AN OBSERVATIONAL STUDY IN LIVERPOOL OF PREGNANT WOMEN WITH A BMI ≥ 35kg/m^2 REGARDING DIETARY INTAKE, LIFESTYLE AND LIVED EXPERIENCE

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Abstract

Background

The prevalence of maternal obesity is on the increase, compromising both maternal and foetal health. Previous intervention studies have been designed to limit the amount of gestational weight gain but in the absence of UK guidelines, relating to optimum weight change in obese pregnancies and the negative experiences of obese women with regard to previous weight loss attempts, it is reasonable to ask whether this is the most effective approach. It has been demonstrated that maternal dietary intake can impact on gestational weight gain and birth weight but there is little in the way of research into the impact that quality of diet has on outcomes.

Aims

To measure the quality of maternal dietary intake and weight change against pregnancy and birth outcomes and to explore and gain insight into the lived experience of obese pregnant women with a view to informing guidelines.

Methods

Pregnant women with a BMI$\geq$35kg/m^2 were recruited from antenatal clinic and asked to complete 3 day food diaries at 16,28 and 36 weeks gestation, The diaries were verified using a food atlas and analysed using Microdiet. A subset of women were then followed up and interviewed regarding their lived experience of obesity.

Results

The women's dietary intake deteriorated over the duration of pregnancy and there were significant associations between some micronutrients and pregnancy and birth outcomes. Women with a BMI 35-39.9kg/m^2 were most likely to gain weight.

Conclusion

The dietary intake of obese pregnant women is an important predictor of pregnancy and birth outcomes and it was demonstrated that the quality of diet significantly deteriorated over the duration of pregnancy. Interventions designed to increase the quality of diet are urgently required.

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Glossary of terms

AA	Arachadonic Acid
ALA	Alpha-linoleic acid
BMI	Body Mass Index
BMR	Basal Metabolic rate
BW	Birth Weight
CEMACH	Confidential Enquiry into Maternal and Child Health
CHD	Coronary Heart Disease
CHO	Carbohydrate
CMACE	Centre for Maternal and Child Enquiries
COMA	Committee of Medical Aspects of Food Policy
CVD	Cardiovascular Disease
DHA	Docosahexaenoic Acid
DLW	Doubly Labelled Water
DRV	Dietary Reference Values
EAR	Estimated Average Requirements
EFA	Essential fatty Acid
EPA	Eicosapentaenoic Acid
FCDB	Food Composition Database
FFB	Fit For Birth
FFQ	Food frequency Questionnaire
GDM	Gestational Diabetes Mellitus
GI	Glycaemic Index
GL	Glycaemic Load
GWG	Gestational Weight Gain
HDL	High Density Lipoprotein
HDP	Hypertensive Disorders in Pregnancy

HG	Hyperamesis Gravidarum
IDQ	Index of Diet Quality
IOM	Institute of Medicine
IUGR	Inter Uterine Growth Restriction
LA	Linoleic acid
LDL	Low Density Lipoprotein
LGA	Large for Gestational Age
LRNI	Lower Reference Nutrient Intakes
LWH	Liverpool Women's Hospital
MUFA	Monounsaturated Fatty Acid
MWG	Maternal Weight Gain
NICE	National Institute for Health and Clinical Excellence
NMES	Non Milk Extrinsic Sugar
NSP	Non Starch Polysaccharide
NTD	Neural Tube Defects
PAL	Physical Activity Level
PAR	Predictive Adaptive Response
PPWR	Post Partum Weight Retention
PTD	Pre-term Delivery
PUFA	Polyunsaturated Fatty Acid
RCOG	Royal College of Obstetricians and Gynaecologists
RCT	Randomised Control Trial
RNI	Reference Nutrient Intakes
SACN	Scientific Advisory Committee on Nutrition
SES	Socio-economic Status
SFA	Saturated Fatty Acid
SGA	Small for Gestational Age

T2DM	Type 2 Diabetes Mellitus
TEE	Total Energy Expenditure
VLDL	Very Low Density Lipoprotein
VTE	Venous Thromboembulism

1 CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

This opening chapter provides an introduction to the study. It gives background and identifies the research problem that informed the study. The aims and objectives of the study are also explored in this chapter and there follows a brief overview of the layout of the thesis.

This is followed by a comprehensive review of the literature related to the themes presented in this thesis.

1.2 THE RESEARCH PROBLEM

Maternal mortality rates in the UK as either a direct or indirect result of pregnancy were 11.39 per 100,000 in the years 2006-2008, which equated to approximately 261 deaths, as reported in Centre for Maternal and Child Enquiries (CMACE (2010). The most common cause of indirect death is cardiac disease with many women having lifestyle related risk factors such as smoking, obesity and poor diet (Draycott et al. 2011). More than 50% of women who died in 2003-2005 were overweight or obese (BMI $\geq 25 kg/m^2$) with 15% being morbidly (BMI $\geq 40 kg/m^2$) or super-morbidly (BMI $\geq 50 kg/m^2$) obese (CEMACH 2007).

The prevalence of maternal obesity is growing with 1 in 5 women presenting for antenatal care with a BMI $\geq 30 kg/m^2$ (Arrowsmith et al. 2011). Maternal obesity is linked with increased risk of hypertension, pre-eclampsia and gestational diabetes mellitus (GDM) potentially leading to antenatal complications and

interventions in labour (Sebire et al. 2001). There are higher rates of induction of labour, instrumental delivery and a 3 fold increase in rates of caesarean section in the obese pregnant population (Galtier-Dereure et al. 2000) and as such there are additional costs and resources associated with women with a BMI ≥35kg/m^2, due to extended hospitalisation (Heslehurst et al. 2008).

Liverpool Women's Hospital (LWH) is one of only two hospitals in the UK dedicated specifically to the healthcare needs of women, babies and their families. Approximately 8000 women give birth each year at LWH (www.LWH) and of those women 26.7% were overweight (Abayomi et al. 2007) and 17.7% defined as clinically obese (Kerrigan and Kingdon 2010). Pregnancy has been identified as a critical period for excessive gestational weight gain (GWG) (NICE 2010) and GWG has been correlated with long term weight retention in the post-partum period (Kinnunen et al. 2007). Over the last few years there have been a number of interventions designed to limit GWG in women of both normal weight (BMI 18–24.9kg/m^2), overweight women (BMI 25-29.9kg/m^2) and obese women (BMI ≥30kg/m^2) and these are reviewed under section 1.14 later in this chapter. It is estimated that 14-20% of women retain weight post-partum, which is associated with birth weight, low breast-feeding rates (Walker 2007), an increased risk of childhood obesity (Drake and Reynolds 2010) and a predisposition to obesity related diseases in adult offspring (D. J. Barker 2007, Poston 2010).

An observational study entitled 'Fit for Birth' (FFB), took place at the LWH and was intended to look at aspects of obesity in the pregnant population in Liverpool to optimise care pathways and reduce potential risk. The project was designed as an observational study to generate baseline data that would shape

further research and develop services for obese pregnant women. There were 2 arms to the study; the first arm was to compare weight change in obese pregnant women with a BMI ≥30kg/m^2 with pregnancy and birth outcomes. The second arm was an additional study 'Fit for Birth plus' (FFB+) and included a subset of women with a BMI ≥35kg/m^2 where data pertaining to lifestyle was collected. This included physical activity, quality of life and sleep apnoea as well as energy and nutritional intake data.

For the purposes of the wider FFB study only data related to total energy intake and total fat intake was requested but a wealth of data relating to macronutrient and micronutrient intake was also recorded.

The author was engaged as the research nutritionist on the FFB+ project and participated in research clinics gathering dietary information via food diaries and validation interviews. Subsequently interviews were conducted during a follow up qualitative phase where the remit was to explore the lifestyles, behaviours and experiences of a subset of women to support and illustrate the findings of the quantitative phase. These findings will be reported in this thesis. The findings of the other aspects to the FFB study will be reported elsewhere.

