural NHS trusts and some variation in deprivation. A limitation of this study is that the majority of the North East population is white, with low representation of ethnic minority groups (Census, 2001). Therefore there may be additional issues to be considered when looking at more ethnically diverse populations.

The results of this study conducted in September and October 2008 have identified that there has been some significant development in maternal obesity services since the previous study conducted in 2005/2006. Maternity units in the region identified that obesity is a risk factor in pregnancy, and that the numerous complications it poses result in high dependency care for the women being required. This was identified in the previous research with the referrals to consultant led care (Heslehurst et al., 2007b), which are still in place. In addition to routine referrals for consultant led care, maternity units also have routine referrals to anaesthetics for obese women which were previously not consistent across the region. There are also referral mechanisms in place for women with diabetes and to dietetics services in a number of maternity units.

Maternity units are in various stages of developing and implementing guidelines across the region, including antenatal and postnatal guidelines for maternal obesity. This is a significant development since the previous study where there was an absence of any form of guidelines throughout the region (Heslehurst et al., 2007b). There are also developments in services relating to working groups. Some maternity units have utilised existing working groups, and are applying that expertise to address specific aspects of maternal obesity services, whereas there has also been the development of a working group specifically to address maternal obesity in its entirety.

More robust interventions to address maternal obesity were identified in this study compared to the previous study. Previous research showed the care and advice given to be ad hoc (Heslehurst et al., 2007b), and developments to address this included defined care pathways, risk assessments, and increased screening and monitoring. However, a lack of weight management services remains, largely due to a lack of evidence about what works and what is safe during pregnancy. The lack of evidence on weight management in pregnancy has resulted in the CEMACH leaving it out of their standards of care for obesity in pregnancy, as they couldn’t get a consensus view on what to include (CEMACH, personal communication). Weight management in pregnancy will be included in the NICE guidance to address obesity in pregnancy (National Institute for Health and Clinical Excellence, 2008e). However this guidance is not due out until 2010 and the current scope is only to look at the prevention of excessive weight gain and not other issues of maternal obesity and weight management. The absence of national guidance for weight management in pregnancy means that advice will continue to be inconsistent and ad hoc as described in this study, and previous research (Heslehurst et al., 2007b), potentially resulting in inequality of information and inconsistent advice for women due to its dependence on the views of the individual HCP.

Some services were actively trying to address the issue of equality for obese women in pregnancy by using equipment that was suitable for obese women for all women accessing their service, and therefore obese women are not seen as being different or stigmatised. There are further developments in service required however, such as addressing the many psychosocial issues relating to obesity. These issues have been identified by a number of key research studies, particularly including the relationship with social exclusion, and stigma (Reilly and McDowell, 2003, Brown et al., 2006), (Roehling, 1999, Wiles, 1994).

Overall HCPs felt that the benefits of maternal obesity services were in safeguarding the health of the mother and her baby. There was increased awareness among HCPs of the complications and risks associated with being obese in pregnancy compared with the study three years previously. This was largely due to national reports, such as the CEMACH reports, which have highlighted the association between obesity, and maternal and neonatal death (Confidential Enquiry into Maternal and Child Health, 2007, Lewis, 2007). This increased awareness has enabled services to prepare and plan for complications that might arise, including establishing appropriate referral mechanisms to ensure the assessments required were more standardised for all women who required them. Some HCPs felt that the development of guidelines to address maternal obesity had also raised awareness among HCPs, with the benefit of services being more focussed and no longer ad hoc, and services could now be audited and evaluated.

Some HCPs discussed the potential for long term health benefits to the mother and baby with further developments of interventions and services to address maternal obesity. The benefits of developing services further would also include reduced long term costs to the NHS, having more focussed services that were woman centred, and better access to services for women. Some HCPs also felt that the development of obesity specific services would ensure the appropriate professionals were available at a dedicated time to see the women. More targeted services would also create a more streamlined service, and obesity specific services could potentially result in better outcomes for the mother as seen with existing services looking at health needs of specific groups of women.

The benefits of implementing obesity services during pregnancy were also discussed. HCPs felt that pregnant women were a captive audience, already in the healthcare system, they regularly attended antenatal services, already had relations built with HCPs, and that pregnancy may be the first contact a woman had with the NHS if they had never experienced ill health before. There was also discussion around how women may be more motivated to address obesity during pregnancy because of the perceived benefit of having a healthy baby, and that outside of being pregnant women can neglect themselves due to other priorities. Some HCPs felt that women were more amenable to change during pregnancy and there may be better engagement in services, and this is supported by the Foresight report which identifies pregnancy as a critical opportunity for intervention (Foresight, 2007).

The potential disadvantages of maternal obesity specific services were also addressed. Some HCPs felt that the current 'one strike' use of booking BMI to define high dependency care was limiting the choice of care for women who were borderline who might be fit and healthy. There was also discussion around how other groups of women may be being overlooked with the use of BMI alone, such as the women who are just below the BMI cut off that would benefit from high dependency care.

The segregation of care was also felt by some to be a disadvantage in the development of maternal obesity specific services. This was due to the potential psychosocial impact on women who may feel stigmatised about having to attend that specific service, and that this may add to the social exclusion experienced by the obese population in society. There were also concerns about the segregation of care removing the expertise in dealing with obese women from the general consultant and midwifery body, and that all HCPs in maternity services needed to have skills and experience in dealing with obesity.

There was also some discussion around underweight women and how they are just as high risk as overweight women but that they are often overlooked with the current emphasis on obesity services. The NICE guidelines relating to maternal weight and pregnancy (under development) also exclude underweight women (National Institute for Health and Clinical Excellence, 2008e). The reason for this is that the scope of the guideline only address the prevention of excessive weight gain which is not applicable to underweight women as you would want them to gain more weight than those women in the overweight and obese groups (Institute of Medicine, 1990). HCPs felt that the current focus on obesity could potentially detract attention from other vulnerable groups during pregnancy, such as underweight women, where there was not as much focus.

The fact that HCPs acknowledged obesity as being an issue, that they were enthusiastic, wanted to be pro-active in addressing maternal obesity, and that there had been some move forward in the development of services is a success. The development of guidelines, and having more structured services was felt by some to be a major contributor to the success of developing services, and the improved data collection in maternity units meant that services now had local evidence to support business cases, and to support the need for partnership working with organisations external to the NHS.

The majority of maternity units had the necessary equipment to manage the care of the obese pregnant woman safely and this was considered to be a successful area of service development. The types of equipment most frequently referred to were theatre tables and delivery beds. These specific equipment requirements were highlighted as an issue in the previous study (Heslehurst et al., 2007b), and this indicates how maternity units are moving forward in terms of addressing the health and safety issues relating to maternal obesity. There were also examples given of maternity units actively risk assessing their facilities and equipment, so they knew where the inadequacies were and what needed to be addressed as a priority. One maternity unit also discussed the novel Trust-wide development of a ‘bariatric box’ to address the difficulties in sourcing consumables for obese patients.

The increased utilisation of multidisciplinary teams and expertise was another success across most maternity units, with established links with anaesthetic departments to address maternal obesity across most maternity units, and improved links with dietetics for some. Utilising existing working groups’ expertise to address aspects of maternal obesity was an area of success across a few maternity units, and the development a multidisciplinary and multiagency maternal obesity steering group in one maternity unit was a particular area of success for this aspect of service development. The steering group was considering the continuity of care issues throughout pregnancy and postnatal periods; they had engaged the community and acute maternity services, and PCT and public health services in the generation of specific care pathways for obesity. The success of this development was considered to be with the members of the group being interested and enthusiastic, and they had an identified lead that had driven the service forward.

Despite the numerous successes in the development of services in the region, and the maternity units addressing some of the issues that had previously been lacking, HCPs felt that there were still barriers to the development of maternal obesity services. Some HCPs had strong views about maternity services having to identify what they were trying to achieve in addressing maternal obesity. There was acknowledgement that the health and safety issues, and the obstetric requirements were key aspects of care that needed to be provided for obese women, and most were addressing these. However, there were differences in opinion about what else maternity units should be providing, or could provide, during the timeframe with which HCPs cared for pregnant women.

It was acknowledged that maternity services could not address this issue alone, and that additional expertise was required, and this was considered to be a barrier. Although links with collaborative HCPs was highlighted as a success, some were still experiencing problems, especially with links between maternity and dietetic services. There were also potential links to be established in other areas of expertise, such as psychological support and public health. HCPs felt that assessing the women and signposting to services that would have that expertise was considered to be a way of addressing this issue. However, there was a lack of knowledge among HCPs about what services were available to signpost women into. In particular, the lack of communication between maternity services and public health services is a barrier in establishing the necessary support pathways to effectively utilise existing expertise.

There were also issues remaining for those maternity units that had successfully established links with other healthcare services, as capacity issues with supporting services meant that although they were addressing maternal obesity with some women, not all women could utilise the services. Capacity issues within maternity units meant that there was difficulty for some to be able to comply with guidance, and some were currently using BMI cut offs higher than recommended in the guidelines. This was most evident with the different BMI cut offs being used across the region to indicate access to services for women. The differences in BMI cut offs being used was also an issue in the previous research, where the differences ranged from a BMI of over 30 to a BMI of over 50 for access to services (Heslehurst et al., 2007b), and the same range in BMI cut offs are still being used, with some offering dietetic referrals for all women with a BMI over 30, and others having routine anaesthetic referrals for women with a BMI over 50.

Another barrier in the development of maternity services to address obesity was that there was disagreement among HCPs relating to which direction services should be heading, and this was a particular issue for monitoring weight, and weight management in pregnancy. The main reason for the disagreement between HCPs was due to the lack of evidence in these areas, and the inconsistency in the advice being given, both between maternity units and within maternity units, was also identified in the previous study (Heslehurst et al., 2007b).

There was also a lack of evidence relating to what women wanted out of a service and how to address the issue without causing increased social stigma and distress. Addressing the issue was again identified as a problem in the previous study (Heslehurst et al., 2007b), and the discussion in this study highlights how services have not really moved forward in relation to this aspect of care. The difference between what HCPs say and what women hear was also identified in this study, and research from over a decade ago by Wiles (1994) shows how this has been a long standing problem for maternity services.

The identification of the benefits, successes, barriers, and disadvantages of maternal obesity services has helped to inform where services need to be developed in order to address maternal obesity effectively.

HCPs felt that addressing obesity in pregnancy was ‘bigger than us’, and that it needed to be on the wider agenda to be addressed effectively, and that national and strategic policy and intervention was required. The need for long term solutions to address maternal obesity were discussed, and how results would not necessarily be seen straight away as there was a need for services to ‘break the cycle’ of obesity for the next generation. HCPs felt that there was also a need for the public health messages relating to obesity to include the impact on pregnancy, and how they needed to be more engaging of the obese population.

HCPs would like to have evidence based government guidelines and information to follow, that define what maternity services should be trying to achieve and how they are achievable, before utilising resources. Many HCPs felt that lessons could be learned from smoking cessation services, and that the same level of resource and support would be required to address obesity. Also regionally agreed principles that could be adapted locally were felt to be helpful. The issues relating to obesity in pregnancy affected all maternity units, and HCPs feel that there should be more of an opportunity to share good practice across the region, that there needs to be more service evaluation, and that maternity services need to think outside the box and beyond what is core service provision to effectively address maternal obesity.

Addressing maternal obesity was also considered to be a form of service development, and units needed to prioritise services, to look at developing business cases and commissioning of services, and that it was a genuine public health issue which needed to involve PCTs. HCPs felt that there was a need for a more holistic approach to women’s health, how initiatives were interlinked, that services shouldn’t look at women in different parts, and that there should be a family based approach to care. Some HCPs felt that there was also a need to involve services external to the

NHS, such as local borough councils and leisure services. They described existing successful initiatives developed in this way, such as in the provision of aqua-natal classes.

The issue of flexibility was raised. Services to address obesity need to be flexible so that they reach all women and not just those that are motivated. There was agreement that the needs of obese pregnant women may differ, and therefore services should take that into consideration and not provide a ‘one size fits all’ service. There was discussion around the use of social marketing, and how there were lessons that could be learned from this approach to enhance behaviour change.

Flexibility was also discussed in relation to HCP training needs. HCPs identified areas of training that would be required in order to provide effective services for obesity. However, they felt that there was little time for training, that training session should be flexible to ensure all required HCPs could attend, and that utilising existing meetings was a way of incorporating training without taking further time out from clinical practice. The training needs identified by HCPs included

- How to broach the subject of maternal obesity with women.
- A need to address the language barrier between HCPs and women.
- How midwives didn’t have the necessary expertise on obesity.

Maternity HCPs felt that they could potentially learn from dietitians in relation to these aspects of training, and that there may also be training needs for dietitians involved with maternal obesity, relating to the maternal and foetal needs during pregnancy.

There were some HCPs that had a great level of understanding of the wider determinants of obesity, and there were discussions around the role of society, social exclusion, stigma, education, life skills, and socio-economic implications. However, other HCPs referred to obesity at the level of individual choice. The evidence base for the determinants of obesity suggests that the causes are highly complex and integrated, and this is seen with the complexity of the map produced by

Foresight (Foresight, 2007) (Figure 1, page 6). This highlights a potential training need for maternity HCPs around the wider determinants of obesity, and this may go some way in addressing the issues that some HCPs have with broaching the subject and the worries of causing further social stigma to women when they raise the issue during a consultation. This is especially important as the evidence shows that pregnancy is potentially the only time when obese women feel more socially acceptable, and they are more likely to engage in lifestyle changes (Wiles, 1994). Therefore HCPs should be working towards increasing women's self esteem and confidence during this stage in their life, and encouraging their engagement in services. A better understanding of obesity in the wider context may help to facilitate this.

There are still issues to be addressed that HCPs don't have the answers to, and more research is required in these areas. More research is required on what women want and how to engage women into services when they are obese to ensure that:

- Service development meets the needs of obese pregnant women.
- To ensure that resources are not wasted implementing interventions that won't be utilised by service users.
- To ensure that women don't feel stigmatised during pregnancy.
- To ensure that women don't disengage from maternity services altogether through feeling stigmatised.

Overall this study has shown that maternity services to address maternal obesity have developed significantly over the last two to three years in terms of the obstetric requirements of obese women, and there are improved multidisciplinary relations throughout maternity units in the majority of the region, especially in relation to anaesthetics services, and to a lesser extent, dietetics services. However there is still a substantial amount of work to be done in terms of having a more holistic and strategic service that looks at the 'wellness' of obese pregnant women rather than just health and safety aspects. It appears that services need to:

- Consider the transition of care between the pregnancy and postnatal period to maximise engagement in services.

- Address the identified training needs of HCPs who care for obese pregnant women.
- Focus on improving communication between acute services and public health services.
- Ensure the issue of maternal obesity is on the wider obesity agenda to facilitate the strategic and national support that is likely to be required to effectively address maternal obesity.
- Be involved in further research to identify how to engage pregnant women into services to address their obesity.

Chapter 7
Discussion and Conclusions

7.1 Discussion of Findings

The objectives of this research programme were to identify the current incidence of obesity in pregnancy in England, to explore the trends in the incidence of maternal obesity over time, to determine the characteristics of the women who are most at risk of being obese in pregnancy and any associated health inequalities, to identify the immediate impact of obesity in pregnancy on maternity unit resources, to identify the level of services, policies or guidelines in place in the North East of England specific to maternal obesity, and any barriers to, and successes in, the development of obesity specific services.

Maternal obesity has more than doubled over the last 19 years in England, and this research highlights how the trends are related to demographic inequalities. Following adjustment for potential demographic confounders, deprivation is shown to be the strongest predictor of maternal obesity. Those most at risk of adverse outcomes are the morbidly obese and super morbidly obese women, and these obesity groups have the strongest link with deprivation. The CEMACH also reports an association between deprivation and increased risk of death (Confidential Enquiry into Maternal and Child Health, 2007, Lewis, 2007), highlighting that the inequality issue of deprivation which is associated with obesity is also an inequality for maternal risks during pregnancy.

The positive relationship between increasing age and maternal obesity supports published data for women in the general population relating to increasing age and obesity prevalence (Department of Health, 2004b). The positive relationship found in this research between increasing parity and maternal obesity supports the evidence that pregnancy is a critical period in a woman's lifecourse in the development of obesity (Gore et al., 2003, Siega-Riz et al., 2004, Gunderson and Abrams, 2000). This research also identified inequalities with unemployment and increased odds of being morbidly obese. This relationship was masked by the analysis of overall obesity (BMI>30kg/m^2), which showed that obese women in general were more likely to be employed than unemployed. The relationship between morbid obesity and unemployment supports the existing evidence for the general population, and this relationship is particularly strong in women (Morris, 2004). The CEMACH also shows that unemployment is positively associated with maternal death (Confidential Enquiry into Maternal and Child Health, 2007, Lewis, 2007), highlighting the health inequalities associated with maternal risk and obesity.

Inequalities within ethnic groups and maternal obesity were also observed. Women from Black and White ethnic groups have significantly increased odds of being obese in pregnancy, with all other ethnic groups having a lower odds of being obese than White women. These findings were interesting, particularly in relation to Asian women, as there is an increased risk of obesity in Asian women in the general population (The Information Centre, 2006). Hypotheses as to why this relationship may not be present include the relationship with body fat distribution, and increased WHR and waist circumference in Asian women (The Information Centre, 2006). The relationship between central adiposity and infertility (Hollmann et al., 1997) may mean that the proportion of obese Asian women conceiving may be lower than in other ethnic groups. Age of women in the general population is also a potential reason why the study findings were not representative of the general population. The increased risk of obesity in Asian women in the general population may be a result of the inclusion of post-menopausal women in this sample, and therefore this would not be representative of the pregnant population included in this research. Also it may be that the current BMI measure is not appropriate for Asian women as a marker of obesity in pregnancy, that lower BMI cut offs for Asian women may be required to indicate excess body mass risk in pregnancy, or that alternative measurements may be required.

In addition to the socio-demographic inequalities identified for women being obese during pregnancy, the relationship between obesity and adverse pregnancy outcomes means that women who are most deprived, unemployed, and from Black or White ethnic groups are also at increased risk of the adverse outcomes. These outcomes include those that affect the immediate health of the mother and the foetus during pregnancy, including the outcomes identified in the systematic review, and maternal and neonatal death (Confidential Enquiry into Maternal and Child Health, 2007, Lewis, 2007). There are also inequalities relating to the long term outcomes, such as the development of gestational diabetes in the mother (Andreasen et al., 2004) and the subsequent development of diabetes mellitus (Linne, 2004). For the infant the long term outcomes relate to the association between obesity and congenital anomalies (Waller et al., 2007), and potential long term development of obesity (Parsons et al., 1999).

The psychosocial inequalities with obesity in the general population also relate to maternal obesity. This research has shown that HCPs have difficulties in addressing the issue of maternal obesity with women during their pregnancy, as women often get angry and upset, and that there are differences between what the HCPs feel they have said and what women hear. This is a longstanding issue as research published over a decade ago identified that the communication between HCPs and pregnant women was a problem, with women often feeling stigmatised and patronised when the issue of obesity was raised (Wiles, 1994). Overall, maternity units in the North East have not been successful in developing their services in a way that addresses this factor. There is also evidence that pregnancy is a time during an obese woman's life course when she feels more socially accepted (Wiles, 1994). Yet this research has identified that HCPs are wary of implementing maternal obesity services without identifying what women want out of the service, and what will engage women, due to women potentially disengaging from maternity care if the issue is not addressed in a sensitive way, and the service becomes stigmatised.

This programme of research has also identified that pregnancy is potentially a good time to intervene in addressing obesity, both for the mother and for the long term health of the next generation. HCPs felt that women were probably more motivated and receptive towards addressing their obesity during pregnancy due to the perceived benefit of having a healthy pregnancy and a healthy baby. This finding supports the Foresight report which identified pregnancy as a critical opportunity for intervention (Foresight, 2007). The long term potential for addressing obesity in pregnancy having an impact on the next generation, would also be addressing obesity at an earlier stage than current public health obesity strategies that aim to reduce childhood obesity, as the interventions could be instigated at the time of foetal development.

The strengths of this programme of research are in the use of mixed methods. The absence of epidemiological maternal obesity data in England meant that a nationally representative dataset needed to be compiled in order to address the research objective of identifying trends in maternal obesity incidence and demographic health inequalities. The success of this stage of research was dependent on maternity units in England having an existing source of data, and in the willingness among heads of service to provide the necessary data. The postal survey identified that there was substantial interest in maternal obesity among HCPs in England, as it resulted in an 89% overall response, with an initial response before follow up of 75%. This response is over and above what was expected using the Total DM, which consistently averages 70% (Dillman, 2007). The enthusiasm of HCPs in addressing maternal obesity, and the persistence with NHS Trusts' research governance, resulted in the compilation of a demographically nationally representative dataset of over 600,000 deliveries for a 19-year period.

The enthusiasm of HCPs to be involved in maternal obesity research was also shown in the qualitative research carried out, which involved representatives from all NHS Trusts which were invited to participate. This has allowed for a regional representation of the issues relating to maternal obesity services, and a richness in the data that quantitative methodology could not yield. The qualitative findings are also supportive of a number of the outcomes identified in the systematic review, in terms of the obstetric needs of obese pregnant women and the health and safety requirements.

The systematic review built upon previous qualitative research which identified a number of pregnancy outcomes that HCPs felt had an impact on maternity services (Heslehurst et al., 2007b). The strength of the review is that it has drawn together a number of pregnancy outcomes that impact on acute maternity services rather than looking at outcomes in isolation. The results of the review therefore provide a more holistic overview of the impact of quantifiable pregnancy outcomes relating to maternal obesity on acute maternity services.

There are also limitations with the programme of research carried out. Firstly there is a potential that the true trends in incidence of maternal obesity have been underestimated due to the dataset only including deliveries, as the relationship between maternal obesity and foetal loss (Confidential Enquiry into Maternal and Child Health, 2007) could have potentially excluded a large proportion of the obese population. The trends in maternal obesity also adjusted for weight gain based on gestational age at booking. This adjustment utilised published population level data on change in BMI by gestational week (Ochsenbein-Kolble et al., 2004), and applied the adjustment to individual level data. The necessity to adjust the BMI data was considered to be important, as the alternative options would be to exclude those women with a late gestational booking age, or to include unadjusted BMI data. The exclusion of women with a late gestational age at booking was theorised to potentially exclude a substantial proportion of the obese population based on the pilot study findings, and using the unadjusted data would not be representative of the BMI at the start of pregnancy due to the pregnancy incurred weight gain, and could have resulted in an overestimation of maternal obesity incidence. The absence of data provided for the East Midlands region is also a limitation, as the estimated incidence of maternal obesity for this region is based on data modelled on the regional prevalence of obesity in women in the general population using the 2006 HSE dataset, and the maternal obesity dataset compiled for this study.

The potential limitation of the systematic review is that it was dependent on the availability of published data, and on the quality of the published data. Although quality checks and sensitivity analyses were performed taking the quality of the studies into account, and the comparability of the data between studies, there may be more limitations to the results of the review. The area of particular limitation is with the obesity categories used. The results of the studies which grouped all levels of obesity together and did not carry out subgroup analysis for morbid obesity may be masking true trends in the pregnancy outcomes. An example of how analysing overall obesity can mask the true results was shown in the analysis of demographic predictors of maternal obesity and the relationship with unemployment and morbid obesity. The inclusion of only English language studies may be a further limitation, and there may also be some level of publication bias among the databases searched, and among grey literature which was not searched.

The limitation of the qualitative research is in terms of how generalisable it is. At every stage of the study steps were taken to increase the rigour, reliability, and validity of the data collection and data analysis. These steps included inviting a range of HCP specialities to participate in the study, the audio-recording and verbatim transcription of the study, member checking of the transcripts among the participants, and the data analysis followed a systematic approach for thematic content analysis of semi structured interviews as described by Burnard (1991). Despite the steps taken to assure the quality of the study, the results of the study may not be applicable to regions outside of the North East of England. Further qualitative research may highlight regional differences in the issues relating to maternal obesity services, and in particular the issues may be different when looking at the demographics of the North East population compared to the general population. The study included a variety of maternity units, with consultant and midwifery led units, and urban and rural populations. However, the ethnic group in the North East population is predominantly white (Census, 2001), and the socio-economic status is predominantly deprived (Index of Multiple Deprivation, 2000), therefore there may be further cultural and social issues relating to developing maternal obesity services that were not identified in this study sample.

7.2 Implications for Service

This programme of research has identified that the rising rates of maternal obesity have resulted in an additional 47,500 women every year requiring high dependency care; an increase from 45,000 women in 1989 to 92,500 women in 2007. This increasing number of women requiring high dependency care places a massive burden on maternity unit resources. The differences in the geographic distribution of maternal obesity in England also mean that some maternity units will feel the strain on resources more than others, and this will be most evident in the West Midlands, Yorkshire and the Humber, the North East, and the East Midlands.

The impact of maternal obesity on resource demands include those outlined in the NICE guidelines and CEMACH recommendations, such as the need for consultant led care, anaesthetic review, additional GTTs, individual assessments, and to have their delivery in a consultant led unit (National Institute for Health and Clinical Excellence, 2008a), (National Institute for Health and Clinical Excellence, 2007) . In addition to these existing guidelines, further guidelines and recommendations are forthcoming, including the NICE intervention guidance on the prevention of excessive weight gain in pregnancy (National Institute for Health and Clinical Excellence, 2008e) and the effective weight maintenance following childbirth (National Institute for Health and Clinical Excellence, 2008c) due to be published in 2010, and the CEMACH consensus of standards for obesity in pregnancy from the preconception period, throughout the pregnancy, and in the postnatal period, due to be published in 2009 (Confidential Enquiry into Maternal and Child Health, 2008). These additional guidelines and recommendations will place further resource demand on the NHS maternity services.

The pregnancy outcomes with significant resource implications that maternity units will need to address include increased caesarean and instrumental deliveries, length of hospital stay, use of neonatal intensive care, maternal haemorrhage, and maternal infection. In addition to this there are also pregnancy outcomes that have less significant resource implications, or may lead to outcomes with a significant resource implication, and these must also be considered. These outcomes include high birth weight, postdate and preterm deliveries, induction of labour, use of oxytocin, the need for an epidural, failure to progress in labour, low apgar score at 5 minutes, meconium, and foetal compromise.

The rising rates of maternal obesity in England emphasise the urgent requirement for interventions to support those women most at risk of being obese in pregnancy, in order to facilitate a safe and healthy pregnancy, childbirth, and transition into motherhood. The relationship between the health inequalities identified highlights the need for all encompassing interventions targeting the groups of women most at risk, to improve nutritional support preconception, access to maternity services, lifestyle support throughout the pregnancy and postnatal period. These services need to be sensitive towards addressing the issue of obesity with women, and culturally sensitive to all ethnic and socio-demographic groups.

Hopefully the NICE guidelines due to be published in 2010 will go some way towards identifying the ways in which these types of interventions will be achievable for maternity units, although there is a noticeable absence of evidence on this subject matter, as identified by HCPs in this study. However, the findings from this programme of research suggest that there is a need for a long term solution that is strategically driven with national support to be able to move services forward and effectively address maternal obesity. Pregnancy should also be included in the wider public health messages about obesity, and the public health messages should be more positive in order to engage the obese population rather than engaging the anti-obesity population. Maternal obesity should also be included in a holistic package of women's health rather than as an isolated factor, and there is a need for more partnership work between agencies to utilise existing knowledge, expertise, and resource. There should be more opportunity for HCPs to share practice and learn from one another about what works in relation to maternal obesity, as the lack of evidence leaves HCPs unsure of where services should be developing. Training requirements have also been identified. Maternity HCPs would appear to benefit in training to address the issue of obesity with mothers in a sensitive manner, and around the wider determinants and complexities of obesity. Dietitians who are not specialists in maternal obesity may also require training in the specific needs of the mother and the baby.

7.3 Implications for Research

This programme of research has identified a need for studies to be carried out with consumers, in order to identify what they want and need from a service to address maternal obesity during preconception, pregnancy, and in the postnatal period. This research should include whether they would engage in services more if they were specialist or mainstream (for example dedicated clinics, antenatal classes, or specialist physical activity sessions), and what would make services more attractive to them to encourage them to engage. Most importantly this research needs to be carried out in order to identify how services can be developed to address maternal obesity without stigmatising the service and potentially disengaging women from maternity care altogether, which could have a more detrimental impact on the health of the mother and her baby than if obesity were not addressed as an issue during pregnancy.

The difference between the perceptions of what HCPs say when discussing maternal obesity, and what women hear is described in the literature review and re-enforced in this programme of research. This indicates a need for further research with women to identify the most appropriate way to address the issue of maternal obesity without further reinforcement of the inherent social stigma relating to obesity in women. This is a particularly important area for further research as pregnancy is potentially the only life event when obese women are more likely to feel positive about their body, and in turn lift their self imposed social sanctions.

The identified awareness issues among women about the impact of maternal obesity on their pregnancy, and the limitations of their care it can cause should be further explored to identify what public health messages need to be developed to increase the awareness and knowledge of issues among women before they conceive. Also further research is required into what services already exist in public health and the community setting which maternity services could work with to address maternal obesity preconception, during the pregnancy, and postnatally. Ways to improve the communication between maternity services and public health should also be explored further so that existing expertise, knowledge, and resource can be utilised to address this issue. The development of a service to engage women during pregnancy and to improve the transition of care into the postnatal period could potentially encourage women to continue to engage in services following childbirth.

An incidental finding of this study not related to obesity but warranting further exploration nonetheless, relates to late bookers. The CEMACH reports a relationship with increased maternal mortality when mother’s access maternity services late (Lewis, 2007). There are also inequalities among vulnerable groups identified in the HC inequalities in access to maternity services report (House of Commons Health Committee, 2003), and this research has highlighted a relationship between deprivation, ethnic group, and late booking. However, only crude data analysis was utilised in this research as the objectives were only to explore issues around maternal obesity. There would be benefit in further exploration of the national dataset used in this research to identify the demographics of women most likely to access services late after adjusting for confounders, followed up with qualitative exploration into the reasons behind why specific social groups access maternity services at a later gestational period than others. Further research in this direction could help in the development of services to address the inequality issues with access to care and this aspect of maternal mortality.

7.4 Conclusions

The mixed methods approach adopted in this programme of research has allowed for different perspectives to be considered when identifying the trends in maternal BMI and the impact on service. The outcomes of the individual components of the programme are complementary, and have shown that maternal obesity has a significant impact on NHS maternity services.

The programme of research has identified that the incidence of maternal obesity in England is increasing over time. Obesity in pregnancy is also associated with maternal demographic and geographic inequalities. The obesity subgroup which is increasing at the quickest rate is the super morbidly obese group. The women most likely to be at future risk of being in this obesity subgroup if the increasing incidence continues are those who are the most socially vulnerable.

The research has also identified that the increasing incidence of maternal obesity has an impact on acute maternity services' resource, that there is a lack of communication between acute maternity services and public health, and that a holistic approach is required to address obesity in pregnancy through partnership work involving multiple agencies. However, the relationship between maternal obesity and adverse pregnancy outcomes which impact on maternity services also means that the most socially vulnerable women are likely to require additional maternity care. Yet there are inequalities in access to maternity services among the most socially vulnerable groups, and HCPs have identified that there are difficulties in engaging the women who have the greatest need with maternity services.

Given the concerning elevation in the incidence of maternal obesity, the related health inequalities, and the impact of obesity on maternity services, and on the health of the mother and baby, future research programmes aimed at preventing the continuation of this trend are imperative.

References

Abrams, B., Carmichael, S. & Selvin, S. (1995) Factors Associated with the Pattern of Maternal Weight Gain During Pregnancy. *Obstetrics and Gynaecology,* 86, 170-176.

Abrams, B. & Newman, V. (1991) Small-for-Gestational-Age Birth: Maternal Predictors and Comparison with Risk Factors of Spontaneous Preterm Delivery in the Same Cohort. *American Journal of Obstetrics & Gynecology,* 164, 785-790.

Al-Shahi Salmon, R., Brock, T. M., Dennis, M. S., Sandercock, P. A. G., White, P. M. & Warlow, C. (2007) Research Governance Impediments to Clinical Trials: A Retrospective Survey. *Journal of the Royal Society of Medicine,* 100, 101-104.

Amorim, A. R., Linne, Y., Kac, G. & Lourenco, P. M. (2008) Assessment of Weight Changes During and after Pregnancy: Practical Approaches. *Maternal and Child Nutrition,* 4, 1-13.

Andreasen, K. R., Andersen, M. L. & Schantz, A. L. (2004) Obesity and Pregnancy. *Acta Obstetricia et Gynecologica Scandinavica,* 83, 1022 - 1029.

Baeten, J. M., Bukusi, E. A. & Lambe, M. (2001) Pregnancy Complications and Outcomes among Overweight and Obese Nulliparous Women. *American Journal of Public Health,* 91, 436-440.

Barker, D. J. (1998) *Mothers, Babies and Health in Later Life*, Churchill Livingstone: Edinburgh.

Batterham, A. M., Tolfrey, K. & George, K. P. (1997) Nevill's Explanation of Klieber's 0.75 Mass Exponent: An Artefact of Collinearity Problems in Least Squares Models? *Journal of Applied Physiology*, 693-697.

Belsley, D. A., Kuh, E. & Welsch, R. E. (1980) *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity,* New York, Wiley.

Bergholt, T., Lim, L. K., Jorgensen, J. S. & Robson, M. S. (2007) Maternal Body Mass Index in the First Trimester and Risk of Cesarean Delivery in Nulliparous Women in Spontaneous Labor. *American Journal of Obstetrics & Gynecology,* 196, 163.e1-5.

Bergmann, M. M., Flagg, E. W., Miracle-Mcmahill, H. L. & Boeing, H. (1997) Energy Intake and Net Weight Gain in Pregnant Women According to Body Mass Index (Bmi) Status. *International Journal of Obesity & Related Metabolic Disorders: Journal of the International Association for the Study of Obesity,* 21, 1010.

Bianco, A. T., Smilen, S. W., Davis, Y., Lopez, S., Lapinski, R. & Lockwood, C. J. (1998) Pregnancy Outcome and Weight Gain Recommendations for the Morbidly Obese Woman. *Obstetrics & Gynecology,* 91, 97-102.

Bland, M. (1996) *An Introduction to Medical Statistics,* Oxford, Oxford University Press.

Bo, S., Menato, G., Signorile, A., Bardelli, C., Lezo, A., Gallo, M. L., Gambino, R., Cassader, M., Massobrio, M. & Pagano, G. (2003) Obesity or Diabetes: What Is Worse for the Mother and for the Baby? *Diabetes & Metabolism,* 29, 175-178.

Brannen, J. (1995) *Mixing Methods: Qualitative and Quantitative Research,* Aldershot, Avebury.

Brannen, J. (2005) Mixing Methods: The Entry of Qualitative and Quantitative Approaches into the Research Process. *International Journal of Social Research Methodology,* 8, 173-184.

Breidahl, H. D. (1996) The Growth and Development of Children Born to Mothers with Diabetes. *Medical Journal of Australia,* 1, 268-270.

Brown, I., Jones, G., Thompson, J. & Tod, A. M. (2006) Obesity Stigma and Quality of Life. *International Journal of Interdisciplinary Social Science,* 1, 169-178.

Bryman, A. (2007) Barriers to Integrating Quantitative and Qualitative Research. *Journal of Mixed Methods Research,* 1, 8-22.

Burnard, P. (1991) A Method of Analysing Interview Transcripts in Qualitative Research. *Nurse Education Today,* 11, 461-46.

Byrne, G., Morgan, J. B., Kendall, S. & Offredy, M. (2005) A Critical Account of Obtaining Research Governance Approval. *Nurse Researcher,* 13, 7-18.

Callaway, L. K., Prins, J. B., Chang, A. M. & Mcintyre, H. D. (2006) The Prevalence and Impact of Overweight and Obesity in an Australian Obstetric Population. *Medical Journal of Australia,* 184, 56-59.

Carmichael, S., Abrams, B. & Selvin, S. (1997) The Pattern of Maternal Weight Gain in Women with Good Pregnancy Outcomes. *American Journal of Public Health,* 87, 1984-1988.

Castro, L. C. & Avina, R. L. (2002) Maternal Obesity and Pregnancy Outcomes. *Current Opinion in Obstetrics and Gynecology,* 14, 601-606.

Cedergren, M. I. (2004) Maternal Morbid Obesity and the Risk of Adverse Pregnancy Outcome. *Obstetrics & Gynecology,* 103, 219-224.

Census (2001) Standard Tables: St001 Age by Sex and Marital Status, St028 Sex and Age by Economic Activity, St101 Sex and Age by Ethnic Group, St007 Age of Frp (Family Reference Person) and Number and Age of Dependent Children by Family Type. Office of National Statistics.

Chauhan, S. P., Magann, E. F., Carroll, C. S., Barrilleaux, P. S., Scardo, J. A. & Martin, J. N., Jr. (2001) Mode of Delivery for the Morbidly Obese with Prior Cesarean Delivery: Vaginal Versus Repeat Cesarean Section. *American Journal of Obstetrics & Gynecology,* 185, 349-54.

Chu, S. Y., Bachman, D. J., Callaghan, W. M., Whitlock, E. P., Dietz, P. M., Berg, C. J., O'keeffe-Rosetti, M., Bruce, F. C. & Hornbrook, M. C. (2008) Association between Obesity During Pregnancy and Increased Use of Health Care. *The New England Journal of Medicine,* 358, 1444.

Clark, A. M., Ledger, W., Galletly, C., Tomlinson, L., Blaney, F., Wang, X. & Norman, R. J. (1995) Weight Loss Results in Significant Improvement in Pregnancy and Ovulation Rates in Anovulatory Obese Women. *Human Reproduction,* 10, 2705-2712.

Cnattingius, S., Bergstrom, R., Lipworth, L. & Kramer, M. S. (1998) Prepregnancy Weight and the Risk of Adverse Pregnancy Outcomes. *New England Journal of Medicine,* 338, 147-152.

Cnattingius, S. & Lambe, M. (2002) Trends in Smoking and Overweight During Pregnancy: Prevalence, Risks of Pregnancy Complications and Adverse Pregnancy Outcomes. *Seminars in Perinatology,* 26, 286-295.

Confidential Enquiry into Maternal and Child Health (2004) Why Mothers Die 2000-2002. RCOG:London

Confidential Enquiry into Maternal and Child Health (2007) Perinatal Mortality 2005. CEMACH.

Confidential Enquiry into Maternal and Child Health (2008) Obesity in Pregnancy: Working Protocol.

Confidential Enquiry into Maternal Deaths (2001) Why Mothers Die 1997-1999. RCOG: London

Crane, S. S., Wojtowycz, M. A., Dye, T. D., Aubry, R. H. & Artal, R. (1997) Association between Pre-Pregnancy Obesity and the Risk of Caesarean Delivery. *Obstetrics and Gynecology,* 89, 213-216.

Cresswell, J. W. (1998) *Qualitative Inquiry and Research Design. Choosing among Five Traditions*, Sage.

Cresswell, J. W., Fetters, M. D. & Ivankova, N. V. (2004) Designing a Mixed Methods Study in Primary Care. *Annals of Family Medicine,* 2, 7-12.

Curhan, G. C., Chertow, G. M., Willett, W. T., Spiegelman, D., Colditz, G. A., Manson, J. E., Speizer, F. E. & Stampfer, M. J. (1996a) Birth Weight and Adult Hypertension and Obesity in Women. *Circulation,* 94, 1310-1315.

Curhan, G. C., Willett, W. T., Rimm, E. B., Spiegelman, D., Ascherio, A. L. & Stampfer, M. J. (1996b) Birth Weight and Adult Hypertension, Diabetes Mellitus, and Obesity in U.S.Men. *Circulation,* 94, 3246-3250.

Dawes, M. G. & Grudzinskas, J. G. (1991) Patterns of Maternal Weight Gain in Pregnancy. *BJOG: an International Journal of Obstetrics & Gynaecology,* 98, 195-201.

Dempsey, J. C., Ashiny, Z., Qiu, C. F., Miller, R. S., Sorensen, T. K. & Williams, M. A. (2005) Maternal Pre-Pregnancy Overweight Status and Obesity as Risk Factors for Cesarean Delivery. *Journal of Maternal-Fetal & Neonatal Medicine,* 17, 179-185.

Department for Education & Employment (1999) National Healthy School Standard Guidance. DfEE Publications:Nottingham

Department of Health (2002a) Health Survey for England 2002: Health and Lifestyle Indicators for Strategic Health Authorities, 1994- 2002. HMSO: London.

Department of Health (2002b) Healthy Start: Proposals for Reform of the Welfare Food Scheme. London:HMSO

Department of Health (2004a) Choosing Health – Making Healthy Choices Easier. London:HMSO.

Department of Health (2004b) Health Survey for England 2003. HMSO: London.

Department of Health (2005a) Health Survey for England 2004. HMSO: London.

Department of Health (2005b) Research Governance Framework for Health and Social Care. 2nd ed., London: DoH.

Department of Health (2006) National Schedule of Reference Costs in the Nhs 2005-06. London, Department of Health.

Department of the Environment Transport and the Regions (Detr) (2000) Measuring Multiple Deprivation at the Small Area Level: The Indices of Deprivation 2000. Department of the Environment Transport and the Regions.

Devine, F. & Heath, S. (1999) *Sociological Research Methods in Context,* Basingstoke, Macmillan.

Di Cianni, G., Volpe, L., Lencioni, C., Miccoli, R., Cuccuru, I., Ghio, A., Chatzianagnostou, K., Bottone, P., Teti, G., Del Prato S. & Benzi, L. (2003) Prevalence and Risk Factors for Gestational Diabetes Assessed by Universal Screening. *Diabetes Research & Clinical Practice,* 62, 131-137.

Dillman, D. A. (1978) *Mail and Telephone Surveys: The Total Design Method,* New York, Wiley-Interscience.

Dillman, D. A. (2007) *Mail and Internet Surveys: The Tailored Design Method,* New Jersey, John Wiley & Sons.

Doherty, D. A., Magann, E. F., Francis, J., Morrison, J. C. & Newnham, J. P. (2006) Pre-Pregnancy Body Mass Index and Pregnancy Outcomes. *International Journal of Gynaecology & Obstetrics,* 95, 242-247.

Dorner, G. & Plagemann, A. (1994) Perinatal Hyperinsulinism as Possible Predisposing Factor for Diabetes Mellitus, Obesity and Enhanced Cardiovascular Risk in Later Life. *Hormone & Metabolic Research,* 26, 213-221.

Dresner, M. (2007) Obesity and Anaesthesia In Baker, P., Balen, A., Poston, L., Sattar, N. (Ed.) *Obesity and Reproductive Health.* London, Royal College of Obstetricians and Gynaecologists.

Edwards, P., Roberts, I., Clarke, M., Diguiseppe, C., Pratap, S. & Wentz, R. (2002) Increasing Response Rates to Postal Questionnaires: Systematic Review. *British Medical Journal,* 324, 1183-1191.

Edwards, P. J., Roberts, I. G., Clark, M. J., Diguiseppe, C., Wentz, R., Kwan, I., Cooper, R., Felix, L. & Pratap, S. (2007) Methods to Increase Response Rates to Postal Questionnaires. *Cochrane Database of Systematic Reviews*, Art. No.:MR000008. DOI: 10.1002/14651858.MR000008.pub3.

Edwards, R. K., Harnsberger, D. S., Johnson, I. M., Treloar, R. W. & Cruz, A. C. (2003) Deciding on Route of Delivery for Obese Women with a Prior Cesarean Delivery. *American Journal of Obstetrics & Gynecology,* 189, 385-390.

Ehrenberg, H. M., Durnwald, C. P., Catalano, P. & Mercer, B. M. (2004a) The Influence of Obesity and Diabetes on the Risk of Cesarean Delivery. *American Journal of Obstetrics and Gynecology,* 191, 969 - 974.

Ehrenberg, H. M., Mercer, B. M. & Catalano, P. M. (2004b) The Influence of Obesity and Diabetes on the Prevalence of Macrosomia. *American Journal of Obstetrics and Gynecology,* 191, 964-968.

Ekblad, U. & Grenman, S. (1992) Maternal Weight, Weight Gain During Pregnancy and Pregnancy Outcome. *International Journal of Gynaecology & Obstetrics,* 39, 277-283.

Elwyn, G., Seagrove, A., Thorne, K. & Cheung, W. Y. (2005) Ethics and Research Governance in a Multicentre Study: Add 150 Days to Your Study Protocol. *British Medical Journal,* 330, 847.

Engstrom, J. L., Paterson, S. A., Doherty, A., Trabulsi, M. & Speer, K. L. (2003) Accuracy of Self-Reported Height and Weight in Women: An Integrative Review of the Literature. *Journal of Midwifery & Women's Health,* 48, 338-345.

Farquar, C. (2007) Obesity and Fertility. In Baker, P., Balen, A., Poston, L., Sattar, N., Balen, A., Poston, L., Taylor, P. & Sattar, N. (Eds.) *Obesity and Reproductive Health.* London, Royal College of Obstetricians and Gynaecologists.

Field, A. (2000) *Discovering Statistics Using Spss for Windows,* London, SAGE.

Foresight (2007) Tackling Obesities: Future Choices – Project Report. 2nd Edition ed., Government Office for Science, Department of Innovation Universities and Skills.

Fry, J. C. (1993) *Biological Data Analysis: A Practical Approach,* Oxford, Oxford University Press.

Galbraith, N. & Hawley, C. (2006) Research Governance Approval Is Putting People Off Research. *British Medical Journal,* 332, 238.

Galtier-Dereure, F., Boegner, C. & Bringer, J. (1995) Weight Excess before Pregnancy: Complications and Cost. *International Journal of Obesity and Related Metabolic Disorders,* 19, 443-448.

Galtier-Dereure, F., Boegner, C. & Bringer, J. (2000) Obesity and Pregnancy: Complications and Cost. *American Journal of Clinical Nutrition,* 71, 1242-1248s.

Garn, S. M. & La Velle, M. (1985) Two Decade Follow up of Fatness in Early Childhood. *American Journal of Diseases of Children* 139, 181-185.

Giuliani, A., Tamussino, K., Basver, A., Haas, J. & Petru, E. (2002) The Impact of Body Mass Index and Weight Gain During Pregnancy on Puerperal Complications after Spontaneous Vaginal Delivery. *Wiener Klinische Wochenschrift,* 114, 383-386.

Gore, S. A., Brown, D. M. & Smith West, D. (2003) The Role of Postpartum Weight Retention in Obesity among Women: A Review of the Evidence. *The Annals of Behavioural Medicine,* 26, 149-159.

Guelinckx, I., Devlieger, R., Beckers, K. & Vansant, G. (2008) Maternal Obesity: Pregnancy Complications, Gestational Weight Gain and Nutrition. *Obesity Reviews,* 9, 140-150.

Gunderson, E. P. & Abrams, B. (2000) Epidemiology of Gestational Weight Gain and Body Weight Changes after Pregnancy. *Epidemiologic Reviews,* 22, 261-274.

Harris, R. (1979) Cultural Differences in Body Perception During Pregnancy. *British Journal of Medical Psychology,* 52, 347-352.

Hellerstedt, W. L., Himes, J. H., Story, M., Alton, I. R. & Edwards, L. E. (1997) The Effects of Cigarette Smoking and Gestational Weight Change on Birth Outcomes in Obese and Normal-Weight Women. *American Journal of Public Health,* 87, 591-596.

Hendler, I., Goldenberg, R. L., Mercer, B. M., Iams, J. D., Meis, P. J., Moawad, A. H., Macpherson, C. A., Caritis, S. N., Miodovnik, M., Menard, K. M., Thurnau, G. R. & Sorokin, Y. (2005) The Preterm Prediction Study: Association between Maternal Body Mass Index and Spontaneous and Indicated Preterm Birth. *American Journal of Obstetrics and Gynecology,* 192, 882-886.

Henry, C. J. K. (1990) Body Mass Index and the Limits of Human Survival. *European Journal of Clinical Nutrition,* 44, 329-335.

