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70th Anniversary Conference on ‘Nutrition and health: from conception to adolescence’

Symposium I: Consequences of obesity and overweight during pregnancy Identifying ‘at risk’ women and the impact of maternal obesity on National Health Service maternity services

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Obesity is a public health concern worldwide, arising from multifaceted and complex causes that relate to individual choice and lifestyle, and the influences of wider society. In addition to a long-standing focus on both childhood and adult obesity, there has been more recent concern relating to maternal obesity. This review explores the published evidence relating to maternal obesity incidence and associated inequalities, the impact of obesity on maternity services, and associated guidelines. Epidemiological data comprising three national maternal obesity datasets within the UK have identified a significant increase in maternal obesity in recent years, and reflect broad socio-demographic inequalities particularly deprivation, ethnicity and unemployment. Obese pregnancies present increased risk of complications that require more resource intensive antenatal and perinatal care, such as caesarean deliveries, gestational diabetes, haemorrhage, infections and congenital anomalies. Healthcare professionals also face difficulties when managing the care of women in pregnancy as obesity is an emotive and stigmatising topic. There is a lack of good-quality evidence for effective interventions to tackle maternal obesity. Recently published national guidelines for the clinical management and weight management of maternal obesity offer advice for professionals, but acknowledge the limitations of the evidence base. The consequence of these difficulties is an absence of support services available for women. Further evaluative research is thus required to assess the effectiveness of interventions with women before, during and after pregnancy. Qualitative work with women will also be needed to help inform the development of more sensitive risk communication and women-centred services.

Obesity: Pregnancy: Maternity services: Trends: Inequalities

Determinants of obesity

Obesity is a growing public health concern in most developed countries worldwide. The WHO estimates that at least 300 million people worldwide are obese⁽¹⁾. Obesity arises from multifaceted and complex causes. The Foresight report ‘Tackling Obesity: Future Choices’ broadly groups the determinants of obesity as being physiological factors, eating habits, activity levels and psychosocial influences⁽¹⁾. There is also a strong emphasis within the

report on the wider societal influences on the increasing levels of obesity seen today, over and above personal responsibility⁽¹⁾. The authors argue that advances in technology have exceeded human evolution, leading to inevitable weight gain through exposure to modern lifestyles:

‘People in the UK today don’t have less willpower and are not more gluttonous than previous generations. Nor is their biology significantly different to that of

Abbreviation: CMACE, Centre for Maternal and Child Enquiries.

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their forefathers. Society, however, has radically altered over the past five decades, with major changes in work patterns, transport, food production and food sales. These changes have exposed an underlying biological tendency, possessed by many people, to both put on weight and retain it⁽¹⁾

Increasing national focus on maternal obesity in the UK

There has been an increasing public health focus on obesity over the past two decades within the UK. The primary focus within this time frame has been tackling childhood obesity, a known pre-cursor to adult obesity. This is seen with the 'Choosing Health' White Paper, which stated that 'halting the growth in childhood obesity is our prime objective'⁽²⁾. Healthy lifestyles for children and young people were considered a priority, with potential interventions targeted towards families and schools⁽²⁾. Maternity services were also featured within the children and young people chapter of the white paper in relation to smoking during pregnancy, domestic violence and teenage pregnancy. However, maternal obesity was not identified as a priority and was therefore absent from the white paper's objectives.

In recent years, there has been an elevated interest in maternal obesity in the UK. The Centre for Maternal and Child Enquiries (CMACE) recently described maternal obesity as 'arguably the biggest challenge facing maternity services today. It is a challenge not only because of the magnitude of the problem ... but also because of the impact that obesity has on women's reproductive health and that of their babies'⁽³⁾.

The recent concern over maternal obesity is not surprising considering the increased national focus on the topic over the past decade. Maternal obesity has featured in over twenty national reports and guidelines within the UK since 2003 (Table 1), the earliest of which was the National Institute for Health and Clinical Excellence Antenatal Care Guidelines for Healthy Pregnancies published in 2003⁽⁴⁾. These guidelines acknowledged that women who were obese at their booking appointment would require additional care outside of the guidelines (defined as a BMI $>35 \text{ kg/m}^2$). However, there was no indication within these guidelines as to what the additional care requirements were⁽⁴⁾. Since the publication of these guidelines maternal obesity has increasingly been included in national guidelines and reports including those published by National Institute for Health and Clinical Excellence⁽⁵⁻¹⁰⁾; the Royal College of Obstetricians and Gynaecologists^(11,12) and Royal College of Obstetricians and Gynaecologists and CMACE⁽¹³⁾. National reports have included those published by Foresight⁽¹⁾ and by the Department of Health⁽¹⁴⁾. CMACE (formerly the Confidential Enquiry into Maternal and Child Health) also began the regular publication of maternal obesity statistics within their maternal and perinatal mortality reports in 2004 and 2007, respectively⁽¹⁵⁻²¹⁾, and published a dedicated report on obesity in pregnancy in 2010⁽³⁾.