A review of the literature was conducted using CINAHL, PubMed, MEDLINE and Science Direct databases. Key terms used were maternal obesity, pregnancy outcomes, maternal nutrition, pregnancy, dietary assessment, dietary intake, nutritional intake, micronutrient intake, dietary interventions.

1.3 AIMS & OBJECTIVES

The aims of this study were to assess the nutrient intakes and quality of diet in pregnant women with a BMI ≥35kg/m^2 to determine any association with pregnancy and birth outcomes and to explore how lifestyle and the lived experience of these women influenced food choice and behaviours. Answering these questions will help to inform future guidelines for the care and management of obesity in pregnancy.

The following objectives will assist in achieving these aims

- To examine the dietary intake of pregnant women with a BMI ≥35kg/m^2 using estimated food diaries

- To investigate the relationship between quality of diet and pregnancy outcomes

- To explore the diet and weight histories of these women with regard to changes in eating behaviours over time as well as investigating their attempts at weight loss using calorie controlled diets and commercial slimming groups

- To gauge the perceptions of these women as to how their obesity impacts on their health and emotions with particular reference to pregnancy

- To draw on the lived experiences of these women to enhance and explain the data collected from the food diaries.

1.4 OUTLINE OF THE THESIS

The thesis is organised into 5 chapters and there follows a brief description of the content of each chapter.

Chapter 1 & 2: The Introduction and Literature Review

This chapter provides an introduction to the study, the research problem which explains the rationale behind it and a review of the literature that identified the gap that informed this study. The aims and objectives are also presented in this chapter.

Chapter 3: The Methodology

This chapter presents a discussion of the theoretical, ethical and methodological considerations which informed the study methods. Descriptions of the sampling strategy, methods of collection and data analysis are also presented in this chapter.

Chapter 4: Methods

This chapter describes what was done and is presented in two parts. The first part details the methods used in the quantitative phase and the second part describes the qualitative phase.

Chapter 5: The Results

A contiguous approach to integration of both the quantitative and qualitative results are reported in this chapter, thus it is presented in two parts (Fetters et al. 2013). The first part describes the results from the quantitative phase. The results are presented in a series of tables and graphs and include descriptions of the statistical tests applied to the data. The second part presents the findings from the qualitative phase of the study. These narrative findings give context to the quantitative results.

Chapter 6: The Discussion

This chapter presents a discussion of the quantitative and qualitative findings and how the qualitative phase supported that of the quantitative phase. The findings are placed in the context of existing research to illustrate the significance of this study. There also follows a reflection of the limitations of the study and recommendations for further research and ends with the conclusion.

2 CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Overweight and obesity is a global problem and is on the increase. It is a relatively new phenomena in human terms and is attributed to obesogenic environments where food is plentiful and relatively cheap and a human evolution that is maladapted to such environments (Ulijaszek 2007). It is defined as an abnormal or excessive accumulation of fat that may impair health and is commonly classified using the body mass index (BMI). This is characterised as the weight in kilograms divided by the square of the height in metres (kg/m^2). The World Health Organisation (WHO 2006) describes overweight as $\geq 25kg/m^2$ and obesity as $\geq 30kg/m^2$. Projections made by WHO indicate that 2.3 billion adults will be overweight and 700 million will be obese by the year 2015. This will have deleterious consequences for human health and the costs attributed to the care and treatment of people with diseases associated with obesity. Obesity is a known risk factor for a number of chronic and degenerative diseases including cardiovascular disease (CVD), type 2 diabetes mellitus (T2DM) and hypertensive disorders, which are also implicated in maternal and foetal health. Maternal obesity is associated with a number of adverse obstetric outcomes including pre-eclampsia, gestational diabetes mellitus (GDM), type 2 diabetes mellitus (T2DM), macrosomia and neural tube defects (NTD) (Cnattingius et al. 1998, Scholl et al. 1995, Sebire et al. 2001) The 2007 Confidential Enquiry into Maternal Deaths (CEMACH) found that in the years 2003 – 2005, 52% of women who died during pregnancy had a BMI $\geq 25kg/m^2$ and 15% of women had a BMI $\geq 35kg/m^2$, half of whom were morbidly obese with a BMI $\geq 40kg/$

(CEMACH 2007). The Centre for Maternal and Child Health Enquiries (CMACE) (2011) has since published a follow up report stating that overweight and obesity during pregnancy continues to be over-represented with 49% of the women who had died having a BMI $\geq 25 kg/m^2$ (CMACE 2010). Women with BMI$\geq 30 kg/m^2$ account for 27% of maternal deaths. The prevalence of overweight and obesity in the pregnant population is on the increase with 24% of women aged 16 and over being classified as obese in 2007. This is up from the 16% that was determined in 1993 (Heslehurst et al. 2007a). Associations with maternal obesity and social deprivation were also observed with 34% of women with a BMI $\geq 35 kg/m^2$ residing in the most deprived quintile. The prevalence of overweight (BMI $\geq 25 kg/m^2$) and clinical obesity (BMI $\geq 30 kg/m^2$) in the Liverpool pregnant population during 2006 was estimated to be 2.7% and 17.7% respectively, of 8176 births (Abayomi et al. 2007, Kerrigan and Kingdon 2010).

2.2 FACTORS ASSOCIATED WITH OBESITY

Liverpool has been classified as one of the most deprived local authorities in England as reported by Office of the Deputy Prime Minister (ODPM 2010). It is widely acknowledged that obesity is correlated with low socio-economic status and health inequalities (Aylott 2008) and increased levels of unemployment. Other social determinants of health inequalities, described in the Marmott report (Marmott 2005) include stress, early life, food, transport, social exclusion and social support. There are multiple factors that associate deprivation and obesity, including genetic, the social, built and obesogenic environment as well as

psycho-social factors such as sedentary lifestyle and ease of access to fast food outlets (Macdonald et al. 2007). Furthermore, the economic drivers of food production and consumption make the tackling of obesity such a complex issue to address. The Foresight Report (King 2007) determined that the key areas for influence and responsibility for tackling obesity lay in early life interventions, adult social care and the strategic development of children's services (Aylott 2008). The report has also determined that a multi-disciplinary approach will be necessary to reverse the trend and will need to consider factors such as the physical and dietary environment as well as psycho-social, cultural and economic.

2.3 THE EVOLUTION OF THE HUMAN DIET

The western diet has changed dramatically from that which sustained early homo-sapiens. East- African ecosystems were situated where land met areas of fresh water and were sites rich in omega 3 (ω3), iodine and vitamins A and D from plant origin and as result of a plentiful fish supply (Muskiet et al. 2006) . There has been a major shift in nutritional characteristics initially as a result of the rise of agricultural practices which began approximately 10,000 years ago and the industrial revolution from about 200 years ago (Pijl 2011). Predominant changes have occurred in macronutrient composition with a reduction in protein consumption and a rise in carbohydrate intake and more recently refined carbohydrates with a high glycaemic load (Cordain 2005). Changes have also occurred over time in the ratio of fatty acid intake, the acid-base balance and sodium and potassium ratio which have all been affected by dietary changes