Her Majesty's Treasury (2007) The Health in Pregnancy Grant (Entitlement, Amount and Administration) Regulations 2007.

Heslehurst, N., Ells, L. J., Simpson, H., Batterham, A., Wilkinson, J. & Summerbell, C. D. (2007a) Trends in Maternal Obesity Incidence Rates, Demographic Predictors, and Health Inequalities in 36 821 Women over a 15-Year Period. *BJOG: an International Journal of Obstetrics & Gynaecology,* 114, 187-194.

Heslehurst, N., Lang, R., Rankin, J., Wilkinson, J. & Summerbell, C. (2007b) Obesity in Pregnancy: A Study of the Impact of Maternal Obesity on Nhs Maternity Services. *BJOG: an International Journal of Obstetrics & Gynaecology,* 114, 334-342.

Hibbard, J. U., Gilbert, S., Landon, M. B., Hauth, J. C., Leveno, K. J., Spong, C. Y., Varner, M. W., Caritis, S. N., Harper, M., Wapner, R. J., Sorokin, Y., Miodovnik, M., Carpenter, M., Peaceman, A. M., O'sullivan, M. J., Sibai, B. M., Langer, O., Thorp, J. M., Ramin, S. M., Mercer, B. M. & S.G., G. (2006) Trial of Labor or Repeat Cesarean Delivery in Women with Morbid Obesity and Previous Cesarean Delivery. *Obstetrics & Gynaecology,* 108, 125-133.

Hill, J. G., Foster, N., Hughes, R. & Hay, E. (2005) Meeting the Challenges of Research Governance. *Rheumatology,* 44, 571-572.

Hollmann, M., Runnebaum, B. & Gerhard, I. (1997) Impact of Waist-Hip-Ratio and Body-Mass-Index on Hormonal and Metabolic Parameters in Young, Obese Women. *International Journal of Obesity,* 21, 476-483.

Hotzel, D. (1986) Suboptimal Nutritional Status in Obesity (Selected Nutrients). *Bibliotheca Nutritio et Dieta* 21, 30-41.

House of Commons Health Committee (2003) Inequalities in Access to Maternity Services. London, The Stationary Office.

House of Commons Health Committee (2004) Obesity - Third Report of Session 2003-2004, Volume 1, Hc 23.1. HMSO: London.

Hulsey, T. C., Neal, D., Bondo, S. C., Hulsey, T. & Newman, R. (2005) Maternal Prepregnant Body Mass Index and Weight Gain Related to Low Birth Weight in South Carolina. *Southern Medical Journal,* 98, 411-415.

Index of Multiple Deprivation (2000) The English Indices of Deprivation. Office of the Deputy Prime Minister.

Index of Multiple Deprivation (2007) The English Indices of Deprivation. Department of Communities and Local Government.

Institute of Medicine (1990) Nutrition During Pregnancy, Subcommittee on Nutritional Status and Weight Gain During Pregnancy. National Academic Press, Washington DC.

Jamrozik, K. (2004) Research Ethics Paperwork: What Is the Plot We Seem to Have Lost? *British Medical Journal,* 329, 286-287.

Jensen, D. M., Damm, P., Sorensen, B., Molsted-Pedersen, L., Westergaard, J. G., Ovesen, P. & Beck-Nielsen, H. (2003) Pregnancy Outcome and Prepregnancy Body Mass Index in 2459 Glucose-Tolerant Danish Women. *American Journal of Obstetrics & Gynecology,* 189, 239-244.

Jensen, H., Agger, A. O. & Rasmussen, K. L. (1999) The Influence of Prepregnancy Body Mass Index on Labor Complications. *Acta Obstetricia et Gynecologica Scandinavica,* 78, 799-802.

Johnson, F., Cooke, L., Croker, H. & Wardle, J. (2008) Changing Perceptions of Weight in Great Britain: Comparison of Two Population Surveys. *British Medical Journal,* 337, a494.

Johnson, J. W., Longmate, J. A. & Frentzen, B. (1992) Excessive Maternal Weight and Pregnancy Outcome. *American Journal of Obstetrics & Gynecology,* 167, 353-370.

Kaiser, P. S. & Kirby, R. S. (2001) Obesity as a Risk Factor for Cesarean in a Low-Risk Population. *Obstetrics and Gynecology,* 97, 39-43.

Kanagalingam, M. G., Forouhi, N. G., Greer, I. A. & Sattar, N. (2005) Changes in Booking Body Mass Index over a Decade: Retrospective Analysis from a Glasgow Maternity Hospital. *BJOG: an International Journal of Obstetrics and Gynaecology,* 112, 1431–1433.

Kenney, N. & Macfarlane, A. (1999) Identifying Problems with Data Collection at a Local Level: Survey of Nhs Maternity Units in England. *British Medical Journal,* 319, 619-622.

Kielmann, T., Tierney, A., Porteous, R., Huby, G., Sheikh, A. & Pinnock, H. (2007) The Departments of Health's Research Governance Framework Remains an Impediment to Multi-Centre Studies: Frindings from a National Descriptive Study. *Journal of the Royal Society of Medicine,* 100, 234-238.

Konje, J. C., Imrie, A. & Hay, D. M. (1993) Pregnancy in Obese Women. *Journal of Obstetrics and Gynaecology,* 13, 413-418.

Kramer, M. S., Platt, R., Yang, H., Mcnamara, H. & Usher, R. H. (1999) Are All Growth-Restricted Newborns Created Equal(Ly)? *Pediatrics,* 103, 599-602.

Kugyelka, J. G., Rasmussen, K. R. & Frongillo, E. A. (2004) Maternal Obesity Is Negatively Associated with Breastfeeding Success among Hispanic but Not Black Women. *Journal of Nutrition,* 134, 1746-1753.

Kumari, A. S. (2001) Pregnancy Outcome in Women with Morbid Obesity. *International Journal of Gynecology and Obstetrics,* 73, 101-107.

Lake, J. K., Power, C. & Cole, T. J. (1997) Women's Reproductive Health: The Role of Body Mass Index in Early and Adult Life. *International Journal of Obesity & Related Metabolic Disorders: Journal of the International Association for the Study of Obesity,* 21, 432.

Larsen, C. E., Serdula, M. K. & Sullivan, K. M. (1990) Macrosomia: Influence of Maternal Overweight among a Low Income-Population. *American Journal Obstetrics Gynecology,* 162, 490-494.

Lashen, H., Fear, K. & Sturdee, D. W. (2004) Obesity Is Associated with Increased Risk of First Trimester and Recurrent Miscarriage: Matched Case-Control Study. *Human Reproduction,* 19, 1644-1646.

Lawlor, D. A. & Chaturvedi, N. (2006) Treatment and Prevention of Obesity—Are There Critical Periods for Intervention? *international Journal of Epidemiology,* 35, 3-9.

Lewis, G. (2007) The Confidential Enquiry into Maternal and Child Health (Cemach). *Saving Mothers' Lives: Reviewing Maternal Deaths to Make Motherhood Safer - 2003-2005.* The Seventh Report on Confidential Enquiries into Maternal Deaths in the United Kingdom., London: CEMACH.

Linne, Y. (2004) Effects of Obesity on Women's Reproduction and Complications During Pregnancy. *Obesity Reviews,* 5, 137-143.

Lombardi, D. G., Barton, J. R., O'brien, J. M., Istwan, N. K. & Sibai, B. M. (2005) Does an Obese Prepregnancy Body Mass Index Influence Outcome in Pregnancies Complicated by Mild Gestational Hypertension Remote from Term? *American Journal of Obstetrics & Gynecology,* 192, 1472-1474.

Lumme, R., Rantakallio, P., Hartikainen, A. L. & Jarvelin, M. R. (1995) Pre-Pregnancy Weight and It's Relation to Pregnancy Outcome. *Obstetrics and Gynaecology,* 15, 69-75.

Macfarlane, A. (1998) At Last-Maternity Statistics for England. *British Medical Journal,* 316, 566-7.

Mancuso, A., D'anna, R. & Leonardi, R. (1991) Pregnancy in the Obese Patient. *European Journal of Obstetrics and Gynecology and Reproductive Biology,* 39, 83-86.

Morin, K. H. (1998) Perinatal Outcomes of Obese Women: A Review of the Literature. *Journal of Obstetric, Gynecologic, and Neonatal Nursing,* 27, 431-440.

Morin, K. H., Brogan, S. & Flavin, S. K. (2002) Attitudes and Perceptions of Body Image in Postpartum African American Women. Does Weight Make a Difference? *MCN, American Journal of Maternal Child Nursing,* 27, 20-5.

Morris, S. (2004) The Impact of Obesity on Employment in England. Tanaka Business School.

Naeye, R. L. (1990) Maternal Body Weight and Pregnancy Outcome. *American Journal Clinical Nutrition,* 52, 273-279.

National Institute for Health and Clinical Excellence (2003) Antenatal Care: Routine Care for the Healthy Pregnant Woman. RCOG: London.

National Institute for Health and Clinical Excellence (2006) Obesity: The Prevention, Identification, Assessment and Management of Overweight and Obesity in Adults and Children.

National Institute for Health and Clinical Excellence (2007) Intrapartum Care: Care of Healthy Women and Their Babies During Childbirth.

National Institute for Health and Clinical Excellence (2008a) Antenatal Care: Routine Care for the Healthy Pregnant Woman.

National Institute for Health and Clinical Excellence (2008b) Diabetes in Pregnancy: Management of Diabetes and Its Complications from Pre-Conception to the Postnatal Period.

National Institute for Health and Clinical Excellence (2008c) Effective Weight Maintenance Following Childbirth. http://www.nice.org.uk/guidance/index.jsp?action=byID&o=11969 [Accessed 16/09/2008].

National Institute for Health and Clinical Excellence (2008d) Induction of Labour Clinical Guideline 070: An Update of Nice Inherited Clinical Guideline D. Department of Health National Collaborating Centre for Women's and Children's Health:London.

National Institute for Health and Clinical Excellence (2008e) Prevention of Excessive Weight Gain in Pregnancy. http://www.nice.org.uk/Guidance/PHIG/Wave18/3 [Accessed 16/09/2008].

Norman, R. J. & Clark, A. M. (1998) Obesity and Reproductive Disorders: A Review. *Reproductive Fertility Development,* 10, 55-63.

Nucci, L. B., Schmidt, M. I., Duncan, B. B., Fuchs, S. C., Fleck, E. T. & Santos Britto, M. M. (2001) Nutritional Status of Pregnant Women: Prevalence and Associated Pregnancy Outcomes. *Revista de Saude Publica,* 35, 502-507.

O'cathain, A., Murphy, E. & Nicholl, J. (2008) The Quality of Mixed Methods Studies in Health Services Research. *Journal of Health Services Research & Policy,* 13, 92-98.

Ochsenbein-Kolble, N., Roos, M., Gasser, T., Huch, R., Huch, A. & Zimmermann, R. (2004) Cross Sectional Study of Automated Blood Pressure Measurements Throughout Pregnancy. *BJOG: an International Journal of Obstetrics & Gynaecology,* 111, 319.

Ogunyemi, D., Hullett, S., Leeper, J. & Risk, A. (1998) Prepregnancy Body Mass Index, Weight Gain During Pregnancy, and Perinatal Outcome in a Rural Black Population. *Journal of Maternal-Fetal Medicine,* 7, 190-193.

Olesen, A. W., Westergaard, J. G. & Olsen, J. (2006) Prenatal Risk Indicators of a Prolonged Pregnancy. The Danish Birth Cohort 1998-2001. *Acta Obstetricia et Gynecologica Scandinavica,* 85, 1338-1341.

Parmanum, J., Field, D., Rennie, J. & Steer, P. (2000) National Census of Availability of Neonatal Intensive Care. *British Medical Journal,* 321, 727-729.

Parsons, T. J., Power, C., Logan, S. & Summerbell, C. D. (1999) Childhood Predictors of Adult Obesity: A Systematic Review. [Review] [283 Refs]. *International Journal of Obesity & Related Metabolic Disorders: Journal of the International Association for the Study of Obesity,* 23 Suppl 12, S1-S107.

Patrick, H. & Nicklas, T. A. (2005) A Review of Family and Social Determinants of Children's Eating Patterns and Diet Quality. *Journal of the American College of Nutrition,* 24, 83-92.

Pettigrew, R. & Hamilton-Fairley, D. (1997) Obesity and Female Reproductive Function. *British Medical Bulletin,* 53, 341.

Pettitt, D. J., Nelson, R. G., Saad, M. F., Bennett, P. H. & Knowler, W. C. (1993) Diabetes and Obesity in the Offspring of Pima Indian Women with Diabetes During Pregnancy. *Diabetes Care,* 16, 310-4.

Phithakwatchara, N. & Titapant, V. (2007) The Effect of Pre-Pregnancy Weight on Delivery Outcome and Birth Weight in Potential Diabetic Patients with Normal Screening for Gestational Diabetes Mellitus in Siriraj Hospital. *Journal of the Medical Association of Thailand,* 90, 229-236.

Plaguemann, A., Harder, T., Kohlhoff, R., Rohde, W. & Dörner, G. (1997) Glucose Tolerance and Insulin Secretion in Children of Mothers with Pregestational Iddm or Gestational Diabetes *Diabetologia,* 40, 1094-1100.

Poston, L. & Taylor, P. (2007) Obesity in Pregnancy and the Next Generation: What Can We Learn from Animal Models? In Baker, P., Balen, A., Poston, L., Sattar, N. (Ed.) *Obesity and Reproductive Health.* London, RCOG.

Power, C., Li, L., Manor, O. & Davey, S. G. (2003) Combination of Low Birth Weight and High Adult Body Mass Index: At What Age Is It Established and What Are Its Determinants? *Journal of Epidemiology & Community Health,* 57, 969.

Ramsay, J. E., Greer, I. & Sattar, N. (2006) Obesity and Reproduction. *British Medical Journal,* 333, 1159-1162.

Ranta, P., Jouppila, P., Spalding, M. & Jouppila, R. (1995) The Effect of Maternal Obesity on Labour and Labour Pain. *Anaesthesia,* 50, 322-326.

Rantakallio, P., Laara, E., Koiranen, M. & Sarpola, A. (1995) Maternal Build and Pregnancy Outcome. *Journal of Clinical Epidemiology,* 48, 199-207.

Reilly, J. J. & Mcdowell, Z. C. (2003) Physical Activity Interventions in the Prevention and Treatment of Paediatric Obesity: Systematic Review and Critical Appraisal. *The Proceedings of the Nutrition Society,* 62, 611-619.

Rode, L., Nilas, L., Wojdemann, K. & Tabor, A. (2005) Obesity-Related Complications in Danish Single Cephalic Term Pregnancies. *Obstetrics & Gynecology,* 105, 537-542.

Rodrigues, S., Ferris, A. M., Perez-Escamilla, R. & Backstrand, J. R. (1998) Obesity among Offspring of Women with Type 1 Diabetes. *Clinical & Investigative Medicine - Medecine Clinique et Experimentale,* 21, 258.

Roehling, M. V. (1999) Weight-Based Discrimination in Employment: Psychological and Legal Aspects. *Personnel Psychology,* 52, 969-1017.

Rosenberg, T. J., Garbers, S., Chavkin, W. & Chiasson, M. A. (2003) Prepregnancy Weight and Adverse Perinatal Outcomes in an Ethnically Diverse Population. *Obstetrics and Gynecology,* 102, 1022-1027.

Rossner, S. & Ohlin, A. (1990) Maternal Body Weight and Relation to Birthweight. *Acta Obstetrica Gynecologica Scandinavia,* 69, 475-478.

Royal College of Obstetricians and Gynaecologists (2007) Obesity and Reproductive Health: Consensus Views. In Baker, P., Balen, A., Poston, L., Sattar, N. (Ed.).

Royal College of Obstetricians and Gynaecologists, Royal College of Midwives, Royal College of Anaesthetists & Royal College of Paediatricians and Child Health (1st November 2006) Safer Childbirth: Minimum Standards for Service Provision and Care in Labour.

Scottish Intercollegiate Guidelines Network (2004) Methodology Checklist 3: Cohort Studies.

Sebire, N. J., Jolly, M., Harris, J. P., Wadsworth, J., Joffe, M., Beard, R. W., Regan, L. & Robinson, S. (2001) Maternal Obesity and Pregnancy Outcome: A Study of 287,213 Pregnancies in London. *International Journal of Obesity,* 25, 1175-1182.

Sheiner, E., Levy, A. & Menes, T. S. (2004) Maternal Obesity as an Independent Risk Factor for Caesarean Delivery. *Paediatric and Perinatal Epidemiology,* 18, 196-201.

Shepard, M. J., Saftlas, A. F., Leo-Summers, L. & Bracken, M. B. (1998) Maternal Anthropometric Factors and Risk of Primary Cesarean Delivery. *American Journal of Public Health,* 88, 1534-1538.

Siega-Riz, A. M., Evenson, K. R. & Dole, N. (2004) Pregnancy-Related Weight Gain - a Link to Obesity? *Nutrition Reviews,* 62, S105-111.

Silverman, B. L., Rizzo, T., Green, O. C., Cho, N. H., Winter, R. J., Ogata, E. S., Richards, G. E. & Metzger, B. E. (1991) Long-Term Prospective Evaluation of Offspring of Diabetic Mothers. *Diabetes,* 40 Suppl 2, 121-5.

Smith, L. (1998) Problems in Retrieving National Data on Births: Questionnaire Survey. *British Medical Journal,* 316, 1710-1711.

Statacorp Lp (2005) Intercooled Stata 9. USA.

Steer, P. (2002) The Maternity Care Data Project. *BJOG: an International Journal of Obstetrics & Gynaecology,* 109, 852-855.

Steinfeld, J. D., Valentine, S., Lerer, T., Ingardia, C. J., Wax, J. R. & Curry, S. L. (2000) Obesity-Related Complications of Pregnancy Vary by Race. *Journal of Maternal-Fetal Medicine,* 9, 238-241.

Teddlie, C. & Yu, F. (2007) Mixed Methods Sampling a Typology with Examples. *Journal of Mixed Methods Research,* 1, 77-100.

The Cochrane Non-Randomised Studies Methods Group (2001) Data Extraction Form Template for Cohort Studies.

The Information Centre (2006) Health Survey for England 2004, Vol 1: Minority Ethnic Groups. NHS.

The Information Centre (2008a) Health Survey for England 2006. NHS.

The Information Centre (2008b) National Child Measurement Programme: 2006/07 School Year, Headline Results. Department of Health.

Unger, R., Kreeger, L. & Christoffel, K. K. (1990) Childhood Obesity: Medical and Familial Correlates and Age of Onset. *Clinical Paediatrics,* 29, 368-373.

Usher Kiran, T. S., Hemmadi, S., Bethal, J. & Evans, J. (2005) Outcome of Pregnancy in a Woman with an Increased Body Mass Index. *BJOG: an International Journal of Obstetrics and Gynaecology,* 112, 768–772.

Vahratian, A., Zhang, J., Troendle, J. F., Savitz, D. A. & Siega-Riz, A. M. (2004) Maternal Prepregnancy Overweight and Obesity and the Pattern of Labor Progression in Term Nulliparous Women. *Obstetrics and Gynecology,* 104, 943-951.

Wald, D. S. (2004) Bureaucracy of Ethics Applications. *British Medical Journal,* 329, 282-284.

Waller, K., Shaw, G. M., Rasmussen, S. A., Hobbs, C. A., Canfield, M. A., Siega-Riz, A., Gallaway, S. & Correa, A. (2007) Prepregnancy Obesity as a Risk Factor for Structural Birth Defects. *Archives of Pediatrics & Adolescent Medicine,* 161, 745-750.

Wang, J. X., Davies, M. J. & Norman, R. J. (2002) Obesity Increases the Risk of Spontaneous Abortion During Infertility Treatment. *Obesity Research,* 10, 551-554.

Warlow, C. (2004) Clinical Research under the Cosh Again: This Time It Is Ethics Committees. *British Medical Journal,* 329, 241-242.

Weiss, J. L., Malone, F. D., Emig, D., Ball, M. H., Nyberg, D. A., Comstock, C. H., Saade, G., Eddleman, K., Carter, S. M., Craigo, S. B., Carr, S. R. & D'alton, M. E. (2004) Obesity, Obstetric Complications and Cesarean Delivery Rate - a Population-Based Screening Study. *American Journal of Obstetrics and Gynecology,* 190, 1091-1097.

Werler, M., Louik, C., Shapiro, S. & Mitchell, A. A. (1996) Prepregnant Weight in Relation to Risk of Neural Tube Defects. *JAMA,* 275, 1089-1092.

Whitaker, R. C., Pepe, M. S., Wright, J. A., Seidel, K. D. & Dietz, W. H. (1998) Early Adiposity Rebound and the Risk of Adult Obesity. *Pediatrics,* 101, E5.

Whitaker, R. C., Wright, J. A., Pepe, S., Seidel, K. D. & Dietz, W. H. (1997) Predicting Obesity in Young Adulthood from Childhood and Parental Obesity. *New England Journal of Medicine,* 337, 869-73.

Wiles, R. (1994) I'm Not Fat, I'm Pregnant. In Wilkinson, S. & Kitzinger, C. (Eds.) *Women and Health: Feminist Perspectives.* London, Taylor & Francis.

Winkvist, A., Stenlund, H., Hakimi, M., Nurdiati, D. S. & Dibley, M. J. (2002) Weight-Gain Patterns from Prepregnancy until Delivery among Women in Central Java, Indonesia. *American Journal of Clinical Nutrition,* 75, 1072.

World Health Organisation (1998) Obesity; Preventing and Managing the Global Epidemic. .

Yekta, Z., Ayatollahi, H., Porali, R. & Farzin, A. (2006) The Effect of Pre-Pregnancy Body Mass Index and Gestational Weight Gain on Pregnancy Outcomes in Urban Care Settings in Urmia-Iran. *BMC Pregnancy & Childbirth,* 6, 15-23.

Zahorick, M. & Webber, V. (2000) Postpartum Body Image and Weight Loss. *New Beginnings,* 17, 156-159.

Appendices

Appendix p1 Peer Reviewed Journal Publication in the BJOG: An International Journal of Obstetrics and Gynaecology, 2007a

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General obstetrics

Obesity in pregnancy: a study of the impact of maternal obesity on NHS maternity services

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Objective To gain a detailed understanding of healthcare professionals' perceptions of the impact that caring for obese pregnant women has on maternity services.

Design Qualitative interview study using purposeful sampling and face-to-face interviews.

Setting Sixteen maternity units in NHS Trusts in the North East Government Office Region of England, UK.

Sample Thirty-three maternity and obstetric healthcare professionals with personal experience of managing the care of obese pregnant women.

Methods Semi-structured interviews with healthcare professionals representing each maternity unit in the region. Transcripts were analysed using systematic content analysis.

Main outcome measures Views on the impact maternal obesity has on maternity services, the facilities required to care for obese mothers in pregnancy, and existing services directed towards maternal obesity.

Results Five dominant themes relating to service delivery emerged; booking appointments, equipment, care requirements, complications and restrictions, and current and future management of care. Many of the issues identified were associated with managing the care of obese women in pregnancy safely, resources and cost issues to be able to do this, multidisciplinary care requirements because of coexisting morbidities when the mother is obese, and restricted care options and patient choice.

Conclusions Healthcare professionals in the North East of England feel that maternal obesity has a major impact on services and resource, on the health of both the mother and child, and on the psychological wellbeing of the mother.

Keywords Maternal, maternity, obesity, pregnancy, service.

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Introduction

The increasing prevalence of obesity in the UK general population is of major public health concern. The Health Survey for England[1] showed that the prevalence of obesity is increasing and that the North East region has consistently had a higher prevalence than the national average, making tackling obesity a public health priority in the North East.

International research has highlighted the fact that maternal obesity has implications for both the mother and her infant. There are increased risks to the mother throughout the pregnancy (including gestational diabetes, hypertensive disorders, and thromboembolic complications) and to the infant (including macrosomia, shoulder dystocia, late fetal death, and congenital abnormalities), and there are also increased complications during labour and also the need for more frequent induced and operative deliveries.[2,3] Limited UK research has shown that these reported health risks and complications are also relevant to the UK population,[4–6] and the 2004 triennial report by the Confidential Enquiries into Maternal and Child Health showed that 35% of all maternal deaths in 2000–2002 were in obese women (body mass index [BMI] $\geq$ 30 kg/m^2); 50% more than in the general population.[7]

In addition to the increased health risks associated with obesity in women who become pregnant, there is also a demand for additional care and resource from health service providers. However, there has been limited research addressing this factor as a measured outcome, internationally or in the UK. Two studies carried out in Montpellier, France,[8,9] addressed the cost implications of obesity in pregnancy and reported the prenatal care cost to be 5.4- to 16.2-fold higher in overweight and obese women with a BMI of 25 to <35 kg/m^2 compared with the prenatal care cost of normal weight women (BMI 18–24.9 kg/m^2). When both prenatal and post-natal care was considered, this cost was seen to rise further in women with a BMI $>$ 29 kg/m^2, as a result of an increased duration of day and night hospitalisation (an average of 4.43 days more than that for lean women). The percentage of infants requiring admission to neonatal intensive care was 3.5 times higher in mothers who were obese.[9]

One reason why the impact of maternal obesity on maternity services may not have been studied thoroughly in previous research could be the difficulty in quantifying many of these factors. Currently, there is no national information strategy relating to the collection of maternal obesity data in the UK; therefore, there is likely to be varied data collection practice between maternity units. Determining the impact of maternal obesity on service delivery and clinical practice using quantitative data may therefore misrepresent the true impact because of the reliance of routinely collected data within maternity units. The healthcare professionals who care for obese mothers and their infants were considered to be in the best position to holistically identify the impact of maternal obesity on service delivery and clinical practice; therefore, a qualitative methodology was used.

This study reports the perceived impact of maternal obesity on maternity services identified by healthcare professionals caring for obese women in pregnancy in the North East region of England.

Methods

An information pack outlining the aims of the study was sent to the heads of midwifery at each maternity unit. Clinical members of staff within all maternity units in the North East region of England were invited to take part in the study. This included midwives, consultant obstetricians, specialist registrars, dietitians, physiotherapists, specialist nurses, clinical ward and service managers, and community practitioners. Any members of staff who had a specific interest in maternal obesity and who were involved in aspects of care specific to obesity were invited to take part in the study as a priority. Interviews were conducted with at least one clinical member of staff either on a one-to-one basis, in small group discussions, or as part of a broader meeting within the department, depending on the request of the clinicians in the maternity units. Any members of staff who had an active interest in maternal obesity but who could not attend the interviews were encouraged to participate by emailing any relevant information or to pass on topics for discussion via a member of staff who would be in attendance.

The semi-structured interviews were carried out between March and October 2005. The interviews used low-structured questions encompassing broad subjects, which were used as prompts for discussion to allow clinical staff to elaborate on issues as required. All subjects for discussion were covered in each interview for consistency; however, the sequence in which the subjects were discussed varied and was dependent on the natural progression of conversations with the interviewees. The interview questions were piloted in one of the maternity units; the topics addressed are shown in Box 1.

The researchers made detailed notes during each interview, which were always transcribed the same day by N.H. to ensure the validity of the data collected. These were then emailed to the interview participants to confirm that they were accurately represented. Any necessary amendments were made and final copies of the transcripts were returned to the interviewees at each unit for their record. Where the interviews took place with more than one person, then two researchers were present (N.H. and R.L.) where possible. Both researchers checked the draft transcripts independently prior to them being sent to the participants for validation.

Interview transcripts were analysed using the recommendations made by Burnard[10] for systematic thematic content analysis of semi-structured interviews, which uses a category system and is adapted from the grounded theory approach. N.H. and R.L. developed category systems independently to enhance the validity of the findings and to remove the potential for researcher bias.

The two independently generated category systems were then compared, and following discussion, a final category system was produced which both researchers accepted as being representative of the data. A third independent researcher who was not familiar with the project (J.S.) was also asked to develop a category system. The final category system was then adjusted where necessary as a result of the third independent researcher's results to ensure that all themes were captured without bias.

Each transcript was coded using the final list of category headings against full statements. The coded transcripts were checked independently for any miscoded statements and continuity of data interpretation. The coded statements were then grouped into the broader categories, which identified the recurring themes. Copies of the full transcripts were retained

Box 1. Topics for discussion

Local service provision implications whether hospital or community based
Any additional care and cost implications to the service providers
Existing policies or guidelines within the units specific to maternal obesity
Any difficulties encountered in carrying out day-to-day care
Multidisciplinary services available
Patient information and advice provided to mothers who are obese

for the write up process to ensure that the key themes identified remained in context with the discussion of the findings.

A confirmatory focus group was carried out following the completion of the interviews to check that saturation of themes had occurred. This additional focus group included clinical representatives of specialties that were underrepresented in the initial interviews.

Results

All maternity units in the region invited to take part in the study responded (n = 16), and 33 healthcare professionals were recruited: 5 heads of midwifery, 11 clinical midwifery managers, 8 midwives, 5 consultant obstetricians, 1 physiotherapist, 1 dietitian, 1 obstetrics specialist registrar and 1 diabetes nurse specialist (see Table 1). The confirmatory focus group involved healthcare practitioners who did not take part in the initial interviews and included one dietitian, one paediatrician, one GP, and one head of midwifery.

Five recurrent themes relating to maternal obesity were identified from the interviews; booking appointments, equipment, care requirements, complications and restrictions, and current and future management of care.

Theme 1: booking appointments

All the maternity units (n = 16) stated that the location of the first antenatal visit when booking details were taken determined whether or not the maternal height and weight were directly measured or self-reported. The general consensus was that if the booking appointment took place in an NHS location then the weights and heights were usually measured if equipment was present, whereas home bookings tended to rely on self-reported weights and heights, as community midwives do not have portable equipment to take accurate measurements. This issue was re-established in the confirmatory focus group where it was emphasised that bariatric equipment was available within hospitals and GP practices; however, scales were not always available for home bookings.

> Weighed or self reported heights tend to be done ad hoc, there is a BMI reported for all women but whether it is measured depends on where the booking appointment takes place - the maternity unit has midwifery led care so many of the bookings are done at home. Home bookings are likely to be self reported unless the midwives utilise bathroom scales if they are available
>
> (Consultant obstetrician, maternity unit 12)

The location of the booking appointment was also considered to potentially influence responses from mothers to sensitive questions.

> If the booking appointment is in the home then there may be external influence due to other people being around at the time, whereas in a hospital booking there is more of an opportunity for one-to-one discussion and this may influence the data. For example if there is something that the mother doesn't want to say in front of others then often this is updated/addressed at follow up hospital appointments.
>
> (Clinical midwifery manager, maternity unit 6)

Theme 2: equipment

The issue of having appropriate equipment for obese mothers was consistently raised; this subject was saturated at a very early stage in the initial interviews and was also re-addressed in the confirmatory focus group. Specific problems related to the requirement and availability of equipment with a maximum expansion or weight load and to the equipment requirements in theatre for surgical deliveries. Theatre tables and

Table 1. Maternity unit staff interviewed

Maternity unit	Staff present
1–5 (within one NHS Trust)	Head of midwifery, consultant obstetrician (×2), ward managers, community services manager, midwife (×2), and women's services manager
6	Antenatal/postnatal services manager and community midwifery services manager
7	Midwife (×4), ward manager (×2), community team leader, administration manager, and deputy maternity services manager
8 and 9 (within one NHS Trust)	Head of midwifery
10	Consultant obstetrician, midwife, senior physiotherapist, diabetes nurse specialist, specialist registrar, and dietitian
11	Head of midwifery and consultant obstetrician
12	Consultant obstetrician
13 and 14 (within one NHS Trust)	Clinical services manager/head of midwifery and gynaecology
15	Head of midwifery and projects clerk
16	Midwife

scales were most frequently cited as examples of equipment that there were issues with.

> The theatre table can hold up to 27 stones. Occasionally the woman has had to have surgery on the general bed as opposed to the theatre bed, and there have been instances where this is not enough and the women have had to go to main theatre for surgery.
>
> (Midwife, maternity unit 16)

> Occasions where women have had to be sent to the medical ward to be weighed as the maternity scales have a maximum weight limit of 125 kg.
>
> (Consultant obstetrician, maternity unit 10)

Other examples of additional equipment requirements were given, most of which have significant financial implications per item such as delivery beds. However, costs associated with less-expensive equipment which is required routinely for obese women could have significant cumulative costs.

> Equipment mainly couches, chairs… Wheelchairs for excess of 300 kg are available in the hospital but not in maternity unit although if required can be obtained from elsewhere. Chairs in the waiting room in the maternity units are not changed yet but they are in the process. There are theatre tables that hold an excess of 300 kg but the units want a permanent one so they are not being moved around all the time. There are issues around the trolleys used to transport women to theatre - they take the weight but not the girth.
>
> (Head of midwifery, maternity unit 8)

> Also less expensive equipment (than the beds etc) is required that adds up the cost, such as longer length needles for spinal anaesthesia, the need to open additional equipment to hold fat back during caesarean section.
>
> (Head of midwifery, maternity unit 13)

Theme 3: care requirements

All maternity units ($n = 16$) have policies for routine referrals for consultant-led care when the mother is obese. Some maternity units also carry out precautionary anaesthetic assessments in case a caesarean delivery is required ($n = 12$). The need for this level of high-dependency care in relation to maternal obesity was based on the mothers' BMI in all maternity units, but the BMI cutoff point that determines routine referrals varied between maternity units, from BMI 30 to 50 kg/m^2. Six maternity units stated that they have had to change their policy for referring obese women for consultant-led care, they had previously referred women with a BMI > 30 kg/m^2, but as the caseload was too great, it was increased to BMI > 35 kg/m^2 ($n = 5$ units) and BMI > 40 kg/m^2 ($n = 1$ unit). The need to increase BMI cutoff points because of difficulties in meeting the demand for services was also discussed in the confirmatory focus group in relation to precautionary anaesthetic referrals.

All maternity units stated that obese mothers had individual care plans made when referred for consultant-led care. The individual care plans made at this time often determined the frequency of follow up, referrals to dietetics, and referrals to physiotherapy. Maternal coexisting morbidities were also described as determining the level of high-dependency care required. It was stated that there are generally more existing and developing morbidities when the mothers are obese and that this impacts on the antenatal care requirements.

A number of additional procedures were identified as being required in the care of obese women. Two maternity units stated that obese mothers required glucose tolerance tests at the start of pregnancy and towards the end of pregnancy. Additional scans were also deemed necessary for obese mothers by some maternity units ($n = 6$), as it was more difficult to see the fetus and to determine the fetal size and presentation. Some maternity units identified the risk of misdiagnosing conditions when the mothers are obese, such as high blood pressure owing to blood pressure cuffs being too tight or difficulty in determining fetal size, resulting in not diagnosing macrosomia or intrauterine growth restriction. These issues were all reiterated in the confirmatory focus group. Carrying out unnecessary procedures and the need to use alternative monitoring methods were identified as being additional care requirements for obese mothers ($n = 8$ units). These related to fetal scalp electrodes sometimes being used to get a direct electrocardiogram when it is difficult to hear the baby's heartbeat during delivery, the need for intrauterine pressure catheters to monitor contractions, and difficulty in determining the presentation, which has implication if it is not a normal vertex presentation.

> The excess layers of fat also make it more difficult to palpate to determine fetal lie when the mother is obese, and there are difficulties when doing ultrasound scans and listening to the fetal heart. During labour it is more difficult to pick up the contractions and fetal heart rate, and this can lead to misinterpretation of what is being picked up, which determines the outcome. For example the labour might be misinterpreted as being abnormal which could lead to an unnecessary change in the plan of action, caesarean etc.
>
> (Clinical midwifery manager, maternity unit 6)

> There isn't a way round monitors, because you can't always get a good pick up of the heart rate, and you have a co-existing problem because you might want to put a scalp electrode on but the internal passages have adipose tissue as well so it makes that more difficult
>
> (Head of midwifery, confirmatory focus group)

When discussing the service requirements relating to maternal obesity, the need for multidisciplinary care (MDC) was highlighted. The majority of existing MDC within maternity units relates to diabetes care, and many maternity units have joint clinics that are attended by a number of different clinical specialties required when caring for mothers with diabetes. Dietetic and physiotherapy support were also discussed as care requirements of obese mothers. Maternity-specific physiotherapists were available at some maternity units, whereas other units referred to the physiotherapy department as and when needed. Dietetic support in the maternity units also varied. All the maternity units had some form of dietetic service; however, the vast majority did not have a specific dietetic service relating to maternity (n = 14), in comparison with those units that did (n = 2).

A number of factors highlighted in the care requirements of obese mothers have an impact on maternity services' waiting lists and other departments' resources, such as loaning equipment and using theatre lists for elective and emergency surgery.

> The lack of an operating table large enough for elective caesareans means that these women are booked in on the gynae theatre list which disrupts the list and has implications on the waiting times for the women who need surgery for gynae problems, this happens approximately twice a month. The gynae theatre table is also required when an emergency caesarean is required which disrupts the theatre list and impacts on the waiting times as well.
>
> (Head of midwifery, maternity unit 14)

There is a need for additional staff in theatre and for consultant theatre staff rather than a registrar. There is more demand for one-to-one care, and the overall length of stay was deemed to be longer, which has an impact on both waiting lists and staff resource.

> Following surgery there are more complications with wound healing and wound infections, the length of stay is also increased, especially if pre-eclampsia develops, usually a five day stay with pre-eclampsia. There is additional cost of the medications required as well, and the medication for pre-eclampsia means that one-to-one care is required from the midwife as they are high dependency.
>
> (Midwife, maternity unit 16)

Theme 4: complications and restrictions

Many of the complications and restrictions addressed by the clinicians caring for obese women were significant throughout the entire pregnancy and included the antenatal period, labour, and postdelivery. The overall consensus was that obese women are more likely to develop co-morbidities throughout the antenatal period. Examples given were pressure sores, deep vein thromboses (DVT), symphysis pubis, incontinence, diabetes, and pre-eclampsia. Reduced mobility was highlighted as an added risk factor for DVT, but this also poses moving and handling issues for the staff. The need for increased pain relief was also identified as an effect of reduced mobility during labour; there was more difficulty in citing and administering analgesia, and failed administration leads to the need for general anaesthesia which is more of a risk when the mothers are obese. Other issues raised by staff related to difficulties in accessing body sites; the main issue for physiotherapy was difficult access to the joints, bones, and peritoneum for assessment and administering treatment.

> Overall the main issues in physiotherapy are access to joints, bone, and peritoneum, which causes difficulties in manipulating as you would like to.
>
> (Physiotherapist, maternity unit 10)

Nine maternity units highlighted reduced patient choice, with method of delivery being the main issue when the mothers were obese. There are restrictions for pool births, not because of the maximum weight restriction of the pool but the lifting and handling issues for staff and the potential for requiring emergency interventions such as an emergency caesarean delivery. Home births were addressed by two maternity units which stated that although obese mothers would be discouraged from having a home birth because of the high risk, they could not refuse them if that was the woman's choice. Reduced choice for midwifery-led care and limited choice for pain relief because of difficulties with citing epidurals were also discussed, and these factors were supported by the confirmatory focus group.

> There are restricted options for deliveries - mothers with a BMI over 30 or weighing more than 90 kg are not able to use the birthing pools due to the increased risk of shoulder dystocia and subsequent emergency and additional procedures being required, also the lifting and handling issues and physically being able to get the women out of the pool, for example in the case of collapse.
>
> (Clinical midwifery manager, maternity unit 7)

Postnatal complications and restrictions were also identified. Three units highlighted that increased support is required for breastfeeding, while most units (n = 11) stated that the main issue was a higher rate of infection and slower wound healing in obese women, which is not only uncomfortable for the mother but also requires additional drugs, dressings, and hospitalisation.

Patient dignity and embarrassment were raised by some of the clinicians. Two units stated that the psychological issues relating to maternal obesity often varied between the mothers. Some women tend to be embarrassed about their weight, whereas others do not see it as a problem during their pregnancy, and this point was raised in the confirmatory focus group with discussion around the normalisation of being overweight and obese making some women not to see it as an issue.

> One problem is non recognition of the fact that they are overweight, and that's quite often the younger end of the age group as their peers are the same.
>
> (Head of midwifery, confirmatory focus group)

Three units stated that they thought there was a general lack of awareness about the effects of being obese when pregnant, of the complications it causes, the restrictions to care, and of the potential effects on the outcome of pregnancy.

> It is embarrassing having to find extra large theatre P.J's for the fathers who are often obese when the mothers are obese as well, and how to word and approach the issues as a member of staff, how to handle the situation without making the mother feel uncomfortable - it's difficult to get a balance. Some women in the past have chosen to deliver elsewhere as this unit has tried to broach the subject and other unit has not – the women felt victimised… There is a lack of awareness of the mothers pre-conceptually and during pregnancy of the outcomes and complications when women are obese, unaware that the overall management is different due to the mothers weight… there is difficulty in getting scan pictures and not being able to see the baby due to fat mass - consequences for care providers but also the parents can't see anything on the picture.
>
> (Clinical midwifery manager, maternity unit 7)

Theme 5: current and future management of care

In most units, study participants thought patient information was an issue ($n = 14$). The NHS patient information booklet was the only form of dietary patient information in the majority of maternity units ($n = 11$). This booklet generally addresses healthy and safe eating rather than weight gain or specific dietary requirements related to BMI. With regard to information about diet and weight gain, some maternity units stated that the advice was likely to be inconsistent and *ad hoc* ($n = 7$), and of the maternity units that discussed weight gain recommendations in the context of policy ($n = 12$), none had a policy or guideline on recommended weight gain during pregnancy. Weight stability rather than weight gain was recommended in obese women in four units. Five maternity units mentioned that a new policy for maternal obesity/nutrition was under development.

> There are maternal nutrition guidelines being developed - previously combined maternal and infant nutrition guidelines but they are now being split. These only advise on healthy eating and "do's and don'ts" relating to soft cheese etc, they don't include weight gain recommendations but do include weight gain indications of what is normal weight gain.
>
> (Head of midwifery, maternity unit 8)

A number of factors were suggested on how to manage maternal obesity. Improved links with dietetics and weight management groups for pregnant mothers in the maternity units were suggested as measures to tackle obesity in pregnant women. Increased dietetic involvement was also discussed in the confirmatory focus group; however, there are resource issues that might make this difficult to achieve. Community interventions were also considered to be important, as it was viewed to be too late by the time mothers attend a maternity unit as they are already pregnant and weight loss could not be advised.

> There could be improved links with dietetics; it would be good to have weight attendance classes or something like that. [2 named midwives] are in the early stages of discussing the possibility of starting some healthy eating classes. Every midwife discusses the diet at booking and gives the woman appropriate dietary leaflets, it would be nice to perhaps have more time to go into more detail with certain things. Time at booking with the midwives is very limited as they only have 45mins - 1hr with each woman and there is a lot of information to get through.
>
> (Midwife, maternity unit 16)

> It's about patient education, making them aware of the risks to themselves and the baby
>
> (GP, confirmatory focus group)

> The referrals we get tend to come from the combined clinic, women with impaired glucose tolerance. I think it would be very valuable to do it [set up a referral service for women based on their BMI] because often you find they are more motivated when they're pregnant, and also to ensure you pick them up post delivery. With the impaired glucose tolerance ones we do but there are other women who may have equal weight problems but they are not referred through because they don't meet the criteria
>
> (Dietitian, confirmatory focus group)

> They [public health interventions] focus on obesity, the bit that's missing is 'do you realise your baby is at risk if you become pregnant?' that bit doesn't seem to be there. They can get that from the midwives when they come in but it doesn't seem to be out there beforehand, apart from those who maybe have a co morbidity and go to say the preconception clinics for diabetes
>
> (Head of midwifery, confirmatory focus group)

The question of where does the responsibility of maternal body weight during pregnancy lie was raised. This was considered to be a major factor for service delivery in one unit. Delivering a balance of information to the mothers was deemed important but recognised to be difficult.

> There needs to be a balance when making women aware of the issues: for example not being blunt and trying to be kind - but by doing this we're perhaps not giving enough information - difficult to get the balance.
>
> (Head of midwifery, maternity unit 13)

> Women do not like to be told they are overweight, when you are going through the risks to them and the baby they really don't want to take it on board that often but you have to because if you don't tell them what the risks are you then get problems later on and they come back and say they weren't told. But when we get them they're already pregnant and we

can't take the pregnancy away, so there has to be something done before they get to that stage to control the weight.

(Head of midwifery, confirmatory focus group)

Discussion

The healthcare practitioners interviewed described maternal obesity as having a major impact on service, specifically in relation to the level of care required, the cost and resource implications, complications and risk to the mother and infant, and existing or developing morbidities related to maternal weight. The psychological issues for the parents when obesity is a part of pregnancy are also deemed to be important. The lack of general awareness of the implications of maternal obesity for parents and the difficulty for staff in getting the balance of information across is something that needs to be addressed for future management of care.

Saturation of certain themes was obvious at an early stage in the study because of much repetition of the same issues throughout the interviews; this was most evident when discussing equipment requirements for the safe care of obese women in pregnancy, and the confirmatory focus group confirmed that saturation of themes had occurred. Despite this, the interviews continued to incorporate discussions around the same subject headings to allow all maternity units an opportunity to identify their issues. This was considered to be important to allow staff from clinical specialties underrepresented at early interviews to have an opportunity to discuss issues specifically related to them.

The regional nature of the study encompassed variations in population groups attending the maternity units in terms of socio-economic status, ethnic background, the maternity units being in a rural or urban setting, the size of the units and whether they were midwife or consultant led, which also could have potentially led to differences in issues raised. Despite using the same low-structured questions for discussion, early interviews may still have influenced later interviews in terms of the interviewers incorporating examples given by other maternity units in instances where clarification of questions was required; however, this was rare because of the low structure of the questions being open to various points for discussion.

Published international research supports a number of the themes identified. Studies relating to labour progression and interventions required particularly support the concerns of the regional healthcare professionals. The need for induction of labour and caesarean deliveries when the mother is obese or morbidly obese has been reported by numerous studies.[5,11–19] Vahratian *et al.*[20] discuss the need for more frequent administration of oxytocin to stimulate contractions during labour and a significant increase in emergency caesarean deliveries in the obese mother. Rode *et al.*[21] also address a significant increase in emergency caesarean delivery rates, as well as overall caesarean rates, and elective caesareans. Cedergren *et al.*[22] report an increase in both caesarean and instrumental deliveries in the moderately obese, severely obese, and morbidly obese mothers, whereas Weiss *et al.*[18] only found a significant association with instrumental deliveries when the mother was morbidly obese.

Other issues relating to maternal obesity that were identified in the interviews and that are supported by published evidence relate to a higher incidence of shoulder dystocia,[5,22] longer duration of labour,[20] postoperative maternal morbidities such as wound infections and urinary tract infections,[15,5] length of stay and frequency of contact/level of care required because of coexisting and developing co-morbidities,[15,8] and complications with the infant during delivery and neonatally such as fetal distress, birth trauma, and feeding difficulties.[5,19,16,22]

A number of issues raised in the interviews are not supported by published research; this may be because of the reliance of the majority of published studies on quantitative methodology and addressing specific biomedical impacts of maternal obesity, in particular relating to the outcome of pregnancy. To the authors' knowledge, no other published studies look at the impact of maternal obesity on service using qualitative methodology. This methodology has allowed for a richer data source than a quantitative study could obtain. This is most evident in discussions relating to the healthcare professionals' perceptions of managing maternal obesity and their view on the emotions that are related to this subject; in particular relating to the psychological impacts of maternal obesity and the difficulties faced by healthcare practitioners when caring for obese women in pregnancy. There is an absence of studies addressing the psychological impact of maternal obesity, which is an important issue, especially if maternal health is to be viewed not in biomedical terms of absence of disease but in the positive view of health as being a state of 'complete physical, mental and social wellbeing and not merely the absence of disease or infirmity'.[23]

The general feeling of not knowing how to handle the subject of obesity with the mothers or how to get a balance of information across without having a detrimental effect is something that requires further study. While the healthcare professionals understand the risks of being obese and pregnant, it was repeatedly stated that the mothers were unaware of the issues. With staff not knowing how to broach the subject and feeling blame for victimising the mothers when they do raise the issue, this then becomes a vicious circle, and the message does not get across to the mothers.