Although numerous guidelines and reports have included reference to maternal obesity, there was an absence of maternal obesity-specific guidelines prior to 2010. In this

year, CMACE and Royal College of Obstetricians and Gynaecologist published joint clinical guidelines for the management of obesity in pregnancy⁽¹³⁾; and National Institute for Health and Clinical Excellence published public health guidelines for weight management before, during and after pregnancy⁽¹⁰⁾. The recent publication of these guidelines offers long-awaited advice for maternity services, public health services and healthcare professionals for the management of maternal obesity and support for women, which had been described as being *ad hoc* and inconsistent⁽²²⁾. However, the guidelines also acknowledge the limitations of the evidence on which they are based due to a lack of good-quality UK evidence on effectiveness of maternal obesity interventions⁽¹⁰⁾. Current UK guidelines for maternal obesity also do not include recommendations for appropriate gestational weight gain for women who are obese before pregnancy. The lack of guidelines for gestational weight gain has been highlighted by health care professionals in the UK as a barrier to consistent practice⁽²³⁾. The Institute of Medicine in the US recently updated their guidelines for gestational weight gain according to early pregnancy BMI status⁽²⁴⁾, originally published in 1990⁽²⁵⁾. These guidelines state that women who are obese during pregnancy should gain between 5 and 9 kg over the course of their pregnancy (0.5–2 kg in trimester 1 and 0.22 kg/week in trimesters 2 and 3)⁽²⁴⁾. However, there has been criticism of the appropriateness of using observational evidence to develop gestational weight gain guidelines, and that the translation of observational evidence to intended weight gain restriction may not produce equivalent benefits⁽²⁶⁾. The National Institute for Health and Clinical Excellence have called for further research in the UK to explore the appropriateness of these guidelines for UK populations⁽¹⁰⁾.

Defining maternal obesity

Despite the recent increased focus on maternal obesity, there are no internationally agreed definitions for clinically 'diagnosing' maternal weight status and associated risks. Maternal BMI is most frequently used in international research and guidelines to determine weight status, including UK guidelines^(10,13). However, there are no evidence-based BMI categories specifically for use in pregnancy to determine risk, and the WHO BMI categories for the general population are usually used. The WHO categories are: BMI $>30 \text{ kg/m}^2$ to define obesity; and sub-classifications of moderate obesity (BMI $30.0\text{--}34.9 \text{ kg/m}^2$), severe obesity (BMI $35.0\text{--}39.9 \text{ kg/m}^2$) and morbid obesity (BMI $>40.0 \text{ kg/m}^2$)⁽²⁷⁾. These measurements are applied to early pregnancy as a proxy for pre-pregnancy weight status, as evidence shows that there is minimal weight gain in the first trimester of pregnancy^(28,29). The majority of the evidence-base for obesity-associated risks is also based on early pregnancy BMI classified according to the WHO definitions due to difficulties in ascertaining accurate pre-pregnancy BMI.

As BMI was developed based on evidence of risk among a non-pregnant population, there are limitations to its use in later stages of pregnancy. During pregnancy there is a naturally incurred weight gain, which includes the weight

Table 1. The increasing focus on maternal obesity among national reports and guidelines within the UK

Guideline or Report	Reference to maternal obesity
NICE Antenatal Care Guidelines for Healthy Pregnant Women (2003) ⁽⁴⁾ CEMACH Maternal Mortality Report (2004) ⁽¹⁵⁾	<ul style="list-style-type: none"> • Women with a booking BMI >35 kg/m² usually require additional care to that detailed in this guideline • The first triennial maternal mortality report with obesity statistics • Maternal mortality data: mothers were obese in 35% of maternal deaths between 2000 and 2002 • Data were not well recorded in maternity units: lots of missing BMI data
NICE Obesity Guidelines (2006) ⁽⁵⁾	<ul style="list-style-type: none"> • Recommends that obesity advice should be tailored to different groups, particularly people at vulnerable life stages for increased risk: such as pregnancy
RCOG Statement No. 4 Exercise in Pregnancy (2006) ⁽¹¹⁾	<ul style="list-style-type: none"> • All women should be encouraged to participate in exercise during pregnancy • Supervision is required for women with a BMI >40 kg/m²
NICE Behaviour Change Guidelines (2007) ⁽⁶⁾ Foresight Report: Tackling Obesity (2007) ⁽¹⁾	<ul style="list-style-type: none"> • Intervention should use key life stages when people are more open to change: such as pregnancy • Naturally occurring life course opportunities in which obesity intervention could be applied include pregnancy, and becoming a parent
CEMACH Maternal Mortality Reports (2007) ⁽¹⁶⁾ CEMACH Perinatal Mortality Report (2007) ⁽¹⁸⁾	<ul style="list-style-type: none"> • Maternal mortality data: mothers were obese in 27% maternal deaths between 2003 and 2005 • First of the annual perinatal mortality reports with maternal obesity statistics • Perinatal mortality data: mothers were obese in 22–30% perinatal deaths in 2005 (including late fetal loss, stillbirth and neonatal death)
NICE Diabetes in Pregnancy (2008) ⁽⁸⁾	<ul style="list-style-type: none"> • Obesity is an independent risk factor for diabetes and women with a BMI >30 kg/m² should be screened • Diabetic women with a BMI >27 kg/m² preconception should be advised to reduce their weight prior to becoming pregnant • The children of diabetic women are more likely to become obese or diabetic later in life
NICE Antenatal Care for Healthy Pregnant Women (2008) ⁽⁷⁾	<ul style="list-style-type: none"> • The BMI criteria for obesity reduced from >35 kg/m² to >30 kg/m² • These guidelines were still only for healthy pregnancies, with additional care required for obese women • However, some additional recommendations specific to obesity were included: <ul style="list-style-type: none"> Obesity was a criterion for ensuring vitamin D supplementation Obese women should be screened for gestational diabetes Raised BMI was identified as a limitation for ultrasound screening, and in cases of inadequate screening women should be offered serum screening for nuchal translucency Obesity as a risk factor for pre-eclampsia should be discussed with women
NICE Maternal and Child Nutrition (2008) ⁽⁹⁾	<ul style="list-style-type: none"> • Recommendation 6: Obesity • Applies to women with a BMI >30 kg/m² who are pregnant, those who may become pregnant and those with a baby • The guideline covers information provision and risk communication; dietary intervention; breast-feeding; and weight loss • Identified the link between early years nutrition and the development of obesity in later life
CEMACH Perinatal Mortality Report (2008) ⁽¹⁹⁾ DH Healthy Child Programme Pregnancy to 5 Years (2009) ⁽¹⁴⁾	<ul style="list-style-type: none"> • Perinatal mortality data: mothers were obese in 22–26% perinatal death in 2006 • Stresses the link between maternal/parental obesity and obesity among children • Has recommendations about the prevention of maternal obesity, and lifestyle interventions during pregnancy and postnatally
CEMACH Perinatal Mortality Report (2009) ⁽²⁰⁾ RCOG Green-top Guideline No. 37a (2009) ⁽¹²⁾	<ul style="list-style-type: none"> • Perinatal mortality data: mothers were obese in 23–26% perinatal death in 2007 • Guideline for reducing the risk of thrombosis and embolism during pregnancy and puerperium • Booking BMI >30 kg/m² is a risk factor and is incorporated into the risk assessments • Clinical guidelines for the management of obesity from preconception to postnatal
CMACE/RCOG Joint Guideline for the Management of Women with Obesity in Pregnancy (2010) ⁽¹³⁾ NICE Guidelines for Weight Management Before, During and After Pregnancy (2010) ⁽¹⁰⁾	<ul style="list-style-type: none"> • Public health guidelines for women with a BMI >30 kg/m² • Dietary interventions and physical activity interventions for weight management at these stages of women's life course
CMACE Perinatal Mortality Report (2010) ⁽²¹⁾ CMACE Maternal Obesity in the UK Report (2010) ⁽³⁾ CMACE Maternal Mortality Report (2011) ⁽¹⁷⁾	<ul style="list-style-type: none"> • Perinatal mortality data: mothers were obese in 23–24% perinatal deaths in 2008 • Report on the findings from a 3-year UK-wide project on obesity in pregnancy • Maternal mortality data: mothers were obese in 27% maternal deaths between 2006 and 2008