(Muskiet et al. 2006). Micronutrient intakes of iodine and vitamins A and D are also now low in comparison and are considered to be amongst the most widely distributed deficiencies in the world (Muskiet et al. 2006). Other micronutrient intakes that have declined over time are iron, folate, magnesium and zinc and these will be discussed in more depth in sections 2.13 and 2.14 later on in the chapter.
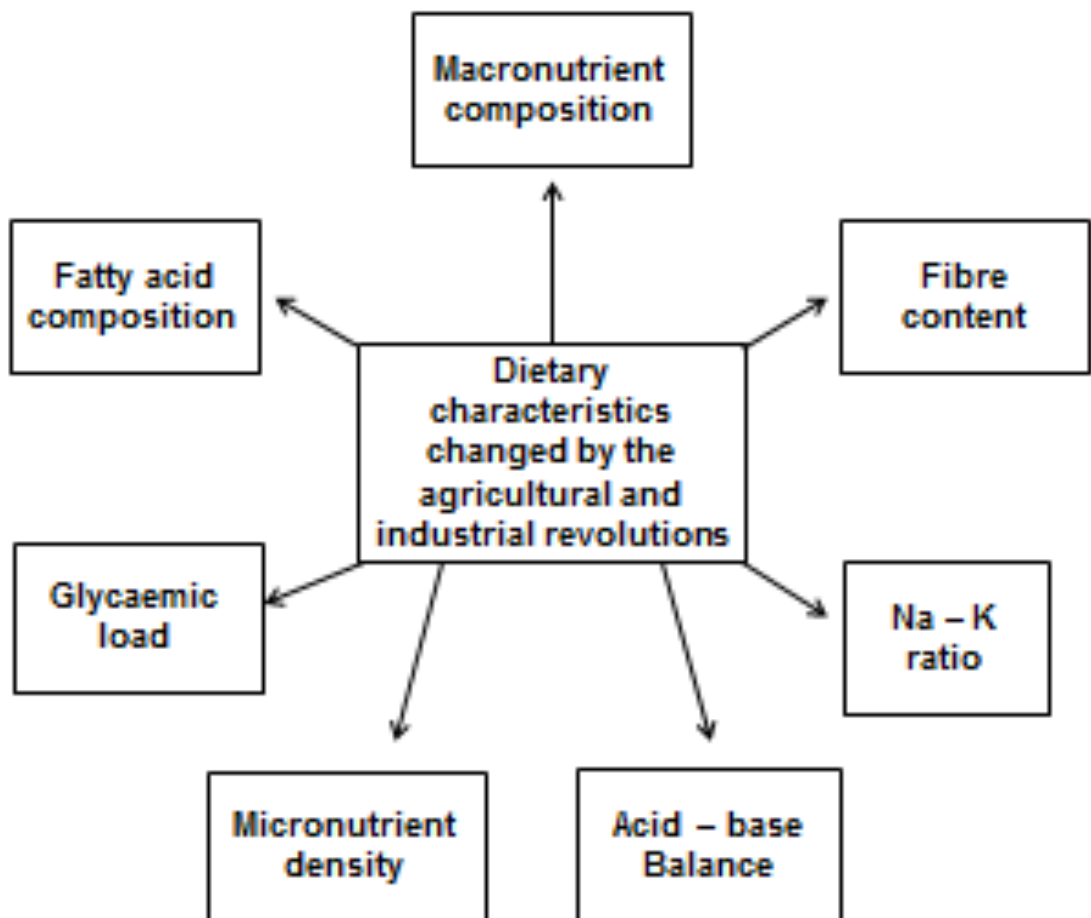
Figure 2-1: Changes in nutritional characteristics since the agricultural and industrial revolutions (reproduced from Muskiet et al 2006 with permission from Elsevier)

Further dietary changes have occurred in the latter half of the 20th and early 21st century commensurate with the enormous growth of the food industry. In the developed world, food has become relatively cheap and there has been a huge

expansion in the type and amount of foods that are readily available. The McDonalds franchise gained rapidly in growth from the early 1980's to the point where now all towns and cities have multiple outlets. Other fast food outlets have gained in popularity and there are areas in most UK towns and cities which are populated by rows of cheap fast food outlets (Dammann and Smith 2009).

2.3.1 Environment

Research studies have demonstrated that fast food outlets tend to be concentrated in the most deprived areas in the UK (Cummins et al. 2005). The increased consumption of fast food reflects the socio-cultural phenomenon that exists in these areas with regard to dietary intake, obesity and health (Macdonald et al. 2007). Socioeconomic and geographic factors may limit access to fresh food resulting in a reliance on readily available fast food, which tends to be high in fat and refined CHO's and are highly palatable. Palatable foods are known to affect taste preferences as well as appetite and satiety regulation (Morrison and Berthoud, 2007). The eating of foods high in fat and sugar stimulates the 'reward system' where endogenous opioids; dopamine and serotonin, act in a similar manner to opiates stimulating feelings of relaxation and well-being (Erlanson-Albertsson 2005). This potentially promotes changes in eating behaviours whereby food is eaten for gratification as opposed to fulfilling an energy deficit and satiety signals are overridden leading to subsequent weight gain. Thus, a craving for palatable foods which has been likened to drug addiction is triggered (Morrison and Berthoud 2007). There is an urge to come back for more and in an obesogenic environment where these

types of foods are more widely available there is a constant supply to help gratify these urges (Morrison and Berthoud 2007).

The role of the lived environment in terms of neighbourhood deprivation and its influence on obesity is the subject of much research attention (Poortinga et al. 2008) and is part of the discourse surrounding obesity and its aetiology. Low socio-economic status and deprivation denotes inequalities in populations. It has been proposed that it is gender-specific and it is exposure to disadvantage at critical time points that leads to a positive association with weight gain and obesity in adulthood. This is particularly so in girls and women brought up with a socially disadvantaged background (Giskes et al. 2008). Moreover, the built environment is implicated; it has been shown that people who live in deprived areas live less healthy lifestyles by being less physically active, eating less fruit and vegetables and smoking (Poortinga et al. 2008, Townshend and Lake 2011).

The amount of open/green space to encourage physical activities, transport and travel time to supermarkets as well as exposure to fast food outlets have been cited as environmental factors contributing to obesity levels in low socio-economic groups (Hackett et al. 2008, Thornton et al. 2011) In Liverpool, a study by (Hackett et al. 2008) 'mapped' dietary habits of school children aged 9-10 years to elicit factors that determine food choice relative to the built environment. The results suggest a correlation between children with less desirable eating habits and areas with small terraced houses, dense housing, narrow streets and heavy traffic with limited open/green space and lots of small shops selling confectionary or fast food but with many of them boarded up. It is not just the built environment that is correlated with obesity; a report by Wansink

(2004) suggests other environmental factors that contribute to an increase in food consumption, including food packaging, plate size, socialising and even lighting. Food volume intake is not the same as food choice and the amount consumed can be unwittingly influenced by these factors (Wansink 2004).

2.4 SOCIO-ECONOMIC STATUS

Differences in food consumption and dietary behaviour have been shown to exist in populations in receipt of state benefits or on a low income in comparison to those in higher socio-economic groups (Turrell 2005). It is suggested that distance to and location of shops and mode of transport play a part in food purchasing behaviour, the majority of people from low socio-economic background shop at local supermarkets (Laraia et al. 2004). Cooking skills, nutritional knowledge, attitudes to healthy eating and upbringing are determining factors for dietary habits and intakes. Intakes of fruit and vegetables are less than the recommended 5 portions per day, as is the intake of non-starch polysaccharide and evidence from the Low Income Diet and Nutrition Survey suggests inadequate iron, folate and vitamin D status and levels of obesity are substantially higher than in higher socio-economic groups (Nelson et al. 2007).

2.4.1 Social/cultural

Obesity has been described as a 'disorder of convenience', and is the result of the industrialisation and modernisation of developed nations that have emerged over the last 60 years (Ulijaszek 2007). These environments provide

convenience of work, leisure and food therefore the biological phenomenon that is obesity was inevitable and Ulijaszek postulates that the 'ceiling' on obesity in the majority of the world's population has yet to be reached (Ulijaszek 2007). The current stance on obesity as being a major threat to world health has been brought about by the media, medical health practitioners and WHO (1998) and has come to be symbolic of self-indulgence and moral failure. The classification of obesity being that of a diagnosed diseased state and requiring treatment (Wray and Deery 2008). However, it is argued by Townend (2009) that the westernised view of obesity as a disease state is based on an economic paradigm that has effectively marginalized obese people and labelled them as morally inferior and an economic burden (Townend 2009). Worldwide media reporting has fuelled public perception; debates in Canada, questioning the fairness of whether people categorised as obese should be fined for not following dietary regimes prescribed by GP's (Geoghegan, BBC news 17/05/2011). In Germany, an MP has stated that people who 'knowingly live unhealthily carry a responsibility for it in a financial respect' and should pay a 'fat tax' to contribute to any medical treatments perceived to be as a result of lifestyle (Hall, Daily Telegraph 22/07/2010). Here in the UK, national newspaper reports claim that obese people could have their lifestyle and physical activity levels monitored and may face cuts in benefits if they fail to participate in GP prescribed activities (Batty, Guardian 03/01/2013). Although many of these reports are speculative and unsubstantiated, they could be perceived as being inflammatory, forming or prejudicing a negative response from society against the overweight and obese. The inference being that obesity is of the individuals

choosing and that health consequences as a result of obesity are self-imposed; comparable to illnesses associated with smoking (Townend 2009).