Some of the healthcare professionals discussed maternal obesity as a public health issue. However, they recognised that obesity-related initiatives in the public health arena tended to focus on associated morbidities and neglected family planning as an issue. Nankervis *et al.*[24] discuss how the attention on the health burden of obesity has focused on all-cause mortality and neglected the effects on the reproductive system and outcomes of pregnancy. They stated that solutions to the problem are inevitably going to be multifaceted and costly, but they suggest that as part of general public health effort to tackle obesity, pre-pregnancy counselling should be carried out for all women and every effort to intervene should be made in those women who are overweight or obese prior to the pregnancy being established. As the majority of women are highly motivated to have healthy babies, this could be very beneficial and a key factor in the success of public health interventions in this field.

Maternity unit staff also suggested some practical changes to practice that could potentially have a positive impact on the issue. The suggestion was made that improved links with dietetics could potentially help improve things. However, it was also stated that the majority of maternity units did not have maternity-specific dietitians, that there was an issue with the dietitians' waiting lists, and that some women refused referrals when they were offered. The suggestion of implementing weight management groups within the maternity unit was also raised. Although this will not help prevent maternal obesity in the first instance, it could potentially be a good way to help make sure that the mothers gain a healthy amount of weight during pregnancy and be the start of preconception counselling for any subsequent pregnancies. However, with an absence of national guidelines or published research in the UK relating to appropriate weight gain during pregnancy when obese, this could also potentially increase the level of inconsistent advice given to mothers.

While the analysis of the data in this study adhered to a stringent methodology to eliminate potential author bias and to ensure validity of the findings, there is a potential for bias to encroach into other aspects of this study.

The interviews were not tape recorded in an attempt to make the environment as natural as possible for the participants, especially with the potential for clinical hierarchy making some interviewees less confident about putting their views across. Steps taken to limit the potential for recall bias or misinterpretation of the data by the researcher were that the interviews were always transcribed the same day by a researcher present at the interview, and the second researcher (if more than one present at the interviews) also checked the interview transcripts for any inaccuracies, as did the interview participants. Changes to the transcripts were made in any instances when the interviewee thought that there were inaccuracies or misinterpretation of the discussions.

There is also some potential for participant bias, as the recruitment was carried out by an 'insider' at each maternity unit, leaving this open to be determined by established working relationships and potentially clinical hierarchy. The decision to use this methodology was to reduce the risk of carrying out the interviews with members of staff who are not in the best position to discuss the content of the study. The varied clinical specialties that attended the interviews suggest the recruitment was not biased, although there was a lack of interviews with dietitians, physiotherapists, GPs, and paediatricians. These underrepresented clinical specialties were included in the confirmatory focus group, with the exception of a physiotherapist where there was a lack of interest from this specialty. This lack of interest is not surprising considering the earlier interviews that highlighted an absence of physiotherapists who were specifically involved in maternity care. The inclusion of the additional specialties did not lead to the development of different key themes in relation to this study's focus of the impact of maternal obesity on NHS maternity services, confirming that saturation had occurred.

The confirmatory focus group did include discussions around additional themes that were not directly relevant to this study; however, these issues are considered to be important and warrant further investigation. In particular, issues were raised relating to the motivation to lose weight and change lifestyles. From a dietetic perspective, it was considered that women attending diabetes preconception clinics, or infertility clinics to lose weight to conceive, are more highly motivated than under circumstances where the only outcome is weight loss. The role of the media was also considered to be a motivational factor for some parents to take their children to see a dietitian, as was a member of the family developing diabetes or some other morbidity related to obesity. From a paediatric perspective, motivation was said to be difficult for the child as an individual unless the situation was addressed from a family perspective, as children do not tend to think of the long-term risks of being overweight; however, it was considered that children who were being bullied tended to be more motivated to lose weight.

Conclusions

Healthcare professionals caring for women in pregnancy feel that maternal obesity has major implications for service delivery. The impact relates to resources and cost implications, additional care requirements because of the complications that arise and the impact on the health of the mother and her infant, the restrictions in care options for the women, difficulties in carrying out certain procedures, and the impact on the psychological health of the mother. Some healthcare professionals feel that maternal obesity is a public health issue, and there is concern relating to the lack of national guidance on which to base local policy for the care of obese women in pregnancy.

Some of the issues raised in this study warrant further research. The nonquantifiable outcomes of patient dignity, the psychological health of the mother, and the difficulties encountered by some healthcare professionals in addressing issues with obese pregnant women have not been addressed by previous published studies, yet are highly important issues. Future research into the quantifiable factors relating to service delivery should also account for the cost to the NHS, as this is also an unexplored topic in the UK.

Ethics

Public health observatories (PHOs) were set up in 2000 and are funded by the Department of Health. There are nine PHOs in England. They have a remit to make better use of routinely available information and to identify gaps in information that need to be filled. PHOs are authorised to hold confidential data on hospital activity by the Department of Health's Security and Confidentiality Advisory Group. In the North East, the handling of confidential data is overseen by a Caldicott Guardian.

This investigation was carried out by the Regional Maternity Survey's Office (RMSO), which is formally a part of the PHO as part of its continuing work to improve the routine information collected in relation to pregnancy and infant health. The work of the RMSO is overseen by the Region's Multicentre Research Ethics Committee. This piece of work was therefore carried out as part of the routine work of the PHO and the RMSO. All confidential data were handled in the confines of the PHO 'safe haven'. In addition, the University of Teesside's ethics committee also approved the work.

Contribution to authorship

All authors contributed to the design of the study. N.H. and R.L. carried out the data collection and analysis. N.H., R.L., J.R., J.W., and C.S. contributed to manuscript writing.

Duplicate publications

The results from this piece of research have not been published elsewhere in a peer-reviewed journal.

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References

1 Department of Health. *Health Survey for England 2003*. London: HMSO, 2003.
2 Andreasen KR, Andersen ML, Schantz AL. Obesity and pregnancy. *Acta Obstet Gynecol Scand* 2004;83:1022–9.
3 Morin KH. Perinatal outcomes of obese women: a review of the literature. *J Obstet Gynecol Neonatal Nurs* 1998;27:431–40.
4 Kiran TSU, Hemmadi S, Bethal J, Evans J. Outcome of pregnancy in a woman with an increased body mass index. *BJOG* 2005;112:768–72.
5 Lashen H, Fear K, Sturdee DW. Obesity is associated with increased risk of first trimester and recurrent miscarriage: matched case-control study. *Hum Reprod* 2004;19:1644–6.
6 Sebire NJ, Jolly M, Harris JP, Wadsworth J, Joffe M, Beard RW, *et al.* Maternal obesity and pregnancy outcome: a study of 287,213 pregnancies in London. *Int J Obes Relat Metab Disord* 2001;25:1175–82.
7 Confidential Enquiry into Maternal and Child Health. *Why Mothers Die 2000–2002*. London: RCOG, 2004.
8 Galtier-Dereure F, Boegner C, Bringer J. Weight excess before pregnancy: complications and cost. *Int J Obes Relat Metab Disord* 1995;19:443–8.
9 Galtier-Dereure F, Boegner C, Bringer J. Obesity and pregnancy: complications and cost. *Am J Clin Nutr* 2000;71(5 Suppl):1242S–8S.
10 Burnard P. A method of analysing interview transcripts in qualitative research. *Nurse Educ Today* 1991;11:461–46.
11 Kaiser PS, Kirby RS. Obesity as a risk factor for cesarean in a low-risk population. *Obstet Gynecol* 2001;97:39–43.
12 Jensen DM, Damm P, Sorensen B, Molsted-Pedersen L, Westergaard JG, Ovesen P, *et al.* Pregnancy outcome and prepregnancy body mass index in 2459 glucose-tolerant Danish women. *Am J Obstet Gynecol* 2003;189:239–44.
13 Hendler I, Goldenberg RL, Mercer BM, Iams JD, Meis PJ, Moawad AH, *et al.* The Preterm Prediction Study: association between maternal body mass index and spontaneous and indicated preterm birth. *Am J Obstet Gynecol* 2005;192:882–6.
14 Ehrenberg HM, Durnwald CP, Catalano P, Mercer BM. The influence of obesity and diabetes on the risk of cesarean delivery. *Am J Obstet Gynecol* 2004;191:969–74.
15 Lumme R, Rantakallio P, Hartikainen AL, Jarvelin MR. Pre-pregnancy weight and it's relation to pregnancy outcome. *Obstet Gynecol* 1995;15:69–75.
16 Rosenberg TJ, Garbers S, Chavkin W, Chiasson MA. Prepregnancy weight and adverse perinatal outcomes in an ethnically diverse population. *Obstet Gynecol* 2003;102:1022–7.
17 Crane SS, Wojtowycz MA, Dye TD, Aubry RH, Artal R. Association between pre-pregnancy obesity and the risk of caesarean delivery. *Obstet Gynecol* 1997;89:213–16.
18 Weiss JL, Malone FD, Emig D, Ball RH, Nyberg DA, Comstock CH, *et al.* Obesity, obstetric complications and cesarean delivery rate – a population-based screening study. *Am J Obstet Gynecol* 2004;190:1091–7.
19 Kumari AS. Pregnancy outcome in women with morbid obesity. *Int J Gynecol Obstet* 2001;73:101–7.
20 Vahratian A, Zhang J, Troendle JF, Savitz DA, Siega-Riz AM. Maternal prepregnancy overweight and obesity and the pattern of labor progression in term nulliparous women. *Obstet Gynecol* 2004;104:943–51.
21 Rode L, Nilas L, Wojdemann K, Tabor A. Obesity-related complications in Danish single cephalic term pregnancies. *Obstet Gynecol* 2005;105:537–42.
22 Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. *Obstet Gynecol* 2004;103:219–24.
23 Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19–22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948.
24 Nankervis AJ, Conn JJ, Knight RL. Obesity and reproductive health. *Med J Aust* 2006;184:51.

Appendix p2 NEPHO Occasional Paper

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Maternal Obesity and Pregnancy Outcome: A Scoping Study

Introduction

Maternal obesity in the region has been raised in a number of discussions as an increasingly important issue for the maternity services in the North East. International research has highlighted the fact that maternal obesity is associated with increased complications throughout pregnancy, and increased health risks to the mother and her infant[1,2]. The 2004 Confidential Enquiry into Maternal and Child Health (CEMACH) reported that 35% of all maternal deaths in 2000-2002 were in obese women (BMI ≥ 30 kg/m^2)[3].

In light of the association between maternal obesity and health risks, the extent of the problem within the North East population needs to be established for effective service planning. However there is an absence of national, regional, or local statistics on the incidence of maternal obesity, therefore the scale of the problem needs to be determined in order to plan, monitor, and budget for service delivery. In addition to the increased health risks when obese women become pregnant, there is also a demand for additional care and resource from service providers, however there has been limited research addressing this aspect as a measured outcome. Due to the absence of reliable evidence relating to the impact on care and resource requirements, the local effects of maternal obesity on service delivery needs to be established.

This paper summarises information gained from interviews carried out with all the maternity units in the North East Government Office Region relating to:

- Methods of data collection for data items relating to maternal obesity, to assess all related pregnancy outcomes to the mother, her infant, and service providers;
- The extent of usage of electronic data capture which would then allow more straightforward manipulation of data; and
- Clinical aspects of maternal obesity in order to identify the impact on service provision, and existing services directed towards maternal obesity.

Contents

Summary of Findings

- Data collection systems allowing us to gain understanding of maternal obesity vary across the region, with data currently being collected, collated and stored in different ways.
- There are consistent concerns from staff relating to maternal obesity throughout the region, which cover the whole spectrum of care in pregnancy.
- There is a lack of consistency in services in the region for obese women in pregnancy.
- There is a lack of evidence on which to base clinical policy.
- Health care professionals in the region consider maternal obesity has a major impact on practice
- Health care professionals find communicating appropriate health advice to obese pregnant women difficult.

Background

The increasing prevalence of obesity in the UK general population is of major public health concern. A Health Select Committee report, published in 2004, shows that the prevalence of obesity has grown by almost 400% in the last 25 years, and states that obesity will soon surpass smoking as the greatest cause of premature loss of life[4]. The prevalence of obesity is associated with health inequality, including socio-economic status and ethnicity[4 page 18]. The Health Survey for England (HSE) reports regional variations in prevalence of obesity; the North East has the highest regional prevalence, with the County Durham and Tees Valley Strategic Health Authority (SHA) having the highest prevalence in the country[5]. The HSE report also shows that the prevalence of obesity is increasing, making tackling obesity a public health priority in the North East.

The Regional Maternity Survey Office (RMSO) houses seven surveys of fetal and perinatal health. Maternal body mass index (BMI) has recently been included in these surveys. Although these surveys demonstrate the relationship between maternal obesity and specific adverse outcomes, they do not extend to all pregnancies in the region. Therefore overall incidence rates, trends, and any pregnancy outcomes that are not included in the datasets routinely collected by the RMSO, are unavailable.

Despite the absence of reliable maternal obesity incidence data in the UK, the HSE[6] shows that the prevalence of obesity in women of childbearing age in the UK is increasing. The Confidential Enquiry into Maternal And Child Health (CEMACH) reports that between 1993 and 2002 the proportion of women classed as obese rose the most in women aged 25–34 years; a rise of 10%[3 Chapter 21]. These factors, along with anecdotal reports by maternity service providers of an increase in maternal obesity at the start of pregnancy, highlight concerns about the effect on the health of the mothers, their infants, and the ability of service providers to cope with the potential additional care and resource requirements.

The latest CEMACH report recommends that the care of women who have a BMI ≥35kg/m^2 should be "shared with an obstetrician and [the mother] advised to deliver in a consultant led obstetric unit" as they are at a higher risk of developing problems[3 page 8]. The National Institute for Health and Clinical Excellence (NICE) supports this recommendation in their Guidelines for Antenatal Care[7] which state that women with a BMI ≥35kg/m^2 are likely to need additional care outside the routine guidelines. However national guidance specific to the needs of obese mothers' antenatal care is not currently available.

International research highlights an association between increased incidence of maternal obesity and low socio-economic status[8-15]. This therefore would suggest the incidence of maternal obesity would be high in the North East region, especially within the County Durham and Tees Valley SHA.

Currently there is no national information strategy relating to the collection of data pertinent to maternal obesity, therefore determining the incidence, trends, and local service implications becomes problematic. As maternity units are not required to collect a generic dataset, there is likely to be wide variation in practice with regard to the collection and recording of maternal weight and height. Therefore it was decided that the first stage of determining any of the local/regional factors must involve a scoping study to assess both the level of relevant data currently routinely collected in the regional maternity units and how accessible these data are in order to be able to carry out complete regional analysis of maternal obesity and its effects in the future.

Methods

The scoping study aimed to determine the extent of data collection, available electronic sources of data, and clinical issues relating to maternal obesity in the North East. All the maternity units in the North East Government Office Region (EU NUTS I) catchment area were included. The Friarage Hospital Northallerton is not in the North East Government Office Region but is under managerial control of South Tees NHS Trust, and has therefore been included in all parts of this study. Also, the RMSO includes part of Cumbria in its catchment area for data collection; therefore these maternity units were also contacted in relation to the current, routine data collection aspect of the study.

The maternity units involved in the study were:

- Alnwick Infirmary
- Berwick Infirmary
- Bishop Auckland General Hospital
- Cumberland Infirmary
- Darlington Memorial Hospital
- Friarage Hospital Northallerton
- Hexham General Hospital
- James Cook University Hospital
- North Tyneside General Hospital
- Queen Elizabeth Hospital
- South Tyneside District Hospital
- Sunderland Royal Hospital
- The Royal Victoria Infirmary
- University Hospital of Hartlepool
- University Hospital of North Durham
- University Hospital of North Tees
- Wansbeck Hospital
- West Cumberland Hospital

The scoping study was carried out between March 2005 and February 2006, using a questionnaire at each NHS Trust. The questionnaire was split into three sections to cover current routine data collection practice, electronic sources of data, and clinical issues relating to maternal obesity.

Current Routine Data Collection in Maternity Units

The first section of the questionnaire looked at specific data items in the antenatal, intrapartum and postpartum period, including:

- Demographic details
- Parental height and weight data
- Maternal morbidity and mortality
- Complications and maternity unit contact
- Maternal drug use
- Delivery data
- Infant details

Electronic Sources of Data

The second section of the questionnaire addressed electronic sources of data, and encompassed aspects of the upkeep of maternity databases (e.g., timeliness, accuracy, validity). For those units without a maternity database the questionnaire covered future plans for implementation of electronic data capture.

Clinic Issues

The final stage involved face-to-face interviews with at least one health care professional at each NHS Trust. A semi-structured questionnaire, with open-ended questions and broad subject headings was used, in order to allow the clinical staff caring for women during pregnancy to identify the clinical issues within their maternity unit(s). The broad subject headings included:

- Local service provision implications whether hospital or community based
- Any additional care and cost implications to the service providers
- Existing policies or guidelines within the units specific to maternal obesity
- Any difficulties encountered in carrying out day to day care
- Availability of multidisciplinary services for obese mothers
- Patient information and advice provided to mothers who are obese
- Healthcare professionals' roles in dealing with maternal obesity.

Results

Current Routine Data Collection in Maternity Units

Eighteen maternity units were invited to participate in the study. One maternity unit did not respond to the invitation to take part in the study, therefore seventeen maternity units were involved in the study. The maternity units covered by the study vary considerably in size from between 23 and 4,913 deliveries each year[16].

KEY
E = Electronic Data Collection
P = Proforma Data Collection (in case notes)
C = Case Notes Only
X = Data Not Routinely Collected

Table 1: Demographics

	Number of Maternity Units Routinely Collecting Data			
Data Item	**E**	**P**	**C**	**X**
Maternal Age	6	11	0	0
Ethnic Origin	6	11	0	0
Postcode	6	11	0	0
Previous Pregnancies	6	11	0	0
Employment	5	11	0	1
Marital status / single parent	6	11	0	0

Most demographic details are collected by all maternity units, with the exception of one unit that does not record any details on the employment status of the mother. This particular maternity unit however does record the employment details of the father if this is known. The demographic details have been recorded electronically in the maternity units with the facility to do so since 2003, with the oldest electronic records dating back to 1989 in one maternity unit, and paper based records dating back to 1975 in four maternity units.

Table 2: Height and Weight Data

	Number of Maternity Units Routinely Collecting Data			
Data Item	**E**	**P**	**C**	**X**
Height	6	11	0	0
Pre pregnancy Weight	2	0	0	15
Weight at 1st Booking appointment	6	11	0	0
Stage of pregnancy at 1st weighing	5	11	1	0
Date of Booking appointment	6	11	0	0
Full term weight / weight gain	0	0	6	11
Waist:Hip Ratio	0	0	0	17
Post pregnancy weight	0	0	0	17
Weight followed up after discharge?	0	0	5	12
BMI	6	11	0	0
Height of Father	0	0	0	17
Weight of Father	0	0	0	17

All maternity units record maternal height, weight, the stage of pregnancy at 1st booking appointment, the date of booking appointment, and maternal BMI in some format. All maternity units record the weight of the mother at the first booking appointment and it is this weight in all cases that is used to calculate the maternal BMI. One maternity unit that records the BMI data electronically has only been calculating BMI since 2004, however the maternal height and weight in that maternity unit has been recorded since 1989.

The maternal weight gain at term (or weight gain at 36 weeks) is recorded by six of the units, but none do so electronically. Five maternity units record the weight of the mother at 16 weeks postnatally if their follow up appointment is in the unit, but this is not recorded electronically. Other than this, there is no record of maternal weight following delivery in any of the maternity units.

Table 3: Maternal Morbidity and Mortality

	Number of Maternity Units Routinely Collecting Data			
Data Item	**E**	**P**	**C**	**X**
Maternal pre-pregnancy morbidity	5	7	5	0
Diabetes	5	6	6	0
Hypertension	5	7	5	0
Thromboembolic complications: DVT, Pulmonary embolism, Thrombophlebitis	5	5	7	0
Other (e.g. endocrine disorders/thyroid dysfunction etc)	5	6	6	0
Maternal pregnancy related morbidity	5	8	4	0
OGTT results / IGT / Gestational Diabetes	4	6	7	0
Blood Pressure/ Hypertensive disorders: PIH, pre/eclampsia, HELLP	5	10	2	0
UTI	4	10	3	0
Thromboembolic complications: DVT, Pulmonary embolism, Thrombophlebitis	4	3	10	0
Other (e.g. antenatal haemorrhage, anaemia etc)	5	8	4	0
Maternal mortality	6	1	10	0

All maternity units record all maternal morbidity and maternal mortality in some format. Four out of the six maternity units with a database record full datasets electronically on pre-existing morbidity, pregnancy related morbidity, and maternal mortality. Of the two units that do not record the full datasets, one records all pre-existing morbidity, selected pregnancy related morbidities, and maternal death electronically, with any additional details recorded in case notes where necessary.

Table 4: Postpartum and Postnatal Complications, and Maternity Unit Contact

	Number of Maternity Units Routinely Collecting Data			
Data Item	**E**	**P**	**C**	**X**
Endometrial / Wound Infection	6	6	5	0
Open wounds	6	6	5	0
Postpartum haemorrhage	6	6	5	0
Puerperal Pyrexia	5	5	6	1
Other complications prior to discharge	6	5	6	0
Inpatient contact during pregnancy	6	1	9	1
Outpatient contact during pregnancy	4	1	11	1
Referral to dietitian	1	1	11	4

All maternity units record complications prior to discharge with the exception of one unit that does not collect data on puerperal pyrexia. All inpatient and outpatient contact throughout the pregnancy is recorded by all units with the exception of one, and four do not record referrals to dietitians. The electronic data relating to complications and inpatient contact could be merged from 2003, however only four maternity units with a database record outpatient contact electronically.

Table 5: Drug Use

	Number of Maternity Units Routinely Collecting Data			
Data Item	**E**	**P**	**C**	**X**
Folate/Folic acid intake	5	4	6	2
Smoking History	7	10	0	0
Never Smoked	7	10	0	0
Ex Smoker (Prior to Pregnancy)	6	10	0	1
Ex Smoker (During Pregnancy)	6	9	0	2
Stage of pregnancy stopped smoking	5	7	2	3
Smoker During Pregnancy	7	10	0	0
Number cigarettes smoked	7	10	0	0
Alcohol Intake	6	11	0	0
Never drinks alcohol	5	11	1	0
Light use prior to pregnancy	3	2	10	2
Heavy use prior to pregnancy	3	2	10	2
No alcohol during pregnancy	3	1	10	3
Light use during pregnancy	4	1	10	2
Heavy use during pregnancy	4	1	10	2
Units recorded Yes / No	5	6	1	5
Illicit Drug Use	5	11	1	0
Never used drugs	4	11	1	1
Drug user prior to pregnancy	4	1	11	1
Drug user during pregnancy	5	1	11	0

All maternity units record some data on smoking, alcohol consumption, and illicit drug use. There are key mandatory data items to be collected during pregnancy relating to smoking. The HSCIC [17] outlines these data items as being:

1. Did the patient smoke at all in the 12 months before the start of her pregnancy? *(Yes / No/ Don't Know)*
2. Does / did the patient smoke at the time of booking? *(Yes / No / Don't Know)*
3. Does / did the patient smoke at the time of delivery? *(Yes / No / Don't Know)*

Of the maternity units with a database, all data that is routinely collected by maternity units is recorded electronically (n=6), with the exception of one maternity unit which has the facility to record all the data, but only records the smoking data, and limited alcohol data electronically. One unit without a maternity unit database for routine data collection purposes does record the smoking data in an electronic format.

Table 6: Delivery Data

	Number of Maternity Units Routinely Collecting Data			
Data Item	**E**	**P**	**C**	**X**
Date of Delivery	6	11	0	0
Length/Start and End Time of Delivery	6	11	0	0
Blood Loss	6	11	0	0
Method of delivery	6	6	5	0
Emergency / Elective Caesarean	6	1	10	0
Induction / Augmentation / Failed induction	6	8	3	0
Ventouse	6	1	10	0
Forceps	6	1	10	0
Spontaneous Vertex	6	6	5	0
Consultant/Midwife Led Delivery	6	11	0	0
Single/ Multiple birth	6	10	1	0
Apgar score	6	10	0	1
Complications Intrapartum	6	11	0	0
Cephalopelvic disproportion / Shoulder dystocia	6	2	9	0
Fetal distress / Infant birth trauma	6	1	10	0
Other Complications Intrapartum	6	1	10	0
Live / Still birth	6	8	3	0
Total Length of Stay	6	6	5	0

All maternity units record the delivery data items, with the exception of one maternity unit that does not record the Apgar score, and one unit that does not record 'instrumental delivery', but does record some specific instrumental deliveries such as forceps. All maternity units with the facility to record this data electronically do so (n=6), and this can be collated for all units from 2003, with the oldest records dating from 1989.

Table 7: Infant Details

	Number of Maternity Units Routinely Collecting Data			
Data Item	**E**	**P**	**C**	**X**
Birth weight	6	11	0	0
Gestational age	6	7	4	0
Infant Gender	6	11	0	0
Infant length	4	4	0	9
Skinfold thickness	0	0	0	17
Weight followed up	2	4	1	10
Feeding method	7	10	0	0
Infant morbidity	6	4	7	0
Congenital Abnormalities	6	8	3	0
Other Infant morbidity	6	2	9	0
Admission to neonatal ICU	6	5	6	0
Length of stay on ICU	6	1	10	0
Infant mortality	6	5	6	0

All maternity units record data on infant birth weight, gestational age, infant gender, feeding method, infant morbidities, admission to neonatal intensive care unit (NICU) or equivalent, length of stay on the unit, and infant mortality. Where the facility is available all maternity units record these details electronically, and this could be collated from 2003 with the oldest electronic records dating from 1989. Seven maternity units record the infant weight which is followed up for varying lengths of time, the longest being for 28 days following discharge. Only two units record this information electronically. None of the maternity units follow the infants' weight into childhood – but infant weight is followed up as part of the routine child health surveillance programmes. Although the infants' weight is routinely measured following discharge by health visitors, this data is not available from the maternity unit databases or hospital notes, as this information is kept in community patient records).

Electronic Sources of Data

There is a national strategy to implement electronic patient records (EPR) for maternity services by 2008. Out of the seventeen units included in the interviews, six currently have EPR's whereas eleven do not. Four maternity units with no current EPR are in the process of implementing an electronic system for data collection, however this was not finalised at the time of the interview. The remaining seven maternity units that do not have any immediate plans to implement EPR's are waiting for the implementation of the national strategy before procuring any software.

In the six units where a database is in place, different people in different maternity units enter the data onto the databases: in five units data entry clerks usually enter the booking data, whereas midwives usually enter the antenatal and delivery data. A clinical member of staff does all the data entry in the remaining maternity unit, as the data is considered to be clinical in nature, and patient care can be based on the data entered. It is usually the midwives who take responsibility for this.

The validation methods utilised by the maternity units for the electronic data are varied, and employ both formal and informal methods of audit. Specific validation exercises in four maternity units include: a monthly audit that looks at data integrity, data extraction at 6-8 weeks following discharge and population of missing data from hand held notes, and a checklist of mandatory data to be collected at booking and missing data collected at the initial scan appointment. Three maternity units use ad hoc reports as a mechanism to check for missing data, and another uses the production of monthly statistics in a similar way.

Clinical Issues

The semi-structured interviews were carried out at the NHS Trusts in the North East Government Office region[‡]. The information from the clinical interviews was analysed using the recommendations made by Burnard[18] for systematic, thematic, content analysis of semi-structured interviews. Five recurrent general themes relating to maternal obesity were identified:

1. Booking appointments
2. Equipment
3. Care requirements
4. Complications and restrictions
5. Current and future management of care

Theme 1: Booking Appointments

The location of the booking appointment was identified as an issue by the clinical staff interviewed at all maternity units. All maternity units (n=16) stated that the location of the booking appointment determined whether or not the maternal height and weight were directly measured or self reported.

> *"Most community bookings are carried out in GP surgeries where equipment is available for weighing and measuring the women and therefore this should be an accurate record. Home bookings are not carried out as often but it is likely that the recorded height and weight are self reported in these circumstances as the community midwives do not have portable equipment to measure and weigh the mothers."*

(Maternity unit 7)

> *"All hospital bookings are measured and weighed in house and the results recorded within the hand held notes. Back-up notes are also held within the hospital. At home bookings use self reported weights and heights, but these are amended by actual measurements taken on first hospital visit."*

(Maternity unit 1)

The location of the booking appointment was also deemed to potentially influence the information obtained from the mother at the time of booking.

> *"If the booking appointment is in the home then there may be external influence due to other people being around at the time, whereas in a hospital booking there is more of an opportunity for one-to-one discussion and this may influence the data. For example if there is something that the mother doesn't want to say in front of others then often this is updated/addressed at follow up hospital appointments."*

(Maternity unit 6)

Theme 2: Equipment Issues

There were numerous issues identified with equipment available for managing the care of obese mothers, however they mainly related to availability of equipment required when mothers are obese, and the need for additional equipment to be used in the management of care.

> *"Equipment mainly couches, chairs… Wheelchairs for excess of 300kg are available in the hospital but not in maternity unit although if required can be obtained from elsewhere. Chairs in the waiting room in the maternity unit are not changed yet but they are in the*

‡ This section did not include the additional RMSO catchment area of Cumbria, but did include the Friarage Hospital as this is under South Tees NHS Trust managerial control, which is part of the region.

process. There are theatre tables that hold an excess of 300kg but the unit wants a permanent one so they are not being moved around all the time. There are issues around the trolleys used to transport women to theatre - they take the weight but not the girth."

(Maternity unit 8)

"Home bookings [weights] *are likely to be self reported unless the midwives utilise bathroom scales if they are available, but they do not have scales to measure the weights at home bookings, only scales to weigh the babies."*

(Maternity unit 12)

"Also less expensive equipment (than the beds etc) is required that adds up the cost, such as longer length needles for spinal anaesthesia, the need to open additional equipment to hold fat back during caesarean section."

(Maternity unit 13)

Theme 3: Care Requirements

The need for high dependency care in relation to maternal obesity was based on the maternal BMI in all maternity units. However, the minimum BMI cut off point that determines routine high dependency care in the region varied between maternity units and included BMI>30 kg/m^2, BMI>35 kg/m^2, BMI>40 kg/m^2, and BMI>50 kg/m^2 for routine referrals for consultant led care, thrombosis assessments, and anaesthetic assessments. Six maternity units also stated that they have had to change their policy for referring obese women for consultant led care due to workload.

"Frequency of contact depends on the individual. If the BMI is more than 40 then the mother is referred to consultant led clinic and for an anaesthetic appointment. This used to be BMI over 30 until the end of 2004 but due to the vast number of cases this was changed to BMI over 40 as the unit could not cope with the number of patients being referred."

(Maternity unit 11)

Maternal co-existing morbidities were also described as determining the level of high dependency care. It was stated that there are generally more existing and developing morbidities when the mothers are obese, and that this impacts on the antenatal care requirements (diabetes and high blood pressure/hypertension were given as examples). There were also issues relating to additional procedures being required to be able to monitor and manage the patient care, and the potential for misinterpretation of the situation due to inadequate monitoring, resulting in an unnecessary change in the management of care.

"The excess layers of fat also make it more difficult to palpate to determine fetal lie when the mother is obese, and there are difficulties when doing ultrasound scans and listening to the fetal heart. During labour it is more difficult to pick up the contractions and fetal heart rate, and this can lead to misinterpretation of what is being picked up, which determines the outcome. For example the labour might be misinterpreted as being abnormal which could lead to an unnecessary change in the plan of action, caesarean etc."

(Maternity unit 6)

The required resource for routine care is considered to be increased when mothers are obese; additional drugs and dressings were often required due to problems with wound healing, additional staff required due to the need for increased multidisciplinary care including diabetes, physiotherapy, and dietetics, more need for 1:1 care due to medications that are often required in obese patients, referrals between maternity units to access resources required, and utilising other hospital departments' resource and waiting lists due to inadequate equipment being available within maternity units.

"Following surgery there are more complications with wound healing and wound infections, the length of stay is also increased, especially if pre-eclampsia develops, usually a 5 day stay

with pre-eclampsia. There is additional cost of medications required as well, and the medication for pre-eclampsia means that 1:1 care is required from the midwife as they are high dependency"

(Maternity unit 16)

"There are additional staff costs such as the cost of consultant care and anaesthetic time, the need for a consultant anaesthesiologist during theatre whereas if the BMI was lower then a registrar could be used, additional staff required in theatre for example to hold the fat away while operating."

(Maternity unit 14)

"The lack of an operating table large enough for elective caesareans means that these women are booked in on the gynae theatre list which disrupts the list and has implications on the waiting times for the women who need surgery for gynae problems, this happens approximately twice a month. The gynae theatre table is also needed when an emergency caesarean is required which disrupts the theatre list and impacts on the waiting times as well."

(Maternity unit 14)

"In the past we have had to refer very large ladies to [a different maternity unit named] *as equipment was not available to handle the patients safely."*

(Maternity unit 4)

Theme 4: Complications and Restrictions

Many of the complications and restrictions addressed by the health care professionals were significant throughout the entire pregnancy, and included the antenatal, intrapartum, and postpartum periods. Developing morbidities throughout the course of pregnancy was identified as the main cause of complications. Reduced mobility adds to the risk factors, but also requires more frequent administering of pain relief, and causes lifting and handling issues for the staff. Siting and administering pain relief and analgesia is also considered to be more problematic due to the fat mass, which makes access to body sites to carry out treatment more difficult.

"There are increased complications that affect the care of the obese mothers - DVT prophylaxis is more likely, anaesthetic risks are greater, there is an increase in instrumental and theatre deliveries, there is more difficulty in administering spinal anaesthesia. Also the more obese the mother is the increased mobility is required to reduce the risk of DVT etc, but the more obese women tend to have less mobility."

(Maternity unit 7)

All of these factors mean that the mothers' choices for care options are restricted; there are restrictions to pool births and other alternative birthing methods, and home births are also discouraged.

"There are restricted options for deliveries - mothers with a BMI over 30 or weighing more than 90kg are not able to use the birthing pools due to the increased risk of shoulder dystocia and subsequent emergency/additional procedures being required, also the lifting and handling issues and physically being able to get the women out of the pool, for example in the case of collapse."

(Maternity unit 7)

There were complications and emergency interventions during labour and delivery highlighted as being necessary when mothers were obese.

Complications and Emergency Interventions Required	Number of maternity units that raised the issue
Difficulty in monitoring the pregnancy and labour:	16
Problems with monitoring contractions	5
Fetal presentation	7
Fetal heartbeat	10
Unsatisfactory scans	7
Labour progression requiring emergency interventions	6
Increased risk of anaesthesia in obese mothers	4
Complications of shoulder dystocia and Fetal distress	2
Vaginal assessments & cephalo-pelvic disproportion	3

The problems with labour progression and emergency interventions being carried out were closely related to the difficulties in monitoring throughout the pregnancy and labour.

> *"It is generally more difficult to monitor the pregnancy and labour. The scans can't always pick up what they're meant to. Measuring using a tape is inaccurate as well due to maternal adipose and performing abdominal examinations can be difficult due to this, often babies are IUGR* [Intra uterine Growth Retarded] *and can be missed as unable to measure accurately, or often the presentation can be misdiagnosed. In labour, overweight women often have to have intra uterine pressure catheters to monitor the contractions, as they often can't be assessed very well, especially when using IV Syntocinon. Occasionally the belts are not big enough. It is harder to palpate + monitor the fetal well being - have had to use fetal scalp electrodes. There is difficulty in getting the women into the lithotomy position and using the footrests. There is a higher risk of developing pre-eclampsia/diabetes - leads to increased induced labour and caesarean sections, therefore added cost implications and the increased risk due to needing abdominal surgery."*

(Maternity unit 16)

In addition to the physical difficulties in doing these examinations and treatments, the issue of patient dignity and embarrassment was raised by some of the clinicians.

> *"It is embarrassing having to find extra large theatre PJs for the fathers who are often obese when the mothers are obese as well, and how to word/approach the issues as a member of staff, how to handle the situation without making the mother feel uncomfortable - it's difficult to get a balance. Some women in the past have chosen to deliver elsewhere as this unit has tried to broach the subject and other units have not – the women felt victimised."*

(Maternity unit 7)

There are also complications and restrictions postnatally when the mother is obese. Three units highlighted that there is increased support required for breastfeeding as obese women tend to have more difficulty, where as most units stated that the main issue was a higher rate of infection and slower wound healing in obese women (n=11).

> *"There are increased infections in obese women - especially in the case of caesarean sections as there is often an "overhang" of fat covering the wound and this causes difficulties in keeping the wounds clean and dry."*

(Maternity unit 7)

Theme 5: Current and Future Management of Care

Most maternity units thought patient information was an issue (n=14). The NHS patient information booklet was the only form of dietary patient information in the majority of maternity units (n=11). This booklet generally addresses healthy and safe eating rather than weight gain or specific dietary requirements related to BMI. With regard to information about diet and weight gain, some maternity units stated that the advice was likely to be inconsistent and ad hoc (n=7), and of the maternity units that discussed weight gain recommendations in the context of policy (n=12), none had a policy or guidelines on recommended weight gain during pregnancy. Weight stability rather than weight gain was recommended in obese women in some units (n=4).

> *"No specific weight gain or dietary advice other than the midwife dietary advice given at booking appointment re healthy eating during pregnancy and the NHS booklets on healthy eating."*
>
> (Maternity unit 11)

There were a few different aspects considered when discussing how to manage maternal obesity. Two maternity units stated that improved links with dietetics could potentially help. Some units addressed weight management groups (n=3). One stated that they would like to run weight management classes for pregnant mothers, whereas two units suggested that weight management groups in the community needed to address the issue of obesity in pregnancy due to it being a bit late when the mothers got to the maternity unit, as they were already pregnant and weight loss couldn't be advised. The issue of resource was also highlighted in terms of staff time and patient information.

> *"There could be improved links with dietetics, it would be good to have weight attendance classes or something like that.* [2 named midwives] *are in the early stages of discussing the possibility of starting some healthy eating classes. Every midwife discusses the diet at booking and gives the woman appropriate dietary leaflets, it would be nice to perhaps have more time to go into more detail with certain things. Time at booking with the midwives is very limited as they only have 45mins - 1hr with each woman and there is a lot of information to get through."*
>
> (Maternity unit 16)

The responsibility of weight during pregnancy was also questioned – where does the responsibility lie: with service providers or with the mother? This was considered to be a major factor for service delivery in one unit. Also staff delivering a balance of information to the mothers was deemed important, and difficult (n=8).

> *"There needs to be a balance when making women aware of the issues: for example not being blunt and trying to be kind - but by doing this we're perhaps not giving enough information - difficult to get the balance."*
>
> (Maternity unit 13)

Discussion

Data Currently Available in Electronic Format

The data collected in the maternity units in the region is recorded in varying formats, with different levels of accessibility, and with differing consistency. The implementation of the information strategy for EPR's in maternity services may help to address the varying formats and accessibility of maternity specific data, however the consistency in the level of data collected needs to be addressed in the form of a minimum dataset for maternity services, in order to make data truly comparable across the region.

The minimum analysis that could be carried out using the current electronic data available in the region would be relating to the incidence and demographics of maternal obesity at booking, as all units collect the demographic data of the mother with the exception of one unit that does not record maternal employment details. Other data categories that are well represented electronically in the units with the facility to do so are:

- Complications in the antenatal, intrapartum, and postnatal period
- Delivery data
- Some infant details

There is also limited smoking, alcohol, and drug use details recorded by all six units electronically that could be used in data analysis. Electronic maternal morbidity data is collected less consistently in the maternity units that use a database, although five of the six units collect enough data to collate for analysis.

There is no readily available electronic data that could be used to retrospectively look at the maternal pre-pregnancy weight (i.e., not the booking weight), weight gain throughout pregnancy, follow up weight of the mother after pregnancy, follow up weight of the infant following discharge, and paternal height and weight details.

Clinical Issues Identified

The most prominent theme identified is that there is a general lack of consistency in services for obese pregnant women across the region. This is largely due to the absence of evidence based clinical guidelines and policy relating to maternal obesity, both nationally and locally.

A number of the issues discussed as being a problem when mothers are obese have significant costs associated with them, which could be a determinant of whether the local services can cope with the perceived increase in maternal obesity in the region. In particular the costs are linked with:

- Equipment (such as operating tables, wheelchairs etc.)
- Staffing Requirements
- Additional Services / Multi Disciplinary Care
- Other Co-existing Conditions / Developing Conditions
- Additional Procedures Required
- Health Promotion Programmes / Long Term Support
- Waiting Lists / Length of Stay (Maternity and Other Departments)
- Drugs and Dressings
- Complications of labour and Interventions
- Increased Care for Infants

The health care practitioners interviewed described maternal obesity as having a major impact on service, relating to the level of care required, cost and resources required, complications and risk to the mother and infant, and existing or developing morbidities related to maternal weight. Much of the information provided was anecdotal, however the clinicians were encouraged to give anecdotal responses as the aim was to get an insight into the clinical issues from the people caring for this group of women.

The psychological issues for the parents when obesity is a part of pregnancy was not addressed as a consistent theme, but it is deemed to be important. The lack of general awareness of the implications of maternal obesity for parents, and the difficulty for staff in getting the balance of information across is something that needs to be addressed for future management of care.

Recommendations

National

There is a lack of evidence about the way in which obese women in pregnancy are managed. There is a lack of clear policy for dealing with obese women. These issues need to be dealt with by NICE, the Department of Health, and the relevant Royal Colleges.

Regional

The new Strategic Health Authority for the North East has the opportunity to mandate a standard approach to data collection, which would enhance our understanding of obesity in pregnancy, and where appropriate to ensure that all existing guidance and standards are adhered to. There is a need to move to recording ***measured*** heights and weights rather than self reported.

Mechanisms need to be put in place by the Strategic Health Authority to collect data on a routine basis on maternal obesity. The Regional Maternity Surveys Office might coordinate this in the future.

Further Investigation and Research

A long-term prospective study should be carried out in order to ensure measured weights and heights are used for increased data quality, and also to capture the additional data required for a complete overview of the effects of maternal obesity; such as weight gain during pregnancy, maternal weight retention following pregnancy and in subsequent pregnancies, and the potential impact on infant and child growth. This would help to identify the long-term impact of maternal obesity and any potential areas for intervention in the future.

Further research could include:

- A prospective study to identify the correlation between self-reported and measured height and weight at pregnancy booking appointment.
- A retrospective study to identify the immediate impact of maternal obesity on service delivery in the region, and any trends in incidence over time.
- A prospective study using measured weights and heights, and following up the mothers and infants after discharge and in to childhood, to look at the long-term impact of maternal obesity.
- A qualitative study to address staff and parental psychological issues relating to maternal obesity, with particular focus on how to communicate the risks of obesity in pregnancy to women which will lead to lifestyle changes to bring weight to a normal level in the future.

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References

1. Andreasen, K.R., Andersen, M. L., Schantz, A. L., *Obesity and pregnancy.* Acta Obstetricia et Gynecologica Scandinavica, 2004. 83(11): p. 1022.
2. Morin, K.H., *Perinatal outcomes of obese women: a review of the literature.* Journal of Obstetric, Gynecologic, and Neonatal Nursing, 1998. 27(4): p. 431.
3. Confidential Enquiry into Maternal and Child Health, *Why mothers die 2000-2002*. 2004, RCOG:London.
4. Health Committee, *Obesity - Third report of session 2003-2004, Volume 1, HC 23.1*. 2004, HMSO: London.
5. Department of Health, *Health Survey for England 2002: Health and lifestyle indicators for Strategic Health Authorities, 1994- 2002*. 2002, HMSO: London.
6. Department of Health, *Health Survey for England 2003*. 2003, HMSO: London.
7. National Institute for Health and Clinical Excellence, *Antenatal Care: Routine Care for the Healthy Pregnant Woman*. 2003, RCOG: London.
8. Cnattingius, S., Bergstrom, R., Lipworth, L., Kramer, M. S., *Prepregnancy weight and the risk of adverse pregnancy outcomes.* New England Journal of Medicine, 1998. 338(3): p. 147.
9. Cnattingius S, L.M., *Trends in smoking and overweight during pregnancy: Prevalence, risks of pregnancy complications and adverse pregnancy outcomes.* Seminars in Perinatology, 2002. 26(4): p. 286-295.
10. Frentzen BH, D.D., Cruz AC, *Maternal weight gain: Effect on infant birth weight among overweight and average-weight low-income women.* Am J Obstet Gynecol, 1988. 159(5): p. 1114-1117.
11. Larsen CE, S.M., Sullivan KM, *Macrosomia: Influence of maternal overweight among a low income-population.* Am J Obstet Gynecol, 1990. 162(2): p. 490-494.
12. Naeye, R.L., *Maternal Body weight and pregnancy outcome.* American Journal Clinical Nutrition, 1990. 52: p. 273-9.
13. Rosenberg, T.J., Garbers, S., Chavkin, W., Chiasson, M.A., *Prepregnancy weight and adverse perinatal outcomes in an ethnically diverse population.* Obstetrics and Gynecology, 2003. 102(5): p. 1022.
14. Rossner, S., Ohlin, A., *Maternal body weight and relation to birthweight.* Acta Obstetrica Gynecologica Scandinavia, 1990. 69: p. 475-478.
15. von Kries R, T.A., Koletzko B et al, *Maternal smoking during pregnancy and the risk of childhood obesity.* Am J Epidemiology, 2002. 156(10): p. 954-961.
16. Regional Maternity Survey Office, *Northern Regional Maternity Survey Office Annual Report 2004.* NEPHO. December 2005.
17. Department of Health, *Data Set Control Notice: 50/2002 - Smoking and Pregnancy*. 2002.
18. Burnard, P., *A method of analysing interview transcripts in qualitative research.* Nurse Education Today, 1991. 11: p. 461-46.

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Epidemiology

Trends in maternal obesity incidence rates, demographic predictors, and health inequalities in 36 821 women over a 15-year period

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Objective The aim of this study was to identify trends in maternal obesity incidence over time and to identify those women most at risk and potential-associated health inequalities.

Design Longitudinal database study.

Setting James Cook University Hospital maternity unit, Middlesbrough, UK.

Sample A total of 36 821 women from 1 January 1990 to 31 December 2004.

Methods Trends in maternal obesity incidence over time were analysed using chi-square test for trend. Demographic predictor variables were analysed using multivariate logistic regression, adjusting for confounding factors after testing for multicollinearity. National census data were used to place the regional data into the context of the general population.

Main outcome measure Trends in maternal obesity incidence. Demographic predictor variables included ethnic group, age, parity, marital status, employment and socio-economic disadvantage.

Results The proportion of obese women at the start of pregnancy has increased significantly over time from 9.9 to 16.0% ($P < 0.01$). This is best described by a quadratic model ($P < 0.01$) showing that the rate is accelerating; by 2010, the rate will have increased to 22% of this population if the trend continues. There is also a significant relationship with maternal obesity and mothers' residing in areas of most deprivation (odds ratio [OR] = 2.44, 95% CI = 1.98, 3.02, $P < 0.01$), with increasing age (OR = 1.04, 95% CI = 1.04, 1.05, $P < 0.01$), and parity (OR = 1.17, 95% CI = 1.12, 1.21, $P < 0.01$).

Conclusions The incidence of maternal obesity at the start of pregnancy is increasing and accelerating. Predictors of maternal obesity are associated with health inequalities, particularly socio-economic disadvantage.

Keywords Incidence, obesity, pregnancy, rates, trends.

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Introduction

The increasing prevalence of obesity in the general population is a serious public health concern in the UK. The Health Survey for England (HSE) reports an increase in the prevalence of obesity among women of childbearing age.[1] In addition to this, the Confidential Enquiry into Maternal and Child Health (CEMACH) reported that between 1993 and 2002, obesity prevalence among women aged 25–34 years rose by 10%.[2] This suggests that the number of women who are obese at the start of pregnancy will also be increasing, which will have an impact on maternity services in the UK. Obesity in pregnancy has serious health implications for the mother and her infant, and increases the complications throughout pregnancy and the demand placed on maternity unit resources.[3] The scale of maternal obesity needs to be determined to plan service delivery and to identify 'at-risk' groups to target priority areas for interventions.