NICE, National Institute for Health and Clinical Excellence; CEMACH, Confidential Enquiry into Maternal and Child Health; DH, Department of Health; RCOG, Royal College of Obstetricians and Gynaecologists; DH, Department of Health; CMACE, Centre for Maternal and Child Enquiries.

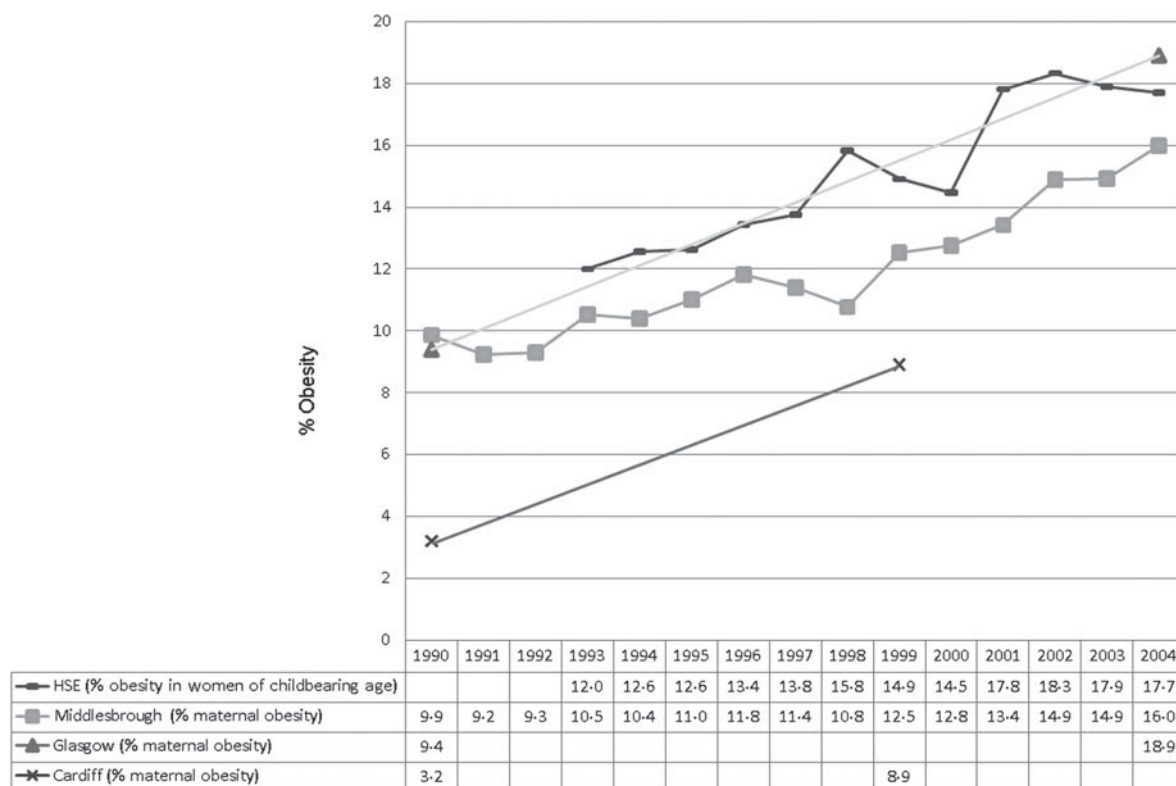


Fig. 1. A comparison of published local maternal obesity data^(33–35) and Health Survey for England (HSE) data⁽³²⁾.

of the fetus, fluids and the placenta in addition to fat mass⁽¹⁰⁾, and there is no evidence to determine what a 'healthy' or 'unhealthy' BMI is when this weight gain is taken into consideration. Current UK guidelines state that weight and height should be measured at the booking appointment (the first antenatal appointment with a health-care professional), and it is this early pregnancy measurement on which subsequent recommendations in the guidelines are made^(7,10,13).