2.4.2 Health

The associations between obesity and disease have been well documented and that overweight and obesity are determinants of reduced life expectancy of approximately 3 years for BMI 30-35kg/m^2 and 8-10 years in BMI 40-5-kg/m^2. Mortality associated with obesity is a result of vascular deaths (23%) and cancer related deaths (6%) (Dent and Swanston 2010). However, there are occasions when deterioration in the health of an individual or an exacerbation of a pre-existing unrelated condition may lead to or possibly cause an increase in weight. Illness and injury can affect physical activity levels and without a commensurate reduction in energy intake can result in a positive energy balance (Smith and Holm 2011). It is speculated that obesity is a causal factor in chronic conditions such as asthma and other respiratory problems with increasing levels of obesity leading to more severe asthma in a dose response effect (Castro-Rodríguez 2007).

2.5 OBESITY AS A FEMALE ISSUE

There are many periods in the life-course where people and women in particular are susceptible to weight gain. They can differ with regard to males and females but encompass a number of, sometimes quite specific, transitional points (Smith and Holm 2011).

2.5.1 Socio-environmental and media influences

Media portrayals of the female shape are unrepresentative of the normal population with the ideal physical frame for females being promoted as being thin and tubular, almost boyish in appearance (Monro and Huon 2005). The idealistic physical appearance of the female form has led to feelings of body dissatisfaction, guilt and shame in a large number of adolescent girls and young women (Calogero and Pina 2011). The mass media holds a powerful influence particularly over impressionable adolescents who are undergoing major emotional and physical transitions (Montani et al. 2006). Moreover, advertisements for diet products and weight loss programmes promote the idea that body shape is within the control of the individual and that if idealised female shape cannot be met then a perception of failure can be experienced (Monro and Huon 2005). The emphasis on physical appearance and subsequent dissatisfaction with body image can lead to changes in eating behaviours, resulting in recurrent weight loss attempts and weight cycling (Montani et al. 2006).

2.5.2 Weight Cycling

There is growing evidence however, to suggest a restriction in energy intake does not lead to sustained weight loss and the majority of commercial weight loss programmes and retail diet foods are ineffective in the long term and may actually perpetuate weight cycling (Montani et al. 2006). It is becoming apparent that in developed cultures, dieting and weight loss strategies are embraced by most women at some time. There are three perceived dimensions of dieting; current dieting, dieting history and weight suppression. Current dieting status

incorporates attempts at weight loss, weight maintenance or weight suppression and may differ to behaviours expressed during previous dieting attempts, as well as differences in eating behaviours relative to current dieting status. Furthermore, chronic dieting and recurrent failed weight loss attempts can effectively alter eating behaviours in the long term with lower dieting self-efficacy resulting in over-eating and binge eating (French 1996).

Weight suppressors are generally people who have lost a significant amount of weight and have modified eating and physical activity behaviours to the extent that the weight loss has been maintained. It is proposed that long term modification of dietary intake can lead to changes in diet with preferences for low fat and low sugar foods as opposed to regular versions. However, successful weight suppressors are the exception and not the rule and the majority of women who engage in chronic dieting patterns end up regaining lost weight and accruing additional weight after each attempt (French 1996). It has been demonstrated that many of the women with higher reported weights, started weight loss attempts before the age of 14 and have engaged in many more attempts at weight loss over time than women with lower reported weights (Ikeda et al. 2004), this suggests that there is a need for earlier intervention. Weight cycling is also detrimental to physical health in the long term and studies indicate that an accumulation of fat over time increases cardiovascular risk markers in subjects (Graci et al. 2004, Montani et al. 2006).

2.6 EMOTIONAL FACTORS AND ANXIETY ASSOCIATED WITH OBESITY

Other primary factors to overcome in addressing the issue of overweight and obesity are the personal issues and barriers of overweight individuals. Many women can feel isolated as a result of obesity, experiencing negative emotional responses such as depression and anxiety leading to a more disturbed eating and psychological profile (Begin et al. 2012). This is particularly so with women who are on low incomes as observed by (Chang et al. 2008) in the US. Time, convenience, cost and availability are all cited as reasons as to why less healthy food options are preferred (Scholder 2008). A lack of available funds to waste on uneaten food is cited as being the primary driver for the purchase of high density foods with low nutritional quality (Aggarwal et al. 2011).

2.6.1 Anxiety in the pregnant women

The stigma associated with obesity adds to the anxiety and stress that overweight and obese women experience as a consequence of feeling side-lined by society which continues into pregnancy exacerbating negative emotions (Furber and McGowan 2011) about body image, which can be reinforced by some health professionals (Fox and Yamaguchi 1997).

These negative feelings experienced by obese pregnant women are reinforced in a study by (Furber and McGowan 2011) in which a cohort of 19 obese women were interviewed in the third trimester of pregnancy and between 3 to 6 weeks after delivery. Questions related to their experiences whilst pregnant, highlighted feelings of humiliation and stigmatism. Most women felt differently about their weight once pregnant, some felt more positive as they perceived

their weight was more socially acceptable because of the pregnancy, whereas some women felt very negatively, describing how the constant scrutiny and awareness of their weight by the health care professionals compounded their humiliation. Two emerging sub-themes, reiterated by the women in the post - delivery interviews were; the humiliation of being pregnant when obese and the medicalisation of obesity during pregnancy.

2.7 OBESITY IN PREGNANCY

Epidemiological, observational and animal studies provide evidence that pre-gravid BMI and gestational weight gain (GWG) are implicated in the later development of metabolic diseases such as obesity, T2DM, CVD and hypertension in the offspring (Guelinckx et al. 2008, Kerrigan and Kingdon 2010, Sebire et al. 2001).

The associations with obesity and non-communicable diseases such as T2DM, CVD and some forms of cancer are well documented, but it is the current food environment in westernised society that is having a profound effect on obesity levels. The availability, cheapness, portion size, energy density and palatability of food are all contributory factors to an increase in energy intake. These factors, coupled with a reduction in physical activity levels are instrumental in determining the upsurge in obesity rates in the human population (Vartanian et al. 2008, Wansink 2004).

Overweight and obesity is a reflection of dietary intake and physical activity levels and in physiological terms is because of over nutrition and a positive energy balance. Weight gained prior to conception as well as GWG can both have detrimental effects on pregnancy outcomes. Emerging evidence suggests

women with a normal, healthy BMI in the pre-conceptual period are more likely to gain the most weight during pregnancy and retain it post-partum (Scholl and Hediger 1995). Moreover, a number of studies suggest that GWG is positively associated with pre-gravid BMI. There are, however, associated risks with both pre-conceptual obesity and gestational weight gain in terms of macrosomic and large for gestational age (LGA) birth weight infants (Laraia et al. 2007, Mamun et al. 2011, Mazumder et al. 2011).

Maternal obesity is a determinant of shoulder dystocia and an increased risk of emergency caesarean section (Arrowsmith et al. 2011). It is implicated in childhood overweight and obesity which is more likely to track into adulthood with an increased risk of T2DM (Drake and Reynolds 2010) and lead to a 'vicious circle across the generations' where LGA babies mature and go on to produce further LGA babies. A Swedish study by (Cnattingius et al. 2011) looked at the association between mothers birth weight, BMI during pregnancy and subsequent offspring birth weight. The study determined that rates of LGA babies were higher in LGA mothers across all BMI groups, but in women who had a BMI ≥35kg/m^2, rates of LGA babies were 18.3% compared to 5.7% in LGA mothers who had a BMI ≤24kg/m^2. In addition to the current obesogenic environment and the availability and relative cheapness of food which, significantly contribute to maternal BMI and birth weight, it is postulated that reduced breastfeeding rates that are prevalent in obese women of lower SES are a causal factor to the increased obesity risk in the offspring and this may be *ad infinitum.* Thereby the mothers own fed status in infancy may have determined the current maternal overweight and be predictive of the later obesity in the offspring (Bergmann et al. 2003).