While Kiran *et al.*[4] reported that the incidence of maternal obesity had more than doubled in Cardiff over the past 10 years, there remains a lack of English data relating to maternal obesity incidence rates and populations at risk. This study provides data for the trends and incidence of maternal obesity gained from a large north-east group of women tracked over 15 years. Further analyses place this dataset into the context of the national population, in addition to examining potential risk factors through the relationship between body mass index (BMI) and maternal age, parity, ethnic origin, marital status, employment status, and deprivation.

Methods

Data collection

Data have been prospectively collected and electronically recorded in a large maternity unit in Middlesbrough since 1990. Maternal height and weight are 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%; H. Simpson, pers. comm.).

The data were examined for all booking appointments between 1 January 1990 and 31 December 2004. As pregnancy naturally incurs weight gain, a cutoff of 16 weeks of gestation at booking was used to eliminate any potential false positives of maternal overweight. The gestational age at booking was calculated by subtracting the number of days between booking and delivery from the gestational age at delivery. Dating scans have been carried out for all women since 2000; before 2000, the dating was based on dates only, so there may be some cases where the dating is less accurate in this group. If there is a discrepancy between the dating scan and the last menstrual period date, then the scan date is always used at the unit. Data were retrieved for 61 850 subjects. Exclusions were made for (1) missing BMI data (n = 8758); (2) data entry errors (n = 1601, including unrealistic BMI,[5] and errors in date records); (3) booking date after 16 weeks of gestation (n = 8420); and (4) missing gestational age (n = 6250, due to incomplete data or incomplete pregnancies). In total, 36 821 subjects remained for the analysis (population characteristics are given in Table 1).

Table 1. Study population characteristics

	All (n = 36 821)	Lean (n = 1576)	Ideal (n = 22 247)	Overweight (n = 8616)	Obese (n = 3922)	P
Maternal BMI, mean (SD)	24.2 (4.5)	17.5 (0.8)	22 (1.7)	27 (1.4)	33.7 (3.5)	<0.01
Maternal weight in kg, mean (SD)	63.2 (12.7)	47.4 (4.5)	58.6 (6.4)	71.4 (7)	77.9 (23.8)	<0.01
Maternal height in m, mean (SD)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	NS
Maternal age at delivery, mean (SD)	27.1 (5.8)	24 (5.4)	26.8 (5.7)	27.9 (5.7)	28.1 (5.5)	<0.01
Parity, mean (SD)	1.1 (1.1)	1.0 (1.0)	1.0 (1.0)	1.2 (1.1)	1.4 (1.2)	<0.01
Deprivation quintile, *n* (%)						<0.01
Most deprived 1	19 174 (54.6)	1039 (5.4)	11 293 (58.9)	4474 (23.3)	2368 (12.4)	
2	6386 (18.2)	220 (3.4)	3923 (61.4)	1557 (24.4)	686 (10.7)	
3	3944 (11.2)	104 (2.6)	2511 (63.7)	962 (24.4)	367 (9.3)	
4	3717 (10.6)	101 (2.7)	2426 (65.3)	903 (24.3)	287 (7.7)	
Least deprived 5	1922 (5.5)	59 (3.1)	1270 (66.1)	459 (23.9)	134 (7)	
Ethnic group, *n* (%)						<0.01
Caucasian	33 420 (91.9)	1356 (4.1)	20 501 (61.3)	7939 (23.8)	3624 (10.8)	
Mixed race	187 (0.5)	11 (5.9)	121 (64.7)	34 (18.2)	21 (11.2)	
Asian/Asian British	1486 (4.1)	148 (10)	850 (57.2)	347 (23.4)	141 (9.5)	
Black/Black British	77 (0.2)	1 (1.3)	46 (59.7)	22 (28.6)	8 (10.4)	
Chinese/other ethnic group	133 (0.4)	14 (10.5)	91 (68.4)	19 (14.3)	9 (6.8)	
Not known	1058 (2.9)	46 (4.3)	638 (60.3)	255 (24.1)	119 (11.2)	
Employment status, *n* (%)						<0.01
Paid employment	19 942 (54.8)	522 (33.1)	12 456 (56)	4903 (56.9)	2061 (52.5)	
No paid employment	15497 (42.6)	981 (62.2)	9162 (41.2)	3547 (41.2)	1807 (46.1)	
Education/training	620 (1.7)	47 (3)	448 (2)	99 (1.1)	26 (0.7)	
Not known	302 (0.8)	26 (1.6)	181 (0.8)	67 (0.8)	28 (0.7)	
Marital status, *n* (%)						<0.01
Married	19 298 (53.1)	592 (3.1)	11 663 (60.4)	4890 (25.3)	2153 (11.2)	
Single	15433 (42.4)	931 (6)	9591 (62.1)	3314 (21.5)	1597 (10.3)	
Separated/divorced/widowed	1113 (3.1)	29 (2.6)	667 (59.9)	284 (25.5)	133 (11.9)	
Not known	517 (1.4)	24 (4.6)	326 (63.1)	128 (24.8)	39 (7.5)	

NS, not significant.

Data analysis

Chi-square analysis was used to identify any significant differences between the included and excluded populations. The included study population was categorised based on their BMI at booking: lean (BMI < 18.5 kg/m^2), ideal (BMI 18.5–24.9 kg/m^2), overweight (BMI 25–29.9 kg/m^2), and obese (BMI > 30 kg/m^2). (BMI categories for the general population were used for this study population as there are no agreed categories for pregnant women, and we were primarily interested in trends over time.) The trends in incidence over time were calculated using the chi-square test for trend for each BMI group (ideal versus nonideal, obese versus nonobese etc.). Linear and nonlinear regression analysis identified the most appropriate model for these incidence trends and to predict future rates of maternal BMI.

Multivariate logistic regression analysis was used to examine predictors of BMI category at the start of pregnancy. Maternal age and parity were analysed as continuous data; the remaining data were categorical, and maternal ethnic group, marital status, and employment were categorised according to the national census data. The reference data for the level of deprivation were taken from the Index of Multiple Deprivation (IMD) for England.[6] The deprivation scores were assigned in quintiles, where 1 = most deprived and 5 = least deprived.

The statistical analyses were performed using SPSS version 13 (SPSS, Chicago, IL). Chi-square analysis showed all variables to have an independent association with BMI category. Prior to deriving the final regression model, the data were screened for multicollinearity using linear regression diagnostics.

The England census and IMD data were used to compare all predictor variables for women of childbearing age in Middlesbrough and England, to place the findings from this study into context with the national population.

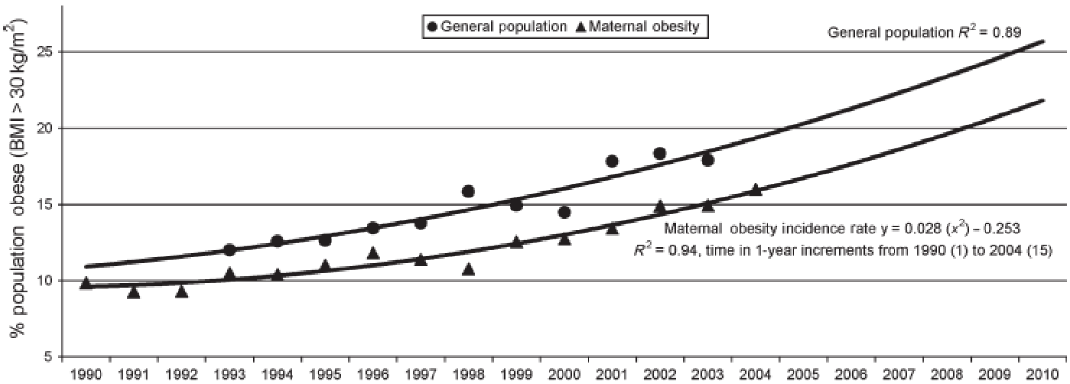
Results

This study population mainly consisted of Caucasian women residing in the most deprived quintile 1. There were significant differences between the BMI groups for all characteristics with the exception of height.

Trends in BMI category over time

The crude trends for incidence of maternal BMI are illustrated in Figure 1. The rates were not adjusted for change in maternal age over time as the mean age of the samples varied less than 1 year over the 15-year period (minimum 26.49, SD 5.16; maximum 27.30, SD 6.05). The gestational age at booking also remained relatively constant over time, with a difference of approximately 2 weeks between the minimum and maximum mean booking gestational age (minimum 11.16, SD 5.22; maximum 13.31, SD 6.01).

Over the 15-year period, there has been a significant decrease in the incidence of women in the ideal BMI group from 64.8% in 1990 to 54.7% in 2004 (chi-square 159.13, $df = 1$, $P < 0.001$). Conversely, there is a significant increase in the incidence of women in the overweight BMI group (21.5–25.3%, chi-square 19.01, $df = 1$, $P < 0.001$), and obesity in the study population has risen from 9.9% in 1990 to 16.0% in 2004 (chi-square 141.36, $df = 1$, $P < 0.001$).



% study population lean BMI = 3.8% in 1990, 4.0% in 2004.*
% study population ideal BMI = 64.8% in 1990, 54.8% in 2004, projected 47% in 2010.
% study population overweight BMI = 21.5% in 1990, 25.3% in 2004.*
% study population obese BMI = 9.9% in 1990, 16.0% in 2004, projected 22% in 2010.

* Cannot extrapolate this data for projected incidence rates: significant fit for linear model, however R^2 = 0.4 for both BMI categories, therefore not a strong relationship.
** General Population Data Source, Health Survey for England Data 1993–2003, http://www.dh.gov.uk/assetRoot/04/09/89/15/04098915.xls.

Figure 1. Incidence of Maternal Obesity in 36 821 women over a 15-year period, the projected incidence of maternal obesity by 2010, and the prevalence of obesity in women of childbearing age (16–44 years) in England's general population.**

The regression analysis showed that obesity incidence is best explained by a quadratic model: incidence = a + b(x^2) (where x is the time point in years; 1 = 1990 and 15 = 2004), with the linear term of the second order polynomial making no contribution to the model fit. This model indicates that the rate of maternal obesity is accelerating over time. If the trend that has been shown in the 15-year period is assumed to continue increasing at the same rate, then the predicted incidence of obesity in this study population will be 22% by the year 2010. This prediction is based on an assumption that the trend remains constant and does not account for saturation of high-risk groups, specifically socio-economic deprivation, which would cause the accelerating rate to slow down and eventually level off at some point in the future.

The increasing incidence of maternal obesity is accelerating over time at a similar rate to that of obesity in all women of childbearing age in the general population in England, although the incidence of maternal obesity lags behind that of the general population (see Figure 1).

Predictors of obesity at the start of pregnancy

All variables had an independent association with BMI category and no multicollinearity; therefore, all were included in the final regression model (Table 2). The subjects in the ideal BMI category were used as the reference group.* Following adjustment for confounding variables, the subjects in the obese group were significantly older, more parous, and residing in the more deprived quintile areas 1 to 3; this was more pronounced in the most deprived quintile 1, where women were almost two-and-a-half times more likely to be obese at the start of pregnancy than those women living in the least deprived quintile 5. For women who were separated, divorced, widowed, or participating in education, there was significant reduction in the incidence of maternal obesity. Ethnicity was not found to have a significant association with maternal obesity, although interpretation of this data is limited due to the small sample size, representing the non-Caucasian populations.

The overweight group had a significant association with residing in the two lowest quintile areas, being slightly older and slightly more parous, and less likely to be single or in education. The lean group was significantly younger, single, in education, and not in paid employment.

*The results for ethnic group used the Caucasian population as the baseline for comparison as this was the majority group (91.7% of the total cohort). The employment status and deprivation categories used paid employment and residing in the least deprived quintile (5) as baselines for comparison as they were considered to be the best social circumstance when considering health inequality issues. Being in the married group was arbitrarily chosen as the comparison group for the marital status category.

Excluded population

There were statistically significant differences between the included and excluded groups for all variables except parity, where both groups had a mean parity of 1 ($P = 0.46$). There was a difference in the mean age of 0.86 years ($P < 0.001$), although this is not of clinical significance. Chi-square analysis showed that there was a significant association between ethnic group and exclusion; proportionally more Caucasians were included (60.5%), while more Black (63.5%) and Asian (53.0%) subjects were excluded. The average inclusion rate relating to deprivation was 59.6%, however, this relationship was not evenly distributed across all quintiles with the least deprived having an inclusion rate above average (63.1%), whereas the most deprived was the only quintile that had an inclusion rate below average (57.7%). As there is a potential association with these factors and inequality, the high exclusion rate of certain groups was further investigated. Chi-square analysis showed missing BMI data to explain the relationship with certain groups: Caucasian and quintiles 2 to 4. A gestational age at booking of more than 16 weeks was the leading explanation for exclusion of all other ethnic groups, not being in paid employment, and being in the least or most deprived quintiles (1 and 5).

Middlesbrough and English population

Middlesbrough contains some of the most deprived parts of England, with nearly 60% of the population living in one of the 10% most deprived wards in England.[7] As there are no national statistics on maternal BMI status at the start of pregnancy, the population of women of childbearing age in Middlesbrough was compared with the population of women of childbearing age in England. The national census data[8] and the IMD data[6] were used to place the results from this study into a more national context; the results are shown in Table 3. CI analysis shows that women of childbearing age in Middlesbrough are more likely to be residing in areas of most deprivation (quintile 1, 62.2 versus 21.5% in England, $P < 0.05$), whereas the proportion residing in quintile 5 is significantly lower in Middlesbrough (1.7 versus 18.5% in England, $P < 0.05$). The Middlesbrough population also has a significantly higher than average proportion of Caucasians and lower proportions of the remaining ethnic groups (although the difference between Asian groups is only 0.3%), more likely to be unemployed or in education, to have three or more dependent children and to not be married.

Discussion

The Government has identified obesity as one of the most serious problems of the 21st century.[9] A joint report from the Audit Commission, the Healthcare Commission, and the National Audit Office suggested the cost of obesity to the NHS in England is approximately £1 billion and by

Table 2. Adjusted logistic regression*

	Lean versus ideal BMI, OR (95% CI)	Overweight versus ideal BMI, OR (95% CI)	Obese versus ideal BMI, OR (95% CI)
Maternal age	0.95 (0.94, 0.96)***	1.03 (1.03, 1.04)***	1.04 (1.04, 1.05)***
Parity	0.99 (0.93, 1.07)	1.10 (1.06, 1.13)***	1.17 (1.13, 1.22)***
Deprivation quintile			
Least deprived 5	Baseline data		
4	0.82 (0.56, 1.20)	1.05 (0.91, 1.22)	1.13 (0.89, 1.44)
3	0.76 (0.52, 1.11)	1.12 (0.97, 1.29)	1.39 (1.10, 1.75)**
2	0.80 (0.56, 1.13)	1.18 (1.03, 1.35)**	1.79 (1.44, 2.23)***
Most deprived 1	0.95 (0.68, 1.32)	1.33 (1.16, 1.51)***	2.42 (1.96, 2.98)***
Unknown quintile	0.86 (0.56, 1.33)	1.00 (0.83, 1.21)	1.14 (0.84, 1.56)
Ethnic group			
Caucasian	Baseline data		
Mixed race	0.84 (0.36, 1.93)	0.83 (0.55, 1.27)	0.86 (0.49, 1.53)
Asian/Asian British	2.34 (1.85, 2.96)***	1.04 (0.90, 1.20)	0.83 (0.68, 1.01)
Black/Black British	0.00	1.27 (0.71, 2.26)	1.08 (0.49, 2.39)
Chinese/other	2.57 (1.31, 5.03)**	0.45 (0.26, 0.79)**	0.55 (0.27, 1.16)
Ethnic group unknown	1.16 (0.80, 1.69)	0.99 (0.83, 1.18)	1.08 (0.85, 1.36)
Employment status			
Paid employment	Baseline data		
No paid employment	1.92 (1.66, 2.23)***	1.00 (0.94, 1.07)	1.08 (0.99, 1.18)
Education or training	1.53 (1.06, 2.22)**	0.72 (0.56, 0.93)**	0.53 (0.34, 0.83)**
Employment unknown	2.77 (1.58, 4.84)***	1.31 (0.94, 1.82)	1.16 (0.72, 1.86)
Marital status			
Married	Baseline data		
Single	1.34 (1.15, 1.56)***	0.93 (0.87, 1.00)**	0.94 (0.86, 1.03)
Separated, divorced, widowed	1.01 (0.68, 1.49)	0.87 (0.75, 1.01)	0.74 (0.61, 0.91)***
Marital status unknown	1.23 (0.77, 1.96)	1.01 (0.80, 1.27)	0.67 (0.46, 0.98)**

*Variable(s): deprivation, age, ethnic group, parity, employment, marital status.
**$P < 0.05$.
***$P < 0.01$.

2010, the cost to the economy could be close to £3.6 billion.[10] Obesity is also one of the six priorities in the English White Paper Choosing Health: Making Healthy Choices Easier.[11] In terms of maternal obesity, there is a body of evidence, which suggests that the offspring of overweight and obese mothers are at increased risk of themselves becoming overweight or obese in childhood or adult hood,[12] and evidence to show that pregnancy is a key stage in the life course associated with weight gain.[13]

This study has confirmed that the incidence of maternal obesity is rising in this study population at a rate similar to that of all women of childbearing age in the general population, although the incidence of maternal obesity lags behind that of the general population. The relationship between obesity and fertility is well documented,[14,15] and it is likely that this lag effect is primarily due to physiological factors, which hinder fertility.

This study has shown that the increasing incidence of maternal obesity is accelerating, however, there is a potential that this is underestimated. Women whose pregnancies were incomplete were excluded from the study population, and the relationship with obesity, miscarriage, and late fetal death[16] could potentially have resulted in the exclusion of a significant proportion of the obese women. The exclusion of women who presented after 16 weeks of gestation could also have added to the underestimation of maternal obesity due to the association with irregular menstruation,[17,18] and slight changes in weight status may not be as noticeable; therefore, confirmation of the pregnancy may be later in these women. There is also evidence to show that self-reported weight is underestimated and height overestimated,[19] therefore this could have led to a further underestimation of the overweight or obese BMI groups in this study, however, the majority of bookings use measured weights and heights, and there has been no change in the location of booking appointments over the 15-year period studied, making the variation in self-reported heights and weights over time limited due to this factor. There has, however, been more stringent measurement of BMI by staff in the maternity unit since 2001, due to the Confidential Enquiry into Maternal Death,[20] emphasising the need to use BMI as a risk assessment for thrombosis after

Table 3. Characteristics of women of childbearing age in Middlesbrough and England

	Proportion in Middlesbrough (95% CI)	Proportion in England
Ethnicity (women aged 15–44)*		
White	0.929 (0.926, 0.932)	0.884****
Mixed	0.010 (0.009, 0.011)	0.014****
Asian or Asian British	0.053 (0.050, 0.055)	0.056****
Black or Black British	0.004 (0.003, 0.005)	0.032****
Chinese/other ethnic group	0.005 (0.004, 0.006)	0.014****
Employment status (women aged 16–44)*		
Paid employment	0.520 (0.515, 0.526)	0.628****
No paid employment	0.327 (0.322, 0.333)	0.241****
Education/training	0.152 (0.148, 0.157)	0.131****
Number of dependent children 0–18 years (women aged <24–49)*,*		
0	0.231 (0.225, 0.237)	0.297****
1	0.319 (0.313, 0.326)	0.277****
2	0.296 (0.290, 0.302)	0.292
3 or more	0.153 (0.149, 0.158)	0.134****
Deprivation quintile (women aged 15–44)***		
Most deprived 1	0.622 (0.616, 0.627)	0.215****
2	0.100 (0.097, 0.103)	0.210****
3	0.122 (0.118, 0.126)	0.199****
4	0.139 (0.135, 0.143)	0.190****
Least deprived 5	0.017 (0.016, 0.019)	0.185****
Marital status (women aged 16–44)*		
Single	0.528 (0.522, 0.533)	0.482****
Married	0.351 (0.345, 0.356)	0.405****
Separated, divorced or widowed	0.122 (0.118, 0.126)	0.113****

*Census data.
**Number of dependent children used in place of parity.
***IMD data.
****England and Middlesbrough populations significantly different $P < 0.05$.

delivery, this was further emphasised in 2004 in the CEMACH enquiry;[2] therefore, there is a potential for a higher level of accuracy in the representation of BMI status following 2001.

The Health Select Committee reports that an increased prevalence of obesity in the general population is associated with health inequalities and deprivation,[21] which fully supports the findings of this study in relation to maternal obesity. There is also an association with prevalence of obesity in women in the general population and increasing age.[1] The relationship with incidence of maternal obesity and increasing age following adjustment for all other confounders was highly significant in this study; however, the relationship showed only a slight increase. The relationship with increasing age and obesity in women in the general population is most significant following menopause;[1] therefore, the magnitude of this significant relationship is not going to be reflected in the women in this study population, and the high significance of the slight increase in odds ratio is realistic for the age group in this study population.

The results of this study show increasing parity to be a predictor of maternal obesity; published evidence supports this as the time period during and between pregnancies is shown to be a critical period in the development of obesity.[22–24] Being in education had a highly significant reduced odds ratio of being obese at the start of pregnancy. The mothers who are in education are more likely to be a younger group, and the significant relationship with increasing age and obesity makes the younger group less likely to be in the obese category, however, there was no collinearity between the age and education variables. Also, age as a confounder had been accounted for in the regression model; therefore, this cannot explain the inverse phenomenon between this group of mothers and obesity. As this research was looking at independent demographic predictors to identify health inequalities that may have a relationship with maternal BMI status, lifestyle factors were not taken into consideration, and this may have influenced the inverse relationship with obesity and mothers being in education.

There was no significant association with any of the ethnic minority groups and maternal obesity, although the numbers in this study population were relatively low, and there was a significantly increased proportion of women excluded from ethnic minority groups, particularly in the Asian and Black groups. One theory that might potentially explain why proportionately more women from some ethnic minority groups had late booking appointments, could be related to inequalities in access to services; a theory which is supported by evidence such as that published in the House of Commons Select Committee report; Inequalities in Access to Maternity Services.[25]

There are certain limitations when trying to quantify health inequality issues, as there is a great deal of speculation when it comes to defining data such as deprivation. The traditional categorisation of socio-economic status is outdated as it is reliant on the occupation of the man in a household, which is unlikely to be an adequate representation in the modern day, particularly in populations that have a higher proportion of single mothers. Deprivation has been numerically categorised for the purposes of this research using area of residence as an indicator of deprivation based on the IMD, which uses postcodes to calculate deprivation based on the areas level of income deprivation, employment deprivation, health deprivation and disability, education, skills and training deprivation, barriers to housing and services, living environment deprivation, and crime. Although there is still the argument that someone living in an area of deprivation does not mean they are necessarily deprived, and also that boundaries of areas of deprivation change with time making it difficult to attribute a deprivation score to one postcode over any length of time, it was considered to be a more accurate indicator of deprivation than the household male occupation.

Conclusion

The results of this study should be comparable with other populations in England where women of childbearing age are mainly Caucasian (with Asian being the highest proportion of ethnic minority groups), have a higher than average level of deprivation, unemployment, and single mothers. The rise in maternal BMI over time in this study population is highly significant, with proportions of maternal obesity accelerating at a rate far greater than any other BMI status. The trends in incidence for the data predict that the proportion of mothers who are obese at the start of pregnancy could potentially have increased from 10% in 1990 to 22% by 2010 assuming that the trend continues, and that the proportion of mothers in the ideal BMI category could potentially have reduced from 65% in 1990 to 47% by 2010. Maternal BMI status is also shown to relate to health inequalities, particularly for women who live in the areas of the most deprivation who are almost two-and-a-half times more likely to be obese at the start of pregnancy than women who live in areas of least deprivation. There are also potentially issues relating to inequalities within ethnic groups and access to maternity services; a theory that is supported by published evidence.

The results from this study indicate serious implications both in terms of public health and service delivery. Given the concerning elevation in the incidence of maternal obesity, future research programmes aimed at preventing the continuation of this trend are imperative.

Ethics

This research was approved by the University of Teesside Ethics Committee, and the South Tees NHS Trust ethics and research and development committees.

Competing interests

The North East Public Health Observatory and the University of Teesside provided the funding for this study; there are no competing interests from any of the authors or organisations involved.

Contribution to authorship

The authors contributing to the design of the study were N.H., C.S., J.W., and L.E. The statistical analysis was conducted by N.H. and A.B. All authors contributed to paper writing.

Duplicate publications

The results from this piece of research have not been published elsewhere in a peer-reviewed journal.

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References

1 Department of Health. *Health Survey for England 2003*. HMSO: London, 2003.
2 Confidential Enquiry into Maternal and Child Health. *Why mothers die 2000-2002*. RCOG: London, 2004.
3 North East Public Health Observatory. OP22: maternal obesity and pregnancy outcome: a scoping study. 2006 [www.nepho.org.uk]. Accessed 22 May 2006.
4 Kiran TSU, Hemmadi S, Bethal J, Evans J. Outcome of pregnancy in a woman with an increased body mass index. *BJOG* 2005;112:768–72.
5 Henry CJK. Body mass index and the limits of human survival. *Eur J Clin Nutr* 1990;44:329–335.

6 Index of Multiple Deprivation (IMD). *The English Indices of Deprivation*. Office of the Deputy Prime Minister, 2000. [www.odpm.gov.uk]. Accessed 22 May 2006.

7 Department of the Environment Transport and the Regions (DETR). *Measuring Multiple Deprivation at the Small Area Level: The Indices of Deprivation 2000*. Department of the Environment Transport and the Regions, 2000. [www.communities.gov.uk]. Accessed 25 April 2006.

8 Census Standard Tables: ST001 Age by Sex and Marital Status, ST028 Sex and Age by Economic Activity, ST101 Sex and Age by Ethnic Group, ST007 Age of FRP (Family Reference Person) and Number and Age of Dependent Children by Family Type. Office of National Statistics, 2001. [www.census.ac.uk]. Accessed 30 March 2006.

9 South East Public Health Observatory. *Choosing Health in the South East: Obesity*, 2005. [www.SEPHO.org.uk]. Accessed 30 April 2006.

10 Comptroller and Auditor General. *Tackling Childhood Obesity—The First Steps*. London: The Stationary Office, 2006. Accessed 22 May 2006.

11 Department of Health. *Delivering Choosing Health: Making Healthier Choices Easier*. London: Department of Health, 2005.

12 Parsons TJ, Power C, Logan S, Summerbell CD. Childhood predictors of adult obesity: a systematic review (Review, 283 refs). *Int J Obes Relat Metab Disord* 1999;23(Suppl 12):S1–S107.

13 National Institute of Health and Clinical Excellence. Obesity consultation. 2006 [www.nice.org.uk]. Accessed 22 May 2006.

14 Clark AM, Ledger W, Galletly C, Tomlinson L, Blaney F, Wang X, *et al.* Weight loss results in significant improvement in pregnancy and ovulation rates in anovulatory obese women. *Hum Reprod* 1995;10:2705.

15 Wang JX, Davies MJ, Norman RJ. Obesity increases the risk of spontaneous abortion during infertility treatment. *Obes Res* 2002; 10:551.

16 Lashen H, Fear K, Sturdee DW. Obesity is associated with increased risk of first trimester and recurrent miscarriage: matched case–control study. *Hum Reprod* 2004;19:1644.

17 Lake JK, Power C, Cole TJ. Women's reproductive health: the role of body mass index in early and adult life. *Int J Obes Relat Metab Disord* 1997;21:432.

18 Linne Y. Effects of obesity on women's reproduction and complications during pregnancy. *Obes Rev* 2004;5:137–43.

19 Engstrom JL, Paterson SA, Doherty A, Trabulsi M, Speer KL. Accuracy of self-reported height and weight in women: an integrative review of the literature. *J Midwifery Womens Health* 2003;48:338–45.

20 Confidential Enquiry into Maternal Deaths. *Why Mothers Die 1997–1999*. RCOG: London, 2001.

21 Health Committee. *Obesity—Third report of session 2003–2004*. Vol 1, HC 23.1. HMSO: London, 2004.

22 Gore SA, Brown DM, Smith West D. The role of postpartum weight retention in obesity among women: a review of the evidence. *Ann Behav Med* 2003;26:149–59.

23 Siega-Riz AM, Evenson KR, Dole N. Pregnancy-related weight gain—a link to obesity? *Nutr Rev* 2004;62:S105–11.

24 Gunderson EP, Abrams B. Epidemiology of gestational weight gain and body weight changes after pregnancy. *Epidemiol Rev* 2000;22: 261–74.

25 House of Commons Health Committee. *Inequalities in Access to Maternity Services*. London: The Stationary Office, 2003.

Appendix p4 Peer Reviewed Journal Publication in Obesity Reviews, 2008

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Complications of Obesity

The impact of maternal BMI status on pregnancy outcomes with immediate short-term obstetric resource implications: a meta-analysis

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Summary

Obesity is rising in the obstetric population, yet there is an absence of services and guidance for the management of maternal obesity. This systematic review aimed to investigate relationships between obesity and impact on obstetric care. Literature was systematically searched for cohort studies of pregnant women with anthropometric measurements recorded within 16-weeks gestation, followed up for the term of the pregnancy, with at least one obese and one comparison group. Two researchers independently data-extracted and quality-assessed each included study. Outcome measures were those that directly or indirectly impacted on maternity resources. Primary outcomes included instrumental delivery, caesarean delivery, duration of hospital stay, neonatal intensive care, neonatal trauma, haemorrhage, infection and 3rd/4th degree tears. Meta-analysis shows a significant relationship between obesity and increased odds of caesarean and instrumental deliveries, haemorrhage, infection, longer duration of hospital stay and increased neonatal intensive care requirement. Maternal obesity significantly contributes to a poorer prognosis for mother and baby during delivery and in the immediate post-partum period. National clinical guidelines for management of obese pregnant women, and public health interventions to help safeguard the health of mothers and their babies are urgently required.

Keywords: Maternal, obesity, pregnancy, service.

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Introduction

Obesity is a growing problem, and tackling obesity is a major focus for public health in the UK. The Choosing Health White Paper identified obesity as one of the key priority areas in public health (1), and the UK Government's Foresight Programme aims to identify a sustainable response to obesity over the next 40 years (2).

The prevalence of obesity in women in England has risen from 16.4% to 24.8% between 2003 and 2005, with the highest prevalence among Black African (38%), Black Caribbean (32%) and Pakistani ethnic groups (28%) (3). There is an absence of national statistics on the impact this increasing prevalence of obesity in women has on obesity in pregnancy. The Health Survey for England showed that the prevalence of obesity in women of childbearing age (16–44 year old) was 17.8% (4). The Confidential Enquiry into Maternal and Child Health (CEMACH) reported that 30% of all mothers who died in 2000–2002 were obese [body mass index (BMI) > 30 kg m^{-2}] (5); by 2003–2005 more than half were overweight or obese (BMI > 25 kg m^{-2}), with over 15% being morbidly (BMI > 40 kg m^{-2}) or super morbidly obese (>50 kg m^{-2}) (6). Despite the absence of national statistics, three UK studies show that incidence rates of maternal obesity have increased from 9.9% to 16.0% between 1990 and 2004 in Middlesbrough (7), from 3.2% to 8.9% between 1990 and 1999 in Cardiff (8) and from 9.4% to 18.9% between 1990 and 2002/4 in

Glasgow (9). Trends in maternal obesity on an international level are difficult to compare directly owing to different criteria in measurement being used; however, Guelinckx *et al.* (10) summarize that obesity varies from 1.8% to 25.3% of the pregnancy population using the World Health Organization criteria of a BMI > 30 kg m^{-2}.

Obesity has an impact on women's reproductive health, and there are health risks to both mother and her infant. There is a relationship with polycystic ovarian syndrome, infertility and the success of infertility treatment (11), whereas weight loss has been shown to alleviate these conditions and improve the success of infertility treatment (12). There is an increased risk of mothers developing gestational diabetes (13) and subsequent development of diabetes mellitus (14), an increased risk of hypertensive disorders and pre-eclampsia (14,15), and thromboembolic complications (15). There is some evidence of an increased risk of late fetal loss (16) and stillbirth (17). The CEMACH reported that in 2005 mothers were obese in 22.9% of all late fetal loss, 30.4% of stillbirths and 30.6% of neonatal deaths (18). Congenital anomalies have been linked with obesity. Waller *et al.* (19) found that mothers of offspring with spina bifida, heart defects, anorectal atresia, hypospadias, limb reduction defects, diaphragmatic hernia and omphalocele were significantly more likely to be obese than mothers of controls (odds ratios ranging between 1.33 and 2.10) (see Box 2 for definitions of obstetrics terminology).

In addition to the obesity-related health risks there is also an impact on service. The CEMACH recommends that the care of women with a BMI ≥ 35 kg m^{-2} should be 'shared with an obstetrician and [the mother] advised to deliver in a consultant led obstetric unit' as they are at a higher risk of developing problems (5). This recommendation is supported by the National Institute for Health and Clinical Excellence in their Guidelines for Antenatal Care (20) which state that women with a BMI ≥ 35 kg m^{-2} are likely to need additional care outside routine guidelines. However, national guidance specific to the needs of obese mothers' antenatal care is not currently available. Heslehurst *et al.* (21) discuss the impact of obesity in pregnancy on the National Health Service (NHS) maternity services as described by the healthcare professionals caring for women during their pregnancy. A number of the issues identified have supporting quantitative evidence, such as the need for more frequent caesarean deliveries (22). Galtier-Dereure *et al.* (23) concluded that the prenatal care cost in overweight and obese women was 5.4- to 16.2-fold higher compared with ideal weight women. However, this study only considered the cost of in patient and outpatient hospitalization in obstetric and surgical units, whereas the impact of obesity on resources has been shown to exceed pure hospitalization costs (21). There is an absence of published studies addressing the quantifiable impact of maternal obesity on service delivery in its entirety.

The aim of this systematic review was to identify the immediate impact on obstetric care when women are obese at the start of pregnancy.

Methods

Electronic databases MEDLINE, CINAHL, the Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, the NHS Economic Evaluation Database, and the Midwives Information and Resource Service (MIDIRS) were searched from January 1990 to June 2007. Searches were limited to English-language studies in humans. References of all published review articles identified and included studies were searched for other eligible studies. A search strategy was developed for MEDLINE and adapted for CINAHL (Box 1). MIDIRS was searched

Box 1 Search strategy

1. *pregnancy/
2. pregnan$.ti,ab.
3. matern$.ti,ab.
4. gravid$.ti,ab.
5. mother.ti,ab.
6. parent.ti,ab.
7. or/1–5
8. or/1–6
9. *obesity/ or *obesity, morbid/
10. obes$.ti,ab.
11. *Weight Gain/ph [Physiology]
12. (overweight or over weight or weight gain).ti,ab.
13. (bmi or body mass index).ti,ab.
14. or/9–13
15. (cohort or observation$ or prospective or longitudinal).ti,ab.
16. 7 and 14
17. 8 and 14
18. 16 and 15
19. 17 and 15
20. animal/
21. humans/
22. 20 not (20 and 21)
23. 18 not 22
24. 19 not 22
25. fertil$.ti,ab.
26. (IVF or in vitro fertili?ation).ti.
27. (PCOS or polycystic ovary syndrome).ti.
28. or/25–27
29. 23 not 28
30. 24 not 28
31. limit 29 to english language
32. limit 30 to english language
33. limit 31 to year = 1990–2007
34. limit 32 to year = 1990–2007

Box 2 Glossary of obstetric terminology

- Third degree tears – involving fourchette, vagina, vulva, pelvic floor, perineal muscles, vaginal muscles, anal sphincter, recto-vaginal septum.
- Fourth degree tears – as third plus; anal and/or rectal mucosa.
- Anorectal atresia – congenital absence of an opening at the bottom end of the intestinal tract.
- Apgar score – a number arrived at 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.
- Asphyxia – a lack of oxygen delivery via the placenta which in turn can lead to morbidity and mortality for the fetus.
- Diaphragmatic hernia – passage of a loop of bowel through a deficit in the diaphragm muscle. This type of hernia occurs as the bowel from the abdomen 'herniates' upward through the diaphragm into the chest (thoracic) cavity.
- Fetal compromise (or distress) – compromise of the fetus during the antepartum period (before labour) or intrapartum period (birth process). The term 'fetal distress' is 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.
- Hyperbilirubinaemia – an elevated level of the pigment bilirubin in the blood. A sufficient elevation will produce jaundice.
- Hypoglycaemia – a clinical syndrome that results from low blood sugar.
- Hypospadias – a birth defect of the penis involving the urethra (the transport tube leading from the bladder to discharge urine outside the body).
- Instrumental delivery (forceps or ventouse/vacuum) – an instrument designed as an aid in the vaginal delivery of a baby.
- 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 newborn. Intrauterine growth restriction is also referred to as intrauterine growth retardation.
- Meconium – dark sticky material normally present in the intestine at birth and passed in the faeces after birth. The passage of meconium before birth can be a sign of fetal compromise.
- Occiput – the back of the fetal head in the region of the occipital bone.
- Occiput anterior – occiput points anteriorly, or slightly to the right or left in the mothers pelvis, this is the optimal position for labour.
- Occiput posterior – occiput points posterior in the pelvis, either directly at the sacrum (direct OP) or to one side of it in the region of the sacroiliac joint (LOP, ROP). Often leading to a longer labour.
- Omphalocele – a birth defect in which part of the intestine, covered only by a thin transparent membrane, protrudes outside the abdomen at the umbilicus.
- Os – the distance between the placenta and the cervix.
- Oxytocin – a hormone made in the brain that plays a role in childbirth by causing muscles to contract in the uterus (womb). A synthetic form is used in induction or augmentation of labour – syntocinon.
- Placenta abruption – 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.
- Polycystic ovarian syndrome (PCOS) – a disorder of chronically abnormal ovarian function and hyperandrogenism (abnormally elevated androgen levels).
- Pre-eclampsia – a condition in pregnancy characterized 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.
- Premature rupture of membranes – rupture of membranes prior to onset of labour.
- Puerperium – the time immediately after the delivery of a baby and up to 6 weeks post-natal.
- Shoulder dystocia – halt to spontaneous delivery because the baby's shoulder is wedged behind the mother's pubis, owing usually to the baby being too big to fit through the birth canal.
- Thromboembolic complications – formation in a blood vessel of a clot (thrombus) that breaks loose and is carried by the blood stream to plug another vessel.

http://www.medterms.com

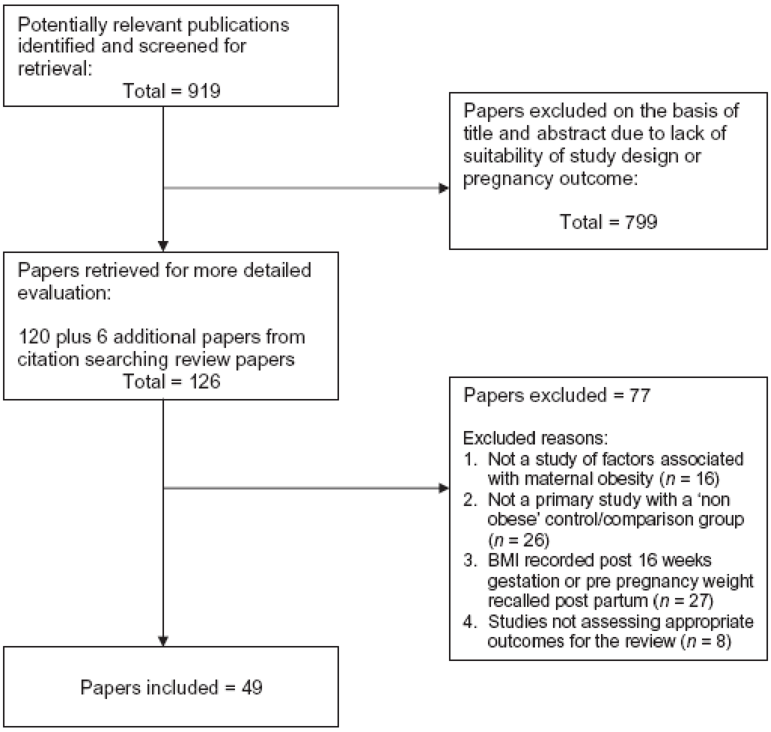

Figure 1 Quorum Statement Flow Diagram.

using their standard search on obesity, and Cochrane was searched using the MeSH facility for pregnancy and obesity, and using the search facility and the following terms: (obes* or overweight) AND (pregnan* or matern*).

Titles and abstracts of all studies identified in the search were scanned and full papers of any studies that were associated with maternal obesity were retained for further independent evaluation by two reviewers. Any disagreement on the inclusion of a study was assessed by a third reviewer.

Inclusion criteria for the review were:

- Maternal weight or BMI was recorded prior to 16 weeks gestation.
- Measured or self-reported weight was recorded at the start of pregnancy (studies were excluded when women were asked to recall their pre-pregnancy weight post-natally).
- There was at least one obese and one comparison group.
- Women were followed up for the duration of the pregnancy and delivery.
- Studies were included whether women were categorized into groups based on their BMI, other weight for height measure or weight alone (only studies using BMI were included in the meta-analysis).

The primary outcome measures being reviewed were those with a major direct NHS resource association; secondary outcome measures were those with an indirect resource association. Primary outcome measures included instrumental and caesarean delivery, length of hospital stay, neonatal intensive care, neonatal trauma, maternal haemorrhage and infection, and 3rd/4th degree tears.

The searches identified 919 records following deduplication and 799 were excluded based on the titles and abstracts. A total of 120 were screened, plus an additional six studies identified through citation searching, of which 77 were excluded (Fig. 1). Forty-nine studies were eligible and included in the review.

Data extraction and quality assessment

Included studies were data-extracted and quality-assessed by two researchers independently. One researcher (NH) carried out data extraction and quality assessment for all studies for consistency. The data extraction utilized the Cochrane data extraction template for cohort studies (24), and the quality assessment forms were based on the Scottish Intercollegiate Guidelines Network methodology checklist for cohort studies (25). Studies were quality-assessed and given a score of low (–), good (+) or excellent (++) based on internal validity, overall assessment of the study and description of the study.

Data analysis

Data were combined for meta-analysis when the following criteria were satisfied in three or more studies:

1. The definition for the outcome data being analysed was sufficiently similar that the clinical service implications could be compared.
2. The definition of maternal body weight status utilized BMI.
3. Where possible the control group BMI categories were comparable.

Where the data were not presented as an odds ratio it was calculated. A *P* value <0.05 was indicative of significant heterogeneity being present. Tests for heterogeneity between combined study results were carried out in STATA (26) to identify whether the variation between studies was attributable to chance. Sensitivity analysis was carried out in this instance accounting for those studies where the results were crude or adjusted, results being split by level of obesity (moderate, severe or morbid obesity), quality score of the studies and consistency in BMI cut-off used. Results of the meta-analysis are presented as ORs and 95% confidence intervals (CI) where possible.

Description of studies

Study characteristics are described in Table 1, and the quality scores and adjustments in Table 2. Included studies were primarily from the USA ($n = 22$) (27–48), and Europe ($n = 20$; four from Finland (49–52) and Denmark (53–56), three from the UK (8,57,58), Italy (59–61) and Sweden (62–64), two from France (23,65) and one from Austria (66)). The remaining studies included one from Australia (67), Canada (68), Abu Dhabi (69), Brazil (70), Thailand (71), Israel (72) and Iran (73). Four of the 49 studies were excluded from the meta-analysis owing to BMI not being the measurement of obesity. All studies presented data in ORs, or had data available for the authors to calculate the ORs (74) (Tables 3–10).

Results

Primary outcomes

Most primary outcomes showed increasing odds associated with increasing BMI category (Table 11).

Labour and delivery meta-analysis

There are increased odds of instrumental delivery in obese women (Fig. 2), whereas there appears to be significant reduced odds for instrumental delivery in overweight women when compared with women of an ideal BMI. Meta-analysis could not be carried out for underweight women and instrumental delivery; however, there was no significant relationship between these factors in the one study identified (54).

Being overweight, obese or morbidly obese shows significant increased odds for overall and emergency caesarean delivery (Figs. 3 and 4), but this is not significant for elective caesarean delivery (Fig. 5). Being underweight has reduced odds with the need for caesarean delivery. For the overall caesarean delivery rate (including studies where the definition of emergency or elective caesarean delivery has not been specified) the meta-analysed results do not show an exponential trend with increasing obesity. However, there are only six studies included in the review that categorize obesity into subgroups that allowed the separate analysis of morbid obesity compared with ideal BMI (Fig. 4), whereas 16 studies analysed obesity generically (Fig. 3) and this might be masking a true exponential trend. It is worth noting that when studies were meta-analysed, comparing morbid obesity with 'non obese' rather than ideal BMI group ($n = 3$), the odds of a caesarean delivery being required increased to 2.36 from 1.43 when compared with ideal BMI only.

Hospital admission meta-analysis

There was a significant gradual increase in mean length of hospital stay as BMI increased, from 2.4 d for ideal BMI to 3.3 d for morbidly obese women (Fig. 6). The data from individual studies included in the meta-analysis showed an overall length of stay as being 2–3 d for those women with an ideal BMI, 2–4 d for women who were overweight or obese and 3–5 d for women who were morbidly obese (Table 10). The neonatal requirement for intensive care was not significant for overweight women, but was shown to be increased for both obese and morbidly obese women (Fig. 7). Neonatal intensive care requirements for underweight women could not be meta-analysed; however, two studies found an increased odds of 1.3 (95% CI 1.0, 1.5) (50) and 4.30 (95% CI 1.32, 13.97) (43), when compared with women with an ideal BMI.