In the UK, an additional BMI category is often used, which is not an internationally agreed definition. Women with a booking BMI $>50 \text{ kg/m}^2$ are considered to have a significantly increased risk during pregnancy. This has been defined as 'super morbid obesity' or 'extreme obesity' in the absence of an internationally agreed definition^(13,30,31).

UK population trends in maternal obesity

For a number of years, healthcare professionals working in maternity services have reported an increasing trend towards obesity in early pregnancy. However, there has been a long-standing absence of national data to support these anecdotal claims. The Health Survey for England has shown that obesity among women of childbearing age has been increasing over time⁽³²⁾. Published data from local maternity units have also shown an increasing trend towards maternal obesity in regions of Middlesbrough in England⁽³³⁾, Glasgow in Scotland⁽³⁴⁾ and Cardiff in Wales⁽³⁵⁾ (Fig. 1).

In 2010, three national-level maternal obesity datasets were published in the UK; one retrospective study and two prospective studies (Table 2). Heslehurst *et al.*⁽³⁰⁾ carried

out retrospective analysis of routinely collected electronic data from maternity units in England. This longitudinal dataset identified a significant increase in first-trimester maternal obesity (defined as BMI $>30 \text{ kg/m}^2$) over two decades⁽³⁰⁾. By 2007, the incidence of maternal obesity within this population had doubled to 15.6% from 7.6% in 1989. Two-thirds of women who were classified as obese during pregnancy were moderately obese (BMI $30.0\text{--}34.9 \text{ kg/m}^2$), and the incidence was shown to decrease as the category of obesity increased⁽³⁰⁾ (Fig. 2).

CMACE⁽³⁾ carried out a prospective cohort study, using a notification system. Maternity units throughout the UK completed notification forms for all women meeting the eligibility criteria. This study identified a similar trend for decreasing obesity incidence as the level of obesity increased (Table 2). The CMACE dataset also identified UK regional differences in maternal obesity, with Wales and the Crown Dependencies having the highest incidence of obesity (6.5% and 6.2%, respectively), whereas England had the lowest (4.9%)⁽³⁾. Knight *et al.*⁽³¹⁾ also carried out a prospective cohort study. This study identified women with extreme obesity BMI $>50 \text{ kg/m}^2$ through the UK Obstetric Surveillance System, which represents 100% of all births in the 226 eligible UK hospitals⁽³¹⁾, showing similar results (Table 2).

Maternal obesity and associated inequalities

Obesity in the UK general population is associated with broad socio-demographic inequalities⁽¹⁾. Maternal obesity largely reflects these inequalities, particularly

Table 2. National data on maternal obesity in the UK

Authors	Study type	Population	Sample size	Period of data collection	Obesity measurement	Incidence of maternal obesity
Heslehurst <i>et al.</i> ⁽³⁰⁾	Retrospective analysis of routinely collected maternity data	England	619 323 births	1 January 1989 to 31 December 2007	BMI >30 kg/m ² BMI 30.0–34.9 kg/m ² BMI 35.0–39.9 kg/m ² BMI 40.0–49.9 kg/m ² BMI >50 kg/m ²	(2007 data) 15.6% 10.0% 3.8% 1.6% 0.18%
CMACE ⁽³⁾	Prospective cohort study (notification)	UK	5068 births	1 March 2009 to 30 April 2009	BMI >35 kg/m ² BMI 35.0–39.9 kg/m ² BMI 40.0–49.9 kg/m ² BMI >50 kg/m ²	5.0% 3.0% 1.8% 0.19%
Knight <i>et al.</i> ⁽³¹⁾	Prospective cohort study (UKOSS)	UK	655 births (out of 764 387)	September 2007 to August 2008	BMI >50 kg/m ²	0.09%

CMACE, Centre for Maternal and Child Enquiries; UKOSS, UK Obstetric Surveillance System.