2.7.1 Health issues during pregnancy

Clinicians and the medical profession view pregnancy as an opportune time to effect behaviour change, as pregnancy is a time where the majority of women engage with health care services on a regular basis. A number of psychosocial factors can influence maternal and foetal health and can include one of or a combination of smoking, alcohol abuse, drug abuse, domestic abuse, mental health problems, and a lack of physical activity, poor nutrition and obesity. The Royal College of Midwives (RCM), the Royal College of Obstetricians and Gynaecologists (RCOG) and the National Institute for Clinical Excellence (NICE) have issued guidelines for the care of pregnant women. Midwives are the first point of contact to advise on lifestyle issues and ensure pregnant women receive the best level of care.

There are a number of pathways with which women can engage and these are based on the immediate needs of the woman and/or baby. Women who are deemed not at risk of pregnancy related complications will receive antenatal care via their GP and community midwives, based in local Health Care Centres or Children's Centres. Women who are identified as having increased risks of adverse obstetric outcomes due to the risk factors described; BMI ≥30kg/m^2, existing medical conditions or having had a previous compromised pregnancy will receive additional care via a consultant led antenatal clinic (Kerrigan and Kingdon 2010, NICE 2010). Once admitted onto the antenatal care pathway the first point of contact for most women is the midwife. She is ideally placed to offer advice to pregnant women on all aspects of lifestyle that will ensure optimal outcomes for mother and child. However, due to the volume of

information that midwives have to impart at the initial appointment, certain aspects can be overlooked or not given the attention that is required.

2.7.2 Health Care Professionals

It is important that pregnant women with a BMI ≥30kg/^{2} are given the appropriate information and advice to ensure optimum pregnancy and birth outcomes. However, it is apparent that the advice and support this group of women receive is confusing and inconsistent, leaving them to feel less than satisfied with the care received (Heslehurst et al. 2011).

Health care professionals are required to inform patients of any risks to themselves or their baby if a BMI ≥30kg/m^2 is confirmed at the antenatal booking in appointment (NICE 2010), usually between 10 -14 weeks gestation. However, a study by Heslehurst et al (2011) found this information can cause feelings of distress and anxiety to the women, particularly when undergoing routine screening procedures such as ultrasound scanning. Difficulties in visualising the foetus by the sonographer due to high body mass can result in ambiguities in the estimation of foetal size (Heslehurst 2011). Moreover, inappropriate documentation of findings in the maternal notes retained by the patient can lead to distress (Furber and McGowan 2011). Decisions regarding mode of delivery can occur, based on the results of ultrasound scans with caesarean sections being elected when large babies are predicted. The study reported that feelings of bias still exist towards obese people from all areas of the health care profession including some from professionals who specialise in maternal obesity. Thus, a meta-synthesis by Smith & Lavender (2011) sought to develop an understanding of the antenatal experiences of women classified as obese (BMI ≥30kg/m^2). Six papers were synthesised including the paper by

Furber and McGowan, highlighted above, and an interpretive approach was taken. Eight initial themes were summarised into three cluster themes relating to: the acceptance and inevitability of GWG; the depersonalisation of care as a result of medicalisation and the benefits of a healthy lifestyle for the mother and baby. The core concept generated is the perception of women that obesity in pregnancy is more acceptable and thus healthier lifestyles are more likely to be adopted in the postnatal period. The paper also commented on the expectations regarding the care the women expect to receive during pregnancy. These tended to be mediated by the negative emotions the women had of their own weight issues and resulted in negative feelings towards HCP, which they felt lacked a personalised approach. It concluded that the findings are important for policy as the design and implementation of care pathways for pregnant women with a BMI ≥30kg/^{2} need to ensure the intervention is suitable and acceptable to the pregnant women (Smith and Lavender 2011). This paper agrees that there is a clear need for more focussed training for health professionals to ensure that appropriate advice and information is conveyed. The authors accept that women are more likely to delay implementing healthy lifestyle changes, advised upon in the antenatal period, until the post natal period rather than adopt healthier approaches immediately. Additionally, there is no reference to the differences between BMI classifications, suggesting that the experiences are the same throughout all BMI thresholds. However, there are likely to be considerable differences in the experiences of women with a BMI of 30 – 35kg/m^2 and women with a BMI ≥50kg/m^2. The implementation of care approaches is likely to differ across the BMI classifications in response to

available resource and level of care required. This is a potential area of further research.

2.8 RISKS ASSOCIATED WITH OBESITY

There are increased risks of adverse pregnancy outcomes both maternal and foetal that are well documented. Some of these risks are linked to the changes in metabolic state as a result of obesity (Sebire et al. 2001). A high BMI is strongly related to maternal hyperglycaemia, hyperinsulinism, hypertensive disorders and adiposity. Maternal obesity is also associated with inflammatory markers such as adipocytokines, which may determine foetal size and adiposity (Metzger 2010). Maternal BMI is also positively associated with GDM and pre-eclampsia. The foetus is also put at risk because of maternal obesity. Some of these risks are highlighted in table 2-1.

Table 2-1: Potential risk factors to mother and infant

MATERNAL RISKS	*FOETAL RISKS*
Gestational diabetes	Macrosomia
Type 2 diabetes	Genetic malformation
Hypertensive disorders and pre-eclampsia	Neural tube defects
Increased risk of caesarean section and other emergency interventions during labour	Stillbirth, neonatal death or late foetal death
Pre-term birth (PTB)	Shoulder dystocia
Thrombo-embolism	Intrauterine growth restriction

(Sebire et al. 2001),(Brockelsby and Dresner 2006, Fraser 2006)

2.8.1 Complications in labour

There are also primary and secondary outcomes that relate to labour and birth which are highlighted in table 2- 2.

Table 2-2: Primary negative composite outcomes related to maternal obesity

Stillbirth	Shoulder dystocia
Termination or spontaneous abortion	3rd or 4th degree tear
Gestational hypertension	Ante-partum haemorrhage
Pre-eclampsia	Post-partum haemorrhage
Labour augmention	Birth before 37 weeks
Augmentation of labour (non-induction use of oxytocin)	Birth weight >90th centile (macrosomia)
Caesarean section	Birth weight <10th centil (IUGR)
Operative vaginal delivery	Maternal hospital stay over 3 days
	Baby admitted to SCBU

Complications that may arise during labour include potentially life threatening maternal conditions such as; thrombosis, haemorrhage and eclampsia, and stillbirth and neonatal death (CEMACH 2007). Other complications that may arise include failure to progress and arrested labour as well as foetal trauma, resulting in low APGAR scores, macrosomia and shoulder dystocia (Arrowsmith et al. 2011). It has been proposed that some birth traumas linked to progression failure in the first stage of labour are due to poor uterine contractility. A study by (Zhang et al. 2007) looked to determine the underlying mechanisms associated with obesity and the increased rate of emergency caesarean sections due to

obstructed labour. The study determined a positive association between raised

BMI and hypercholesterolaemia. Cholesterol is an essential component of cell

membranes and is implicated in the regulation of smooth muscle contractility of

uterine tissue. *In vitro* testing of myometrial tissue samples from 73 obese

subjects (who underwent elective caesarean sections) investigated the

amplitude and frequency of the spontaneous contractions of smooth muscle

induced under controlled conditions. Results suggested an inverse relationship

between obesity and myometrial contractility. The mechanism could be due to

high cholesterol, LDL and VLDL levels in obese women resulting in a reduction

in the fluidity of cell membranes, affecting the translocation of Ca++ from

extracellular space to the cytoplasm during the contract/relax cycle of smooth

muscle cells.