Maternal complications meta-analysis

Women who were overweight, obese and morbidly obese had significantly increased odds of haemorrhage when compared with women with an ideal BMI (Fig. 8), whereas being underweight has reduced odds for this outcome. The rate of infection (including wound $n = 2$, abdominal wound $n = 1$, combined wound and uterine $n = 1$, and combined wound, urinary tract, perineum, chest and breast $n = 1$) was significantly higher in obese women with almost a 3.5-fold increase when compared with women of an ideal BMI (Fig. 9). Meta-analysis could not be carried out for under- or

Table 1 Characteristics of included studies

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Abrams and Newman (1991) (27)	USA – San Diego California	January 1978–December 1988 Prenatal Nutrition Project *n* = 2228	% ideal body weight (IBW)	Ideal weight (90–119% ideal) *n* = 1352	Underweight (<90% ideal) *n* = 389 Overweight (120–135% ideal) *n* = 261 Obese (>135% ideal) *n* = 226	Pre-pregnancy weight based on maternal recall at 1st antenatal visit	Pregnancies complicated by antepartum death, twin gestations, major congenital anomalies	• White (41%) • Hispanic (32%) • Black (15%) • Asian (11%) • Other (<1%)	• Small for gestational age (<10th percentile of reference standards for birth weight for gestational age and sex in California)
Baeten *et al.* (2001) (28)	USA – Washington	1992–1997 Identified by state birth certificates *n* = 96 801	BMI (kg m^{-2})	Underweight (<20) *n* = 18 988	Ideal (20–24.9) *n* = 50 425 Overweight (25–29.9) *n* = 17 571 Obese (≥30) *n* = 9817	Data taken from Washington state drivers licences for height, and Washington state birth certificates for pre-pregnancy weight	BMI not calculable, lost to follow-up, multiparous (but included previous termination <20 weeks), multiple gestations, diabetes, hypertensive conditions, non-live births	• White (80.8%) • African American (3.1%) • Native American (1.9%) • Asian (6.2%) • Hispanic (6.2%)	• Low birth weight (<2500 g) • Macrosomia (≥4000 g) • Small for gestational age (<sex specific 10th percentile) • Preterm delivery (<37 weeks gestation) • Very preterm delivery (≤32 weeks) • Caesarean delivery
Bergholt *et al.* (2007) (57)	UK – Wycombe General Hospital, Bucks, England	1 Jan 1995–31 Dec 2000 Consecutive nulliparous women with a single cephalic presentation and spontaneous onset of labour from 37 to 42 weeks *n* = 4341	BMI (kg m^{-2})	Ideal (<25) *n* = 1179	Overweight (25–30) *n* = 2043 Moderately obese (30–35) *n* = 859 Severely/morbidly obese (>35) *n* = 260	Direct weight measurement and self-reported height	Multiple gestations, non-cephalic presentation, previous pregnancies, non-spontaneous labour	• Not stated	• Caesarean delivery total • Caesarean delivery owing to fetal distress • Caesarean delivery owing to failure to progress

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Bianco *et al.* (1998) (29)	USA – New York	1988–1995 Mount Sinai Medical Centre *n* = 11 926	BMI (kg m^{-2})	Ideal (19–27) *n* = 11 313	Morbidly obese (>35) *n* = 613	Pre-pregnant BMI used	Women aged under 20 and over 34, multiple gestations, missing height or weight data	• White (71.1%) • Non-white (28.9%)	• Fetal growth restriction (definition consistent with American College of Obstetricians and Gynaecologists definition) • Placenta previa-abruption • Fetal distress (presence of repeated late decelerations, severe variable decelerations, persistent fetal tachycardia, poor beat to beat variability) • Presence of meconium • Failure to progress (arrest of dilation descent, failure to descend, or protracted dilation or descent) • Shoulder dystocia (difficulty delivering the anterior shoulder requiring one or more of the following manoeuvres: suprapubic pressure, hyperflexion of the hips, rotation of the shoulder girdle 180, delivery of the posterior arm, or fracture of the clavicle or humerous) • Preterm delivery (less than 37-week gestation) • Caesarean section • Post-partum haemorrhage (greater than 1000cc of estimated blood loss) • Wound infection • Low Apgar score (<4 at 1 min, <7 at 5 min) • Birth weight: low birth weight (<2500 g), very low birth weight (<1500 g) • Small for gestational age (<10th percentile for age and sex) • Large for gestational age (>90th percentile age and sex according to the Brenner nomogram) • Neonatal intensive care admissions • Hospital stay (mean days)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Bo *et al.* (2003) (59)	Italy – Turin	April 1999–Feb 2001 University of Turin obstetrics and gynaecology department. Women recruited with diabetes and non-diabetes as the comparison group. Data extraction for non-diabetes only *n* = 450	BMI (kg m^{-2})	Ideal (20–25) *n* = 333	Overweight and obese BMI (>25) *n* = 117	Pre-pregnancy BMI used	Pre-existing hypertension, diabetes mellitus, diseases affecting glucose metabolism	Not stated	• Caesarean delivery • Preterm delivery (<37 weeks) • Birth weight (mean) • Large for gestational age (>90th percentile for northern Italy) • Small for gestational age (<10th percentile for northern Italy)
Callaway *et al.* (2006) (67)	Australia – Brisbane	1998–2002 Mater Mothers Hospital obstetric database *n* = 11 252	BMI (kg m^{-2})	Ideal (20.01–25) *n* = 6443	Overweight (25–30) *n* = 2882 Obese 30–40 *n* = 1679 Morbidly obese >40 *n* = 248	Pre-pregnancy BMI recorded by recall at the 1st visit, usually before 12 weeks	Underweight women, missing BMI record, emergency and unbooked admissions	• Caucasian (82.0%) • Asian (8.7%) • Aboriginal or Torres Straight Islander (2.2%) • Other (7.0%)	• Birth weight (standard deviation *z* score, corrected for sex and gestation at delivery) • Length of stay (mean in days, and >5 d) • Spontaneous vaginal delivery • Assisted vaginal delivery • Caesarean section • Respiratory distress • Mechanical ventilation • Hypoglycaemia • Jaundice • Phototherapy • Premature (<34 weeks, <37 weeks) • Neonatal intensive care admission
Cerdergren (2004) (85)	Sweden	1992–2001 Identified by the Medical Birth Registry *n* = 610 969	BMI (kg m^{-2})	Ideal (19.8–26) *n* = 526 038	Obese (29.1–35) *n* = 69 143 Severely obese (35.1–40) *n* = 12 402 Morbidly obese (>40) *n* = 3386	Maternal height and weight measured at 10–12 weeks gestation	Insulin-dependent diabetes mellitus, multiple gestations, only 1st delivery used if >1 in the study time period, maternal height/weight missing, hypertension	• Caucasian (majority) • South American (1%) • Asian (1.4%) • Sub-Saharan African (1%)	• Abruptio placenta • Placenta previa • Caesarean delivery • Instrumental delivery • Anal sphincter laceration (only vaginal deliveries) • Shoulder dystocia (only vaginal deliveries) • Major post-partum haemorrhage (only vaginal deliveries) • Epidural anaesthesia (only vaginal deliveries) • Induction of labour • Small for gestational age (<2 SD) • Large for gestational age (>2 SD) • Presence of meconium aspirate • Fetal distress • Low Apgar score (<7 at 5 min) • Macrosomia (>4500 g) • Gestational age at delivery (42, <37, <32 weeks)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Cnattingius *et al.* (1998) (63)	Sweden	1992–1993 Identified via Swedish Medical Birth Register for all infants born in Sweden *n* = 167 750	BMI (kg m^{-2})	Underweight (<20) *n* = 22 634	Normal (20–24.9) *n* = 101 266 Overweight (25–29.9) *n* = 33 438 Obese (>30) *n* = 10 412	Weight recorded by patient recall prior to 15-week gestation	Non-singleton births, information on pre-pregnancy BMI was not available	All mothers born in Sweden, Denmark, Finland or Iceland. No further details given	• Preterm delivery (<37 weeks) • Very preterm delivery (≤32 weeks) • Small for gestational age (birth weight >2 SD below mean for GA for Sweden)
Crane *et al.* (1997) (30)	USA – New York	1994–1995 Central New York Regional Perinatal Data System [1]Entire sample *n* = 19 699 [2]Singleton, no prior caesarean *n* = 16 391	BMI (kg m^{-2})	Non-obese (<29) [1]*n* = 16 108 [2]*n* = 13 672	Results split into two groups with different BMI categories: Obese (>29) [1]*n* = 3591 [2]*n* = 2791 ----------------- Obese (29–34.9) [1]*n* = 2340 [2]*n* = 1819 [2]Severe obese (35–39.9) [1]*n* = 813 [2]*n* = 605 [2]Morbidly obese (>39.9) [1]*n* = 438 [2]*n* = 295	Pre-pregnancy weight and height were self-reported	Stillbirths, births <20 weeks gestation, multiple pregnancies, incomplete data	• White (control 89.6%, obese 89.7%) • Black (control 6.7%, obese, 7.9%) • Other (control 3.7%, obese 2.4%)	• Mode of delivery (vaginal, caesarean) • Birth weight (mean)
Dempsey *et al.* (2005) (31)	USA – Seattle and Washington	1996–2000 Omega Study – women attending prenatal care clinics primarily designed to examine maternal dietary risk factors of pre-eclampsia and gestational diabetes. Initially included nulliparous, later included multiparous *n* = 738	BMI (kg m^{-2})	Underweight (<20) *n* = 158	Normal (20–24.9) *n* = 424 Overweight (25–30) *n* = 103 Obese (>30) *n* = 53	Data were collected by interview prior to 16-week gestation	Lost to follow-up, declined to participate, spontaneous abortion, induced abortion, diabetes, missing data, presented >16 weeks, <18 years, not able to speak/read English, intended to deliver elsewhere	• White (85.2%) • African American (1.8%) • Asian (7.3%) • Other (5.7%)	• Caesarean delivery • No caesarean • Indication for caesarean: ▪ Fetal position ▪ Cephalopelvic disproportion/failure to progress ▪ Fetal distress (not defined) ▪ Other (placenta previa, failed induction, placental abruption, active herpes, patient desire, other indications not specified)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Di Cianni *et al.* (2003) (60)	Italy – Pisa	1987–1992 University of Pisa obstetrics and gynaecology computerized data system. Population selected at random to be a comparison group for women with gestational diabetes mellitus (GDM). Data extraction only for non GDM women *n* = 110	BMI (kg m^{-2})	Ideal (<25) *n* = 44	Overweight (25–30) *n* = 39 Obese (>30) *n* = 27	Pre-pregnancy BMI used	No gestational diabetes or family history	Not stated	• Gestational age (mean weeks) • Preterm (<38 weeks) • Macrosomia (neonatal size >4 kg at 40th week, or >95th percentile – states 95th percentile in the methods and 90th percentile in the discussion) • Hyperbilirubinaemia (not defined)
Doherty *et al.* (2006) (32)	USA	Recruitment dates unclear Data were collected during a randomized controlled trial evaluating the effectiveness of Doppler ultrasound in unselected pregnancies *n* = 2769	BMI (kg m^{-2})	Ideal (18.5–25) *n* = 1982	Underweight (<18.5) *n* = 331 Overweight (25–30) *n* = 326 Obese (>30) *n* = 188	Questionnaire completed by research midwives at initial visit (16–20 weeks) and pre-pregnancy BMI was used	Non-singleton gestations, pregnancy loss, missing BMI	• Ethnicity Caucasian (89.92%)	• Labour induction • Caesarean delivery • Caesarean delivery for fetal distress • Post-partum haemorrhage • Perineal trauma • Infection (wound, perineum, urinary tract, chest, breast) • Retained placenta • Intrauterine growth restriction • Neonatal resuscitation
Ehrenberg *et al.* (2004) (33)	USA – New Orleans	1997–2001 Metrohealth medical centre database *n* = 12 303	BMI (kg m^{-2})	Ideal (19.8–25) *n* = 5142	Underweight (<19.8) *n* = 1728 Overweight (25–30) *n* = 2828 Obese (>30) *n* = 2605	Prenatal weight was self-reported and height was measured at the initial visit	Multiple gestation, pregnancies not eligible for a trial of labour, delivered <23 weeks, prior caesarean, non-vertex presentation, scheduled for elective caesarean, contra indicated for vaginal delivery	• Black (39.9%) No further details given	• Caesarean section • Preterm delivery (<37 weeks) • Term delivery (≥37 weeks) • Labour onset induced • Labour dystocia
Ehrenberg *et al.* (2004) (34)	USA – New Orleans	1997–2001 Metrohealth medical centre database *n* = 12 950	BMI (kg m^{-2})	Ideal (19.8–25) *n* = 5391	Underweight (<19.8) *n* = 1640 Overweight (25–30) *n* = 2991 Obese (>30) *n* = 2928	Prenatal weight was self-reported and height was measured at the initial visit	Multiple gestation, non-live born, preterm delivery (<37 weeks)	• Black (39%) No further details given	• Large for gestational age (gestational weight >90th percentile for gestational age at the institution of study) • Birth weight (mean and SD)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Ekblad and Grenman (1992) (49)	Finland	1 July 1985 (6 months) Subjects recruited from the Turku University Central Hospital delivery room logbook *n* = 271	Percent ideal weight for height (IWH)	Ideal weight for height *n* = 166	Overweight (≥20% over IWH) *n* = 77 Underweight (≤20% under IWH) *n* = 28	Pre-pregnancy weight used, height measured at delivery	The study population was selected because of the abnormal pre pregnancy weight or abnormal weight gain (≥20 or ≤5 kg) and the next sequential normal weight woman selected	Not stated	• Gestational age (mean weeks) • Birth weight (mean grams) • Induction • Vaginal delivery • Forceps or vacuum (instrumental delivery) • Caesarean (elective, emergency) • Shoulder dystocia • Vaginal repair (2nd, 3rd degree) • Birth weight (weight percentile >90%, <10%) • Apgar score (mean at 1, 5 and 10 min) • Admission to neonatal intensive care
Galtier-Dereure *et al.* (1995) (23)	France – Montpellier	1980–1993 Department of Obstetrics & Gynaecology, Montpellier Hospital *n* = 112	BMI (kg m^{-2})	Ideal (18–24.9) *n* = 54	Overweight (25–29.9) *n* = 48 Obese (30–34.9) *n* = 34 Morbidly obese (>35) *n* = 30	Pre-gravid weight	Hepatic, cardiac or renal failure, previous DM, height <145 cm, age <18 years	Not stated	• Macrosomia (birth weight >90th percentile for gestational age) • Growth retardation (birth weight <10th percentile for gestational age) • Preterm labour (not defined) • Mean term (weeks) • Duration of labour (hours – overall and primiparous) • Caesarean delivery (overall and 1st caesarean) • Duration of hospitalization (days – outpatients and inpatients) • Cost of prenatal care (hospitalization)
Galtier-Dereure *et al.* (2000) (65)	France – Montpellier	October 1993–December 1994 Pregnant women seen consecutively at Montpellier Hospital. 54 women had a BMI>26, each paired with a normal weight control *n* = 84	BMI (kg m^{-2})	Ideal (18–25) *n* = 42	Overweight and obese (>26) *n* = 42	Pre-pregnancy BMI used	Previous diabetes mellitus or severe disease, height <145 cm, age <18 years, incomplete hospital records	Not stated	• Daytime hospitalization • Night-time hospitalization

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Giuliani *et al.* (2002) (66)	Austria – Graz	1996–2000 Department of Obstetrics & Gynaecology, Graz n = 11 114	BMI (kg m^{-2})	Ideal (19.8–26) n = 6998	Underweight (<19.8) n = 2198 Overweight (26–29) n = 1025 Obese (≥29) n = 893	Pre-pregnancy weight was self-reported	Deliveries <36 weeks, multiple gestations, non-spontaneous delivery, incomplete datasets	• Caucasian (98%) • Asian (1%) • Black (1%)	• Puerperal period complications (occurring between 2 h after delivery and 42 d post-partum) • Urine tract infection (presence of positive urine culture (>1 000 000 micro organisms/mL with or without fever) • Wound infection (pain purulent drainage from episiotomy, perineal rupture, or laceration site with indurations) • Haemorrhage • Readmission to hospital • Thromboembolic events
Hellerstedt *et al.* (1997) (35)	USA – Minnesota	January 1977–August 1993 St. Paul-Ramsey Medical Centre deliveries, matched obese with normal weight for ethnicity, delivery date, age and parity n = 1343	BMI (kg m^{-2})	Ideal (19.8–26) n = 660	Obese (>29) n = 683	Pre-gravid weight used	Missing data, multiple gestations, fetal deaths	• White (69.0%) • Black (20.5%) • Hispanic (6.6%) • Native American (3.5%)	• Birth weight (mean grams as a continuous variable) • Birth weight as a dichotomous variable (large for gestational age >90th percentile sex-specific weight for age, small for gestational age <10th percentile sex-specific weight for age) • Mean gestational age at birth • Preterm birth (<37 weeks)
Hendler *et al.* (2005) (36)	USA – Detroit	1992–1994 Preterm Prediction Study n = 2910	BMI (kg m^{-2})	Results split into two groups with different BMI categories: [1]Ideal (19–24.9) n = not stated [2]Non-obese (<30) n = 2313	[1]Underweight (<19) n = not stated Overweight (25–29.9) n = not stated Obese (30–34.9) n = not stated Morbidly obese (>35) n = not stated [2]Obese (≥30) n = 597	Pre-pregnancy weight used	Multifetal gestation, prenatally detected major fetal abnormalities, history of cervical cerclage in current pregnancy, placenta previa, maternal height and weight data not available	• Black (62.3%)	• Caesarean delivery (group 2) • Birth weight (mean, group 2) • Macrosomia (>4000 g, group 2) • Spontaneous preterm birth (SPB <37, <34, <32 weeks, group 2) • Total rate preterm deliveries • Gestational age (mean weeks, group 2) • SPB (<37 weeks, group 1)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Hulsey *et al.* (2005) (37)	USA – South Carolina	1998–1999 Data provided by the Division of Biostatistics, South Carolina Department for Health and Environmental Control. Birth certificate data were linked to the South Carolina Pregnancy Risk Assessment Monitoring System. Women selected for the study by a systematic stratified sampling strategy that is weighted on the basis of birth weight *n* = 87 293	BMI (kg m^{-2})	Ideal (19.8–26) *n* = 45 916	Underweight (<19.8) *n* = 14 141 Overweight (26.1–29.0) *n* = 10 039 Obese (>29) *n* = 17 197	Pre-pregnant weight used	Multiple gestation, non-live birth	• White (56.3%) • Black (43.7%)	• Very low birth weight (500–1499 g) • Moderately low birth weight (1500–2499 g)
Jensen *et al.* (1999) (54)	Denmark – Herning	1993–1998 Herning Central Hospital Obstetric Department *n* = 4258	BMI (kg m^{-2})	Ideal (20–24.9) *n* = 2520	Underweight (<20) *n* = 757 Overweight (25–29.9) *n* = 727 Obese (≥30) *n* = 254	Pre-pregnancy weight and height recorded on the database	Registered complication in an actual pregnancy. Pre- or post-term delivery, induction of present delivery, non-vertex presentation, antepartum fetal death, previous caesarean delivery	Not stated	• Oxytocin • Induced (amniotomy <6 cm) • Instrumental delivery (ventouse/forceps) • Caesarean • Episiotomy • Imminent asphyxia • Dysproportion • Primary inertia • Secondary inertia • Pushing (>1 h for primiparous, >30 min for multiparous) • Shoulder problems • Retained placenta • Perineal rupture • Sphincter rupture • Uterine atony • Bleeding (>499 mL) • Occiput posterior • Low birth weight (≤2500 g) • Macrosomia (birth weight ≥4500 g) • Apgar < 7 (5 min) (not many outcomes defined)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Jensen *et al.* (2003) (53)	Denmark – Copenhagen, Odense, Aarhus	1992–1996 Recruited women who underwent screening for gestational diabetes mellitus using oral glucose tolerance tests in one of the four recruitment centres (Copenhagen County Hospital, Rigshospitalet, Aarhus, and Odense) *n* = 2459	BMI (kg m^{-2})	Ideal (18.5–24.9) *n* = 1094	Overweight (25–29.9) *n* = 728 Obese (≥30) *n* = 637	Pre-pregnancy BMI used	Gestational diabetes, dietary treatment despite normal glucose tolerance test, underweight (BMI < 18.5), data height or weight missing, subsequent pregnancies in recruitment time frame, well-defined chronic disease, multiple gestations	Not stated	• Macrosomia (birth weight ≥4000 g) • Large for gestational age (birth weight in 90th percentile for standard Danish population) • Small for gestational age (birth weight <10th percentile for Danish population) • Caesarean delivery • Induction of labour (% of total excluding elective caesareans) • Respiratory distress (infants with respiratory distress were treated with continuous positive airway pressure for at least 30 min) • Shoulder dystocia (additional obstetric manoeuvres required) • Preterm delivery (before 37 weeks) • Hypoglycaemia (need for intravenous glucose during 1st 48 h) • Jaundice
Johnson *et al.* (1992) (38)	USA – Florida	1987–1989 Identified via the maternity units computerized medical record system at the University of Florida Department of Obstetrics and Gynaecology *n* = 3191	BMI (kg m^{-2})	Underweight (<19.8) *n* = 755	Ideal (19.8–26) *n* = 1621 Overweight (27–29) *n* = 329 Obese (>29) *n* = 486	Self-reported pre-gravid weight	Preterm delivery (<38 weeks), multiple gestation, fetal abnormalities, oligohydraminos, polyhydraminos, medical or surgical complications, incomplete risk data, incomplete outcome data, stillbirth	• White (58%) • Black (40%) • Other	• Fetal macrosomia (≥4000 g) • Low birth weight (<2500 g where the risk factor for birth weight <2500, 2500–4000, >4000 was excluded) • Presence of meconium staining • Unscheduled caesarean section • Labour abnormality – (prolonged latent phase, protracted active phase, secondary arrest of dilation, arrest of descent, prolonged second stage) • Fetal compromise/heart rate abnormality (decreased variability, bradycardia or tachycardia for >10 min, multiple variables, late decelerations) • Newborn resuscitation (artificial ventilation and endotracheal intubation) • Post-dates – (gestational age excluded as a risk factor)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Kaiser and Kirby (2001) (39)	USA – Milwaukee	1994–1998 Nurse-midwifery centre, Milwaukee Medical Campus, recruited healthy women undergoing midwife-led care *n* = 1881	BMI (kg m^{-2})	Ideal (19.8–26) *n* = 954	Underweight (≤19.7) *n* = 249 Overweight (26–29) *n* = 226 Obese (≥29) *n* = 452	Self-reported pre-pregnancy weight was used, unless there was a discrepancy then measured before 12-week gestation	Chronic conditions (diabetes, hypertension, unstable asthma), prenatal complications (multiple gestation, fetal malformations, gestational diabetes), repeat caesareans (chosen by the mother), missing height and weight data	• Black (77.1%) • Hispanic (6.6%) • White (14.9%) • Other (1.4%)	• Caesarean delivery
Kiran *et al.* (2005) (8)	UK – Cardiff, Wales	1990–1999 Study population drawn form the Cardiff Birth Survey *n* = 8350	BMI (kg m^{-2})	Non-obese (20–30) *n* = 7673	Obese (≥30) *n* = 677	Height and weight measured by midwife at booking	Non-primigravidas, multiple gestation, non-cephalic presentation, <37 weeks gestation, height and weight not measured, congenital abnormalities, pre-eclampsia, gestational diabetes mellitus, medical disorders (diabetes, chronic hypertension, cardiac or endocrine disorders, and surgical conditions), BMI < 20	• White (91.5%)	• Macrosomia (>4000 g) • Post-dates (>41 weeks) • Oxytocin • Labour duration (first stage/second stage, second stage >2 h) • Mode of delivery (spontaneous vaginal, assisted vaginal, caesarean: emergency/elective, induced, not induced, failed instrumental) • Blood loss (>500 mL – post-partum haemorrhage as defined by WHO) • Transfusion • Uterine and wound infection • Perineal tear (3rd/4th degree) • Apgar at 5 min (<7) • Asphyxia (based on clinical impression of the infant including Apgar score, respiratory difficulty, blood pressure, pulse, muscle tone and coma if present) • Trauma (cuts, grazes, bruises, fractures, muscle haematomas, dislocation, cephalhaematomas, nerve palsies) • Shoulder dystocia • Neonatal unit admissions • Cord (pH < 7.2) • Tube feeding • Incubator requirement • Urine tract infection • Evacuation uterus

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Konje *et al.* (1993) (58)	UK – Hull	January 1989–June 1990 Women who booked before 16-week gestation at Hull Maternity Hospital, and were obese were matched with non-obese women n = 862	Percent IWH	Non-obese n = 354	Obese (>130 IWH for Hull population) n = 508	Women weighed and categorized into obese and non-obese using data from Hull Maternity Unit to define cut-offs. 750 women were randomly sampled at <16-week gestation, between Sept and Dec 1988. Data plotted to make a nonogram for the Hull population	Booking gestation >16 weeks	Not stated	• Difficulty determining fetal lie • Antepartum haemorrhage • Premature rupture of membranes • Preterm labour (<37 weeks) • Prolonged pregnancy (>42 weeks) • Birth weight (mean) • Macrosomia (>4000 g) • Onset of labour (spontaneous or induced) • Instrument delivery (forceps) • Caesarean delivery (total, elective) • Epidural analgesia • Duration of labour (hours) • Blood loss (mean) • Retained placenta • Perineal wound infection • Abdominal wound infection
Kramer *et al.* (1999) (68)	Canada – Montreal	1978–1996 Royal Victoria Hospital computerized obstetric and neonatal database n = 37 164	BMI (kg m^{-2})	Ideal (19.8–26) n = 22 819	Underweight (<19.8) n = 9179 Overweight (26–29) n = 2750 Obese (≥29) n = 2416	Pre-pregnant BMI used	Multiple gestations, congenital abnormalities	Not stated (ethnically diverse population)	• Intrauterine growth restriction (No IUGR = Birth Weight Ratio of ≥0.85, Mild IUGR = BWR of ≥0.75 to <0.85, Severe IUGR = BWR of <0.75) • Intrauterine growth restriction at term (≥37 completed weeks gestation) • Intrauterine growth restriction preterm (<37 completed weeks gestation)
Kugyelka *et al.* (2004) (40)	USA – New York	1998–2000 (Hispanic group) 1999–2000 (Black group) Community-based study reviewing medical records and information in the perinatal database at two hospitals in upstate New York Black n = 640 Hispanic n = 587	BMI (kg m^{-2})	Black: Ideal (19.1–26.0) n = not stated Hispanic: Ideal (19.1–26.0) n = not stated	Black: Overweight (26.1–29) n = not stated Obese (>29.1) n = not stated Hispanic: Overweight (26.1–29) n = not stated Obese (>29.1) n = not stated	Pre-pregnancy BMI	Multiple gestation, preterm birth, BMI unobtainable, lost to follow up, death in infancy, stay in hospital ≥7 d (mother or baby), neonatal intensive care, cleft lip and palate, neural tube defects, discharged to foster care/adoption, maternal diabetes or serious medical conditions	• Hispanic (47.8%) • Black (52.2%)	• Birth weight (g) • Age of infant at discharge (days – used as length of stay data) • Apgar at 5 min (continuous score)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Kumari (2001) (69)	Abu Dhabi	1996–1998 Women who attended the Al-Mafraq hospital within the first 12 weeks of pregnancy and weighed >90 kg had their BMI measured, matched for age and parity with non-obese controls. Data retrieved from the delivery room records and prospectively entered into computerized forms *n* = 488	BMI (kg m^{-2})	Non-obese (22–28) *n* = 300	Morbidly obese (≥40) *n* = 188	Measured height and weight within 12 weeks of pregnancy	Chronic hypertension or diabetes, didn't attend antenatal clinic within 12 weeks	Not stated	• Placental previa • Abruption • Caesarean section (elective, emergency and total) • Shoulder dystocia • Preterm labour • Intrauterine growth restriction • Low birth weight (<2500 g) • Macrosomia (birth weight >4000 g) • Low Apgar (<7 at 1 min) • Neonatal intensive care admission
Lombardi *et al.* (2005) (41)	USA – Kentucky	1990–2000 Patients enrolled in an outpatient management programme, normal weight pregnant women with mild gestational hypertension matched with obese for gestational age at diagnosis, race and parity *n* = 730	BMI (kg m^{-2})	Ideal (20–25) *n* = 365	Obese (≥30) *n* = 365	Pre-pregnancy BMI used	Patients with associated medical problems, fetal compromise, rupture of membranes	• White (80.8%)	• Abruptio placenta • Caesarean delivery • Preterm (<34 weeks) • Birth weight (mean) • Low birth weight (<2500 g) • Very low birth weight (<1500 g)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Lumme *et al.* (1995) (50)	Finland	1985–1986 University of Oulu *n* = 9015	BMI (kg m^{-2})	Ideal (19–24.9) *n* = 6437	Underweight (<19) *n* = 992 Overweight (25–29.9) *n* = 1235 Obese (≥30) *n* = 352	Pre-pregnancy body weight was self-reported, then checked at the first antenatal visit	Multiple pregnancies, missing height and weight data	Not stated	• Preterm delivery (<37 weeks) • Post-term delivery (>41 weeks) • Small for gestational age (birth weight <10th percentile for gestational age for the same cohort) • Large for gestational age (birth weight >90th percentile for gestational age based on the same cohort) • Low birth weight (<2500 g) • Macrosomia (≥4500 g) • Low Apgar score (<7) • Neonatal intensive care • Hospital admission during pregnancy • Labour induction • Non-spontaneous delivery (induced labour and those delivered by elective caesarean) • Caesarean section • Intra-operative haemorrhage (>1000 mL in caesarean deliveries) • Post-operative maternal morbidity (total) • Wound infection
Mancuso *et al.* (1991) (61)	Italy	Dates of enrolment not stated Pregnant women admitted to the Institute of Gynaecology of the Messina University with a gestational age of 34–42 weeks recruited into the study *n* = 140	BMI (kg m^{-2})	Non-obese (<30) *n* = 90	Obese (≥30) *n* = 70	Pre-pregnant BMI used	Gestational age <34 or >42 weeks	Not stated	• Gestational age at delivery (<37, 38–41, >42 weeks) • Spontaneous delivery • Caesarean delivery • Iterative caesarean section • Instrumental delivery (forceps) • Low birth weight (<2500 g) • Macrosomia (birth weight >4000 g) • Apgar score at 1 min (<7, >7) • Puerperium complications (pyrexia, haemorrhage, uterine sub-involution)
Naeye (1990) (42)	USA – 12 medical school-affiliated hospitals in different regions of the USA	1959–1966 Collaborative Perinatal Study (CPS) of the neurological and communicative disorders and stroke. Prospectively follows children from before birth to 7 years *n* = 55 665 singletons *n* = 598 twins	BMI (kg m^{-2})	Underweight (<20) *n* = 12 669	Ideal (20–24) *n* = 28 810 Overweight (25–30) *n* = 10 160 Obese (>30) *n* = 5218	Pre-gravid BMI used, maternal height was measured and pre-gravid weight was self-reported at the first antenatal clinic visit	Women who delivered at a non-CPS hospital	• Black (46.3%) No further details specified	• Premature (24–30 weeks, 31–37 weeks) • Birth trauma (skull fracture) • Neonatal respiratory distress syndrome (not defined)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Nucci *et al.* (2001) (70)	Brazil	1991–1995 Prenatal clinics in six state capitals *n* = 5314	BMI (kg m^{-2})	Ideal (18.5–24.9) *n* = 3583	Underweight (<18.5) *n* = 309 Overweight (25–29.9) *n* = 1086 Obese (≥30) *n* = 336	Pre-pregnancy weight used by maternal recall. Height was measured in duplicate	Diabetic women, age <20, missing data to calculate BMI	• White (45.2%) • Mixed race (41.4%) • Black (13.4%)	• Large for gestational age (birth weight ≥90th percentile for gestational age of the study sample) • Microsomia (birth weight ≤10th percentile for gestational age of the study sample) • Gestational age (hierarchal criteria based on four clinical examinations)
Ogunyemi *et al.* (1998) (43)	USA – New Jersey & Alabama	1990–1995 Women who registered for prenatal care in the 1st trimester at Morristown Memorial Hospital, predominantly a rural black population *n* = 582	BMI (kg m^{-2})	Ideal (19.8–26) *n* = 223	Underweight (<19.8) *n* = 78 Overweight (26–29) *n* = 78 Obese (≥29) *n* = 203	Pre-pregnancy weight and height self-reported at 1st visit, measured in 1st trimester, women wearing light clothes and no shoes	Multiple gestation, >37-week gestation at delivery, self-reported height and weight if difference between measured weight >10%, not low income women, registration for prenatal care not in 1st trimester	• Black (100%)	• Low birth weight (<2500 g) • Birth weight (mean and SE) • Neonatal intensive care • Caesarean delivery
Olesen *et al.* (2006) (55)	Denmark	1998–2001 Data retrieved from the Danish Birth Cohort which are a follow-up study that recruited 100 000 pregnant women in Denmark from 1996 to 2004 *n* = 48 064	BMI (kg m^{-2})	Ideal (20–24) *n* = 26 468	Underweight (<20) *n* = 7918 Overweight (25–30) *n* = 9201 Moderately obese (30–34) *n* = 2713 Severely/ morbidly obese (>35) *n* = 1020	Interviewed at 12 weeks and asked for pre-pregnancy BMI	Women who could not speak Danish well enough or those without access to a phone, multiple gestations, non-live birth	• Not stated	• Post-term delivery (>42 weeks)
Phithakwatchara and Titapant (2007) (71)	Bangkok, Thailand	Jan 2003–Dec 2005 Retrospective review using medical records of pregnant women who received prenatal care and delivered at the Siriraj Hospital. All women in the study were at risk of gestation diabetes mellitus *n* = 660	BMI (kg m^{-2})	Ideal (20–25) *n* = 330	Obese (≥27) *n* = 330	Pre-pregnancy BMI from medical records	Those women without pre-pregnancy weight status recorded, multiple gestation, pre-existing chronic illness, planned elective CD, no non-cephalic presenting pregnancies	• Not stated	• Preterm delivery (<37 weeks) • Caesarean delivery (non-planned) • Macrosomia (>4000 g) • Low birth weight (not defined) • Neonatal Jaundice (requiring phototherapy) • Hypoglycaemia (requiring intravenous glucose in 1st 48 h) • Shoulder dystocia

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Ranta *et al.* (1995) (51)	Finland	1992 (3-month period) University of Oulu n = 662	BMI (kg m^{-2})	Ideal (20–24.9) n = 609	Obese (≥30) n = 53	Pre-pregnancy BMI recorded from measured height and self-reported weight at 1st antenatal visit (7–12 weeks)	Scheduled caesarean deliveries	Not stated	• Pain intensity (in delivery room, 11-point visual scale where 0 is no pain and 10 is worst pain) • Vaginal delivery • Induced • Instrumental delivery (vacuum extraction) • Caesarean delivery: emergency • Duration of labour (1st and 2nd stage) • Epistiotomy • Vaginal repair • Analgesia (none, epidural, paracervical block, nitrous oxide, pethidine) • Birth weight (mean) • Apgar score (median at 1, 5 and 15 min) • Intubation • Neonatal intensive care admission
Rantakallio *et al.* (1995) (52)	Finland	1985–1986 University of Oulu n = 9243	BMI (kg m^{-2})	Ideal (20–24.9) n = 5357	Underweight (<20) n = 2161 Overweight (25–29.9) n = 1254 Obese (30–35) n = 283 Morbidly obese (>35) n = 73	Pre-pregnancy weight used	Unknown height/weight	Not stated	• Preterm birth (<37th full gestational week) • Low birth weight (<2500 g) • Small for gestational age (birth weight <10th percentile for gestational age specific percentile curve)
Rode *et al.* (2005) (56)	Denmark	1998–2001 Copenhagen First Trimester Study, Gestational age <15 weeks at enrolment n = 8092	BMI (kg m^{-2})	Ideal (<25) n = 6350	Overweight (25–29.9) n = 1298 Obese (≥30) n = 444	Pre-pregnancy BMI recorded prior to 15-week gestation	Multiple gestation, non-cephalic delivery, delivery <37 weeks, missing BMI record, miscarriage	Not stated	• Premature rupture of membranes • Placental abruption • Caesarean delivery (overall, emergency, elective) • Instrumental delivery (vacuum extraction) • Shoulder dystocia • Perineal rupture (3rd/4th degree) • Preterm delivery (<37 weeks) • Post-term (>42 weeks) • Low umbilical cord pH (<7) • Low Apgar score (<7 at 5 min) • Birth weight (<2500 g and >3999 g)

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Rosenberg *et al.* (2003) (44)	USA – New York	1998–1999 Birth certificate data from the New York City Department of Health, Office of Vital Statistics and Epidemiology *n* = 213 208	Weight (lb kg^{-1})	100–149 lb/45–67 kg *n* = 135 932	≤99 lb/45 kg *n* = 6206 150–199 lb/ 68–90 kg *n* = 57 758 200–299 lb/ 91–135 kg *n* = 12 897 ≥300 lb/136 kg *n* = 415	Pre-pregnancy weight identified via birth certificates (BMI could not be calculated as the birth certificates do not record maternal height)	Missing weight data, multiple gestation, non-live births	• White (29.5%) • Black (27.6%) • Hispanic (32.2%) • Asian/other (10.7%)	• Caesarean delivery • Very low birth weight (<1500 g) • Macrosomia (≥4000 g) • Neonatal intensive care admission
Rossner and Ohlin (1990) (64)	Sweden	Dates of enrolment not defined The Stockholm Pregnancy and Weight Development Study *n* = 1423	BMI (kg m^{-2})	Underweight (<20) *n* = 657	BMI (20.0–23.9) *n* = 1326 BMI (24–25.9) *n* = 174 Overweight/obese (>26) *n* = 127	Pre-pregnancy self-reported body weight was retrieved from the maternity unit standardized chart	Twin deliveries, serious complications, women who withdrew at 6-month and 12-month follow-up	Not stated	• Birth weight • Mode of delivery (vaginal, caesarean)
Sheiner *et al.* (2004) (72)	Israel – Negev	1988–2002 Soroka Medical Centre computerized medical records *n* = 126 080	BMI (kg m^{-2})	Non-obese (BMI not stated assume <30) *n* = 124 311	Obese (≥30) *n* = 1769	Pre-pregnant BMI used	Hypertension, gestational and pre-gestational diabetes, patients lacking prenatal care (less than three visits)	• Jewish (54.9%) • Bedouins (45.1%)	• Macrosomia • Previous caesarean delivery • Caesarean delivery • Labour induction • Placental abruption • Placenta previa • Failure to progress (1st and 2nd stage) • PROM • Meconium-stained amniotic fluid • Malpresentation • Low Apgar score (1 min and 5 min <7) • Shoulder dystocia • Post-partum haemorrhage • Packed cells transfusion • Peripartum fever • Low birth weight (<2500 g)
Shepard *et al.* (1998) (45)	USA – New Haven (Yale)	1988–1992 Yale – New Haven Hospital, privately insured women only *n* = 2301 or 2714, details unclear	BMI (kg m^{-2})	Low average (19.5–22.4) *n* = not stated	Underweight (<19.4) *n* = not stated High average (22.5–28.5) *n* = not stated Obese (>28.5) *n* = not stated	Pre-pregnancy weight recorded at initial interview less than 16-week gestation	Multiple gestation, missing BMI data, mode of delivery data not available, repeat caesarean, GDM, not privately insured	• White (90.8%) • Black (5.0%) • Asian (2.5%) • Hispanic (1.1%) • Other (0.5%)	• Mode of delivery (caesarean and vaginal)
Steinfeld *et al.* (2000) (46)	USA – Connecticut	1994–1997 Hartford Hospital Department of Obstetrics and Gynaecology computerized records *n* = 2424	BMI (kg m^{-2})	Non-obese (BMI not stated assume <29) *n* = 2256	Obese (>29, if BMI not available weight of 200 lb or more) *n* = 168	Pre-pregnancy weight used	Not stated	• Hispanic (65.8%) • African American (16.8%) • White (13.7%) • Asian (1.4%) • Mixed/other	• Fetal macrosomia (≥4500 g) • Caesarean delivery (excluded caesarean delivery for fetal malpresentation, placenta previa or patient request) • Operative/instrumental vaginal delivery (including vacuum assisted and forceps delivery)

Table 1 *Continued*

Paper	Setting	Enrolment dates/ recruitment procedure	Classification body weight status	Control group	Study group(s)	Measurement of weight status	Exclusions	Ethnic population	Outcome (definition)
Vahratian *et al.* (2004) (47)	USA – North Carolina	1995–2000 Pregnancy, Infection and Nutrition study *n* = 612	BMI (kg m^{-2})	Ideal (19.8–26) *n* = 297	Overweight (26–29) *n* = 115 Obese (>29) *n* = 200	Self-reported pre-pregnancy weight, 1st measured weight at booking <16 weeks, measured height at booking	Term status misclassified, nulliparity misclassified, patient charts not located, elective caesarean, <16 years, multiple gestation, non-English speaker, no telephone access, prenatal visit not before study enrolment, planned to be delivered at non-study hospitals, multiparous, pre-pregnancy BMI < 19.8	• White (53.9%) • African American (39.7%) • Other (6.4%)	• Macrosomia (not defined) • Birth weight (mean, SD) • Method Membrane Rupture (spontaneous, artificial/induced, undetermined) • Spontaneous vaginal delivery • Instrument-assisted vaginal delivery • Primary emergent caesarean • Indications for primary caesarean (failure to progress, malpresentation, fetal distress, placental abruption, failed induction, failed forceps/vacuum delivery, other factor) • Oxytocin • Epidural
Weiss *et al.* (2004) (48)	USA – New York	Enrolment dates not stated FASTER Trial: multi-centre study designed to assess down syndrome risk *n* = 16 102	BMI (kg m^{-2})	Non-obese (<30) *n* = 13 752	Severely obese (30–34.9) *n* = 1473 Morbidly obese (>35) *n* = 877	Self-reported weight and height at 1st visit (enrolled at 10–14 weeks gestation)	Multiple gestation, incomplete records (caesarean delivery – nulliparous women only as data on previous caesarean delivery was not available)	• White (70.9%) • American Indian (0.6%) • Asian (3.5%) • African American (4.8%) • Hispanic (19.5%) • Other (0.6%)	• Caesarean delivery (total rate amongst nulliparous) • Operative vaginal delivery (% of all except elective caesareans, forceps or vacuum assisted) • Preterm delivery (<37 weeks) • Preterm premature rupture of membranes (<37 weeks) • Intrauterine growth restriction (estimated fetal weight by ultrasound below 10th percentile or birth weight below the 10th percentile for gestational age) • Birth weight (>4000 g and >4500 g) • Placenta previa (placenta completely or partially covering the internal os) • Placental abruption (premature separation of a normally implanted placenta)
Yekta *et al.* (2006) (73)	Iran, Urmia	2002 and 2003 Prospective cross-sectional study recruiting women who enrolled in public healthcare centres in urban areas of Urmia *n* = 270	BMI (kg m^{-2})	Ideal (19.8–26) *n* = 140	Underweight (<19.8) *n* = 30 Overweight (26–29) *n* = 52 Obese (>29) *n* = 48	Baseline weight and height recorded during first visit, pre-pregnancy weight based on measure weight in first 2 months of pregnancy	Preterm delivery (<37 weeks), Low birth weight (<2500 g) and c-section Women with uncomplicated pregnancies that did not include: pre-eclampsia, twin gestation, history of diabetes, cardiovascular and kidney diseases	• Not stated	• Birth weight (mean) • Low birth weight • Preterm • Caesarean section

Table 2 Quality score and statistical adjustments for included studies

Paper	Quality score	Results	Adjustments
Abrams and Newman (1991) (27)	–	OR AOR (low birth weight for underweight only)	Multiple logistic regression and backwards elimination
Baeten *et al.* (2001) (28)	++	AOR	Age, smoking, weight gain, marital status, education, trimester prenatal care, payer prenatal care, plus excluded diabetes and hypertension
Bergholt *et al.* (2007) (57)	+	AOR	Age, gestational age, birth weight, height, oxytocin use, epidural
Bianco *et al.* (1998) (29)	+	ORC (fetal growth retardation, shoulder dystocia, preterm delivery, post partum haemorrhage, wound infection, low Apgar score, low birth weight, very low birth weight, small for gestational age) AOR for the following results: 1. Placenta previa-abruption, fetal distress, meconium, failure to progress, neonatal intensive care unit 2. Caesarean delivery 3. Large for gestational age	Adjustments for results 1–3: 1. Ethnic origin, parity, substance abuse, clinic service, pre-existing medical condition 2. As 1 plus controlled for macrosomia 3. As 1 plus controlled for gestational diabetes
Bo *et al.* (2003) (59)	+	ORC	None
Callaway *et al.* (2006) (67)	++	AOR (caesarean delivery, jaundice, preterm, admission to intensive care, length of stay more than 5 d) ORC (vaginal delivery, respiratory distress, mechanically ventilated, phototherapy)	For AOR: age, ethnic group, parity, smoking, education
Cerdergren (2004) (27)	++	AOR	Age, parity, smoking, year of birth, maternal education (only available for 1992–1995), excluded pre-exist hypertension and insulin dependent diabetes mellitus
Cnattingius *et al.* (1998) (63)	+	AOR	Age, parity, smoking, education, height, living with father, weight gain
Crane *et al.* (1997) (30)	+	AOR	Age, parity, hypertension, diabetes, birth weight, excluded multiple gestations and prior caesarean
Dempsey *et al.* (2005) (31)	–	AOR	Age, ethnic group, height, excluded pre-eclampsia and gestational diabetes
Di Cianni *et al.* (2003) (60)	–	ORC	None
Doherty *et al.* (2006) (32)	++	AOR	Adjusted for all statistically significant confounders such as age and parity, but detail on adjustments for each variable is not given
Ehrenberg *et al.* (2004a) (33)	+	ORC (induction and macrosomia) OR (overall caesarean)	Univariate analysis for OR
Ehrenberg *et al.* (2004b) (34)	+	AOR	Ethnic group, parity, newborn gender, only included term deliveries
Ekblad and Grenman (1992) (49)	–	ORC	None
Galtier-Dereure *et al.* (1995) (23)	–	ORC	None
Galtier-Dereure *et al.* (2000) (65)	+	AOR	Matched for age and parity, sum of the duration of night-time and corrected daytime hospitalization, correcting coefficient 0.766 daytime, 1.40 night-time
Giuliani *et al.* (2002) (66)	–	ORC	None
Hellerstedt *et al.* (1997) (35)	+	ORC	Matched for race/ethnicity, delivery date, age and parity
Hendler *et al.* (2005) (36)	+	ORC (macrosomia, caesarean delivery) AOR (preterm delivery)	For AOR: age, ethnic origin, parity, previous spontaneous preterm birth, bacterial vaginosis, fetal fibronectin, cervical length at 23–24 weeks gestation, education
Hulsey *et al.* (2005) (37)	–	AOR	Ethnicity, intendedness of pregnancy, Medicaid status, WIC status, prenatal care utilisation, diabetes, hypertension
Jensen *et al.* (1999) (54)	–	ORC	None

Table 2 *Continued*

Paper	Quality score	Results	Adjustments
Jensen *et al.* (2003) (53)	+	OR (small for gestational age, shoulder dystocia, preterm delivery, hypoglycaemia, jaundice) AOR for the following results: 1. Large for gestational age, macrosomia 2. Induction of labour, caesarean	Adjustments for results 1–2: 1. Age, ethnic group, parity, smoking, gestational age, weight gain, glucose tolerance, clinical centre, screening indicators for gestational diabetes (family history diabetes, >20% pre-pregnancy overweight, previous unexplained stillbirth, previous macrosomic infant >4500 g, age >35, gestational diabetes in previous pregnancy, glucosuria) 2. All adjustments plus excluded women with hypertensive complications
Johnson *et al.* (1992) (38)	++	AOR	All term deliveries, age, ethnicity, parity, smoking/alcohol/drug use, post-date, weight gain, pre-pregnancy weight, height, married, fetal gender, diabetes, maternal education
Kaiser and Kirby (2001) (39)	++	AOR	Age >35 years, maternal race black, parity, primi gravidity, weight gain, marital status, very low birth weight, height (short stature), failure to progress, breech, placental abruption, fetal brachycardia, severe pre-eclampsia
Kiran *et al.* (2005) (8)	+	ORC	None
Konje *et al.* (1993) (58)	–	OR	Matched for gestational age, socio economic status, age, parity
Kramer *et al.* (1999) (68)	+	AOR	Age, parity, smoking, weight gain, marital status, education, hypertension, height, diabetes
Kugyelka *et al.* (2004) (40)	++	ORC	None
Kumari (2001) (69)	+	OR (preterm, shoulder dystocia, low birth weight, placenta abruption and previa, intrauterine growth retardation) AOR (caesarean delivery, macrosomia, Apgar score, neonatal intensive care)	For OR: matched for age, parity, gestational age For AOR: matched plus excluded gestational diabetes and pregnancy induced hypertension
Lombardi *et al.* (2005) (41)	–	ORC	Matched for gestational age, ethnic group, parity
Lumme *et al.* (1995) (50)	++	ORC (hospital admission during pregnancy, induction, caesarean delivery, intra-operative haemorrhage, post-operative maternal morbidity, wound infections) AOR (preterm and post-date delivery, small for gestational age, large for gestational age, low birth weight, macrosomia, Apgar score, neonatal intensive care)	For AOR: age, parity, smoking, education, only extracted data on women without complications (i.e. without diabetes mellitus, gestational diabetes, gestational or chronic hypertension, pre-eclampsia)
Mancuso *et al.* (1991) (61)	–	ORC	None
Naeye (1990) (42)	–	ORC	None
Nucci *et al.* (2001) (70)	–	OR	None
Ogunyemi *et al.* (1998) (43)	–	ORC	Population note: ethnic group – black women only, low income, rural population
Olesen *et al.* (2006) (55)	+	AOR	Maternal age, parity
Phithakwatchara and Titapant (2007) (71)	–	AOR	Weight gain, screening indicators for gestational diabetes, excluded pre-existing chronic illness (hypertension, diabetes mellitus, HIV)
Ranta *et al.* (1995) (51)	–	ORC	None
Rantakallio *et al.* (1995) (52)	+	ORC from data provided on incidence per 1000	Confounders identified as age group, parity, smoking, fathers social class, area of residence (urban vs. rural), marital status. Confounder score attached to each and used as a categorical covariate in subsequent modelling

Table 2 *Continued*

Paper	Quality score	Results	Adjustments
Rode *et al.* (2005) (56)	+	OR (preterm and post-date delivery) AOR for the following results: 1. Caesarean delivery (overall) 2. Emergency caesarean, vacuum extraction 3. Elective caesarean 4. Low birth weight 5. High birth weight	Adjustments for results 1–5: 1. Age, assisted reproduction, pre-eclampsia, macrosomia, diabetes 2. Age, pre-eclampsia, macrosomia 3. Age, assisted reproduction, macrosomia 4. Pre-eclampsia 5. Gestational age >42 weeks
Rosenberg *et al.* (2003) (44)	++	AOR for the following results: 1. Caesarean delivery 2. Low birth weight, high birth weight, neonatal intensive care unit	Adjustments for results 1–2: 1. Age, ethnic group, parity, smoking, marital status, education, prenatal care, infant gender, social risk, care payer 2. As above plus excludes chronic diabetes, GDM, chronic high blood pressure, pregnancy induced hypertension, pre-eclampsia, eclampsia
Rossner and Ohlin (1990) (64)	–	ORC	None
Sheiner *et al.* (2004) (72)	–	OR (induction, placental abruption and previa, failure to progress 2nd stage, meconium-stained amniotic fluid, caesarean delivery, Apgar scores, shoulder dystocia, post-partum haemorrhage) AOR (failure to progress 1st stage, malpresentation, macrosomia, premature rupture of membranes)	For AOR: multivariable logistic regression with backward elimination
Shepard *et al.* (1998) (45)	+	ORC	None
Steinfeld *et al.* (2000) (46)	–	ORC	None
Vahratian *et al.* (2004) (47)	–	ORC	None
Weiss *et al.* (2004) (48)	++	AOR	Age, ethnic origin, parity, gestational age, education, marital status, birth weight, assisted reproductive technology
Yekta *et al.* (2006) (73)	–	ORC	None

AOR, adjusted odds ratio; OR, crude odds ratio; ORC, odds ratio calculated for review.

overweight women; however, two studies did not show a significant relationship with either of these BMI groups (32,66).