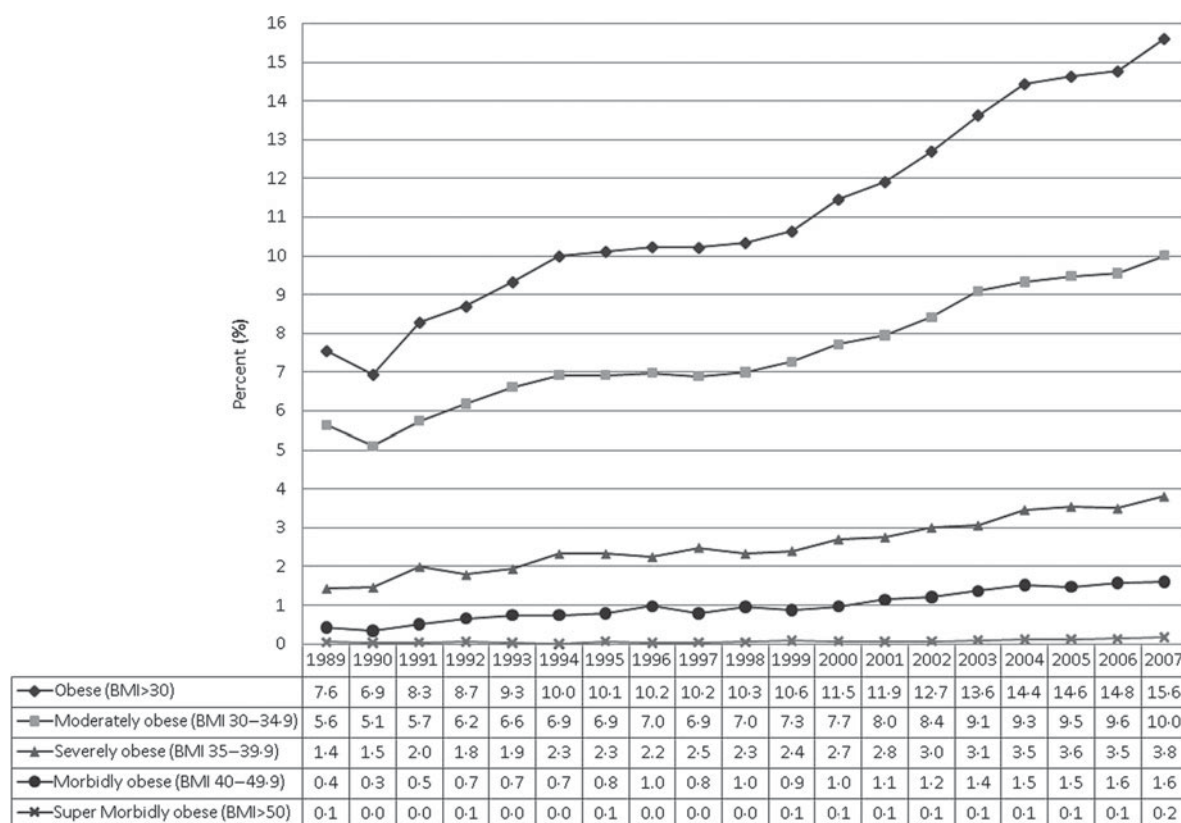


Fig. 2. Trends in maternal obesity subgroups in England. Data from Heslehurst *et al.*⁽³⁰⁾.

relating to deprivation, ethnic group and unemployment^(3,30,31).

National data have identified a significant association between area of residence deprivation and maternal obesity^(3,30). These studies categorised area of residence deprivation using Index of Multiple Deprivation scores for maternal postcode, mapped to quintiles for England. The quintiles ranged from least deprived to most deprived areas of residence, according to multiple determinants (including the 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)⁽³⁶⁾.

Following adjustment for potential socio-demographic confounders, Heslehurst *et al.* identified that obese women in England were more than twice as likely to be living in areas of most deprivation compared with those women living in areas of least deprivation⁽³⁰⁾. This association increased as the obesity classification increased, and women with extreme obesity were almost five times as likely to be living in areas of most deprivation compared with least deprivation (Table 3). The CMACE dataset also identified

Table 3. Association between maternal obesity and residing in areas of most deprivation in England according to the index of multiple deprivation

Class of obesity	Heslehurst <i>et al.</i> ^{(30)*†}	CMACE ^{(3)‡}
Obese (all BMI >30 kg/m ²)	AOR 2.2 (95% CI 2.1, 2.3)	–
Moderately obese (BMI 30–35 kg/m ²)	AOR 2.0 (95% CI 1.9, 2.0)	–
Severely obese (BMI 34–40 kg/m ²)	AOR 2.7 (95% CI 2.5, 2.9)	11.3% (least deprived quintile), 34.6% (most deprived quintile)
Morbidly obese (BMI 40–50 kg/m ²)	AOR 3.0 (95% CI 2.7, 3.3)	11.0% (least deprived quintile), 33.8% (most deprived quintile)
Super morbidly obese (BMI >50 kg/m ²)	AOR 4.7 (95% CI 3.2, 6.9)	10.2% (least deprived quintile), 35.7% (most deprived quintile)

AOR, adjusted OR; CMACE, Centre for Maternal and Child Enquiries.

*Baseline data: least deprived quintile.

†Adjusted for age, parity, ethnic group and employment.

‡England only data. Per cent compared with deprivation among all maternities in England according to the Office of National Statistics: 15.7% (least deprived quintile), 27.6% (most deprived quintile).

Table 4. Association between maternal obesity and employment status in England, and the UK

	Heslehurst <i>et al.</i> ⁽³⁰⁾			Knight <i>et al.</i> ⁽³¹⁾	
	England population			UK population	
	AOR* (95% CI)			OR (95% CI)	
	Employed (baseline)	Unemployed	Housewife or full-time carer	Managerial/Professional occupation (baseline)	Other occupation
Obese BMI >30 kg/m ²	1.0	0.91 (0.88, 0.94)	0.94 (0.92, 0.97)	–	–
Moderate obesity BMI 30.0–34.9 kg/m ²	1.0	0.88 (0.85, 0.92)	0.91 (0.88, 0.94)	–	–
Severe obesity BMI 35.0–39.9 kg/m ²	1.0	0.93 (0.87, 0.99)	0.96 (0.92, 1.01)	–	–
Morbid obesity BMI 40.0–49.9 kg/m ²	1.0	1.02 (0.93, 1.11)	1.09 (1.02, 1.17)	–	–
Extreme obesity BMI >50 kg/m ²	1.0	1.50 (1.12, 2.02)	1.40 (1.10, 1.78)	1.0	1.70 (1.27, 2.27)

*OR adjusted for age, parity, ethnic group and area of residence deprivation.

an over-representation of obese pregnant women residing in areas of most deprivation compared with all pregnant women in England ($P<0.0001$)⁽³⁾ (Table 3).