2.9 NICE GUIDELINES AND PRACTICE RE WEIGHT RECOMMENDATIONS AND MANAGEMENT

Pre-pregnancy BMI and GWG pose potential risks for post-partum weight

retention, large for gestational age babies and childhood obesity for the

offspring. It is also considered the primary predictor for adverse pregnancy

outcome. NICE guidelines recommend that women should achieve a healthy

weight prior to conception to reduce the risk for GDM, hypertensive disorders

including pre-eclampsia, emergency intervention in the intra-partum period and

other risk factors associated with being overweight or obese during pregnancy.

NICE reports that 1 in every 1000 women who give birth in the UK have

extreme obesity (BMI $\geq 50 kg/m^2$). In the Liverpool area 1.6% of women who give

birth had a BMI $\geq 40 kg/m^2$ (Abayomi et al 2007) but no evidence based

guidelines for recommended weight gain ranges exist here in the UK. The US Institute of Medicine (IOM) is often frequently used as a guide and a revised report was issued in May 2009 re-examining weight gain guidelines first published in 1990. Recommendations for obese pregnant women with a BMI ≥30kg/m^2 are to gain between 11-20lbs (5-9kgs). This guideline is more flexible than the previous weight gain recommendation of 6.8kg but there is no distinction made for classes of BMI over 30kg/m^2.

There is evidence to suggest that it is women who are classified as overweight (BMI 25 -29.9kg/m^2), who are more susceptible to weight gain during pregnancy and women who are in the morbidly obese category (BMI ≥35kg/m^2), gain less weight overall throughout the duration of pregnancy (Olafsdottir et al. 2006). O'Toole et al (2003) reported that data gathered in the US from a National Maternal and Infant Health Survey described the amount of weight gained in pregnancy as a predictor for post-partum weight retention (O'Toole et al. 2003). This in turn can lead to further weight gain in subsequent pregnancies and long term weight retention. During a 15 year follow up of 563 women who participated in The Stockholm Pregnancy and Women's Nutrition (SPAWN) study, it was found that women who gained the most weight (>15.6kg) retained more weight at 1 year and 15 years post-partum (Shaikh et al. 2010). Interventions to reduce weight are either targeted at post-partum women (Kuhlmann et al. 2008), whereas interventions during pregnancy are generally confined to limiting the amount of weight gain (Lindholm et al. 2010, Oteng-Ntim et al. 2012) or to treat pregnancy related conditions such as GDM (Artal et al. 2007, Crowther 2005).

Table 2-3: Summary of lifestyle interventions for obese pregnant women

Author (year)	Study design	Sample size	Arms to study	Intervention	Outcome measures	Conclusion
Claessen et al (2007)	Case-controlled study	n=348	193 non-intervention 155 intervention	Dietary and weight counselling Exercise groups	GWG, GDM, CS, BW, PPWR	Nothing of statistical significance
Guelinckx et al (2008)	RCT	n=195	65 control 65 passive 65 intervention	Standard care. Written advice on nutrition & PA. Group sessions with dietitian providing active dietary & PA advice.	Dietary habits, GWG, GDM, CS, BW	Improved dietary habits but nothing else of statistical significance
Kinnunen et al (2007)	Controlled trial	n=196	95 non-intervention 101 intervention	Individual counselling at antenatal appointments Dietary guidance and optional PA sessions	Dietary changes, GWG, BW	Reduction in GL but nothing else of statistical significance
Mottola et al (2010)	Single arm Intervention study	n=65	65 matched 260 non-parallel control	Individual nutrition plan, walking programme 3-4 times/week using pedometers	GWG, CS, BW, PPWR	Reduction in GWG but nothing else of statistical significance
Ong et al (2009)	RCT	n=12	6 control 6 intervention	Supervised 10 week home based exercise programme	Aerobic fitness GDM	Nothing of statistical significance
Quinliven et al (2011)	RCT	n=132	65 non-intervention 65 intervention	Attendance at research clinic, weight recorded, brief dietary intervention, psychological assessment and intervention if indicated	GWG, GDM, BW	Statistically significant reduction in GWG and prevalence of GWG but nothing else of statistical significance
Thornton et al (2009)	RCT	n=257	116 control 116 intervention 25 lost	Nutritional regime for GDM (food diary notebooks completed and collected but no analysis reported)	GWG, GDM, CS, pregnancy outcome	Statistically significant reduction in GWG but nothing else of statistical significance
Wolfe et al (2008)	RCT	n=50	23 control 27 intervention	Intensive intervention with dietitian 10 x 1hr visits with dietary guidance	GWG, GDM, CS, BW	Statistically significant reduction in GWG but nothing else of statistical significance

2.10 REVIEW OF WEIGHT MANAGEMENT INTERVENTIONS

A number of reasons exist why women in the UK may lose weight during the gestational period include; hyperemesis gravidarum, intentional energy restriction and loss of appetite due to other factors. However, observational studies, particularly that of the Dutch famine study, related weight loss as a result of severe energy restriction to negative pregnancy outcomes (Roseboom et al. 2006). A recent review by Furber et al (2013) has concluded that no interventions past or present have been designed specifically for the purpose of gestational weight loss and as such the recommendation that women should refrain from losing weight during pregnancy still stands. However, some women have lost weight during pregnancy with favourable outcomes with respect to pre-eclampsia and delivery complications, although, small for gestational age (SGA) birth weights are still a cause for concern (Blomsberg et al 2011). The majority of interventions conducted, both in the USA and Europe, over the last 5 years have included randomised controlled trials (RCT), observational studies, cohort and case control studies and have been designed to limit weight gain during pregnancy. They have looked at various aspects of lifestyle including dietary intake, physical activity, a combination of both and complete lifestyle interventions that also incorporate a psychological/counselling component with the intention of reducing obstetric complications. Pregnancy is now viewed as a key time for changes in lifestyle and dietary behaviour to reduce adverse pregnancy outcomes and the predisposition of offspring to later obesity and related morbidities. The many factors that are implicated in the short term health of the mother and the long term health risk to the offspring i.e. pre-gravid BMI, weight change during pregnancy, post-partum weight retention, maternal

nutrition and infant birth weight, which need to be considered during the intervention design process.

Intervention studies to limit GWG can be divided into 2 categories; firstly there are feasibility studies focussing on lifestyle interventions. These are aimed at limiting GWG but lack any evaluation of the intervention components against outcome variables but rather discuss the impact of the intervention design. The second type evaluates the intervention components such as dietary intake and physical activity against pregnancy outcome variables such as GWG and birth weight to determine if there is any association.

Studies date from as far back as 2002 up to 2014 and include RCT's, feasibility studies and pilot studies. The studies differ greatly in the aims, the research design and the target population. A RCT by Polley et al (2002), a community based exercise and dietary intervention by Hui et al (2004) and a prospective cohort study by Olsen et al (2004), all recruited pregnant women of normal weight. Interventions included educational programmes relating to physical activity and healthy eating during pregnancy. In the study by Hui et al (2004), a Food Choice Map (FCM) interview was used to assess dietary intakes but in most cases not all aspects of dietary intakes were formally assessed or statistically tested against outcome variables. There were no statistically significant findings in these studies but all indicated that lifestyle intervention could potentially be beneficial in reducing excessive weight gain during pregnancy and improving pregnancy outcomes in women defined as being normal weight (Hui et al. 2006, Olson et al. 2004, Polley et al. 2002).

A study by (Bergmann et al. 1997) was conducted to investigate the relationship between BMI, net weight gain and energy intake during pregnancy. The results after analysis of nutritional and anthropometrical data suggested differences across the BMI groups as to net weight gain and energy intake. Women in the higher BMI groups showed lower energy intakes. Under-reporting of energy intakes were suspected but the lower net weight gain of this group supported the findings. Birth outcomes were not reported in this study. There is some suggestion that optimum birth outcomes were achieved in a Swedish population based cohort study by (Blomberg 2011) in which women in the morbidly obese range BMI ≥40kg/m^2 who lost weight throughout pregnancy reduced the risk of caesarean section by 24% and large for gestational age births by 11.2 %. This was in comparison with women in the same BMI class who gained within IOM recommendations for weight gain during pregnancy. There was no significant increased risk for pre-eclampsia, excessive bleeding during delivery, instrumental delivery, foetal distress or low APGAR scores associated with the weight loss group. There was a 3.7% increased risk of a small for gestational age baby compared to no increased risk in the weight gain group. However this is only slightly above the normally observed incidences of small for gestational age babies born in Sweden.