Maternal complications non-meta-analysis

It was not possible to combine studies for 3rd and 4th degree tears owing to an insufficient number of identified studies. One study showed no significant relationship between anal sphincter laceration and moderate, severe, or morbid obesity when compared with women in the ideal BMI group (62), and one study showed no relationship with 3rd/4th degree tears when obese women were compared with non-obese women (8).

Neonate non-meta-analysis

It was not possible to combine studies for neonatal birth trauma owing to an insufficient number of studies being identified in the search. The studies that were identified showed a significant increase in trauma incidence (where trauma was defined as cuts, grazes, bruises, fractures, muscle haematomas, dislocation, cephalhaematomas and nerve palsies) in obese mothers when compared with non-obese (OR 1.50, 95% CI 1.10, 2.10) (8), whereas there was no statistically significant relationship with obesity, overweight or underweight and skull fracture (42).

Secondary outcomes

The results of the meta-analysis for the secondary outcomes that may incur an indirect resource implication for maternity services are shown in Table 12.

Birth weight and growth meta-analysis

There is a trend for an increasing mean birth weight and high birth weight with increasing BMI category, and significant reduced odds of high birth weight when mothers are underweight. However, there were not enough studies to analyse high birth weight and morbid obesity separately to that of overall obesity. The trend for low birth weight is significantly higher in underweight women compared with women in the ideal BMI group, with significant reduced odds for women who are overweight and obese. The morbidly obese group shows a slight increase in low birth weight; however, this is not significant (OR 1.11, 95% CI 0.92, 1.34).

Table 3 Results of included studies – obese: labour and delivery 1

Paper	Labour onset: spontaneous		Labour onset: induced		Labour onset: failed induction		Caesarean delivery: total		Caesarean delivery: emergency		Caesarean delivery: elective		Vaginal delivery		Instrumental delivery		Failed instrumental delivery		Oxytocin		Failure to progress	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Baeten *et al.* (2001) (28)	–	–	–	–	–	–	2.7	2.5 2.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bergholt *et al.* (2007) (57)	–	–	–	–	–	–	a/b 1.9	a/b 1.3 2.8	–	–	–	–	–	–	–	–	–	–	–	–	a/b 1.6	a/b 1.0 2.7
							c 3.8	c 2.4 6.2													c 3.3	c 1.9 5.9
Bianco *et al.* (1998) (29)	–	–	–	–	–	–	b/c 2.3	b/c 1.9 2.8	–	–	–	–	–	–	–	–	–	–	–	–	b/c 2.6	b/c 2.0 3.5
Bo *et al.* (2003) (59)	–	–	–	–	–	–	1.4	0.9 2.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Callaway *et al.* (2006) (67)	–	–	–	–	–	–	a/b 2.0	a/b 1.8 2.3	–	–	–	–	a/b 0.7	a/b 0.6 0.7	a/b 0.6	a/b 0.5 0.8	–	–	–	–	–	–
							c 2.5	c 1.9 3.3					c 0.5	c 0.4 0.7	c 0.4	c 0.2 0.8						
Cerdergren (2004) (27)	–	–	a 1.8	a 1.7 1.8	–	–	a 1.2	a 1.1 1.2	–	–	–	–	–	–	a 1.2	a 1.1 1.2	–	–	–	–	–	–
			b 2.3	b 2.2 2.4			b 1.2	b 1.1 1.3							b 1.2	b 1.1 1.3						
			c 2.5	c 2.3 2.8			c 1.3	c 1.2 1.6							c 1.3	c 1.2 1.6						
Crane *et al.* (1997) (30)	–	–	–	–	–	–	1.6	1.5 1.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dempsey *et al.* (2005) (31)	–	–	–	–	–	–	2.7	1.5 4.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Doherty *et al.* (2006) (32)	–	–	2.4	1.7 3.5	–	–	2.4	1.7 3.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 3 *Continued*

Paper	Labour onset: spontaneous		Labour onset: induced		Labour onset: failed induction		Caesarean delivery: total		Caesarean delivery: emergency		Caesarean delivery: elective		Vaginal delivery		Instrumental delivery		Failed instrumental delivery		Oxytocin		Failure to progress	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Ehrenberg *et al.* (2004a) (33)	–	–	1.8	1.6 2.1	–	–	2.0	1.7 2.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ekblad and Grenman (1992) (49)	–	–	23.1	7.7 69.2	–	–	–	–	2.9	0.8 10.2	1.2	0.5 3.1	1.4	0.8 2.7	0.3	0.0 2.1	–	–	–	–	–	–
Galtier-Dereure *et al.* (1995) (23)	–	–	–	–	–	–	a 1.7 b/c 7.5	a 0.5 6.3 b/c 2.3 24.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hendler *et al.* (2005) (36)	–	–	–	–	–	–	3.4	2.7 4.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Jensen *et al.* (1999) (54)	–	–	2.8	1.9 4.0	–	–	1.7	0.9 3.0	–	–	–	–	–	–	1.1	0.7 1.7	–	–	1.93	1.5 2.5	–	–
Jensen *et al.* (2003) (53)	–	–	3.2	2.2 4.6	–	–	2.7	1.9 3.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Johnson *et al.* (1992) (38)	–	–	–	–	–	–	–	–	1.4	1.0 1.9	–	–	–	–	–	–	–	–	–	–	–	–
Kaiser and Kirby (2001) (39)	–	–	–	–	–	–	4.0	2.0 8.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kiran *et al.* (2005) (8)	–	–	–	–	–	–	1.6	1.4 2.0	2.0	1.2 3.5	0.8	0.5 1.3	0.7	0.6 0.9	1.0	0.8 1.2	1.8	1.1 2.9	1.2	1.0 1.6	–	–
Konje *et al.* (1993) (58)	0.8	0.6 1.2	1.3	0.9 1.9	–	–	1.3	0.8 1.9	–	–	0.8	0.4 1.5	–	–	0.8	0.4 1.5	–	–	–	–	–	–
Kumari (2001) (69)	–	–	–	–	–	–	2.4	1.2 4.9	3.1	1.1 9.0	1.9	0.8 4.7	–	–	–	–	–	–	–	–	–	–
Lombardi *et al.* (2005) (41)	–	–	–	–	–	–	1.9	1.5 2.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lumme *et al.* (1995) (50)	–	–	1.0	0.7 1.4	–	–	2.0	1.5 2.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mancuso *et al.* (1991) (61)	–	–	–	–	–	–	1.6	0.8 3.4	–	–	–	–	–	–	0.6	0.1 7.2	–	–	–	–	–	–
Ogunyemi *et al.* (1998) (43)	–	–	–	–	–	–	1.7	0.9 3.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 3 *Continued*

Paper	Labour onset: spontaneous		Labour onset: induced		Labour onset: failed induction		Caesarean delivery: total		Caesarean delivery: emergency		Caesarean delivery: elective		Vaginal delivery		Instrumental delivery		Failed instrumental delivery		Oxytocin		Failure to progress	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Phithakwatchara and Titapant (2007) (71)	–	–	–	–	–	–	–	–	1.5	1.2 1.9	–	–	–	–	–	–	–	–	–	–	–	–
Ranta *et al.* (1995) (51)	–	–	1.3	0.5 3.1	–	–	–	–	1.3	0.4 3.7	–	–	0.9	0.4 2.1	1.0	0.2 4.2	–	–	–	–	–	–
Rode *et al.* (2005) (56)	–	–	–	–	–	–	1.7	1.3 2.2	1.7	1.3 2.3	1.6	1.0 2.5	–	–	0.9	0.7 1.3	–	–	–	–	–	–
Rosenberg *et al.* (2003) (44)	–	–	–	–	–	–	a 2.1 c 2.7	a 2.0 2.2 c 2.2 3.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rossner and Ohlin (1990) (64)	–	–	–	–	–	–	–		–	–	–	–	0.8	0.5 1.4	–	–	–	–	–	–	–	–
Sheiner *et al.* (2004) (72)	–	–	2.3	2.1 2.6	–	–	3.2	2.9 3.5	–	–	–	–	–	–	–	–	–	–	–	–	3.1	2.5 3.7
Shepard *et al.* (1998) (45)	–	–	–	–	–	–	2.4	1.6 3.6	–	–	–	–	0.4	0.3 0.6	–	–	–	–	–	–	–	–
Steinfeld *et al.* (2000) (46)	–	–	–	–	–	–	2.1	1.5 3.1	–	–	–	–	–	–	0.6	0.3 1.0	–	–	–	–	–	–
Vahratian *et al.* (2004) (47)	–	–	1.2	0.9 1.8	2.5% ($n = 5$) compared with 0% for ideal BMI		–	–	1.6	1.0 2.4	–	–	0.9	0.6 1.3	0.7	0.4 1.1	1.7	0.3 8.8	2.3	1.6 3.5	1.6	0.9 2.8
Weiss *et al.* (2004) (48)	–	–	–	–	–	–	a 1.7 b/c 3.0	a 1.4 2.2 b/c 2.2 4.0	–	–	–	–	–	–	a 1.0 b/c 1.7	a 0.8 1.3 b/c 1.2 2.2	–	–	–	–	–	–
Yekta *et al.* (2006) (73)	–	–	–	–	–	–	1.6	0.8 3.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Where data are split into obesity subgroups: a, moderately obese; b, severely obese; c, morbidly obese.

Table 4 Results of included studies – obese: labour and delivery 2

Paper	Premature rupture of membranes (PROM)		Placenta abruption		Placenta previa		Malpresentation		Difficulty in determining fetal lie		Labour abnormalities		Occiput posterior	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Cerdergren (2004) (27)	–	–	a 1.0 b 1.0 c 1.0	a 0.9 1.1 b 0.7 1.5 c 0.8 1.1	a 0.9 b 0.6 c 0.3	a 0.7 1.0 b 0.4 0.9 c 0.1 0.9	–	–	–	–	–	–	–	–
Jensen *et al.* (1999) (54)	–	–	–	–	–	–	–	–	–	–	–	–	1.4	0.8 2.4
Johnson *et al.* (1992) (38)	–	–	–	–	–	–	–	–	–	–	1.5	1.0 2.3	–	–
Konje *et al.* (1993) (58)	1.3	0.6 3.0	–	–	–	–	–	–	12.8	4.4 41.8	–	–	–	–
Kumari (2001) (69)	–	–	c 1.6	c 0.1 25.0	c 0.8	c 0.1 8.8	–	–	–	–	–	–	–	–
Lombardi *et al.* (2005) (41)	–	–	6.1	0.7 50.8	–	–	–	–	–	–	–	–	–	–
Sheiner *et al.* (2004) (72)	1.2	1.0 1.5	0.4	0.2 1.2	0.8	0.4 1.9	1.4	1.2 1.6	–	–	–	–	–	–
Vahratian *et al.* (2004) (47)	–	–	$n = 0$ for obese		–	–	$n = 0$ for obese		–	–	–	–	–	–
Weiss *et al.* (2004) (48)	a 1.3 b/c 1.3	a 0.9 2.0 b/c 0.8 2.2	a 1.0 b/c 1.0	a 0.6 1.9 b/c 0.5 2.2	a 1.3 b/c 0.7	a 0.7 2.5 b/c 0.3 2.0	–	–	–	–	–	–	–	–

Where data are split into obesity subgroups: a, moderately obese; b, severely obese; c, morbidly obese.

Table 5 Results of included studies – obese: labour and delivery 3

Paper	Pain score		Epidural		Pethidine		Nitrous oxide		Duration of labour (mean hours)		Primary inertia		Secondary inertia		Uterine atony		Labour dystocia	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	Mean	SD	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Cerdergren (2004) (27)	–	–	a 1.2 b 1.2 c 1.2	a 1.2 1.2 b 1.1 1.2 c 1.1 1.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ehrenberg *et al.* (2004a) (33)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.7	1.5 1.9
Galtier-Dereure *et al.* (1995) (23)	–	–	–	–	–	–	–	–	a 5.4 b/c 4.7	a 2.9 b/c 2.8	–	–	–	–	–	–	–	–
Jensen *et al.* (1999) (54)	–		–	–	–	–	–	–	–	–	0.6	0.4 0.7	0.7	0.5 1.0	0.6	0.2 1.7	–	–
Kiran *et al.* (2005) (8)	–	–	–	–	–	–	–	–	8.1	4.2	–	–	–	–	–	–	–	–
Konje *et al.* (1993) (58)	–	–	0.2	0.1 0.3	–	–	–	–	5.4	not reported	–	–	–	–	–	–	–	–
Ranta *et al.* (1995) (51)	Median 8	85% 7–10	0.7	0.4 1.3	12.4	3.0 50.9	6.4	3.2 13.0	Median 7	2–28 (range)	–	–	–	–	–	–	–	–
Vahratian *et al.* (2004) (47)	–	–	0.8	0.6 1.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Where data are split into obesity subgroups: a, moderately obese; b, severely obese; c, morbidly obese.

Paper	Birth weight (g)		Macrosomia		Large for gestational age		Low birth weight (<2500 g)		Very low birth weight (<1500 g)		Small for gestational age		Intrauterine growth restriction (IUGR)		Preterm (<37 weeks)		Preterm (<34 weeks)		Preterm (<32 weeks)		Post-date (>41/42 weeks)	
	Mean	SD	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Abrams and Newman (1991) (27)	–	–	–	–	–	–	–	–	–	–	Data for control group not provided	–	–	–	–	–	–	–	–	–	–	–
Baeten *et al.* (2001) (28)	–	–	2.1	1.9 2.3	–	–	1.1	0.9 1.2	–	–	0.8	0.8 0.9	–	–	1.3	1.2 1.5	–	–	1.6	1.2 2.1	–	–
Bianco *et al.* (1998) (29)	b/c 3352	b/c 598	–	–	b/c 1.8	b/c 1.4 2.3	–	–	–	–	b/c 0.8	b/c 0.5 1.2	–	–	b/c 1.3	b/c 1.0 1.6	–	–	–	–	–	–
Bo *et al.* (2003) (59)	3413	589	–	–	2.6	1.5 4.3	–	–	–	–			–	–	1.0	0.4 2.3	–	–	–	–	–	–
Callaway *et al.* (2006) (67)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	a/b 1.0	a/b 0.8 1.2	a/b 1.2	a/b 0.8 1.7	–	–	–	–
															c 1.5	c 1.0 2.4	c 2.1	c 1.1 4.0				
Cerdergren (2004) (27)	–	–	a 2.2	a 2.1 2.2	a 2.2	a 2.1 2.3	–	–	–	–	a 1.0	a 0.9 1.0	–	–	a 1.2	a 1.1 1.3	–	–	a 1.5	a 1.3 1.6	a 1.4	a 1.3 1.4
			b 3.0	b 2.9 3.2	b 3.1	b 3.0 3.3					b 1.0	b 0.9 1.2			b 1.5	b 1.4 1.6			b 2.0	b 1.7 2.3	b 1.5	b 1.4 1.6
			c 3.6	c 3.2 3.9	c 3.8	c 3.5 4.2					c 1.4	c 1.1 1.7			c 1.9	c 1.6 2.1			c 2.3	c 1.7 3.1	c 1.8	c 1.6 2.0
Cnattingus *et al.* (1998) (27)	–	–	–	–	–	–	–	–	–	–	0.5	0.4 0.6	–	–	1.0	0.9 1.1	–	–	1.1	0.8 1.3	–	–
Crane *et al.* (1997) (30)	3519	633	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Di Cianni *et al.* (2003) (60)	–	–	4.8	1.1 20.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Doherty *et al.* (2006) (32)	–	–	–	–	–	–	–	–	–	–	–	–	0.8	0.5 1.4	–	–	–	–	–	–	–	–
Ehrenberg *et al.* (2004b) (34)	3410	500	–	–	1.6	1.4 1.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ekblad and Grenman (1992) (49)	3712	614	–	–	5.1	2.5 10.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Galtier-Dereure *et al.* (1995) (23)	–	–	b/c 35.3	b/c 4.3 291.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hellerstedt *et al.* (1997) (35)	3420	760	–	–	1.9	1.3 2.7	–	–	–	–	0.7	0.4 1.0	–	–	1.5	1.0 2.2	–	–	–	–	–	–

Table 6 *Continued*

Paper	Birth weight (g)		Macrosomia		Large for gestational age		Low birth weight (<2500 g)		Very low birth weight (<1500 g)		Small for gestational age		Intrauterine growth restriction (IUGR)		Preterm (<37 weeks)		Preterm (<34 weeks)		Preterm (<32 weeks)		Post-date (>41/42 weeks)	
	Mean	SD	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Hendler *et al.* (2005) (36)	3289	660	3.4	2.7 4.3	–	–	–	–	–	–	–	–	–	–	0.6	0.4 0.8	0.6	0.3 1.2	0.5	0.2 1.3	–	–
Hulsey *et al.* (2005) (37)	–	–	–	–	–	–	0.8	0.6 1.1	1.4	1.1 1.8	–	–	–	–	–	–	–	–	–	–	–	–
Jensen *et al.* (1999) (54)	–	–	1.7	1.0 2.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Jensen *et al.* (2003) (53)	–	–	2.5	1.8 3.6	2.5	1.8 3.6	–	–	–	–	0.9	0.5 1.4	–	–	1.6	0.9 2.9	–	–	–	–	–	–
Johnson *et al.* (1992) (38)	–	–	3.2	2.2 4.7	–	–	0.0	0.0 0.3	–	–	–	–	–	–	–	–	–	–	–	–	1.5	1.0 2.2
Kiran *et al.* (2005) (8)	–	–	2.1	1.6 2.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.4	1.2 1.7
Konje *et al.* (1993) (58)	3692	NS	4.8	3.1 7.5	–	–	–	–	–	–	–	–	–	–	0.6	0.4 0.8	–	–	–	–	0.2	0.1 0.7
Kramer *et al.* (1999) (68)	–	–	–	–	–	–	–	–	–	–	–	–	Mild IUGR 0.6 Severe IUGR 0.7	Mild IUGR 0.5 0.7 Severe IUGR 0.5 1.0	–	–	–	–	–	–	–	–
Kugyelka *et al.* (2004) (40)	3378* 3466†	441* 459†	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kumari (2001) (69)	–	–	c 3.8	c 2.1 7.0	–	–	c 0.3	c 0.1 1.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lombardi *et al.* (2005) (41)	3033	747	–	–	–	–	0.7	0.5 0.9	1.0	0.4 2.3	–	–	–	–	–	–	0.6	0.4 1.1	–	–	–	–
Lumme *et al.* (1995) (50)	–	–	2.3	1.7 3.0	2.3	1.7 3.0	0.7	0.3 1.3	–	–	0.5	0.3 0.8	–	–	1.1	0.7 1.7	–	–	–	–	1.1	0.6 1.9
Mancuso *et al.* (1991) (61)	–	–	1.8	1.4 2.2	–	–	1.6	0.5 5.5	–	–	–	–	–	–	2.6	1.0 6.5	–	–	–	–	4.0	0.4 39.2
Naeye (1990) (42)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.8	1.7 1.9	–	–	2.4	2.1 2.8	–	–
Nucci *et al.* (2001) (70)	–	–	–	–	1.5	1.1 2.2	–	–	–	–	0.5	0.3 0.8	–	–	–	–	–	–	–	–	–	–
Ogunyemi *et al.* (1998) (43)	3304	NS	–	–	–	–	0.8	0.2 2.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Paper	Birth weight (g)		Macrosomia		Large for gestational age		Low birth weight (<2500 g)		Very low birth weight (<1500 g)		Small for gestational age		Intrauterine growth restriction (IUGR)		Preterm (<37 weeks)		Preterm (<34 weeks)		Preterm (<32 weeks)		Post-date (>41/42 weeks)	
	Mean	SD	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Olesen *et al.* (2006) (55)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	a 1.4	a 1.2 1.5
																					b/c 1.5	b/c 1.3 1.8
Phithakwatchara and Titapant (2007) (71)	–	–	8.3	2.5 27.3	–	–	0.6	0.3 1.1	–	–	–	–	–	–	0.9	0.5 1.7	–	–	–	–	–	–
Ranta *et al.* (1995) (51)	3865	1610– 5320 (range)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rantakallio *et al.* (1995) (52)	–	–	–	–	–	–	a 0.6	a 0.2 1.3	–	–	a 0.5	a 0.3 0.9	–	–	a 1.2	a 0.7 2.0	–	–	–	–	–	–
							b/c 1.1	b/c 0.3 3.6			b/c 0.8	b/c 0.3 2.0			b/c 1.3	b/c 0.5 3.3						
Rode *et al.* (2005) (56)	–	–	–	–	–	–	2.8	1.4 5.6	–	–	–	–	–	–	1.4	0.9 1.9	–	–	–	–	1.4	1.1 1.9
Rosenberg *et al.* (2003) (44)	–	–	a/b 3.1	a/b 2.9 3.3	–	–	–	–	a/b 0.5	a/b 0.1 1.9	–	–	–	–	–	–	–	–	–	–	–	–
			c 3.8	c 2.8 5.1					c 1.3	c 1.1 1.6												
Rossner and Ohlin (1990) (64)	3556	531	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sheiner *et al.* (2004) (72)	–	–	1.4	1.2 1.7	–	–	0.8	0.7 1.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Steinfeld te al (2000) (46)	–	–	8.0	3.3 19.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vahratian *et al.* (2004) (47)	3445	468	1.0	0.6 1.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Weiss *et al.* (2004) (48)	a 3430	a 563	–	–	–	–	–	–	–	–	–	–	a 0.9	a 0.5 1.6	a 1.1	a 0.9 1.5	–	–	–	–	–	–
	b/c 3467	b/c 578											b/ c 0.8	b/c 0.4 1.8	b/c 1.5	b/c 1.1 2.1						
Yetka *et al.* (2006) (27)	3470	588	–	–	–	–	0.4	0.1 1.7	–	–	–	–	–	–	0.4	0.1 1.7	–	–	–	–	–	–

Where data are split into obesity subgroups: a, moderately obese; b, severely obese; c, morbidly obese.
*Black women only.
†Hispanic women only.
NS, not stated by authors.

Table 7 Results table for maternal complications for obese BMI group

Paper	Haemorrhage		Transfusion		Infection		Retained placenta		Evacuation uterus		Thromboembolic events		Overall puerperal complications		3rd/4th degree tears (including anal sphincter tear)		Vaginal repair/ perineal trauma	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Bianco *et al.* (1998) (29)	b/c 1.4	b/c 0.6 3.4	–	–	b/c 5.0	b/c 1.6 15.0	–	–	–	–	–	–	–	–	–	–	–	–
Cerdergren (2004) (27)	a 1.2 b 1.4 c 1.7	a 1.2 1.2 b 1.3 1.5 c 1.5 2.0	–	–	–	–	–	–	–	–	–	–	–	–	a 1.0 b 1.0 c 1.0	a 1.0 1.1 b 0.9 1.2 c 0.8 1.4	–	–
Doherty *et al.* (2006) (32)	1.7	1.2 2.4	–	–	2.0	1.1 3.8	0.6	0.1 2.5	–	–	–	–	–	–	–	–	1.6	1.1 2.3
Ekblad and Grenman (1992) (49)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	$n = 0$ for obese	–
Giuliani *et al.* (2002) (66)	0.4	0.1 1.3	–	–	1.7	1.3 2.3	–	–	–	–		$n = 0$ for obese	1.2	0.9 1.6	–	–	–	–
Jensen *et al.* (1999) (54)	2.5	0.8 7.6	–	–	–	–	0.6	0.2 1.9	–	–	–	–	–	–	–	–	1.0	0.5 1.8
Kiran *et al.* (2005) (8)	1.3	0.8 2.4	1.3	0.9 2.0	10.4	5.2 20.7	–	–	0.6	0.2 2.1	–	–	–	–	1.1	0.4 2.7	–	–
Konje *et al.* (1993) (58)	0.8	0.4 1.6	–	–	8.4	2.1 73.4	0.7	0.2 3.0	–	–	–	–	–	–	–	–	–	–
Lumme *et al.* (1995) (50)	2.0	1.5 2.7	–	–	6.5	4.6 9.1	–	–	–	–	–	–	–	–	–	–	–	–
Ranta *et al.* (1995) (51)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0	0.5 1.9
Sheiner *et al.* (2004) (72)	1.0	0.5 2.1	1.4	0.9 1.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Where data are split into obesity subgroups: a, moderately obese; b, severely obese; c, morbidly obese.

Table 8 Results table for neonate outcomes for obese BMI group 1

Paper	Low Apgar score 1 min		Low Apgar score 5 min		Fetal compromise		Presence of meconium		Shoulder dystocia		Jaundice		Phototherapy		Cord pH		Tube feeding	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Bergholt *et al.* (2007) (57)	–	–	–	–	a 2.2 b/c 4.4	a 1.1 4.4 b/c 2.0 10.1	–	–	–	–	–	–	–	–	–	–	–	–
Bianco *et al.* (1998) (29)	b/c 1.8	b/c 0.8 3.8	b/c 1.8	b/c 0.6 4.9	b/c 1.3	b/c 1.1 1.7	b/c 1.3	b/c 1.1 1.7	b/c 1.5	b/c 0.8 2.8	–	–	–	–	–	–	–	–
Callaway *et al.* (2006) (67)	–	–	–	–	–	–	–	–	–	–	a/b 1.0 c 1.4	a/b 0.9 1.1 c 1.1 1.9	a/b 1.0 c 1.7	a/b 0.8 1.4 c 1.0 2.9	–	–	–	–
Cerdergren (2004) (27)	–	–	a 1.6 b 1.8 c 2.9	a 1.5 1.7 b 1.6 2.1 c 2.4 3.6	a 1.6 b 2.1 c 2.5	a 1.5 1.7 b 1.9 2.4 c 2.1 3.0	a 1.6 b 2.9 c 2.9	a 1.3 2.1 b 2.1 3.9 c 1.6 5.1	a 1.0 b 1.0 c 1.0	a 1.0 1.2 b 0.9 1.2 c 0.8 1.4	–	–	–	–	–	–	–	–
Dempsey *et al.* (2005) (31)	–	–	–	–	3.7	1.4 10.2	–	–	–	–	–	–	–	–	–	–	–	–
Doherty *et al.* (2006) (32)	–	–	–	–	4.6	2.2 9.4	–	–	–	–	–	–	–	–	–	–	–	–
Ekblad and Grenman (1992) (49)	8.4 (mean)	1.5 (SD)	8.8 (mean)	1.1 (SD)	–	–	–	–	*n* = 0 for obese		–	–	–	–	–	–	–	–
Jensen *et al.* (1999) (54)	–	–	2.0	0.4 9.2	–	–	–	–	1.9	0.7 4.9	–	–	–	–	–	–	–	–

Table 8 *Continued*

Paper	Low Apgar score 1 min		Low Apgar score 5 min		Fetal compromise		Presence of meconium		Shoulder dystocia		Jaundice		Phototherapy		Cord pH		Tube feeding	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Jensen *et al.* (2003) (53)	–	–	–	–	–	–	–	–	0.9	0.4 2.2	1.0	0.6 1.7	–	–	–	–	–	–
Johnson *et al.* (1992) (38)	–	–	–	–	1.3	1.1 1.7	1.8	1.3 2.3	–	–	–	–	–	–	–	–	–	–
Kiran *et al.* (2005) (8)	–	–	1.3	0.6 2.8	–	–	–	–	2.9	1.4 5.8	–	–	–	–	1.5	0.7 3.3	1.5	1.1 2.1
Kumari (2001) (69)	c 1.5	c 0.3 8.2	–	–	–	–	–	–	c 3.2	c 0.6 17.7	–	–	–	–	–	–	–	–
Lumme *et al.* (1995) (50)	1.0	0.2 2.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mancuso *et al.* (1991) (61)	3.8	1.7 8.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Phithakwatchara and Titapant (2007) (71)	–	–	–	–	–	–	–	–	1.7	1.3 2.2	0.9	0.5 1.8	–	–	–	–	–	–
Sheiner *et al.* (2004) (72)	1.0	0.8 1.3	1.0	0.5 1.8	–	–	1.4	1.2 1.6	1.6	0.7 4.0	–	–	–	–	–	–	–	–
Vahratian *et al.* (2004) (47)	–	–	–	–	1.5	0.8 2.9	–	–	–	–	–	–	–	–	–	–	–	–

Where data are split into obesity subgroups: a, moderately obese; b, severely obese; c, morbidly obese.

Table 9 Results table for neonate outcomes for obese BMI group 2

Paper	Hypoglycaemia		Hyperbilirubinaemia		Mechanically ventilated		Birth trauma		Respiratory distress		Resuscitation		Incubator required		Asphyxia		Fetal heart rate abnormalities	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Callaway *et al.* (2006) (67)	–	–	–	–	a/b 1.8	a/b 0.9 3.5	–	–	a/b 1.5	a/b 1.0 2.2	–	–	–	–	–	–	–	–
					c 3.0	c 0.9 10.0			c 1.4	c 0.6 3.4								
Di Cianni *et al.* (2003) (60)	–	–	1.8	0.5 6.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Doherty *et al.* (2006) (32)	–	–	–	–	–	–	–	–	–	–	1.8	1.3 2.4	–	–	–	–	–	–
Jensen *et al.* (1999) (54)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0	0.5 1.8	–	–
Jensen *et al.* (2003) (53)	0.9	0.5 1.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Johnson *et al.* (1992) (38)	–	–	–	–	–	–	–	–	–	–	Data not provided		–	–	–	–	1.3	1.0 1.7
Kiran *et al.* (2005) (8)	–	–	–	–	–	–	1.5	1.1 2.1	–	–	–	–	1.6	1.0 2.6	2.8	0.6 13.4	–	–
Naeye (1990) (42)	–	–	–	–	–	–	1.4	0.2 12.4	1.7	1.4 2.1	–	–	–	–	–	–	–	–

Where data are split into obesity subgroups: a, moderately obese; b, severely obese; c, morbidly obese.

Table 10 Results table for hospital admission for obese BMI group

Paper	Neonatal intensive care		Length of stay		Readmission to hospital		Outpatient hospitalization during pregnancy		Inpatient hospitalization during pregnancy		Hospital admission during pregnancy		Daytime hospitalization		Night-time hospitalization		Cost of prenatal care	
	OR	95% CI	Mean	SD	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	Mean	SD
Bianco *et al.* (1998) (29)	b/c 1.2	b/c 1.0 1.3	b/c 3.2	b/c 2.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Callaway *et al.* (2006) (67)	a/b 1.3	a/b 1.0 1.6	a/b 3.1	a/b 2.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	c 2.8	c 1.8 4.3	c 3.9	c 3.6														
Ekblad and Grenman (1992) (49)	1.5	0.2 8.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Galtier-Dereure *et al.* (1995) (23)	–	–	a 3.7	a 7.1	–	–	a 10.4	a 3.1 35.6	a 5.6	a 1.8 17.9	–	–	–	–	–	–	–	–
			b/c 8.6	b/c 15.2			b/c 20.0	b/c 5.5 72.6	b/c 18.5	b/c 5.4 63.0								
Galtier-Dereure *et al.* (2000) (65)	–	–	–	–	–	–	–	–	–	–	–	–	d 3.9	Not specified	d 6.2	Not specified	d 4.5	d 6.0
Giuliani *et al.* (2002) (66)	–	–	–	–	0.4	0.1 2.8	–	–	–	–	–	–	–	–	–	–	–	–
Kiran *et al.* (2005) (8)	1.5	1.1 2.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kugyelka *et al.* (2004) (40)	–	–	2.5* 2.5†	1.1* 1.1†	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kumari (2001) (69)	c 7.3	c 2.9 18.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lumme *et al.* (1995) (50)	1.4	1.0 1.9	–	–	–	–	–	–	–	–	2.7	2.2 3.3	–	–	–	–	–	–
Ogunyemi *et al.* (1998) (43)	3.0	1.0 8.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ranta *et al.* (1995) (51)	*n* = 0 for obese		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Where data are split into obesity subgroups: a, moderately obese; b, severely obese; c, morbidly obese; d, overweight and obese.
*Black women only.
†Hispanic women only.

Table 11 Meta-analysis results: primary outcomes

	Underweight vs. ideal BMI	Overweight vs. ideal BMI	Obese vs. ideal BMI	Morbidly obese vs. ideal BMI
	OR (95% CI)			
Labour and delivery				
Total caesarean delivery	0.807 (0.720, 0.903)[†] *n* = 9	1.483 (1.390, 1.581)[†] *n* = 14	2.005 (1.872, 2.148)[†‡] *n* = 16	1.432 (1.346, 1.524)[§] *n* = 6
Elective caesarean delivery	–*	–*	1.240 (0.899, 1.710) *n* = 3	
Emergency caesarean delivery	–*	–*	1.626 (1.396, 1.893)[†] *n* = 6	
Instrumental delivery	–*	0.773 (0.674, 0.888)[†] *n* = 3	1.169 (1.130, 1.209)[†‡] *n* = 4	
Hospital admission				
Length of hospital stay (mean days)[¶]	–*	2.563 (2.460, 2.666) *n* = 6	2.706 (2.623, 2.788) *n* = 4	3.279 (3.131, 3.428) *n* = 3
Neonatal intensive care unit use	–*	1.121 (0.979, 1.283) *n* = 3	1.377 (1.157, 1.639) *n* = 4	1.331 (1.175, 1.507) *n* = 3
Mother				
Haemorrhage	0.671 (0.547, 0.822)[†] *n* = 4	1.420 (1.095, 1.842)[†] *n* = 3	1.202 (1.163, 1.243)[‡] *n* = 4	1.430 (1.328, 1.540)[‡] *n* = 3
Infection	–*	–*	3.335 (2.738, 4.062) *n* = 6	

*Data not available for meta-analysis.
†No significant heterogeneity.
‡Results following sensitivity analysis.
§Sensitivity analysis with non-obese comparison group rather than ideal BMI shows no heterogeneity and increases odds to 2.36 (2.03, 2.73).
¶Length of stay compared with women in the ideal BMI category where OR 2.421 (2.407, 2.434).

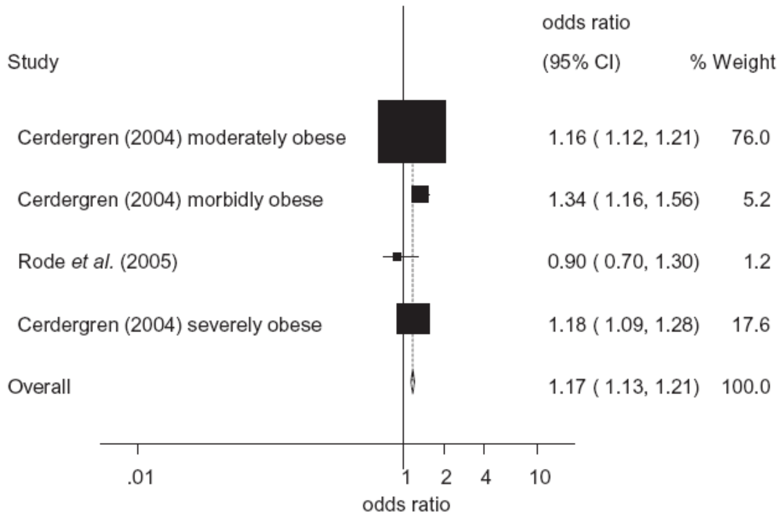

Figure 2 Instrumental delivery forest plot for obese BMI compared with ideal BMI following sensitivity analysis including adjusted odds ratios only.

There is an increasing odds of post-date delivery as the BMI category increases. Meta-analysis could not be carried out for underweight and post-date data; one study showed reduced odds (OR 0.87, 95% CI 0.8, 0.94) (55), whereas another study showed no significant relationship (OR 1.0, 95% CI 0.7, 1.4) (50). Interestingly in addition to having an increased odds of post-date delivery, there was also an increasing odds of preterm delivery at <37 weeks with increasing BMI category, whereas underweight was not significant. Delivery at <32 weeks (which has the biggest

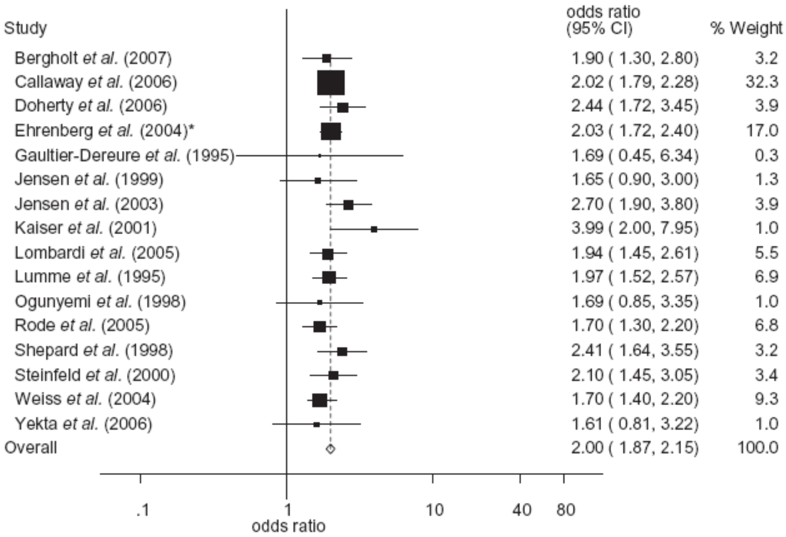

Figure 3 Overall caesarean delivery forest plot including emergency and elective caesarean delivery for obese BMI compared with ideal BMI following sensitivity analysis for control group definition. *Refer to number 33 in References section.

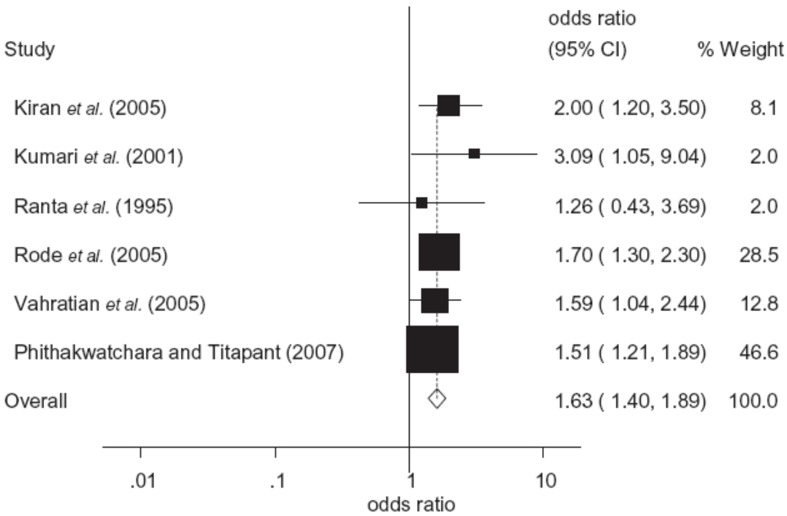

Figure 4 Emergency caesarean delivery forest plot for obese BMI compared with ideal BMI.

impact on service in terms of neonatal care) showed a positive relationship with obesity with an increased rate of over 1.5-fold when compared with women in the ideal BMI group. The meta-analysis showed no significance in the results at 34 weeks for obese women.

Labour and delivery meta-analysis

There are increased odds for induction of labour in overweight and obese women, and failure to progress with the labour is more than twice as likely in obese women. The odds for requiring oxytocin or epidurals are also increased, and although these outcomes could not be meta-analysed by degree of obesity, one study shows an apparent increase in the requirement for epidurals with increasing severity of obesity (62).

There are significant reduced odds for vaginal delivery in both overweight and obese women; however, morbidly obese and underweight BMI groups could not be meta-analysed for this outcome owing to limited studies. Two studies identified no significant relationship with underweight (45,49), whereas one study identified a significant reduced odds for morbid obesity and vaginal delivery (OR 0.52, 95% CI 0.40, 0.67) (67). The meta-analysis also showed significant slightly reduced odds for placenta previa in obese women, but no apparent relationship with placenta abruption.

Labour and delivery non-meta-analysis

It was not possible to include a number of labour and delivery outcomes in the meta-analysis. One study found a

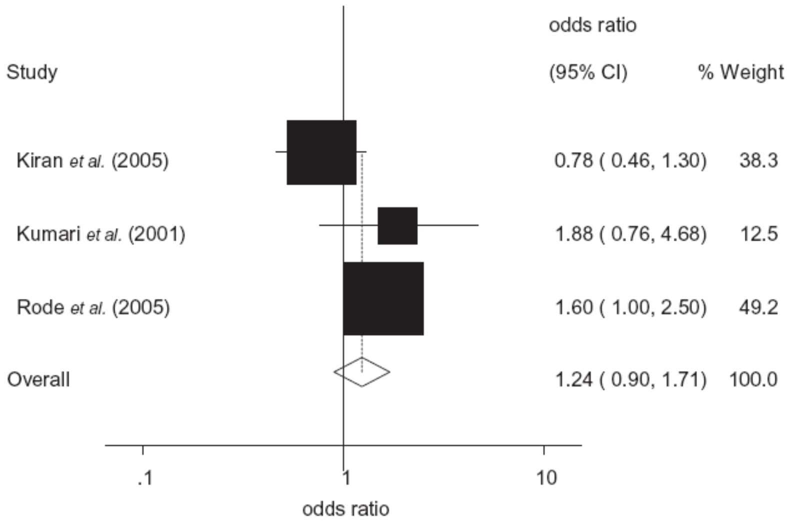

Figure 5 Elective caesarean delivery forest plot for obese BMI compared with ideal and non-obese BMI.

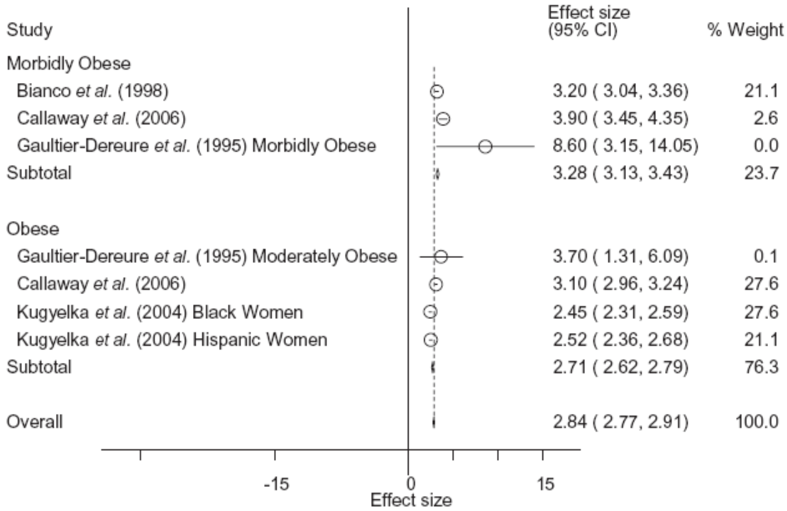

Figure 6 Mean length of hospital stay (days) for obese and morbidly obese BMI compared with ideal BMI (ideal mean length of stay 2.4 d).

12-fold significant increase in having difficulty in determining fetal lie in obese women when compared with non-obese women (58); malpresentation was significant with increased odds of 1.4 (95% CI 1.2, 1.6) in obese women (72), but this was not significant in overweight women (47), and incidence of occiput posterior was not found to be significant in obese, overweight or underweight women (54). Premature rupture of membranes was identified to have increased odds of between 1.2 and 1.3 in three studies (48,58,72); however, this was only significant in one study with odds of 1.20 (95% CI 1.02, 1.5) (72).

Failed induction increased from 0% in the ideal BMI group, to 1.7% and 2.5% in overweight and obese mothers respectively (47). Failed instrumental delivery was significantly higher in obese compared with non-obese women in one study (8), whereas another study found no significance in either obese or overweight women when compared with the ideal BMI group (47). Labour abnormalities (including prolonged latent phase, protracted active phase, secondary arrest of dilation, arrest of descent, prolonged second stage) were found to be significantly increased in overweight women when compared with underweight women (OR 1.78, 95% CI 1.11, 2.81), but this was not found to be significant in obese women (38). There was an increased odds of labour dystocia and obesity (1.67, 95% CI 1.50, 1.86) (33), and duration of labour ranged between a mean of 4.7 h (SD 2.8) (23) and 8.1 h (SD 4.2) (8) for obese women, compared with 5.7 h (SD 2.9) (23) to 7.7 h (SD 4.0) (8) in non-obese women.

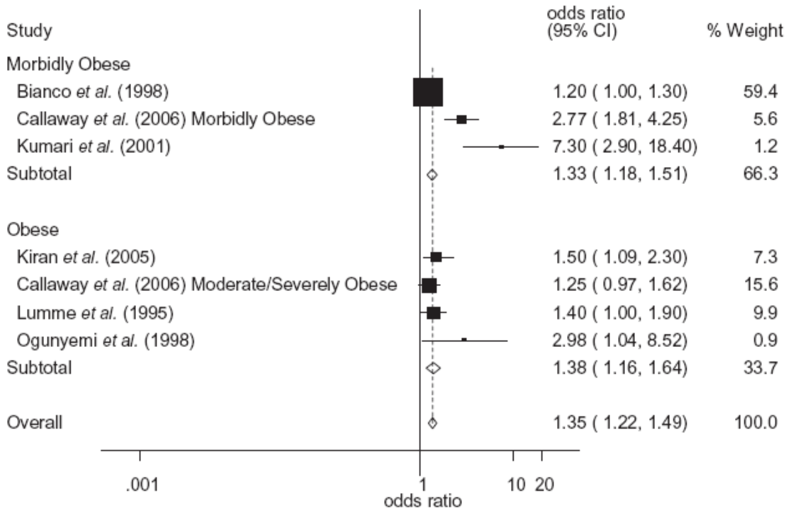

Figure 7 Neonatal intensive care unit treatment for obese and morbidly obese BMI compared with ideal BMI.