Two of the national datasets also explored the relationship between maternal employment and obesity^(30,31). Heslehurst *et al.* identified that obese women were more likely to be employed compared with the other employment categories explored (including unemployed, full-time housewife or carer, higher education or school age/in education under 18 years)⁽³⁰⁾. However, analysis within obesity classifications revealed that women with extreme obesity were significantly more likely to be unemployed; and women with extreme or morbid obesity were significantly more likely to be full-time housewives or carers (Table 4). Knight *et al.* also identified that women with extreme obesity were significantly more likely to be in non-managerial or professional employment⁽³¹⁾ (Table 4).

All three national datasets reported the relationship between maternal obesity and ethnic group^(3,30,31). Heslehurst *et al.* reported that Black women were significantly more likely to be obese in pregnancy (BMI >30 kg/m²) compared with White women; whereas all other ethnic groups were significantly less likely to be obese compared with White women⁽³⁰⁾ (Table 5). Analysis within obesity

classifications identified that this relationship with Black ethnic group was significant for moderate obesity adjusted OR (AOR) 1.95, 95% CI 1.85, 2.06), severe obesity (AOR 1.60, 95% CI 1.47, 1.74) and morbid obesity (AOR 1.51, 95% CI 1.34, 1.72)⁽³⁰⁾. Although the odds remained increased for extreme obesity, this was no longer significant (AOR 1.45, 95% CI 0.96, 2.18)⁽³⁰⁾. Knight *et al.* reported similar findings for ethnic group and extreme obesity (BMI >50 kg/m²), where White women were significantly more likely to have a BMI >50 kg/m² compared with Black and Minority Ethnic Groups⁽³¹⁾. CMACE also reported a significantly reduced proportion of non-white women among their obese cohort in comparison with all maternities in England⁽³⁾ (Table 5).

Maternal obesity is significantly associated with increasing maternal age (Table 6). Increasing maternal age was found to be significant for all BMI groups following adjustment for confounding socio-demographic variables by Heslehurst *et al.*⁽³⁰⁾, with extreme obesity showing the strongest relationship. CMACE reported a decreased association with maternal age below 20 years for all obesity categories, and an increased association with maternal age over 35 for both morbid and extreme obesity categories⁽³⁾. The strongest relationship was again shown for women within the extreme obesity group. A similar trend

Table 5. Association between maternal obesity and ethnic group in England, and the UK

Ethnic group	Heslehurst <i>et al.</i> ⁽³⁰⁾ BMI >30 kg/m ² in England	CMACE ⁽³⁾ BMI >35 kg/m ² in UK	Knight <i>et al.</i> ⁽³¹⁾ BMI >50 kg/m ² in UK
White	AOR 1.0 (baseline)*	84.9%	OR 1.0 (baseline)
Black	AOR 1.8 (95% CI 1.7, 1.9)	1.1%	—
South Asian	AOR 0.6 (95% CI 0.6, 0.7)	6.0%	—
Mixed	AOR 0.8 (95% CI 0.7, 0.9)	4.6%	—
Chinese	AOR 0.5 (95% CI 0.5, 0.5)	0.6%	—
Other	—	1.9%	—
All BME groups	—	—	OR 0.71 (95% CI 0.52, 0.97)

AOR, adjusted OR; BME, Black and Minority Ethnic; CMACE, Centre for Maternal and Child Enquiries.

*Adjusted for age, parity, employment and area of residence deprivation.

Table 6. Association between maternal obesity and maternal age in England, and the UK

	Age as a continuous variable	Younger than 20 years	20–34 years	35 years or older
Obesity (BMI >30 kg/m ²)				
Heslehurst <i>et al.</i> ^(23,30)	AOR 1.02 (95% CI 1.02, 1.02)*	—	—	—
Moderate obesity (BMI 30.0–34.9 kg/m ²)				
Heslehurst <i>et al.</i> ^(23,30)	AOR 1.02 (95% CI 1.01, 1.02)*	—	—	—
Severe obesity (BMI 35.0–39.9 kg/m ²)				
Heslehurst <i>et al.</i> ^(23,30)	AOR 1.02 (95% CI 1.02, 1.03)*	—	—	—
CMACE ^{(3)†}	—	3.7%	76.8%	19.5%
Morbid obesity (BMI 40.0–49.9 kg/m ²)				
Heslehurst <i>et al.</i> ^(23,30)	AOR 1.03 (95% CI 1.03, 1.04)*	—	—	—
CMACE ^{(3)†}	—	3.1%	74.5%	22.4%
Extreme obesity (BMI >50 kg/m ²)				
Heslehurst <i>et al.</i> ^(23,30)	AOR 1.07 (95% CI 1.05, 1.09)*	—	—	—
CMACE ^{(3)†}	—	2.6%	66.7%	30.7%
Knight <i>et al.</i> ⁽³¹⁾	—	OR 0.15 (95% CI 0.07, 0.32)	1.0 (Baseline)	OR 1.15 (95% CI 0.89, 1.49)

CMACE, Centre for Maternal and Child Enquiries.