An evaluation of a pilot study by Lindolm et al (2010) in Sweden to restrict weight gain to the IOM recommendation of ≤6kg recorded the pregnancy outcomes of 25 women (92%) with a BMI ≥30kg/m^2 who participated. The study found that 88% of the women had uncomplicated vaginal births and all delivered babies within the optimal weight range, with all the babies recording normal APGAR scores. It was also found that weight gain was significantly less in those

women with a BMI ≥35kg/m^2 at study entry (Lindholm et al. 2010). Other interventions to limit weight gain in obese pregnant women reported positive birth outcomes when weight gain was limited to less than 7kg and found that a restricted weight gain was safe for both mother and baby (Claesson et al. 2009).

An exercise only intervention by Ong et al (2009) set out to investigate the effectiveness of a supervised 10 week home based exercise programme on glucose tolerance. The study recruited 12 women with a BMI ≥35kg/m^2 who were randomised to intervention group (n6) and control group (n6) following a pre-intervention Aerobic Power Index test and Oral Glucose Tolerance Test. The intervention consisted of 3 x stationary cycling per week for 10 weeks with increasing intensity and duration. The study found increased aerobic fitness with improved glucose tolerance in the intervention group with no adverse effects reported compared with a decreased glucose tolerance in the control group. It was suggested that previously sedentary obese women could safely take up structured exercise during pregnancy in addition to attenuating the decline in glucose tolerance in women at risk of developing GDM. However, due to the very small sample size it is impossible to generalise this to the wider population (Ong et al. 2009).

What these studies illustrate is that limiting GWG and exercising during pregnancy may have implications for the prevention of T2DM, metabolic syndrome and obesity in the offspring in later life. Further studies in support of this hypothesis include a study by Mottola et al (2009), which set out to determine the effects of a nutrition and exercise lifestyle intervention programme (NELIP) on GWG, birth weight and weight retention in overweight

(BMI 25-29.9kg/m^2) and obese (BMI ≥30kg/m^2). The treatment consisted of individualised nutrition developed from participant baseline 3 day food intake assessments but adapted from a nutrition therapy for women diagnosed with GDM. Additionally, the exercise consisted of a walking program on 3 – 4 days of the week. Pedometers were used to count steps taken. Compliance with the nutritional element was evaluated using a weekly 1-day food record form. However, dietary intake data was not assessed against pregnancy outcome data. Study findings indicated a reduction in the risk for GWG and postpartum weight retention but there was nothing of statistical significance (Mottola et al. 2010).

A Danish study by (Wolff et al. 2008) recruited 50 women with a BMI ≥35kg/m^2 to determine the effects of dietary counselling on gestational weight gain and glucose metabolism. The study found that those women randomised to the intervention group, receiving 10 x one hour consultations with a dietitian during pregnancy, limited weight gain to ≤6.6kg had significantly reduced levels of pregnancy induced insulin, leptin and glucose. Alterations in the metabolic control of blood glucose mediated by elevated levels of insulin and leptin are thought to be important predictors of obstetric complications. However, in this study the women were supplied with supplements throughout and therefore, only macronutrient composition and the effects of a limited total energy intake on GWG were measured, as opposed to the overall nutritional adequacy.

A further intervention that was designed to limit GWG and reduce the risk for GDM, was conducted by Quinliven et al (2011). In this study, a four step multidisciplinary protocol developed to reduce the risk for GDM was evaluated. The protocol was developed for use in the antenatal care of overweight and

obese pregnant women. The study recruited 132 women who were either randomised to treatment (n63) or standard care (n61). The four step protocol consisted of: continuity of obstetric provider, a routine weighing at each antenatal visit, a 5 minute consultation with a food technologist before each visit and a clinical psychology assessment to determine levels of depression or anxiety. The study reported significant reductions in the incidence of GDM in the intervention group over the control group (6% vs. 29% p = 0.04) and GWG (7kg vs. 13.8kg p < 0.0001) with no significant difference in birth weight (p > 0.05) (Quinlivan et al. 2011). However, the 5 minutes the food technologist had would be insufficient time in which to ascertain the previous day's food intake, give information regarding food labelling, shopping within a budget, as well as providing healthy eating recipes suitable for pregnancy. Therefore, the previous days dietary intakes recorded by the food technologist were unlikely to be anywhere detailed enough to be assessed against outcomes.

2.11 CURRENT STUDIES IN PROGRESS

Up to 2005, it has been shown by Heslehurst (2007) that maternity service provision and the care requirements of obese pregnant women have been mismatched (Heslehurst et al. 2007b). There remains an absence of official guidelines in respect of recommended weight gain and care pathways for the management of obese pregnant women. There were inadequate links between maternity, dietetic and physiotherapy services that would effectively make up the multidisciplinary team necessary for the safe management of obese women with co-morbidities. Since then NICE have incorporated clinical guidance and

recommended that these women are considered to be among high risk groups that qualify for additional screening, monitoring and intervention. However, there is still no international agreement on evidence based weight gain amounts or weight management intervention. In response to this there are a number of lifestyle interventions that have been designed to address these issues. The UK Clinical Research Network Study Portfolio database search has listed a number of unpublished feasibility/intervention studies currently in progress. The studies mainly take a holistic approach and are looking at aspects of lifestyle pertaining to physical activity levels, dietary intake and including a psychological well-being element to the programme in some cases. Known studies in progress include:

The Community Lifestyle Programme (Lavender, T), run over a 10 week period, is a feasibility study underpinned by Social Learning Theory and following on from that:

A pilot randomised control trial of The Lifestyle Course (TLC) (Lavender, T.) - multi-centre, Manchester, Bolton and Oldham. The study will use behavioural change techniques to equip women (BMI ≥30kg/^{m}) with the necessary skills and knowledge to incorporate healthy behaviours into their lifestyle. Health care professionals engaged with the study include health psychologists, midwives, physical activity instructors and food and nutrition community workers. The intervention consists of a 10 week course facilitated by the aforementioned and covering different topics and activities each week.

Current progress: The feasibility phase of the project has been completed and published. Acceptability of the data collection tools were variable, with a low response rate for the 'lifestyle' diaries (32%) and pedometers (16%). There was

a much higher response rate for the food diaries, introduced at a later stage of the feasibility study to replace the lifestyle diaries, and completed by the women firstly at recruitment and again towards the end of pregnancy (80-81%). Overall findings suggest that the design of the study is suitable for the needs of pregnant women with a BMI ≥30kg/m^2 with good acceptability and attendance rates. The analysis and results of outcome measures are yet to be published. There is indication that the lifestyle diaries will be analysed using content analysis, however, the manner of analysis is not specified for the food diaries, introduced in place of lifestyle diaries, or what outcome measures relating to dietary intake will be investigated (Smith et al. 2015).

HELP! [Healthy eating and lifestyles in pregnancy trial] (Simpson,S.) – Multi-centre, Cardiff. This study is a cluster randomised trial to evaluate the effectiveness of a weight management intervention in pregnancy, on weight at 12 months following birth, gestational weight gain and pregnancy and birth outcomes. Women with a BMI ≥30kg/m^2 were invited to attend weekly weight management groups facilitated by midwives and a Slimming World consultant, where advice on lifestyle, diet, general pregnancy advice and goal setting would be provided.