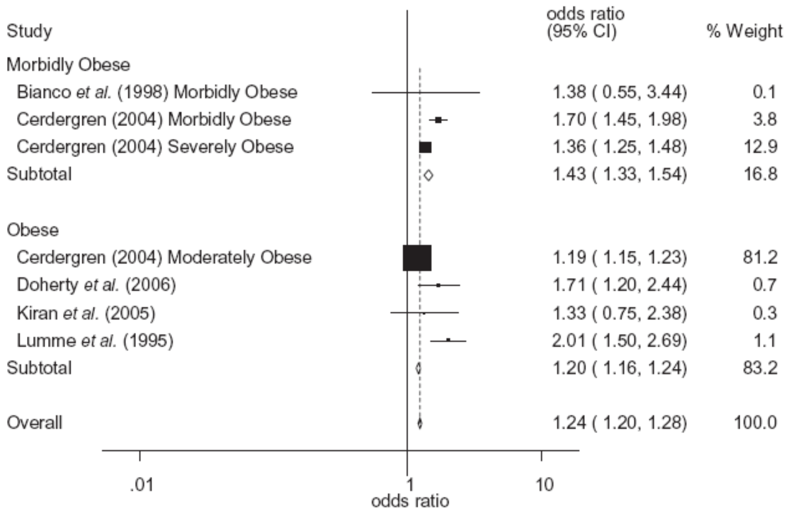

Figure 8 Maternal haemorrhage forest plot for obese and morbidly obese BMI compared with ideal BMI.

Only one study measured pain and obese women were found to have a lower median pain score compared with women with an ideal BMI (9 and 8 respectively). However, the proportion of women who reported a high pain score of 7–9 was slightly higher in the obese group (85% vs. 83%) (51). There was also an increased odds of obese women requiring nitrous oxide (OR 6.43, 95% CI 3.17, 13.04) and pethidine (OR 12.35, 95% CI 3.00, 50.89) (51).

Hospital admission non-meta-analysis

Studies looking at hospitalization could not be meta-analysed; however, most showed an increasing level of hospital contact with obesity and overweight. For moderate obesity and severe or morbid obesity the odds of outpatient hospitalization were 10.42 (95% CI 3.05, 35.55) and 20.00 (95% CI 5.51, 72.58), respectively, when compared with women in the ideal BMI group (23). This pattern was reflected in the odds of inpatient hospitalization being 5.60 (95% CI 1.75, 17.90) for moderate obesity, and 18.51 (95% CI 5.44, 62.99) for severe or morbid obesity, and increased hospitalization was also shown in the overweight group (OR 6.25, 95% CI 1.92, 20.38 for outpatient, and 4.90, 95% CI 1.63, 14.70 for inpatient hospitalization). The odds of overall admission to hospital was also increased in obese women when compared with women with an ideal BMI (OR 2.67, 95% CI 2.15, 3.32) but not significant for underweight women (50). Readmission to hospital showed a significant relationship with underweight (OR 3.36, 95% CI 1.84, 6.12) but was not found to be significant for obese or overweight women (66).

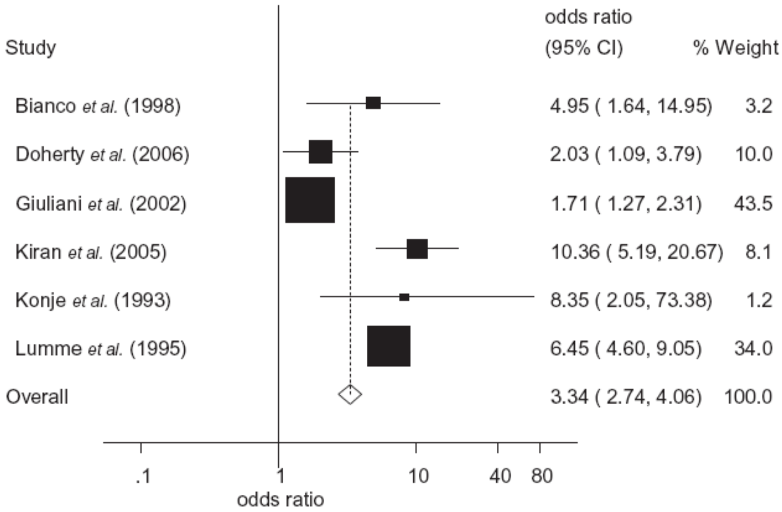

Figure 9 Maternal infection for obese BMI compared with ideal BMI.

Neonate meta-analysis

There is no significant relationship with Apgar score at 1 min and maternal obesity; however having a low Apgar score at 5 min increases by 1.5-fold in obese women, and this rises twofold if the mother is morbidly obese. The relationship between Apgar score and underweight could not be meta-analysed; however, no apparent significant relationship with Apgar score at 1 min (50) or 5 min (54) was found.

There is a significant increase in fetal compromise in the overweight, obese and morbidly obese groups, and there are increased odds of meconium being present when mothers are obese. Fetal compromise in underweight women could not be meta-analysed but was found not to be significant in two studies (31,32). There doesn't appear to be any significant relationship with shoulder dystocia (Fig. 10); however, the control groups for this outcome included both ideal and non-obese BMI. Following sensitivity analysis including only ideal BMI control groups no significance remained (OR 1.02, 95% CI 0.95, 1.11). Jaundice in neonates born to obese mothers showed no significance; however, the analysis could not be carried out for morbid obesity separately for either jaundice or shoulder dystocia. One study that provided data on morbid obesity showed a significant increase in the odds of jaundice (OR 1.44, 95% CI 1.09, 1.89) (67), but there remained no significance for shoulder dystocia (62).

Neonate non-meta-analysis

There were a number of outcomes affecting the neonate that have an impact on resources and could not be meta-analysed. No significant relationship between obesity or overweight and the need for mechanical ventilation was reported (67), whereas there appears to be a significant relationship with obesity and incubator requirement (OR 1.64, 95% CI 1.02, 2.63) (8), respiratory distress (OR 1.71, 95% CI 1.38, 2.11) (42) and resuscitation (OR 1.75, 95% CI 1.26, 2.43) (32), with similar findings in the overweight BMI group (32,38,42), but not in the underweight group (32,42). There is a reported increased odds of fetal heart rate abnormalities in both obese and overweight women (OR 1.33, 95% CI 1.01, 1.67 and 1.38, 95% CI 1.03, 1.85 respectively) (38), and increased tube feeding required (OR 1.51, 95% CI 1.08, 2.10) (8). The incidence of asphyxia was not found to be significantly related to obesity, overweight or underweight (8,54); obesity and overweight appear not to be related to the incidence of hyperbilirubinaemia (60), hypoglycaemia (53) or cord pH < 7.2 (8).

Maternal complications meta-analysis

Third and fourth degree tears are considered to be a primary outcome with a direct NHS resource implication; however, these have been combined with the other reported tears (perineal tear/trauma, and vaginal repair) owing to insufficient studies being suitable for meta-analysis. There was no significant relationship with tears and lacerations and maternal obesity. It was not possible to meta-analyse underweight or overweight and tears; however, there was no apparent relationship with overweight and perineal trauma (32,54), whereas underweight was seen to have a significantly inverse relationship with perineal trauma in one study (OR 0.70, 95% CI 0.49, 0.99) (32), and another study identified no significant relationship (54).

Maternal complications non-meta-analysis

The maternal outcomes identified as having resource implications that could not be meta-analysed were retained placenta, evacuation of uterus, thromboembolic events and puerperal complications, and these largely showed no

Table 12 Meta-analysis results – secondary outcomes

	Underweight vs. ideal BMI	Overweight vs. ideal BMI	Obese vs. ideal BMI	Morbidly obese vs. ideal BMI
	OR (95% CI)			
Birth weight and growth				
Birth weight (mean)§	3225 (3206, 3243) $n = 4$	3334 (3317, 3351)†‡ $n = 3$	3429 (3418, 3439) $n = 15$	
Low birth weight	1.781 (1.677, 1.891)† $n = 11$	0.933 (0.890, 0.978) $n = 14$	0.841 (0.782, 0.905) $n = 19$	1.113 (0.924, 1.340) $n = 5$
High birth weight	0.522 (0.458, 0.596) $n = 4$	1.308 (1.215, 1.407)†‡ $n = 8$	2.357 (2.293, 2.422)‡ $n = 15$	
>41/42 weeks	–*	1.282 (1.198, 1.372)† $n = 3$	1.370 (1.332, 1.409)† $n = 4$	1.556 (1.479, 1.636) $n = 3$
<37 weeks	1.049 (0.871, 1.265)† $n = 3$	1.166 (1.051, 1.293)† $n = 6$	1.226 (1.149, 1.308)† $n = 9$	1.495 (1.409, 1.587) $n = 6$
<34 weeks	–*	–*	0.885 (0.670, 1.169)† $n = 3$	
<32 weeks	–*	–*	1.586 (1.467, 1.715) $n = 4$	
Labour and delivery				
Labour onset induced	0.728 (0.639, 0.829)‡ $n = 4$	1.302 (1.163, 1.458)†‡ $n = 3$	1.880 (1.844, 1.917)‡ $n = 10$	
Oxytocin	–*	–*	1.593 (1.356, 1.872) $n = 3$	
Epidural	–*	–*	1.228 (1.191, 1.266) $n = 5$	
Vaginal delivery	–*	0.777 (0.712, 0.847) $n = 3$	0.654 (0.592, 0.722)†‡ $n = 4$	
Failure to progress	–*	–*	2.306 (1.871, 2.842)† $n = 4$	
Placenta abruption	–*	–*	0.984 (0.899, 1.078)† $n = 8$	
Placenta previa	–*	–*	0.826 (0.714, 0.955)† $n = 7$	
Neonate				
Low Apgar score (1 min)	–*	–*	1.494 (0.808, 2.763)†‡ $n = 3$	
Low Apgar score (5 min)	–*	–*	1.570 (1.465, 1.682)† $n = 4$	2.095 (1.866, 2.353) $n = 3$
Fetal compromise	–*	2.062 (1.439, 2.955)† $n = 4$	1.623 (1.545, 1.705) $n = 5$	2.082 (1.924, 2.254) $n = 4$
Meconium	–*	–*	1.570 (1.422, 1.732) $n = 5$	
Shoulder dystocia	–*	–*	1.042 (0.966, 1.125) $n = 9$	
Jaundice	–*	–*	1.041 (0.933, 1.162)† $n = 4$	
Mother				
Tears/lacerations	–*	–*	1.021 (0.969, 1.076)† $n = 7$	

*Data not available for meta-analysis.
†No significant heterogeneity.
‡Results following sensitivity analysis.
§Birth weight (g) compared with women in the ideal BMI category where mean birth weight 3281 (3273, 3288).

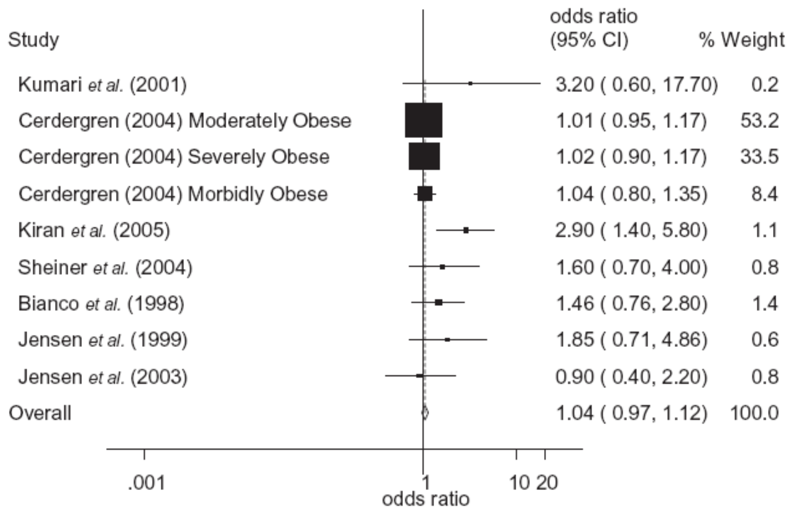

Figure 10 Shoulder dystocia forest plot for obese BMI compared with combined ideal and non-obese BMI.

significant relationship with BMI group (8,32,54,58, 66,72). One study did show significantly reduced odds for retained placenta in the underweight group when compared with women in the ideal group (32); however, these results are not supported by a second study which identified no significant relationship between these factors (54).

Discussion

The findings of this review have been split into outcomes that are deemed to have the greatest impact on services in terms of direct resource implications, and those outcomes that have the potential to lead to additional care being required that would also impact on NHS maternity service provision. A number of the outcomes identified as having a significant positive relationship with obesity support the findings of qualitative research carried out with healthcare professionals to identify their views on the impact of obesity on maternity service provision (21).

This review has identified a relationship between obesity and increased demand for deliveries that require additional resources such as instrumental and caesarean deliveries, and an inverse relationship with vaginal delivery. A vaginal delivery is the least costly option when considering the resources required for the NHS in both staffing and length of stay. The requirement for instrumental and caesarean deliveries increases the cost from £817 for a vaginal delivery without complications, to £1129 for an assisted delivery and £1682 for a caesarean delivery (75). These costs are seen to rise further to £2239 and £2337 when the assisted and caesarean deliveries have complications. The increased rate of caesarean delivery may be attributed to women who are identified as having larger babies prior to the onset of labour; also those women who may fail to progress in the first or second stages of labour may require an emergency caesarean delivery. Both of these outcomes are shown to be positively associated with maternal obesity in this review. Women who have had previous caesarean deliveries are at increased risk of requiring subsequent caesarean deliveries (76,77). As obesity in pregnancy is associated with increasing parity in mothers (7), and pregnancy is a factor which promotes obesity owing to gestational weight gain and inadequate weight loss between pregnancies (78–80), it would be reasonable to presume that increasing rates of repeat caesarean deliveries would be higher in those women who are obese. This is supported by Hibbard *et al.* (81) where morbid obesity in women who had a previous caesarean delivery was associated with failure of a trial of labour, and increased requirement for caesarean delivery. Failure to progress with labour is also shown in this review to be over twofold higher in obese women, which in addition to a relationship with more frequent caesarean deliveries, demands more intense midwifery care and need for an increased number of epidurals.

The implications of a caesarean delivery in terms of the mother's health when they are obese should be considered. There are greater anaesthetic risks during surgery when obesity is a factor (82) and there is an increased risk of wound infections following surgery. The 1.5-fold relationship with obesity and infections found in this review impacts on resources with the requirement for antibiotics and intravenous infusions, longer length of stay, and potentially debridement for severe wound infections which may require input from a plastic surgeon. The risk of haemorrhage is also shown to be increased in obese mothers, which may require longer hospitalization, increased drugs, blood transfusion, fluids, and may result in a return to theatre and intensive care treatment.

The potential for the increased risk of caesarean delivery and longer length of stay is associated with a number of the secondary outcomes. In addition to the caesarean risks associated with high birth weight, low birth weight [especially in the case of intrauterine growth restriction (IUGR)] is also an indicator for early caesarean delivery in order to minimize the risk of further restricted fetal growth *in utero*. Morbid obesity poses a risk for clinicians to fail to diagnose IUGR owing to an inability to obtain accurate fetal measurements, which could ultimately result in stillbirth if there is no intervention at an appropriate stage. With high birth weight there are resources that may be required in addition to caesarean delivery, such as repeat growth scans and clinic visits if the fetal measurements are above the cut-off for gestational age, and the mothers may require additional tests to exclude diabetes, such as glucose tolerance or fasting glucose tests.

The gestational age at delivery has a potential impact on maternity resources. Post-dates tend to have a higher induction rate associated with increased requirement for caesarean delivery and longer hospitalization. The resource implications for premature deliveries largely relate to neonatal special care or intensive care requirements, especially those deliveries under 32 weeks (where obese mothers have a 1.5-fold increased risk). The neonatal risk of having a low Apgar score at 5 min was shown to rise from over 1.5-fold in the overall obese group, to over twofold in the morbidly obese group. The resource implications of having a low Apgar score are increased input from paediatric teams, resuscitation and neonatal care. Additional staff requirements such as medical teams and increased midwifery care are needed for other fetal outcomes such as signs of fetal compromise, which may result in repeat fetal blood sampling if there is an abnormal heart pattern on monitoring, an operative vaginal or caesarean delivery, staff input during delivery and neonatal care requirements. Meconium stain can be a sign of fetal compromise; however, it can also be present in the case of post-date babies. If the meconium stain is significant, a paediatrician may be required at the delivery, therefore increasing staffing costs. In addition to the financial cost of neonatal intensive care, there is also a shortage of neonatal intensive care beds on a national level (83) and increased maternal hospitalization adds to the increased pressure on bed capacity. In addition to the neonatal intensive care requirements, there is generally a longer length of stay when babies are premature. Large tertiary centres that provide care for premature deliveries require the facilities to care for mothers to stay both prenatally and post-delivery, and there is a social cost because mother and baby are separated following birth.

In addition to the well-documented health implications to the obese mother and her baby, the huge demand on NHS resources as a consequence of this is apparent. The safer childbirth minimum care requirements for service provision (84) include indicators for increased midwife to mother ratio. These indicators incorporate a number of the risks for obese women identified in this review. The lowest risk categories I and II are deliveries between 37 and 42 weeks, normal birth, no intervention, good birth weight and Apgar score, and no epidural, requiring a 1:1 midwife to mother ratio. As the risk categories and midwifery ratios increase, the relationship with obesity and the indicators for increased midwifery care also increase. Category III requires a 1:1.12 ratio and includes induction, fetal monitoring, instrumental delivery, third degree tear and preterm birth, category IV includes the use of epidural and a 1:1.3 ratio, and the highest risk category requiring a 1:1.4 ratio includes emergency caesarean, medical or obstetric complications, and severe pregnancy induced hypertension.

Despite the adverse health implications and additional resource demand, there is an apparent lack of national guidelines for clinical practice, and an absence of public health interventions and research devoted to the prevention of maternal obesity. The CEMACH (6) recommends that obese women are high-risk group and require preconception counselling and support, especially in the case of fertility treatment, and stresses that guidelines are urgently needed for the management of obese women in pregnancy. This drive to develop clinical guidelines for the management of the obese pregnant woman is vital to help safeguard the health of mothers and their babies, and to develop public health interventions both prior to conception and post-natally to help prevent the rise in maternal obesity. Ideally women would have a healthy weight status prior to conception, and efforts need to be focused on adolescents and young women, potentially through school-based programmes and via family-planning services. Developing a successful programme of public health interventions to prevent maternal obesity would stem rising NHS resource implications, and minimize the risks to both the mother and her baby.

Conflict of Interest Statement

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References

1. Department of Health. *Choosing Health – Making Healthy Choices Easier*. HMSO: London, 2004.
2. Government Office for Science. FORESIGHT *Tackling Obesities: Future Choices – Project Report*, 2nd edn. Department of Innovation Universities and Skills: 2007.
3. Department of Health. *Health Survey for England 2004*. HMSO: London, 2005.
4. Department of Health. *Health Survey for England 2003*. HMSO: London, 2003.
5. Confidential Enquiry into Maternal and Child Health. *Why Mothers Die 2000–2002*. RCOG: London, 2004.
6. Lewis G. *The Confidential Enquiry into Maternal and Child Health (CEMACH). Saving Mothers' Lives: Reviewing Maternal Deaths to Make Motherhood Safer* – 2003–2005. The Seventh Report on Confidential Enquiries into Maternal Deaths in the United Kingdom (ed.). CEMACH: London, 2007.
7. Heslehurst N, Ells LJ, Simpson H, Batterham A, Wilkinson J, Summerbell CD. Trends in maternal obesity incidence rates, demographic predictors, and health inequalities in 36 821 women over a 15-year period. *BJOG* 2007; **114**: 187–194.
8. Kiran TSU, Hemmadi S, Bethal J, Evans J. Outcome of pregnancy in a woman with an increased body mass index. *Br J Obstet Gynaecol* 2005; **112**: 768–772.
9. Kanagalingam MG, Forouhi NG, Greer IA, Sattar N. Changes in booking body mass index over a decade: retrospective analysis from a Glasgow Maternity Hospital. *BJOG* 2005; **112**: 1431–1433.
10. Guelinckx I, Devlieger R, Beckers K, Vansant G. Maternal obesity: pregnancy complications, gestational weight gain and nutrition. *Obes Rev* 2008; 9: 140–150.
11. Wang JX, Davies MJ, Norman RJ. Obesity increases the risk of spontaneous abortion during infertility treatment. *Obes Res* 2002; **10**: 551–554.
12. Clark AM, Ledger W, Galletly C, Tomlinson L, Blaney F, Wang X, Norman RJ. Weight loss results in significant improvement in pregnancy and ovulation rates in anovulatory obese women. *Hum Reprod* 1995; **10**: 2705–2712.
13. Andreasen KR, Andersen ML, Schantz AL. Obesity and pregnancy. *Acta Obstet Gynecol Scand* 2004; 83: 1022–1029.
14. Linne Y. Effects of obesity on women's reproduction and complications during pregnancy. *Obes Rev* 2004; 5: 137–143.
15. Castro LC, Avina RL. Maternal obesity and pregnancy outcomes. *Curr Opin Obstet Gynecol* 2002; **14**: 601–606.
16. Lashen H, Fear K, Sturdee DW. Obesity is associated with increased risk of first trimester and recurrent miscarriage: matched case-control study. *Hum Reprod* 2004; **19**: 1644–1646.
17. Cnattingius S, Lambe M. Trends in smoking and overweight during pregnancy: prevalence, risks of pregnancy complications and adverse pregnancy outcomes. *Semin Perinatol* 2002; **26**: 286–295.
18. Confidential Enquiry into Maternal and Child Health. *Perinatal Mortality 2005*. CEMACH: London, 2007.
19. Waller K, Shaw GM, Rasmussen SA, Hobbs CA, Canfield MA, Siega-Riz A, Gallaway S, Correa A. Prepregnancy obesity as a risk factor for structural birth defects. *Arch Pediatr Adolesc Med* 2007; **161**: 745–750.
20. National Institute for Health and Clinical Excellence. *Antenatal Care: Routine Care for the Healthy Pregnant Woman*. RCOG: London, 2003.
21. Heslehurst N, Lang R, Rankin J, Wilkinson J, Summerbell C. Obesity in pregnancy: a study of the impact of maternal obesity on NHS maternity services. *BJOG* 2007; **114**: 334–342.
22. Chu SY, Kim SY, Schmid CH, Dietz PM, Callaghan WM, Lau J, Curtis KM. Maternal obesity and risk of cesarean delivery: a meta-analysis. *Obes Rev* 2007; 8: 385–394.
23. Galtier-Dereure F, Boegner C, Bringer J. Weight excess before pregnancy: complications and cost. *Int J Obes Relat Metab Disord* 1995; **19**: 443–448.
24. The Cochrane Non-Randomised Studies Methods Group. *Data extraction form template for cohort studies. 2001*. [WWW document]. URL http://www.cochrane.dk/nrsmg/guidelines.htm (accessed 6 September 2005).
25. Scottish Intercollegiate Guidelines Network. *Methodology Checklist 3: Cohort studies* 2004. [WWW document]. URL http://resources.fpin.org/documents/ClinicalInquiries/Resources/SIGN%20Cohort%20checklist3.pdf (accessed 2 November 2005).
26. StataCorp LP. *Intercooled STATA 9*. 2005: USA.
27. Abrams B, Newman V. Small-for-gestational-age birth: maternal predictors and comparison with risk factors of spontaneous preterm delivery in the same cohort. *Am J Obstet Gynecol* 1991; **164**: 785–790.
28. Baeten JM, Bukusi EA, Lambe M. Pregnancy complications and outcomes among overweight and obese nulliparous women. *Am J Public Health* 2001; **91**: 436–440.
29. Bianco AT, Smilen SW, Davis Y, Lopez S, Lapinski R, Lockwood CJ. Pregnancy outcome and weight gain recommendations for the morbidly obese woman. *Obstet Gynecol* 1998; **91**: 97–102.
30. Crane SS, Wojtowycz MA, Dye TD, Aubry RH, Artal R. Association between pre-pregnancy obesity and the risk of caesarean delivery. *Obstet Gynecol* 1997; 89: 213–216.
31. Dempsey JC, Ashiny Z, Qiu CF, Miller RS, Sorensen TK, Williams MA. Maternal pre-pregnancy overweight status and obesity as risk factors for cesarean delivery. *J Matern Fetal Neonatal Med* 2005; **17**: 179–185.
32. Doherty DA, Magann EF, Francis J, Morrison JC, Newnham JP. Pre-pregnancy body mass index and pregnancy outcomes. *Int J Gynaecol Obstet* 2006; **95**: 242–247.
33. Ehrenberg HM, Durnwald CP, Catalano P, Mercer BM. The influence of obesity and diabetes on the risk of cesarean delivery. *Am J Obstet Gynecol* 2004; **191**: 969–974.
34. Ehrenberg HM, Mercer BM, Catalano PM. The influence of obesity and diabetes on the prevalence of macrosomia. *Am J Obstet Gynecol* 2004; **191**: 964–968.
35. Hellerstedt WL, Himes JH, Story M, Alton IR, Edwards LE. The effects of cigarette smoking and gestational weight change on birth outcomes in obese and normal-weight women. *Am J Public Health* 1997; 87: 591–596.
36. Hendler I, Goldenberg RL, Mercer BM, Iams JD, Meis PJ, Moawad AH, MacPherson CA, Caritis SN, Miodovnik M, Menard KM, Thurnau GR, Sorokin Y. The preterm prediction study: association between maternal body mass index and spontaneous and indicated preterm birth. *Am J Obstet Gynecol* 2005; **192**: 882–886.
37. Hulsey TC, Neal D, Bondo SC, Hulsey T, Newman R. Maternal prepregnant body mass index and weight gain related to low birth weight in South Carolina. *South Med J* 2005; 98: 411–415.
38. Johnson JW, Longmate JA, Frentzen B. Excessive maternal weight and pregnancy outcome. *Am J Obstet Gynecol* 1992; **167**: 353–370.

39. Kaiser PS, Kirby RS. Obesity as a risk factor for cesarean in a low-risk population. *Obstet Gynecol* 2001; **97**: 39–43.
40. Kugyelka JG, Rasmussen KR, Frongillo EA. Maternal obesity is negatively associated with breastfeeding success among Hispanic but not black women. *J Nutr* 2004; **134**: 1746–1753.
41. Lombardi DG, Barton JR, O'Brien JM, Istwan NK, Sibai BM. Does an obese prepregnancy body mass index influence outcome in pregnancies complicated by mild gestational hypertension remote from term? *Am J Obstet Gynecol* 2005; **192**: 1472–1474.
42. Naeye RL. Maternal body weight and pregnancy outcome. *Am J Clin Nutr* 1990; **52**: 273–279.
43. Ogunyemi D, Hullett S, Leeper J, Risk A. Prepregnancy body mass index, weight gain during pregnancy, and perinatal outcome in a rural black population. *J Matern Fetal Med* 1998; **7**: 190–193.
44. Rosenberg TJ, Garbers S, Chavkin W, Chiasson MA. Prepregnancy weight and adverse perinatal outcomes in an ethnically diverse population. *Obstet Gynecol* 2003; **102**: 1022–1027.
45. Shepard MJ, Saftlas AF, Leo-Summers L, Bracken MB. Maternal anthropometric factors and risk of primary cesarean delivery. *Am J Public Health* 1998; **88**: 1534–1538.
46. Steinfeld JD, Valentine S, Lerer T, Ingardia CJ, Wax JR, Curry SL. Obesity-related complications of pregnancy vary by race. *J Matern Fetal Med* 2000; **9**: 238–241.
47. Vahratian A, Zhang J, Troendle JF, Savitz DA, Siega-Riz AM. Maternal prepregnancy overweight and obesity and the pattern of labor progression in term nulliparous women. *Obstet Gynecol* 2004; **104**: 943–951.
48. Weiss JL, Malone FD, Emig D, Ball MH, Nyberg DA, Comstock CH, Saade G, Eddleman K, Carter SM, Craigo SB, Carr SR, D'Alton ME. Obesity, obstetric complications and cesarean delivery rate – a population-based screening study. *Am J Obstet Gynecol* 2004; **190**: 1091–1097.
49. Ekblad U, Grenman S. Maternal weight, weight gain during pregnancy and pregnancy outcome. *Int J Gynaecol Obstet* 1992; **39**: 277–283.
50. Lumme R, Rantakallio P, Hartikainen AL, Jarvelin MR. Prepregnancy weight and its relation to pregnancy outcome. *Obstet Gynaecol* 1995; **15**: 69–75.
51. Ranta P, Jouppila P, Spalding M, Jouppila R. The effect of maternal obesity on labour and labour pain. *Anaesthesia* 1995; **50**: 322–326.
52. Rantakallio P, Laara E, Koiranen M, Sarpola A. Maternal build and pregnancy outcome. *J Clin Epidemiol* 1995; **48**: 199–207.
53. Jensen DM, Damm P, Sorensen B, Molsted-Pedersen L, Westergaard JG, Ovesen P, Beck-Nielsen H. Pregnancy outcome and prepregnancy body mass index in 2459 glucose-tolerant Danish women. *Am J Obstet Gynecol* 2003; **189**: 239–244.
54. Jensen H, Agger AO, Rasmussen KL. The influence of prepregnancy body mass index on labor complications. *Acta Obstet Gynecol Scand* 1999; **78**: 799–802.
55. Olesen AW, Westergaard JG, Olsen J. Prenatal risk indicators of a prolonged pregnancy. The Danish Birth Cohort 1998–2001. *Acta Obstet Gynecol Scand* 2006; **85**: 1338–1341.
56. Rode L, Nilas L, Wojdemann K, Tabor A. Obesity-related complications in Danish single cephalic term pregnancies. *Obstet Gynecol* 2005; **105**: 537–542.
57. Bergholt T, Lim LK, Jorgensen JS, Robson MS. Maternal body mass index in the first trimester and risk of cesarean delivery in nulliparous women in spontaneous labor. *Am J Obstet Gynecol* 2007; **196**: 163.e1–5.
58. Konje JC, Imrie A, Hay DM. Pregnancy in obese women. *J Obstet Gynaecol* 1993; **13**: 413–418.
59. Bo S, Menato G, Signorile A, Bardelli C, Lezo A, Gallo ML, Gambino R, Cassader M, Massobrio M, Pagano G. Obesity or diabetes: what is worse for the mother and for the baby? *Diabetes Metab* 2003; **29**(2 Pt 1): 175–178.
60. Di Cianni G, Volpe L, Lencioni C, Miccoli R, Cuccuru I, Ghio A, Chatzianagnostou K, Bottone P, Teti G, Del Prato S, Benzi L. Prevalence and risk factors for gestational diabetes assessed by universal screening. *Diabetes Res Clin Pract* 2003; **62**: 131–137.
61. Mancuso A, D'Anna R, Leonardi R. Pregnancy in the obese patient. *Eur J Obstet Gynecol Reprod Biol* 1991; **39**: 83–86.
62. Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. *Obstet Gynecol* 2004; **103**: 219–224.
63. Cnattingius S, Bergstrom R, Lipworth L, Kramer MS. Prepregnancy weight and the risk of adverse pregnancy outcomes. *N Engl J Med* 1998; **338**: 147–152.
64. Rossner S, Ohlin A. Maternal body weight and relation to birthweight. *Acta Obstet Gynecol Scand* 1990; **69**: 475–478.
65. Galtier-Dereure F, Boegner C, Bringer J. Obesity and pregnancy: complications and cost. *Am J Clin Nutr* 2000; **71**: 1242–1242.
66. Giuliani A, Tamussino K, Basver A, Haas J, Petru E. The impact of body mass index and weight gain during pregnancy on puerperal complications after spontaneous vaginal delivery. *Wien Klin Wochenschr* 2002; **114**: 383–386.
67. Callaway LK, Prins JB, Chang AM, McIntyre HD. The prevalence and impact of overweight and obesity in an Australian obstetric population. *Med J Aust* 2006; **184**: 56–59.
68. Kramer MS, Platt R, Yang H, McNamara H, Usher RH. Are all growth-restricted newborns created equal(ly)? *Pediatrics* 1999; **103**: 599–602.
69. Kumari AS. Pregnancy outcome in women with morbid obesity. *Int J Gynecol Obstet* 2001; **73**: 101–107.
70. Nucci LB, Schmidt MI, Duncan BB, Fuchs SC, Fleck ET, Santos Britto MM. Nutritional status of pregnant women: prevalence and associated pregnancy outcomes. *Rev Saude Publica* 2001; **35**: 502–507.
71. Phithakwatchara N, Titapant V. The effect of pre-pregnancy weight on delivery outcome and birth weight in potential diabetic patients with normal screening for gestational diabetes mellitus in Siriraj Hospital. *J Med Assoc Thai* 2007; **90**: 229–236.
72. Sheiner E, Levy A, Menes TS. Maternal obesity as an independent risk factor for caesarean delivery. *Paediatr Perinat Epidemiol* 2004; **18**: 196–201.
73. Yekta Z, Ayatollahi H, Porali R, Farzin A. The effect of pre-pregnancy body mass index and gestational weight gain on pregnancy outcomes in urban care settings in Urmia-Iran. *BMC Pregnancy Childbirth* 2006; **6**: 15–23.
74. Bland M. *An Introduction to Medical Statistics*, 2nd edn. Oxford University Press: Oxford, 1996.
75. Department of Health. *National Schedule of Reference Costs in the NHS 2005–2006*. Department of Health: London, 2006.
76. Chauhan SP, Magann EF, Carroll CS, Barrilleaux PS, Scardo JA, Martin JN, Jr. Mode of delivery for the morbidly obese with prior cesarean delivery: vaginal versus repeat cesarean section. *Am J Obstet Gynecol* 2001; **185**: 349–354.
77. Edwards RK, Harnsberger DS, Johnson IM, Treloar RW, Cruz AC. Deciding on route of delivery for obese women with a prior cesarean delivery. *Am J Obstet Gynecol* 2003; **189**: 385–390.
78. Gore SA, Brown DM, Smith West D. The role of postpartum weight retention in obesity among women: a review of the evidence. *Ann Behav Med* 2003; **26**: 149–159.
79. Gunderson EP, Abrams B. Epidemiology of gestational weight gain and body weight changes after pregnancy. *Epidemiol Rev* 2000; **22**: 261–274.
80. Siega-Riz AM, Evenson KR, Dole N. Pregnancy-related weight gain – a link to obesity? *Nutr Rev* 2004; **62**: S105–111.

81. Hibbard JU, Gilbert S, Landon MB, Hauth JC, Leveno KJ, Spong CY, Varner MW, Caritis SN, Harper M, Wapner RJ, Sorokin Y, Miodovnik M, Carpenter M, Peaceman AM, O'Sullivan MJ, Sibai BM, Langer O, Thorp JM, Ramin SM, Mercer BM, Gabbe SG. Trial of labor or repeat cesarean delivery in women with morbid obesity and previous cesarean delivery. *Obstet Gynaecol* 2006; **108**: 125–133.
82. Dresner M. Obesity and Anaesthesia. In: Baker P, Balen A, Poston L, Sattar N (eds). *Obesity and Reproductive Health*. Royal College of Obstetricians and Gynaecologists: London, 2007, pp. 175–179.
83. Parmanum J, Field D, Rennie J, Steer P. National census of availability of neonatal intensive care. *Br Med J* 2000; **321**: 727–729.
84. Royal College of Obstetricians and Gynaecologists, Royal College of Midwives, Royal College of Anaesthetists and Royal College of Paediatricians and Child Health. *Safer Childbirth: Minimum Standards for Service Provision and Care in Labour*. 1 November 2006.
85. Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. *Obstetrics & Gynecology* 2004; **103**: 219–224.

Appendix p5 Conference Proceedings for the 10th International Congress on Obesity (ICO), 2006

Funding Disclosure: This study was supported by educational grant-in-aid by Roche Products Ltd.

PO0389

Maternal obesity incidence, demographic trends, and impact on service delivery in a north east England maternity unit, using data for 36 625 subjects over a 15 year period

Heslehurst N[1], Ells L[1], Simpson H[2], Walrond S[3] and Summerbell C[1]

[1]*University of Teesside, Middlesbrough, UK;* [2]*James Cook University Hospital, Middlesbrough, UK;* [3]*The North East Public Health Observatory, Stockton, UK*

Introduction: Local maternity staff anecdotally report an increase in maternal obesity. This study aims to identify the incidence, trends, and immediate impact of maternal obesity on maternity resource.

Methods: Data from a large maternity unit in the northeast of England, UK, between 1990 and 2004 was grouped into lean (BMI<18.5 kg/m^2), normal (BMI 18.5–24.9 kg/m^2), overweight (BMI 25–29.9 kg/m^2), and obese (BMI>30 kg/m^2). Trends in incidence over time utilised the Chi squared test for trend, and logistic regression calculated adjusted OR (95%CI) for demographic trends in maternal obesity.Analysis on the immediate impact on service delivery will use regression analysis, and will include the obesity subgroups: moderate (BMI 30–34.9 kg/m^2), severe (BMI 35–39.9 kg/m^2), and morbid obesity (BMI>40 kg/m^2). This will be completed by April 2006.

Results: Incidence and trends analysis was performed on 36 625 subjects. Maternal obesity has significantly increased from 1990 to 2004 (9.9%-16.0% $P < 0.01$). Predictors of maternal obesity were residing in areas of deprivation (OR 2.00, 1.73–2.31, $P < 0.01$), parity (OR 1.16, 1.11–1.20, $P < 0.01$), unemployment (OR 1.14, 1.05–1.24, $P < 0.01$), and age (OR 1.04, 1.04–1.05, $P < 0.01$). Maternal obesity was significantly reduced in Indian or Bangladeshi ethnic origin (OR 0.35, 0.18–0.66, $P < 0.01$), and Pakistani origin also showed a borderline reduction (OR 0.81, 0.64–1.01, $P = 0.06$).

Conclusions: The increasing incidence of maternal obesity in the local area confirms the anecdotal reports of obstetric staff. The predictors of maternal obesity are closely related to health inequality issues of obesity in the general population, with the exception of ethnic origin: in 1999 obesity was higher than the national average by 25% in Pakistani women.

PO0390

Change in waist circumference and metabolic consequences over 9 years: the D.E.S.I.R. study

Balkau B[1], Picard P[1], Vol S[2], Eschwège E[1] and the D.E.S.I.R. Study Group[2]

[1]*INSERM U780, Villejuif, France;* [2]*IRSA, La Riche, France*

Background: The long-term effect on metabolic parameters, of gaining or loosing abdominal adiposity has been little analysed in longitudinal studies.

Methods: 1863 men and 1938 women, aged 30–65 years at inclusion in the French D.E.S.I.R. cohort (Data from an Epidemiological Study on the Insulin Resistance Syndrome) were studied for metabolic syndrome parameters over 9 years.

Results: At baseline, 8% of men and 13% of women had NCEP defined abdominal adiposity: waist > 102/88 cm (men/women); at 9 years, 16% and 25% respectively. Over this period, 25% of the men and 34% of the women increased their waist by more than 7 cm, while 14% and 13% lost more than 2 cm. In subjects with a 7 cm or more increase in waist circumference, in comparison to those with a stable waist (± 2 cm), the age-adjusted odds ratios were, in men and women, for incident: hyperglycaemia (≥6.1 mmol/L) 1.7 (1.0–2.8) and 2.7 (1.4–5.0); high arterial blood pressure (SBP/DBP ≥135/85 mmHg) 1.5 (0.9–2.4) and 1.5 (1.0–2.2); hyper-triglyceridaemia (≥1.7 mmol/L) 2.3 (1.5–3.5), 2.2 (1.4–3.6); hypo-HDL-cholesterolaemia (<1.03/1.29 mmol/L men/women) 2.0 (1.1–3.4) and 1.9 (1.2–2.8); the NCEP defined metabolic syndrome 6.6 (3.9–11.3), 4.5 (2.6–7.4). These results were little attenuated after adjusting on BMI

Conclusion: Increasing waist circumferences had similar deleterious metabolic effects in men and women, which was accentuated when combined together into the metabolic syndrome: odds-ratios were more than 6 in men and 4 in women whose waist circumferences increased by more than 7 cm over 9 years.

PO0391

Weight and weight-related problems – the Otago Diabetes Register, 1998–2004

Coppell K[1,2], Williams S[3], Mann J[1,4]

[1]*Edgar National Centre for Diabetes Research, University of Otago, New Zealand;* [2]*Otago Diabetes Trust Otago, Dunedin, New Zealand;* [3]*Department of Preventive and Social Medicine, University of Otago, New Zealand;* [4]*Department of Human Nutrition, University of Otago, New Zealand*

Background: Obesity is an important risk factor for the development of type 2 diabetes (T2DM) and its complications. Almost half of the patients enrolled on the Otago Diabetes Register (ODR) are obese and the mean weight of both men and women has increased significantly since 1998. The aim of this study was to describe weight and weight-related problems of new T2DM cases diagnosed between 1998 and 2004 according to age using ODR data.

Methods: Data held on the ODR were collected annually from general practices and Births, Deaths and Marriages Office. Demographic and diabetes information was extracted from the ODR for T2DM cases diagnosed between 1998 and 2004. Demographic, clinical and test result information for the year of diagnosis were compared between four age groups (<40, 40–59, 60–79 and ≥80 years).

Results: 1 589 new cases of T2DM were identified. 5% were aged <40 years and 38% were aged 40–59 years at diagnosis. Weight, body mass index and diastolic blood pressure increased significantly across age groups from 105.4 kg, 36.0 kg/m^2 and 80.2 mmHg, respectively, for the youngest age group to 69.3 kg, 26.4 kg/m^2 and 76.4 mmHg, respectively, for the oldest year age group. The reverse was observed for systolic blood pressure. HbA1c and triglycerides were significantly higher and HDL-cholesterol significantly lower in the <40 year age group compared with the other groups.

Conclusions: Obesity is more prevalent amongst diabetic patients diagnosed at a young age. Implementation of lifestyle changes is necessary to prevent the onset of diabetes and its serious complications at a young age

PO0392

The effect of socio-economic status on obesity and diabetic control in a diabetes care clinic population in the UK

Moore HJ[1], Wilkinson J[2], Kelly W[3], Kopelman P[4] and Summerbell CD[1]

[1]*Food and Nutrition Group, University of Teesside, Middlesbrough, UK;* [2]*North East Public Health Observatory, Durham University, Stockton, UK;* [3]*Diabetes Care Centre, James Cook University Hospital, Middlesbrough, UK;* [4]*Queen Mary's School of Medicine & Dentistry, London, UK*

Background: Over 5,000 patients a year are seen by staff at the Diabetes Care Centre based at James Cook University Hospital, Mid-

Appendix p6 Conference Proceedings for the 16th European Congress on Obesity (ECO), 2008

Abstracts

S21

T2:OS2.1

The Impact of Maternal BMI Status on Pregnancy Outcomes with Immediate Short-Term Obstetric Resource Implications: A Meta Analysis

Heslehurst, N [1], Simpson, H [2], Ells, L [3], Rankin, J [4], Wilkinson, J [3], Lang, R [1], Summerbell, C [1]

[1]University of Teesside, Middlesbrough, England
[2]James Cook University Hospital, Middlesbrough, England
[3]The North East Public Health Observatory, Stockton on Tees, England
[4]Newcastle University, Newcastle, England

Objective: To investigate the relationship between obesity at the start of pregnancy and the impact on obstetric care using meta analysis.
Population: Cohort studies of pregnant women with anthropometric measurements taken within 16 weeks gestation, followed up for the term of the pregnancy, with at least one obese and one comparison group.
Method: Systematic searches were carried out using Medline, CINAHL, MIDIRS, and the Cochrane databases. 126 papers were independently screened for inclusion by two researchers. 49 studies were eligible for inclusion in the review and two researchers independently used a fixed protocol for data extraction and quality evaluation of each study included.
Outcome Measures: Pregnancy outcomes that have an impact on maternity resources, both directly and indirectly. Primary outcome measures are instrumental delivery, caesarean, hospital stay, neonatal intensive care unit (NICU), neonatal trauma, haemorrhage, infection, and 3rd/4th degree tears.
Results: There is a significant relationship with obesity and increased odds of caesarean and instrumental deliveries, longer length of hospital stay, increased use of NICU, haemorrhage, and infection.

	Obese vs. Ideal	Morbidly Obese vs. Ideal
Caesarean delivery	2.005(1.872,2.148)	1.432(1.346,1.524)
Instrumental delivery*	1.169(1.130,1.209)	
Haemorrhage	1.202(1.163,1.243)	1.430(1.328,1.540)
Infection*	3.335(2.738,4.062)	
NICU	1.377(1.157,1.639)	1.331(1.175,1.507)
Hospital stay compared with ideal 2.421(2.407,2.434)	2.706(2.623,2.788)	3.279(3.131,3.428)

* Includes obese and morbidly obese groups

Conclusions: There is a clear impact on obstetric care in terms of utilisation of resources, and complications for both the mother and her infant. However, there is an absence of guidelines for clinicians to use relating to the management of obese mothers during their pregnancy.
Funding: Research relating to this abstract was funded by the North East Public Health Observatory and the University of Teesside

Appendix 1 CEMACH Specific Recommendations for Thromboembolism

Thromboembolism: Specific recommendations

There is an urgent need for a guideline on the management of obese pregnant women with a BMI over 35.

Public information and education messages are necessary so that women at risk of problems in pregnancy because of their weight, family history or past history can seek advice before pregnancy.

Health professionals must be aware that women are at risk of thromboembolism from the very beginning of pregnancy. Guidelines for the management of women at risk of thromboembolism are contained in the Annex to this Chapter.

At booking, a full risk and needs assessment must be undertaken before maternity care plans are decided. Because of their co-morbidity, obese women with a BMI of 35 or more are unsuitable for midwife-only care.

Telephone consultations require particular care because early symptoms of life-threatening embolism are generally mild and reassurance is too easy to give and accept.

Thromboprophylaxis should be a routine part of the management of ovarian hyperstimulation syndrome.

(Lewis, 2007)

Appendix 2 Obesity in Pregnancy and Anaesthesia Learning Points

All obstetric units should develop protocols for the management of morbidly obese women. These should include pre-assessment procedures, special community, ward and theatre equipment such as large sphygmomanometer cuffs, hoists, beds and operating tables and long regional block needles.

Morbidly obese women should be referred for anaesthetic assessment and advice as part of their antenatal care.

Management by consultant anaesthetists is essential and difficulties with airway management and intubation should be anticipated.

Positioning the women requires skill and sufficient manpower in the event of a requirement for induction of general anaesthesia.

Direct arterial pressure measurement may be useful in the morbidly obese women where sphygmomanometry is often inaccurate.

All morbidly obese women in childbirth should be given prophylactic low molecular weight heparin and the duration of therapy needs to be determined in view of likely immobility. Thromboembolic stockings of appropriate size need to be available.

(Lewis, 2007)

Appendix 8 University of Teesside School of Health and Social Care Ethical Approval Letter

UNIVERSITY OF
TEESSIDE

PRIVATE AND CONFIDENTIAL

Direct Line: 01642 384154

31st May 2004

Prof. Carolyn Summerbell
School of Health & Social Care
University of Teesside

Dear Carolyn

Study 040/05 Analysis of the scale of maternal obesity in the local area, and the association between maternal obesity and adverse pregnancy
Researcher: Nicola Heslehurst Supervisor: Carolyn Summerbell

The Research Ethics Committee reviewed the above proposal at the meeting on 25th May 2005 , the committee had no concerns with this study and agreed that this could proceed.

- The Committee were impressed with this application.

Please forward to me a copy of the approval letter from the local research ethics committee, before proceeding with the study.

The School of Health & Social Care Research Ethics Committee wish you well with your study.