*Adjusted for parity, ethnic group, employment and deprivation.

†Percent compared with age group among all maternities in England according to the Office of National Statistics: 6.3% (younger than 20 years), 73.7% (20–34 years), 20% (35 or older).

was reported by Knight *et al.*, who identified that maternal age below 20 years was significantly negatively associated with extreme obesity⁽³¹⁾. This study also identified a relationship between maternal age over 35 and extreme obesity; however, this was not statistically significant⁽³¹⁾ (Table 6).

A significant relationship between increasing parity and maternal obesity was reported by Heslehurst *et al.* for all obesity classifications with the exception of extreme obesity⁽³⁰⁾ (Table 7). Knight *et al.* found a significant relationship between extreme obesity and a parity of 3 or more compared with a parity of 0, but no significance for a parity of 1–2⁽³¹⁾ (Table 7).

Maternal obesity complications and the impact on maternity services

Obese pregnancies present increased risk of complications, with multiple long- and short-term adverse health implications for both women and their infants. Maternal implications include mortality⁽¹⁶⁾, cardiac disease⁽¹⁶⁾, spontaneous first trimester and recurrent miscarriage^(16,37,38), pre-eclampsia^(16,39,40), gestational diabetes (and subsequent development of type 2 diabetes)^(16,41), thromboembolism⁽¹⁶⁾, caesarean and instrumental deliveries^(40,42,43), induction of labour and failure to progress⁽⁴²⁾,

infections^(16,42) and postpartum haemorrhage^(16,42). Implications for the infant include low breast-feeding rates⁽¹⁶⁾, stillbirth and neonatal death^(18,37), congenital anomalies^(18,44,45), low- and high-birth weight^(40,42), sub-optimal gestational age (both prematurity and postdate)^(18,40,42,46), fetal distress⁽⁴²⁾ and neonatal intensive care^(3,42). Maternal weight status is also thought to influence the development of childhood obesity, and subsequent adult obesity through fetal exposure to maternal obesity influencing appetite, metabolism and activity levels^(47–49). However, more robust evidence is required to support this fetal programming theory⁽²⁶⁾.

Although these numerous adverse outcomes have a significant impact on maternal and infant health, the prevention and management of such complications also require more resource intensive maternity care. Some of the additional resource requirements are straightforward to quantify, such as induction of labour, mode of delivery and intensive care use. These outcomes alone have a high impact on maternity service resources, and all have a significant association with maternal obesity (Table 8).

However, there are also additional resource implications that are more problematic to determine. Healthcare professionals have reported difficulties with ultrasonography and external electronic fetal monitoring when mothers

Table 7. Association between maternal obesity and parity in England, and the UK

	Heslehurst <i>et al.</i> ⁽³⁰⁾	Knight <i>et al.</i> ⁽³¹⁾		
	Parity as a continuous variable	Parity 0	Parity 1–2	Parity 3 or more
Obesity (BMI >30 kg/m ²)	AOR 1·17 (95% CI 1·16, 1·18)*	–	–	–
Moderate obesity (BMI 30·0–34·9 kg/m ²)	AOR 1·16 (95% CI 1·15, 1·18)*	–	–	–
Severe obesity (BMI 35·0–39·9 kg/m ²)	AOR 1·18 (95% CI 1·16, 1·19)*	–	–	–
Morbid obesity (BMI 40·0–49·9 kg/m ²)	AOR 1·19 (95% CI 1·16, 1·21)*	–	–	–
Extreme obesity (BMI >50 kg/m ²)	AOR 1·07 (95% CI 0·99, 1·16)*	1·0 (Baseline)	OR 1·23 (95% CI 0·97, 1·56)	OR 2·85 (95% CI 1·98, 4·11)

AOR, adjusted OR.

*Adjusted for age, ethnic group, area of residence deprivation and employment.

Table 8. Association between maternal obesity and pregnancy outcomes with a high impact on maternity services

Reference	Data source	Obesity classification	Induction of labour	Caesarean delivery	Intensive care
Heslehurst <i>et al.</i> ⁽⁴²⁾	Systematic review with meta analysis	BMI >30 kg/m ²	OR 1·9 (95% CI 1·8, 1·9)	OR 2·0 (95% CI 1·9, 2·2)	OR 1·4 (95% CI 1·2, 1·5)*
		BMI >40 kg/m ²	–	–	OR 1·3 (95% CI 1·2, 1·5)*
Poobalen <i>et al.</i> ⁽⁴³⁾	Systematic review with meta analysis	BMI 30–35 kg/m ²	–	OR 2·3 (95% CI 2·0, 2·5)	–
		BMI >35 kg/m ²		OR 3·4 (95% CI 2·5, 4·6)	
CMACE ⁽³⁾	UK prospective cohort	All maternities§	16·6%	24·6%	–
		BMI 35–39·9 kg/m ²	26·5%	34·7%	1·0 (baseline)
		BMI 40–49·9 kg/m ²	26·2%	40·4%	OR 1·3 (95% CI 1·0, 1·7)*
		BMI >50 kg/m ²	27·5%	45·8%	OR 2·0 (95% CI 1·2, 3·4)*
Knight <i>et al.</i> ⁽³¹⁾	UK prospective cohort†	BMI >50 kg/m ²	AOR 2·0 (95% CI 1·5, 2·5)	AOR 3·5 (95% CI 2·7, 4·5)	AOR 3·9 (95% CI 1·4, 10·6)‡

AOR, adjusted OR; CMACE, Centre for Maternal and Child Enquiries.

*Neonatal Intensive Care Unit.

†Adjusted for age, socio-economic group, parity, ethnicity, and smoking.

‡Maternal Intensive Care Unit.

§All maternities in England obtained from the Hospital Episode Statistics.

are obese, due to excess adipose tissue limiting the capabilities of these methods of assessment^(22,23,50,51). Therefore, the resource implications may be longer ultrasound scan appointments, repeated ultrasound scans and alternative screening and monitoring procedures such as serum screening for nuchal translucency or fetal scalp electrodes to monitor fetal heart rate^(7,22,51). There are also issues with equipment provision within maternity units that can restrict clinical practice. This is a particular issue when equipment has a maximum weight or expansion capacity, such as delivery beds, theatre tables, scales, blood pressure cuffs and spinal needles^(22,50,52). Surgery and anaesthesia can also be more difficult technically, requiring more staff to be present during delivery, including multiple senior health care professionals^(13,22,26,50).

Non-clinical implications for maternal obesity management among health care professionals

When considering the impact of maternal obesity management on maternity services, the non-clinical implications for healthcare professionals should also be considered. National guidelines state that women's BMI should be measured at booking, and an explanation given to women about why the measurement is being taken, how it will be used to plan their care and the risks associated with obesity in pregnancy⁽¹⁰⁾. Although healthcare professionals understand their responsibility to explain potential risks and complications to women during pregnancy, this in itself is a difficult task⁽²³⁾. Obesity is an emotive and stigmatised topic^(53–55), and healthcare professionals have described their difficulties in broaching the topic with women during pregnancy^(22,23,56). Midwives have described their concerns about labelling women as obese, the need for more sensitive risk communication and apprehension about raising the issue due to past experiences of complaints from women^(22,23,52).

'Sonographers will often say how to diplomatically talk to women 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 ... "what are you saying, I'm too fat?" but ... we're being honest and saying "there are limitations to what this machine can tell you because of this"' (Midwife)⁽²³⁾

Obesity communication issues are also identified by obese pregnant women and non-pregnant obese patients. Healthcare professionals have been described by obese patients (including pregnant and non-pregnant populations) as being insulting, demeaning, discriminating, judgmental, blame-inducing, patronising and derogatory in their care^(57–61). Pregnant women have described avoiding confronting healthcare professionals about humiliating treatment relating to their obesity, due to the fear of jeopardising their maternity care⁽⁶²⁾. Avoidance is also reflected in the non-pregnant obese population, where previous negative experiences with healthcare professionals have led to patients avoiding or delaying seeking health care^(23,57,58).

'When I was delivering my son ... I think I weighed 215 pounds when he was born and I just felt huge ... I can remember in the delivery room the doctor saying something to me ... during the birthing process. He said, "Just relax and just envision yourself on a beach like a big ole whale beached" ... That hurt me so much because already I felt big'. (Doris)⁽⁵⁸⁾

Healthcare professionals' own weight concerns can also influence their discussions with pregnant women (and non-pregnant populations) about their weight, in both a positive and negative way^(52,63).

'Like I'm overweight. You know, how can I sit there and tell this lady about her weight when I'm overweight?' (Midwife)⁽⁵²⁾

'I've always found it's a little bit easier to address it when you are overweight than if you're this gorgeous skinny looking thing saying well you're a bit chubby there' (Healthcare Professional Not Specified)⁽⁵²⁾

There is also a call from maternity service healthcare professionals for more support services for women as they feel they 'can't do it alone', with some midwives having concerns about increasing social stigma among women if they highlight the risks associated with maternal obesity without any support mechanisms in place^(23,52). The level of support required has been compared with antenatal smoking cessation services, where there has been more national-level support, resources and infrastructure to support healthcare professionals as well as women, which has raised awareness among healthcare professionals and their subsequent engagement with this aspect of care^(23,56).

Summary

National data within the UK have identified an increasing trend towards obesity among women of childbearing age, as well as within the pregnant population^(30,32). Data also suggest strong associations between maternal obesity and area of residence deprivation; and evidence of associations with unemployment, ethnic group, increasing maternal age and increasing parity for some obesity sub-groups^(3,30,31). However, there is a degree of variation between the datasets for some of these socio-demographic inequalities. Potential explanations for the differences observed could be the different BMI classifications used, data analysis methods such as adjustment for confounding variables, sample sizes and the comparison groups used in the studies.

The relationship between socio-demographic inequalities and maternal obesity is of paramount importance not only in relation to the need for public health intervention, but also more directly to the multiple associations between maternal inequalities and pregnancy risk. There is a wealth of evidence which equates maternal obesity with health implications for mothers and infants. These implications also have a direct impact on maternity services' resources, and how well equipped they are to prevent and manage maternal obesity. Healthcare professionals face additional difficulties in communicating risk to obese pregnant women due to the sensitive and emotive nature of obesity.

Despite an increasing national focus on maternal obesity over the past decade, there remains an absence of good-quality evidence for the effectiveness of interventions to support women, and to manage obesity pre-conception, during pregnancy and postnatally. The consequence of the lack of evidence, in addition to the difficulties healthcare professionals face, is an absence of support services available for women. Further evaluative research is thus required to assess the effectiveness of interventions for women before, during and after pregnancy. More research is also required with obese women to help inform the development of more sensitive risk communication and women-centred services.

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