Yours sincerely,

Tricia Forster

Tricia Forster
Chair
Research Ethics Committee
School of Health & Social Care

INVESTOR IN PEOPLE

DEAN: Professor PAUL KEANE
SCHOOL OF HEALTH & SOCIAL CARE
UNIVERSITY OF TEESSIDE
MIDDLESBROUGH TEES VALLEY
TS1 3BA UK

Appendix 9 South Tees NHS Trust LREC Approval Letter

NHS
South Tees Local Research Ethics Committee
Academic Centre
The James Cook University Hospital
Marton Road
Middlesbrough
Cleveland
TS4 3BW

Telephone: 01642 282451
Facsimile: 01642 854768

01 July 2005

Miss Nicola Heslehurst
Research Assistant
University of Teesside
Borough Road
Middlesbrough TS1 3BA

Dear Miss Heslehurst

Full title of study: **Analysis of the scale of maternal obesity in the local area, and the association between maternal obesity and adverse pregnancy outcomes**
REC reference number: **05/Q1003/58**

The Research Ethics Committee reviewed the above application at the meeting held on 30 June 2005.

Ethical opinion

The members of the Committee present gave a favourable ethical opinion of the above research on the basis described in the application form, protocol and supporting documentation.

The favourable opinion applies to the research sites listed on the attached form.

Conditions of approval

The favourable opinion is given provided that you comply with the conditions set out in the attached document. You are advised to study the conditions carefully.

Approved documents

The documents reviewed and approved at the meeting were:

Document	*Version*	*Date*
Application	4.1	07 June 2005
Investigator CV		07 June 2005
Investigator CV		07 June 2005
Protocol	V.1	07 June 2005
Covering Letter		07 June 2005
Letter from Sponsor		08 June 2005
Other		31 May 2005
Other		13 May 2005
Other		07 June 2005

Appendix 9 Continued. South Tees NHS Trust LREC Approval Letter

05/Q1003/58 Page 2

Management approval

The study should not commence at any NHS site until the local Principal Investigator has obtained final management approval from the R&D Department for the relevant NHS care organisation.

Membership of the Committee

The members of the Ethics Committee who were present at the meeting are listed on the attached sheet.

Notification of other bodies

The Committee Administrator will notify the research sponsor and the R&D Department for NHS care organisation(s) that the study has a favourable ethical opinion.

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.

05/Q1003/58	**Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project,

Yours sincerely

Dr John Drury
Chair

Email: carol.cheesebrough@stees.nhs.uk

Enclosures:

Attendance at Committee meeting on 30 June 2005
Standard approval conditions
Site approval form (SF1)

SF1 list of approved sites

Appendix 10 South Tees NHS Trust R&D Approval Letter

South Tees Hospitals NHS
NHS Trust

16th September 2005

Professor Carolyn Summerbell
Professor of Human Nutrition
University of Teesside
Parkside West Offices
MIDDLESBROUGH
TS1 3BA

Academic Division
Directorate of Research and Development
The Academic Centre
The James Cook University Hospital
Marton Road
Middlesbrough
TS4 3BW

Dear Professor Summerbell

ID: 2005072 - Analysis of the scale of maternal obesity in the local area, and the association between maternal obesity and adverse pregnancy

Your project was reviewed at the Research Approval Board on 7th September 2005. I am pleased to report that we approved the project although some of the reviewers noted that while the primary and secondary outcomes were clear in the formal protocol, the version that was transferred onto the official application forms painted a much vaguer picture of the intentions of the study recognising the potential for false positive outcomes in any extensive trawl of the database such as this. It was felt that it should be reinforced that the final paper should formally state the primary and secondary outcomes upon which the project was constructed.

I would like to take this opportunity to remind you that STHNHS Trust manages all research in accordance with the requirements of the Research Governance Framework. As a researcher working in the Trust you must comply with all reporting requirements, systems and duties of action put in place by the Trust to deliver Research Governance. You will be expected to read and familiarise yourself with conditions of approval as well as incident reporting procedures in relation to your project.

If the R&D Department can be of any further assistance, please do not hesitate to contact myself on the above telephone number or Karen Stage, R&D Manager on (01642) 854965.

Yours sincerely

Dr S Graham
Chairman of Research Approval Board

Cc Miss Nicola Heslehurst
Research Assistant
University of Teesside
Borough Road
Middlesbrough
TS1 3BA

Enclosures

Professor Rob Wilson MD FRCS - Director of Research & Development Tel 01642 854149 E-mail r.wilson@ncl.ac.uk
Karen Stage - Research & Development Manager Tel 01642 854965 E-mail karen.stage@stees.nhs.uk

Appendix 11 Correspondence from the Department of Health Regarding a List of all Maternity Units in England

From: DHMail@dh.gsi.gov.uk [mailto:DHMail@dh.gsi.gov.uk]
Sent: 15 November 2006 17:00
To: Heslehurst, Nicola
Subject: Response to your Query: - Ref: DE00000156612 - DE00000156612

Your ref:
Our ref: DE00000156612

N.Heslehurst@tees.ac.uk

15 November 2006

Dear Ms Heslehurst,

Thank you for your email of 6 November to the Department of Health about a list of all maternity units in England. Your email has been passed to me for reply.

Unfortunately, the Department of Health does not hold such a list centrally. However, I would suggest you view the Birth Choice UK website as the information you require is list there. I have included a link to the site below:

http://www.birthchoiceuk.com/

I hope that this information is helpful.

Yours sincerely,

Barry Davis
Department of Health

Appendix 12 National Survey Cover Letter to Heads of Midwifery and Clinical Directors

NORTH EAST PUBLIC HEALTH OBSERVATORY

UNIVERSITY OF TEESSIDE
SCHOOL OF HEALTH & SOCIAL CARE

The Centre for Food, Physical Activity, and Obesity Research
School of Health and Social Care
University of Teesside
Middlesbrough
TS1 3BA
Tel: (01642) 342758
Fax: (01642) 342770
n.heslehurst@tees.ac.uk
http://www.nepho.org.uk/maternityquestionnaire/

7th August 2006

Dear,

RE: Obesity in Pregnancy

The Centre for Food, Physical Activity, and Obesity Research at the University of Teesside is currently carrying out a programme of work on maternal obesity. The Centre is one of the NICE Public Health Collaborating Centre's on Obesity, and is the World Cancer Research Fund Systematic Literature Review (SLR) Centre on Obesity. The aim of our current research project is to investigate national trends in the incidence rates and demographic predictors of maternal obesity, in collaboration with the North East Public Health Observatory. The Royal College of Obstetricians and Gynaecologists are also aware of this research project.

Findings from our pilot study carried out in a large local cohort (n=36,821) showed that the incidence of maternal obesity has increased rapidly over the past 15 years and could reach 22% by 2010 if the current trend continues. Given the apparent acceleration in the rates of maternal obesity identified within the NE region we are very keen to explore the impact of maternal obesity across England. We would therefore like to identify a nationally representative sample of maternity units across England. The first step is to carry out a scoping study of all English maternity units to identify whether your maternity unit holds electronic data, and whether you would be happy to share this information with us.

We would be most grateful if you could please complete the attached short questionnaire and return by 30th September 2006 at the latest, in the SAE provided, by fax, or via online submission at http://www.nepho.org.uk/maternityquestionnaire/.

We feel the collection of this data will provide an important dataset, which we hope will raise awareness of the national incidence of maternal obesity and assist in optimising service delivery for groups at highest risk. For more information on this project please visit our website or contact Nicola Heslehurst who is co-ordinating this project.

We very much look forward to hearing from you.

Yours sincerely

Carolyn Summerbell

John R Wilkinson

Professor Carolyn Summerbell
Professor in Human Nutrition, University of Teesside

Professor John Wilkinson
Professor in Public Health, NEPHO

Appendix 13 National Survey Follow up Letter to Heads of Midwifery and Clinical Directors

The Centre for Food, Physical Activity, and Obesity Research
School of Health and Social Care
University of Teesside
Middlesbrough
TS1 3BA
Tel: (01642) 342758
Fax: (01642) 342770
n.heslehurst@tees.ac.uk

24th October 2006

Dear ,

RE: Obesity in Pregnancy

The University of Teesside and the North East Public Health Observatory recently wrote to you regarding the obesity in pregnancy study that we are involved in. This study aims to identify which maternity units in England have an electronic source of data relating to maternal obesity that could potentially be involved in our national study of incidence rates and trends in the demographics of obesity in pregnancy. We have had an excellent response so far form all maternity units in England (~75%). We do not appear to have had a response from your maternity unit however, and we would like to give you another opportunity to be involved in this exciting and novel piece of research.

The documentation originally sent to you has been attached. We would be most grateful if you could please complete the attached short questionnaire and return by 17th November 2006 at the latest, in the SAE provided, by fax, or via online submission at http://www.nepho.org.uk/maternityquestionnaire/

We very much look forward to hearing from you.

Yours sincerely

Professor Carolyn Summerbell
Professor in Human Nutrition, University of Teesside

Professor John Wilkinson
Professor in Public Health, NEPHO

Appendix 14 National Study Invitation to Participate in the Sampling Process Letter to Heads of Midwifery and Clinical Directors

nepho
NORTH EAST PUBLIC HEALTH OBSERVATORY

UNIVERSITY OF TEESSIDE
SCHOOL OF HEALTH & SOCIAL CARE

The Centre for Food, Physical Activity, and Obesity Research
School of Health and Social Care
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Tel: (01642) 342758
Fax: (01642) 342770
n.heslehurst@tees.ac.uk
http://www.nepho.org.uk/maternityquestionnaire/

11th December 2006

Dear ,

RE: Obesity in Pregnancy

Thank you for your response to the Obesity in Pregnancy survey, developed to establish routine maternal obesity data collection practices across England. The survey well received with a response rate of 89% (please see the enclosed map for an overview of all the responding maternity units).

The aim of this research project is to investigate national trends in the incidence rates and demographic predictors of maternal obesity. Findings from our pilot study carried out in a large local cohort (n=36,821) showed that the incidence of maternal obesity has increased rapidly over the past 15 years and could reach 22% by 2010 if the current trend continues (please see attached abstract, in press BJOG). The Royal College of Obstetricians and Gynaecologists are also aware of this research project.

The next stage of this project will involve selecting a nationally representative sample of maternity units who would be willing to share their dataset, subject to the ethical and R&D approvals that are currently in progress. We can now confirm that your maternity unit is eligible to participate and would like to take this opportunity to invite you to take part. There is no obligation to participate, but we would be grateful if you could return the form at the end of this letter by no later than 12/01/2007. This will enable us to identify a nationally representative sample of maternity units to investigate national trends, and also provide feedback for your maternity unit/NHS Trust.

If selected for this sample, you will be asked to export any of the following electronic data items, for all women who attended your maternity unit during a specified time period (maternal height, weight, BMI, DOB, ethnic group, marital status, employment, parity, postcode, date & stage of pregnancy at booking, date & gestational age at delivery). These data items will be anonymised and transferred securely to the NEPHO, a Department of Health safe haven for the analysis and storage of hospital data.

We feel the collection of this data will provide an important dataset, which we hope will raise awareness of the national incidence of maternal obesity and assist in optimising service delivery for groups at highest risk. For more information on this project please visit our website or contact Nicola Heslehurst (project co-ordinator).

We very much look forward to hearing from you.

Yours sincerely

Professor Carolyn Summerbell
Professor in Human Nutrition, University of Teesside

Professor John Wilkinson
Professor in Public Health, NEPHO

Enc.
Map of responders to the obesity in pregnancy survey

PLEASE COMPLETE, DETACH, AND RETURN IN THE ENVELOPE PROVIDED OR BY FAX, NO LATER THAN 12/01/2007. RETURN ADDRESS:
Nicola Heslehurst
The Centre for Food, Physical Activity, and Obesity Research
C/o Parkside West Offices
University of Teesside
Middlesbrough
TS1 3BR
FAX: 01642 242770

Maternity Unit(s):
(If you represent more than one maternity unit you may give details of all units on this form)

NHS Trust:

Contact Name/Position:

The above mentioned maternity units would / would not like to participate in the national obesity in pregnancy study.

Appendix 15 Letter to Inform Heads of Midwifery and Clinical Directors that they were not Included in the Sampling for the National Study

nepho
NORTH EAST PUBLIC HEALTH OBSERVATORY

UNIVERSITY OF TEESSIDE
SCHOOL OF HEALTH & SOCIAL CARE

The Centre for Food, Physical Activity, and Obesity Research
School of Health and Social Care
University of Teesside
Middlesbrough
TS1 3BA
Tel: (01642) 342758
Fax: (01642) 342770
n.heslehurst@tees.ac.uk
http://www.nepho.org.uk/maternityquestionnaire/

07/12/2006

Dear ,

RE: Obesity in Pregnancy

Thank you for your response to the Obesity in Pregnancy survey, developed to establish routine maternal obesity data collection practices across England. The survey well received with a response rate of 89% (please see the enclosed map for an overview of all the responding maternity units).

The aim of this research project is to investigate national trends in the incidence rates and demographic predictors of maternal obesity. Findings from our pilot study carried out in a large local cohort (n=36,821) showed that the incidence of maternal obesity has increased rapidly over the past 15 years and could reach 22% by 2010 if the current trend continues (please see attached abstract, in press BJOG). The Royal College of Obstetricians and Gynaecologists are also aware of this research project.

The next stage of this research is to identify a nationally representative sample of maternity units, however unfortunately your maternity unit does not collect all of the data we require in electronic format, so regretfully we are unable to invite you to take part in this next stage. We would however, like to thank you for your interest in this study and taking part in the initial survey.

Yours sincerely

Carolyn Summerbell

Professor Carolyn Summerbell
Professor in Human Nutrition, University of Teesside

John R Wilkinson

Professor John Wilkinson
Professor in Public Health, NEPHO

Enc.
Map of responders to the obesity in pregnancy survey

Appendix 16 University of Teesside School of Health and Social Care Ethics Approval Letter

Providing **Opportunities** - Pursuing **Excellence**

UNIVERSITY OF **TEESSIDE**

PRIVATE AND CONFIDENTIAL

Direct Line: 01642 384154

28th February 2007

Carolyn Summerbell
School of Health & Social Care
University of Teesside

Dear Carolyn,

Study 170/06 – An epidemiological study of the trends in incidence and demographic predictors of maternal obesity, and associated health inequalities
Researcher: Nicola Heslehurst: Supervisor: Carolyn Summerbell

Thank you for resubmitting the changes to the above proposal. I acknowledge that the comments raised by the Research Governance and Ethics Committee have been addressed as discussed with myself, and therefore, through Chair's action the study can now proceed.

Please forward me a copy of the approval letter from the Local Research Ethics Committee before proceeding with the study.

The School of Health & Social Care Research Ethics Committee wish you well with your study.

Yours sincerely

Tricia Forster

Tricia Forster
Chair
Research Ethics Committee
School of Health & Social Care

Professor Paul Keane
Dean
SCHOOL OF HEALTH & SOCIAL CARE
UNIVERSITY OF TEESSIDE MIDDLESBROUGH
TEES VALLEY TS1 3BA UK
TEL: +44 (0)1642 384100 FAX: +44 (0)1642 384105
www.tees.ac.uk

INVESTOR IN PEOPLE

POSITIVE ABOUT DISABLED PEOPLE

VAT REG NO. GB 686 4809 81

Appendix 18 MREC Ethics Approval Letter

NHS
National Research Ethics Service
Sunderland Research Ethics Committee
Room 215, TEDCO Business Centre
Viking Industrial Park
Jarrow, Tyne & Wear
NE32 3DT

Telephone 0191 4283545
Fax 0191 4283303

Bill Hackett, Manager, e-mail: bill.hackett@suntpct.nhs.uk
Shelley Rowe, Assistant Co-ordinator, e-mail: shelley.rowe@suntpct.nhs.uk

22 May 2007

Miss Nicola Heslehurst
Research Assistant
University of Teesside
School of Health and Social Care
Parkside West Offices
Borough Road
Middlesbrough
TS1 3BA

Dear Miss Heslehurst

Full title of study:	**An Epidemiological Study of the Trends in Incidence and Demographic Predictor's of Maternal Obesity, and Associated Health Inequalities**
REC reference number:	**07/Q0904/30**

Thank you for your letter which was received on 18 May 2007, 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 myself as Chairman.

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.

Ethical review of research sites

The Committee has designated this study as exempt from site-specific assessment (SSA). There is no requirement for [other] Local Research Ethics Committees to be informed or for site-specific assessment to be carried out at each site.

Conditions of approval

The favourable opinion is given provided that you comply with the conditions set out in the attached document. You are advised to study the conditions carefully.

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

07/Q0904/30 Page 2

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Application	5.3	19 March 2007
Investigator CV	Nicola Heslehurst	19 March 2007
Investigator CV	Carolyn D Summerbell	
Protocol		
Covering Letter		27 March 2007
Peer Review	Ltrs from Tricia Forster	28 February 2007
Compensation Arrangements		01 August 2006
Response to Request for Further Information		
Units for Sampling	Units for Sampling	
Approval ltr for pilot study	Approval ltr for pilot study	01 July 2005
Demographic chart		11 May 2007
Letter to Maternity Units		07 August 2006

R&D approval

All researchers and research collaborators who will be participating in the research at NHS sites should apply for R&D approval from the relevant care organisation, if they have not yet done so. R&D approval is required, whether or not the study is exempt from SSA. You should advise researchers and local collaborators accordingly.

Guidance on applying for R&D approval is available from
http://www.rdforum.nhs.uk/rdform.htm

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.

Feedback on the application process

Now that you have completed the application process you are invited to give your view of the service you received from the National Research Ethics Service. If you wish to make your views known please use the feedback form available on the NRES website at:

https://www.nresform.org.uk/AppForm/Modules/Feedback/EthicalReview.aspx

We value your views and comments and will use them to inform the operational process and further improve our service.

07/Q0904/30	**Please quote this number on all correspondence**

07/Q0904/30 Page 3

With the Committee's best wishes for the success of this project.

Yours sincerely

pp

Mr P Stevenson
Chairman

Email: shelley.rowe@suntpct.nhs.uk

Enclosures: Standard approval conditions

Copy to: Professor Paul Keane
School of Health and Social Care
The University of Teesside
Middlesbrough
TS1 3BA

Appendix 20 Maternity Unit Instructions for Data Transfer

nepho NORTH EAST PUBLIC HEALTH OBSERVATORY

UNIVERSITY OF TEESSIDE SCHOOL OF HEALTH & SOCIAL CARE

Dear,

Re: An Epidemiological Study of the Trends in Incidence and Demographic Predictors of Maternal Obesity, and Associated Health Inequalities (MREC Ref: 07/Q0904/30)

I am delighted to inform you that following the necessary research governance approvals we are ready to commence with the national obesity in pregnancy study which will collate the BMI and demographic data of women who present at maternity units across England in order to identify national trends in rates of obesity in pregnancy and "at risk" groups of women. This study will ultimately provide the first national level dataset and statistics relating to maternal obesity, and will be invaluable in informing public health interventions.

In the first instance can I ask you to please contact me with the name and contact details of the person who will be involved in exporting the data from your maternity unit database so precise instructions regarding data transfer and data protection can be given.

The data is required at the earliest convenience in 2008 (no later than 28th February). The data provided should include all complete years of data stored electronically in your unit up to the end of 2007, for all women who have delivered at your maternity unit. The data required for the study is as follows:

- Mother's height
- Mother's weight at booking
- Mother's BMI at booking (if not available then height and weight at booking must be provided to allow for calculation of BMI at booking)
- Date of booking appointment
- Stage of pregnancy at booking
- Date of delivery
- Gestational age at delivery (if stage of pregnancy at booking is not available both date of delivery and booking, and gestational age at delivery must be provided to calculate stage of pregnancy at booking)
- Mother's age
- Mother's ethnic group
- Mother's marital status
- Mother's employment status
- Parity
- Postcode

Thank you, I look forward to working with you in the near future and we will keep you informed of the progress of this study. If you have any queries please do not hesitate to contact me.

Yours sincerely

Nicola Heslehurst (Chief Investigator)
Lecturer in Research/Maternal Obesity Research Lead
The Centre for Food, Physical Activity and Obesity Research
School of Health and Social Care
C/o Parkside West Offices (P2.13)
University of Teesside
Middlesbrough
TS1 3BA
Tel: 01642 342758
Fax: 01642 342770
n.heslehurst@tees.ac.uk

Appendix 21 National Census Standard Tables for Marital Status and Living Arrangements

Help

1 Define study area

2 Select data

3 Output data

Select variables from table KS004: 2001 Census

1 Select the data items you wish to extract individually or by row or column using the checkboxes. To add variables to your selection click *"Add variables to data selection"*, the variables will then appear in the list in the right hand panel.

2 Click *"Get Data"* in the right hand panel to extract the data
Or Click here to select another table.

Supplementary information about this table may be found in the table footnotes and comments at the bottom of the table. Information on definitions and classifications used in the 2001 Census can be found in the 2001 Census Definitions Volume (opens in new window), available from the ONS website.

Marital status: All people aged 16 and over

NB: This table contains counts of Persons

Add variables to data selection | Select all | Clear all

	All people aged 16 and over	People aged 16 and over ☐					
		Single (never married)	Married	Re-married	Separated (but still legally married)	Divorced	Widowed
Select all ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

Help

1 Define study area

2 Select data

3 Output data

Select variables from table KS003: 2001 Census

1 Select the data items you wish to extract individually or by row or column using the checkboxes. To add variables to your selection click *"Add variables to data selection"*, the variables will then appear in the list in the right hand panel.

2 Click *"Get Data"* in the right hand panel to extract the data
Or Click here to select another table.

Supplementary information about this table may be found in the table footnotes and comments at the bottom of the table. Information on definitions and classifications used in the 2001 Census can be found in the 2001 Census Definitions Volume (opens in new window), available from the ONS website.

Living arrangements:

All people aged 16 and over in households

NB: This table contains counts of Persons

Users are recommended to review table footnotes and comments for supplementary information relating to individual tables.

Add variables to data selection | Select all | Clear all

	All people aged 16 and over living in households	People aged 16 and over living in households ☐						
		Living in a couple ☐		Not living in a couple ☐				
		Married or re-married	Cohabiting	Single (never married)	Married or re-married	Separated (but still legally married)	Divorced	Widowed
Select all ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	8 ☐

Footnotes and Comments for Table KS003

1 The living arrangements variable is different to marital status. It combines information from both marital status and the relationship matrix. Therefore a person living as part of a 'cohabiting couple' could in fact be married (to someone else) but will not appear as married or separated in this classification.

2 A person not living in a couple can be classified married (or re-married) if they denote their marital status as married (or re-married) but have no spouse or partner resident in the household.

(http://casweb.mimas.ac.uk// [Accessed 11/08/2008])

Appendix 22 National Study Data: Proportion of Ethnic Groups in each Year

	Ethnic Group Code											
	Asian or Asian British		Black or Black British		Chinese or Other Ethnic Group		Mixed		Not Known		White	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Year 1989	1	.0%	0	.0%	0	.0%	0	.0%	3769	99.9%	3	.1%
1990	99	1.6%	16	.3%	12	.2%	4	.1%	5738	94.2%	223	3.7%
1991	278	2.1%	37	.3%	54	.4%	35	.3%	5992	46.0%	6633	50.9%
1992	382	3.0%	52	.4%	62	.5%	25	.2%	5669	44.7%	6497	51.2%
1993	1017	6.4%	69	.4%	93	.6%	45	.3%	5189	32.9%	9362	59.3%
1994	1094	7.0%	101	.6%	106	.7%	56	.4%	5095	32.5%	9212	58.8%
1995	1503	9.3%	201	1.2%	202	1.3%	67	.4%	2496	15.4%	11691	72.3%
1996	1830	11.2%	259	1.6%	295	1.8%	79	.5%	1532	9.4%	12376	75.6%
1997	1927	11.6%	278	1.7%	271	1.6%	105	.6%	1751	10.6%	12248	73.9%
1998	2015	12.3%	298	1.8%	259	1.6%	71	.4%	1886	11.5%	11830	72.3%
1999	2126	13.1%	273	1.7%	236	1.5%	70	.4%	2202	13.5%	11346	69.8%
2000	2268	9.1%	370	1.5%	318	1.3%	94	.4%	6601	26.4%	15313	61.3%
2001	2580	9.1%	460	1.6%	409	1.4%	132	.5%	5615	19.8%	19160	67.6%
2002	3100	8.8%	673	1.9%	608	1.7%	203	.6%	2621	7.4%	28106	79.6%
2003	3531	6.5%	2650	4.9%	891	1.6%	599	1.1%	4795	8.9%	41574	76.9%
2004	4601	7.0%	3499	5.3%	1375	2.1%	751	1.1%	5467	8.3%	49908	76.1%
2005	5135	6.7%	4012	5.2%	1597	2.1%	981	1.3%	6270	8.1%	59174	76.7%
2006	6803	7.9%	4446	5.1%	2002	2.3%	1163	1.3%	4464	5.2%	67750	78.2%
2007	10448	10.6%	4831	4.9%	2604	2.6%	1482	1.5%	4129	4.2%	75017	76.2%
Total	50738	8.2%	22525	3.6%	11394	1.8%	5962	1.0%	81281	13.1%	447423	72.2%

Appendix 26 Summary of Data Received from NHS Trusts

NHS Trust Codes	Trust Name	Years	Trust (n)	Unit 1 (n)	Unit 2 (n)	Unit 3 (n)	Total number of maternity units in each NHS Trust
BWHNHST	Birmingham Womens Hospitals NHS Trust	2007	7,696				1
BHNHST	Bolton Hospitals NHS Trust	2007	3,937				1
CDDNHST	County Durham and Darlington Hospitals NHS Trust (3 x Maternity Units	2006-2007[1,2], 2002-2007[3]	20,437	752	4,643	15,042	3
ECNHST	East Cheshire NHS Trust	2001-2007	13,153				1
EKHNHST	East Kent Hospitals NHS Trust	2005-2006	11,646				2
ESHNHST	East Sussex Hospitals NHS Trust	2005-2007	11,715				3
EASHUHNHST	Epsom and St Helier University Hospitals NHS Trust	2006-2007	5,866				1
GHNSHFT	Gateshead Health NHS Foundation Trust	2004-2007	7,002				1
GHNHSFT	Gloucestershire Hospitals NHS Foundation Trust	2003-2007	28,190				1
HWPNHST	Heatherwood and Wexham Park Hospitals NHS Trust	1989-2007	88,322				1
HEYHNHST	Hull and East Yorkshire Hospitals NHS Trust	2002-2007	30,230				1
KCHNHST	King's College Hospital NHS Trust	2003-2007	22,255				1
MTWNHST	Maidstone and Tunbridge Wells NHS Trust	1995-2007*	39,856				1
MHNHST	Mayday Healthcare NHS Trust	2004-2007	18,981				1
ORHNHST	Oxford Radcliffe Hospitals NHS Trust	2000-2007	60,784				5
PAHNHST	Pennine Acute Hospitals NHS Trust	1993-2007	54,488				4
PHNHST	Portsmouth Hospitals NHS Trust	2000-2007	42,869				1
STHNHSFT	Sheffield Teaching Hospitals NHS Foundation Trust	2004-2007	26,836				1
STNHST	South Tees Hospitals NHS Trust (2 x Maternity Units)	1991-2007[1], 2000-2007[2]	72,700	62,939	9,761		2
SUHNHST	Southampton University Hospitals NHS Trust	2003-2007	26,054				1
SEUHNHST	Southend University Hospital NHS Foundation Trust	2003-2007	17,955				1
SSHNHST	Surrey and Sussex Healthcare NHS Trust	2000-2006	27,999				1
TSNHST	Taunton and Somerset NHS Trust	1991-2007	50,092				1
WMUHNHST	West Middlesex University Hospital NHS Trust	1990-2007	49244				1
		Total	738,307				37

*data provided for 92-07 but 92-94 date booked not recorded therefore can only use data from 95 onwards

Appendix 28 Exclusion Reasons

Included or Excluded

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Excluded	118984	16.1	16.1	16.1
	Included	619323	83.9	83.9	100.0
	Total	738307	100.0	100.0	

Exclusion Reason: Unable to Calculate BMI

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	13231	11.1	11.1	11.1
	yes	105753	88.9	88.9	100.0
	Total	118984	100.0	100.0	

Exclusion Reason: Unable to Calculate Gestational Age at Booking

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	102837	86.4	86.4	86.4
	yes	16147	13.6	13.6	100.0
	Total	118984	100.0	100.0	

Exclusion Reason: Unrealistic BMI at the Lower Limit (<13)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	118395	99.5	99.5	99.5
	yes	589	.5	.5	100.0
	Total	118984	100.0	100.0	

Exclusion Reason: Unrealistic BMI at the Upper Limit (>80)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	118667	99.7	99.7	99.7
	yes	317	.3	.3	100.0
	Total	118984	100.0	100.0	

Exclusion Reason: Unrealistic BMI Following Adjustment at the Lower Limit (<13)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	118807	99.9	99.9	99.9
	yes	177	.1	.1	100.0
	Total	118984	100.0	100.0	

Appendix 31 Search Strategy for Medline and CINAHL

1. *pregnancy/
2. pregnan$.ti,ab.
3. matern$.ti,ab.
4. gravid$.ti,ab.
5. mother.ti,ab.
6. parent.ti,ab.
7. or/1-5
8. or/1-6
9. *obesity/ or *obesity, morbid/
10. obes$.ti,ab.
11. *Weight Gain/ph [Physiology]
12. (overweight or over weight or weight gain).ti,ab.
13. (bmi or body mass index).ti,ab.
14. or/9-13
15. (cohort or observation$ or prospective or longitudinal).ti,ab.
16. 7 and 14
17. 8 and 14
18. 16 and 15
19. 17 and 15
20. animal/
21. humans/
22. 20 not (20 and 21)
23. 18 not 22
24. 19 not 22
25. fertil$.ti,ab.
26. (IVF or in vitro fertili?ation).ti.
27. (PCOS or polycystic ovary syndrome).ti.
28. or/25-27
29. 23 not 28
30. 24 not 28
31. limit 29 to english language
32. limit 30 to english language
33. limit 31 to yr=1990-2007
34. limit 32 to yr=1990-2007

Appendix 32 Cochrane Data Extraction Template for Cohort Studies

Identification	Reviewer
Title	
Author	Year
Setting	Location Language Study Name
Dates of Enrolment/ Follow up	
Endpoint See Included and NOT Included Table	Endpoint (Immediate service delivery factors) Criteria (defined as…)
Exposure Definition used (e.g. BMI, weight etc) Categories for obese and controls	Maternal Obesity

Design: ❑ Prospective Cohort ❑ Retrospective Cohort

	Total Cohort	**Control Group BMI (kg/m2):**	**Study Group 1** BMI (kg/m2):
Number Identified (Describe)			
Number Excluded/ Lost to Follow Up (Describe)			
Final Number Included			
All Subjects Accounted for?			

Group Selection – Details of inclusion criteria for the exposed and unexposed group (where exposure is maternal obesity)	Control BMI Group	Study BMI Group
Group Determination – measure of maternal obesity	❑ Direct Measurement ❑ Medical Records ❑ Self Report ❑ Unclear Blinding ❑ Yes ❑ No	❑ Direct Measurement ❑ Medical Records ❑ Self Report ❑ Unclear Blinding ❑ Yes ❑ No
Ascertainment of Outcome – service delivery	❑ Direct Measurement ❑ Medical Records ❑ Self Report ❑ Unclear Blinding ❑ Yes ❑ No	❑ Direct Measurement ❑ Medical Records ❑ Self Report ❑ Unclear Blinding ❑ Yes ❑ No

Subject Characteristics – demographics etc

Characteristic	Total Cohort	Control BMI Group	Study BMI Group	P value
Maternal Age				
Gestational Age				
Ethnicity				
Baseline BMI				
Baseline Weight				
Baseline Height				
Smoking Status				
Illicit Drug Use				
Alcohol Intake				
Socio-Economic Status (employment/marital status/education etc) ………………………….				
Parity				
Singleton Gestation				

Group Differences:

Data Analysis: ❑ All subjects ❑ Loss to follow up excluded

Outcome and Exposure	**N**				**Crude RR/OR %(CI)**	**Adjusted RR/OR %(CI)**	**Factors Adjusted**
Outcome (O)		O	_	Total	p	p	❑ Age ❑ Ethnic origin ❑ Parity ❑ Smoking ❑Gestational Age ❑ Weight gain ❑ _______________ ❑ _______________ ❑ _______________ ❑ _______________
Exposure - Control group	_						
E Study group	E						

Appendix 33 SIGN Quality Assessment Template for Cohort Studies

SIGN	**ADAPTED Methodology Checklist: Cohort studies**		
Study identification (*Include author, title, year of publication, journal title, pages*)			
Checklist completed by:			
Section 1: Internal validity			
In a well conducted cohort study:		In this study the criterion is:	
1.1	The study addresses an appropriate and clearly focused question.	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable
SELECTION OF SUBJECTS			
1.2	The two groups being studied are selected from source populations that are comparable in all respects other than the factor under investigation.	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable
1.3	The study indicates how many of the people asked to take part did so, in each of the groups being studied.	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable
1.6	**Comparison is made between full participants and those lost to follow up, by exposure status.**	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable
ASSESSMENT			
1.7	The outcomes are clearly defined.	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable
1.8	The assessment of outcome is made blind to exposure status.	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable
1.9	Where blinding was not possible, there is some recognition that knowledge of exposure status could have influenced the assessment of outcome.	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable

1.10	The measure of assessment of exposure is reliable. Measured weight = Well covered Medical records = Adequately addressed Self reported = Poorly addressed	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable
1.11	Evidence from other sources is used to demonstrate that the method of outcome assessment is valid and reliable.	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable
1.12	Exposure level or prognostic factor is assessed more than once.	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable
CONFOUNDING			
1.13	The main potential confounders are identified and taken into account in the design and analysis.	Well covered Adequately addressed Poorly addressed	Not addressed Not reported Not applicable
STATISTICAL ANALYSIS			
1.14	Have confidence intervals been provided?		
SECTION 2: OVERALL ASSESSMENT OF THE STUDY			
2.1	How well was the study done to minimise the risk of bias or confounding, and to establish a causal relationship between exposure and effect? *Code ++, +, or –*		
2.2	Taking into account clinical considerations, your evaluation of the methodology used, and the statistical power of the study, are you certain that the overall effect is due to the exposure being investigated?		
SECTION 3: DESCRIPTION OF THE STUDY (*Note: The following information is required for evidence tables to facilitate cross-study comparisons. Please complete all sections for which information is available).* **PLEASE PRINT CLEARLY**			
3.8	*How was this study funded?* *List all sources of funding quoted in the article, whether Government, voluntary sector, or industry.*		
3.9	Does this study help to answer your key question? *Summarise the main conclusions of the study and indicate how it relates to the key question?*		

Appendix 38 Qualitative Study Information Packs for Maternity Clinical Leads

nepho NORTH EAST PUBLIC HEALTH OBSERVATORY | UNIVERSITY OF TEESSIDE SCHOOL OF HEALTH & SOCIAL CARE | RMSO REGIONAL MATERNITY SURVEY OFFICE

The Centre for Food, Physical Activity and Obesity Research
Parkside West Offices PS2.13
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Dear

RE: Developments in NHS Maternity Services for Obesity in Pregnancy

The North East Maternal Obesity Research Group is a multi-disciplinary collaboration including members from NEPHO, the University of Teesside, the RMSO, Newcastle University, the Local Supervising Authority for Midwives, and James Cook University Hospital. We are following up some research carried out in 2005/2006 that involved all maternity units in the north east region, which you may have been involved in. This previous research identified that the north east region as a whole lacked in services directed specifically towards obesity in pregnancy (publication enclosed). Your maternity unit will have recently completed the CEMACH questionnaire about maternal obesity, and we would like to get a more detailed picture of any developments in the provision of services, policy, or guidance specific to maternal obesity in the region over the last 2 to 3 years.

We are inviting all north east regional maternity units to participate in this study to get an update on the regional perspective of services for maternal obesity. If you are happy to participate in this study we will be asking you to take part in a one-to-one or group discussion about the services in your maternity unit for obesity in pregnancy. We would like you to participate in this study even if your maternity unit has no obesity specific services as it is important for us to gather information about any barriers to implementing services.

To ensure representation of all health care professionals who care for women who are obese in pregnancy are included in this service evaluation, please can I encourage you to distribute the enclosed information sheets to a variety of members of staff, including for example midwives, obstetricians, dietitians, physiotherapists, diabetes specialists and any members of staff who have a particular interest in maternal obesity.

If you would like more details on the project please contact me on the above number, to arrange an interview or group discussion please contact the NEPHO admin team on the details below. Thank you for your co-operation, I look forward to meeting with you to discuss this important issue.

N Heslehurst

Nicola Heslehurst
Lecturer in Research/Maternal Obesity Research Lead

Katie Dykes, NEPHO Administration Team, Wolfson Research Institute, Durham University, Queens Campus, Stockton on Tees, TS17 6BH, 0191 334 0400, katie.dykes@durham.ac.uk

Cc. Prof. Carolyn Summerbell, Assistant Dean for Research/Prof in Human Nutrition, University of Teesside
Prof. John Wilkinson, Director of NEPHO/Prof. in Public Health
Dr. Judith Rankin, Director RMSO/Reader Newcastle University

Developments in NHS Maternity Services for Obesity in Pregnancy: A Follow up Study

Information Sheet for Health Care Professionals

We represent the North East Maternal Obesity Research Group which includes members from NEPHO, the University of Teesside, the RMSO, Newcastle University, the Local Supervising Authority for Midwives, and James Cook University Hospital. We have been funded by the Government Office North East (GONE) to follow up previous research carried out in north east maternity units relating to obesity in pregnancy, which you may have been involved in (http://www.blackwell-synergy.com/toc/bjo/114/3). We would like to find out more about maternity services specifically for obesity in the region, and we would like to invite you to take part. This sheet will give you information to help you decide whether you would like to take part.

Purpose of the study

The previous research that we carried out identified a lack of services, policy and guidance for obesity in pregnancy in the north east, however a number of maternity units in the region expressed that they were developing services, policy, and guidance in this clinical area. The purpose of this study is to establish what services are in place, under development, or do not exist in the north east, and to establish any specific areas of difficulty or success in the development of maternal obesity services.

Informed consent and confidentiality

We are inviting you to take part in a group discussion with other health care professionals in your maternity unit, or to have a one-to-one interview with a researcher from the North East Maternal Obesity Research Group. You can withdraw from this research at any time during the discussion without giving a reason, however if you are participating in a group discussion the comments you make can influence other people's comments and as such you cannot withdraw them. If you wish to withdraw your one-to-one interview from the study please contact the researcher on the details below and provide them with your participant ID before 19th September 2008.

If you agree to take part, all the information that we collect from you will be kept strictly confidential and you will not be identified in any reports or publications.

What will be involved if I take part in the research?

We would like you to attend a meeting with other health care professionals in your maternity unit, or to have a one-to-one discussion with the researcher which will be audio recorded. We will be discussing different aspects relating to obesity services in your maternity unit, such as the benefits and disadvantages of obesity specific services, and any problems or successes encountered when developing obesity services.

Your views will help us to understand the practical implications in the clinical setting that are important when developing maternal obesity services. This will provide some evidence to help inform organisations about the issues when developing clinical guidelines, and help to share experiences across the north east region.

Safe storage of information

All information collected as part of this study will be stored in accordance with the Data Protection Acts (1984, 1998). Access to the study materials and data, while the study is underway, will be restricted to members of the research team. Any audio recording and transcript of your interview, notes taken or any paper based materials you may give us will be stored in a locked filing cabinet at the University Teesside for the length of the project, and stored electronically on a password protected computer in the University of Teesside. After the project is completed all the study materials and information will be archived securely for six years by the University of Teesside and then destroyed.

Who will see the information?

The completed anonymised report will be sent to the GONE, all participating NHS Trusts in the north east, and may be sent to some Department of Health organisations. The findings of the study may also be published in a peer reviewed journal.

Thank you for reading through this information. If you have any further questions please contact Nicola Heslehurst. If you would like to arrange an interview or group discussion please contact Katie Dykes in the NEPHO administration team.

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Appendix 40 University of Teesside School of Health and Social Care Ethics Approval Letter

Dean: Professor Paul Keane
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Direct Line: 01642 342750

29th July 2008

Carolyn Summerbell
School of Health & Social Care
University of Teesside

Dear Carolyn

Study 125/08 – Developments in NHS Maternity Services for Obesity in Pregnancy: A Follow Up Study Researcher: Nicola Heslehurst Supervisor: Carolyn Summerbell

Decision: Approved

Thank you for your application to the School of Health & Social Care Research Governance and Ethics Committee.

The applicant(s) are commended on submitting an excellent application pack.

The Committee reviewed and approved your application on 23rd July 2008 and your study may proceed as it was described in your application pack.

Please note:

Where applicable, your study may only proceed when you have also received written approval from any other ethical committee (e.g. NRES) and operational / management structures relevant (e.g. Local NHS R&D). A copy of this approval letter **must** be attached to applications to any other ethical committee. If applicable please forward to me a copy of the approval letter from NRES before proceeding with the study.

In all cases, should you wish to make any substantial amendment to the protocol detailed, or supporting documentation included, in your approved application pack (other than those required as urgent safety measures) you must obtain written approval for those, from myself and all other relevant bodies, prior to implementing any amendment. Details of any changes made as urgent safety measures must be provided in writing to myself and all other relevant bodies as soon as possible after

Professor Carolyn Summerbell
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the relevant event; the study should not continue until written approval for those changes has been obtained from myself and all other relevant bodies.

On behalf of the School of Health & Social Care Research Governance and Ethics Committee please accept my best wishes for success in completing your study.

Yours sincerely

Dr. Alasdair MacSween
Chair
Research Governance and Ethics Committee
School of Health & Social Care

Appendix 41 NRES Confirmation that the Qualitative Study is Exempt from the NHS Ethical Approval Process

From: NRES Queries Line [mailto:queries@nres.npsa.nhs.uk]
Sent: 06 March 2008 12:44
To: Heslehurst, Nicola
Subject: RE: Research, Evaluation, or Audit

Thank you for your query.

The following reply has been provided by Hilary Tulloch, Business Support Coordinator.

Our leaflet "Defining Research", which explains how we differentiate research from other activities, is published at:

http://www.nres.npsa.nhs.uk/applicants/help/guidance.htm#audit

Based on the information you provided I would deem this a `Service evaluation`, our advice is that the project is not considered to be research according to this guidance. Therefore it does not require ethical review by a NHS Research Ethics Committee.

If you are undertaking the project within the NHS, you should check with the relevant NHS care organisation(s) what other review arrangements or sources of advice apply to projects of this type. Guidance may be available from the clinical governance office.

Although ethical review by a NHS REC is not necessary in this case, all types of study involving human participants should be conducted in accordance with basic ethical principles such as informed consent and respect for the confidentiality of participants. When processing identifiable data there are also legal requirements under the Data Protection Act 2000. When undertaking an audit or service/therapy evaluation, the investigator and his/her team are responsible for considering the ethics of their project with advice from within their organisation. University projects may require approval by the university ethics committee.

This response should not be interpreted as giving a form of ethical approval or any endorsement of the project, but it may be provided to a journal or other body as evidence that ethical approval is not required under NHS research governance arrangements.

However, if you, your sponsor/funder or any NHS organisation feel that the project should be managed as research and/or that ethical review by a NHS REC is essential, please write setting out your reasons and we will be pleased to consider further.

Where NHS organisations have clarified that a project is not to be managed as research, the Research Governance Framework states that it should not be presented as research within the NHS.

Regards

IRAS (Integrated Research Application System) is now available for use and consultation. To view IRAS and for further information visit www.myresearchproject.org.uk

Queries Line
National Research Ethics Service
National Patient Safety Agency
4-8 Maple Street
London
W1T 5HD

Website: www.nres.npsa.nhs.uk
Email: queries@nres.npsa.nhs.uk

Ref: 04/01
** This reply may have been sourced in consultation with other members of the NRES team.

Appendix 42 Generation of Themes

Theme 1: Maternal Obesity Services

Subtheme 1: Factors that influence service development
- Safety and risks
- Complications
- Defining what services are meant to achieve

Subtheme 2: Using BMI to Define Service and Access to Services
- The appropriate BMI cut off was to determine services
- Questioned the use of BMI alone in determining high dependency care
- BMI groups being overlooked when maternity units used BMI cut offs
- Different pathways being developed for different BMI groups

Subtheme 3: Services Development
- Services currently in place and planned implementation
- Working groups
- Guidelines
- Referral mechanisms
- Signposting

Subtheme 4: Resource
- Equipment and facilities
- Time - to address the issue effectively, contact time
- Capacity – BMI cut off and capacity, capacity of collaborative departments
- Funding – needed for service development, get PCT's on board

Subtheme 5: Specialist Roles and Multidisciplinary Involvement
- Need an identified lead
- The roles of specialist midwives and consultants (what would be involved, appropriate to segregate roles)
- The need for specialist teams to adequately care for obese women in pregnancy
- Dietetics (links with, the role of the dietitian)
- The role of support workers

Subtheme 6: Obesity specific antenatal care
- What obesity specific services would include
- The benefits and disadvantages of obesity specific services
- What to call an obesity clinic
- Mainstream services

Subtheme 7: Weight Gain in Pregnancy
- Monitoring weight gain
- Advice about recommended weight gain
- The need for evidence based guidelines
- Conflicting messages for women
- Dietitians unclear of what's expected from them with referrals

Theme 2: Psychosocial Issues and Maternal Obesity Services

Subtheme 1: Addressing the issue
- Difficulties in discussing obesity
- Differences between what HCP’s say and what women hear
- Developing rapport needs experience and training
- Give information in a positive way when discussing (not blame)
- Terminology used
- Psychological links made them feel as if they were opening a can of worms – need clearly defined pathways to know what to do after addressed the issue

Subtheme 2: Acceptance, Equality, and Stigma
- Women’s acceptance of their obesity, normalisation of obesity
- Socio-economic considerations
- Equality
- Society – cultural change required, negative view of obesity in society and the media
- Stigma and psychological support
- Anxiety and distress

Subtheme 3: Engaging into Services
- Considerations that needed to be made when developing services
- Flexibility of services and need to reach all women not just those with motivation
- What women want?
- Disengage from services
- Captive audience
- Pregnant women are more motivated
- Social marketing

Subtheme 4: Choice
- Women having choice taken from them
- Giving women choice to encourage engagement in services
- Individual’s choice of lifestyle

Theme 3: Information, Evidence, and Training

Subtheme 1: Information

- Information for HCP’s to use
- Information for women
- Leaflets
- Nutritional assessment tool
- Women receptive to information about nutrition – problems with FSA
- Generic nutritional info given, and specific classes for young mothers
- Sources of information – internet

Subtheme 2: Evidence

- Research, audit, and evaluation
- The need for data to support service development
- HCP’s sharing practice
- Learn from other successful initiative (smoking cessation)
- National and strategic involvement

Subtheme 3: Education, Training, and Knowledge

- Training in addressing the issue
- Training for maternity HCP’s from dietetics
- Flexibility of training required
- Dietetics training on needs of the mother and foetus
- Knowledge among maternity HCP’s about public health services
- The lack of knowledge among women, public health message and education needed
- Preconception clinics

Theme 4: Where to Go From Here?

Subtheme 1: Long term/bigger picture

- The benefits of weight loss for the mother's general health with the potential for a reduced risk of developing obesity related disease in her later life
- The need to look at the bigger picture of the food industry and advertising
- That a long term solution was required

Subtheme 2: Being Pro-active and the Need to do More

- Current focus of obesity services – treatment rather than prevention
- Enthusiasm required from HCP's in effectively addressing the issue
- What else HCP's felt needed to be done especially in relation to weight management

Subtheme 3: Holistic Approach

- Looking at the whole health of the mother rather than just obesity
- Thinking outside the box in service development
- Social marketing and joined up thinking
- Nutrition and physical activity
- Obesity should be addressed in the postnatal period as well as during the pregnancy
- Transition of care
- The health of the whole family should be considered rather than just the mother's health in isolation
- Community focus

Subtheme 4: Partnership Working

- The remit of the maternity HCP in dealing with maternal obesity
- How departments within acute services needed to work together to address the issue of maternal obesity – can't address it alone
- Working with external partnership organisations
- Getting the issue on others' agendas
- Public health role
- The types of services that maternity units could link with to improve maternal obesity care
- Utilise existing services
- Continuity of care