Current progress: The feasibility phase of the study is now complete and findings suggest acceptance of the intervention by those who participated. Out of 148 women who participated, 39 women lost weight during pregnancy but delivered babies with a mean birth weight consistent with that of women who did not lose weight. No data regarding dietary intakes were collected during this phase. Therefore, compliance with the healthy eating advice cannot be determined. As such, it is not possible to assess whether weight lost during

pregnancy was as a result of a reduction in total energy following a healthy eating plan or not (Jewell et al. 2014).

UPBEAT! [Pregnancies better eating and activity trial] (Poston, L.) – individualised dietary and physical activity regimes – multi-centre, St Thomas's London. The aim of this study is to develop a complex intervention leading to improved pregnancy outcomes in obese pregnant women. Individualised diet and physical activity regimes will be used to reduce glucose sensitivity in the cohort and reduce the incidences of maternal, foetal and neonatal complications.

Current progress: A pilot RCT in which 183 women were randomised to intervention or standard antenatal care reported reductions in saturated fatty acid (SFA) and glycaemic load (GL) in women the intervention arm. However, physical discomfort was identified as reason as to why physical activity (PA) did not change. The pilot study also identified issues relating to recruitment, group attendance and compliance resulting in modifications in the delivery of the intervention (Poston et al. 2013). The protocol for the larger RCT where a sample size of 1546 women will provide an 80% power to detect a 25% reduction in the incidence of GDM and 30% reduction in incidence of infants large for gestational age has recently been published (Briley et al. 2014).

Preventing excessive weight gain in pregnancy study (Daley, A.) – single centre, Birmingham. The study is aimed at low risk women with a BMI<30kg/m^2, the intention being to prevent excessive weight gain during pregnancy.

2.12 NUTRITION IN PREGNANCY

Changes in eating behaviours can lead to pre-gravid weight gain, which can track into pregnancy potentially compromising pregnancy outcomes and foetal development (Melzer and Schutz 2010). Therefore, it is important that the maternal diet is of sufficient quality to meet nutritional requirements for optimum foetal growth and development. This may in turn reduce a predisposition to later adiposity and associated diseases (Blincoe 2008). Moreover, as evidence suggests that alterations in metabolic function, as a result of epigenetic factors, increases the possibility that obesity is transmissible between the generations (Godfrey et al. 2011, Hanson et al. 2011), then it is reasonable to assert that quality of dietary intake, and not just total energy intake, influences predisposition to obesity.

Both UK NICE (2010) and US IOM (2009) guidelines recommend that overweight/obese women should normalise weight prior to conception to reduce risk. However, approximately 50% of pregnancies in the UK are unplanned (DH, 2000) and women may not have had the time or the opportunity to reduce weight prior to conception, resulting in a growing number of women conceiving with a BMI ≥30kg/m^2. Even in planned pregnancies, where women may have a prior knowledge of the risks associated with obesity, women who are already overweight or obese may find it difficult to reduce weight prior to conception as a result of barriers to weight loss or weight cycling (Mottola et al. 2009). This has led to an increased need to minimise risk during gestation. There have been a number of studies and interventions developed over the last few years designed to reduce the obstetric risks and subsequent increased costs associated with being obese during pregnancy (see table 2-3). Many of these

current interventions are designed to limit the amount of weight gained during pregnancy and so far outcomes have been varied. The studies tend to focus predominantly on weight and the risks associated with overweight and obesity rather than on health or quality of diet.

2.13 MATERNAL OBESITY LINKED TO NUTRITION

Weight gain in pregnancy is directly related to birth outcomes and it has been shown by De Jersey et al (2011) that those women who do not receive advice as to the optimal amount of weight to gain, tend to gain more than is recommended (De Jersey et al. 2011). It has been demonstrated that an optimal weight gain is associated with a positive pregnancy outcome, but that excessive weight gain is associated with the gestational complications, described previously by (Olafsdottir et al. 2006). A review by Sen et al (2012) looking at experimental evidence on the impact of maternal obesity on long term risks for obesity in offspring, suggests that non-genetic factors may also be implicated in the transmission of obesity from one generation to the next.

Nutritional intake is an important determinant of optimal pregnancy outcomes in terms of maternal and child health. However, maternal nutrition is very complex and is affected by many factors such as socio-economic, psychosocial factors and nutritional knowledge as well as biological factors (Abu-Saad and Fraser 2010). De Jersey et al (2011) asserts that there is a deficit of studies relating weight gain to nutritional intakes in the pregnant population.

Obesity and GWG have a significant impact on maternal metabolism, as glycaemic control, lipid oxidation and amino acid synthesis are affected by insulin resistance, which increases normal postprandial plasma concentrations

of glucose, lipid and amino acids (King 2006). Furthermore, it has been found that maternal eating behaviours promotes over-eating and the resultant weight gain is associated with increased levels of umbilical leptin, with an elevated risk of T2DM for the offspring in adulthood (Sen et al. 2012). An overview of the mechanisms involved in trans-generational obesity is illustrated in figure 2-2. It is postulated that variations in the hypothalamic regulation of energy homeostasis in response to genetic and/or environmental stimuli has resulted in a change in leptin sensitivity which may have contributed to the obesity epidemic (Breton 2013).
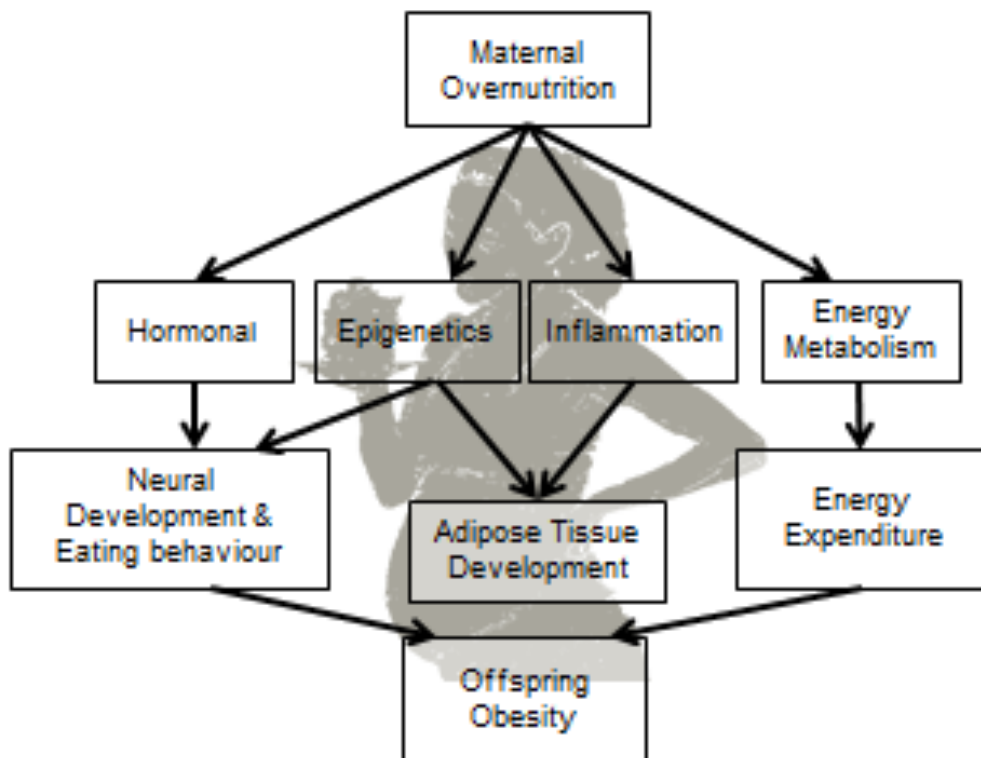
Figure 2-2: Mechanisms postulated to be involved in trans-generational obesity (reprinted from Sen et al **2012 with permission from Elsevier)**

Although leptin levels are commensurate with adiposity in obese people, indications are that there may be a malfunction in the leptin signalling pathway

resulting in a state of leptin resistance, even though leptin production is normal (Morrison and Berthoud 2007). Plasma leptin levels can increase 2-fold during pregnancy in comparison to the non-gravid state and is thought to be as a result of placental contributions as opposed to maternal adipose tissue. As such there appears to be growing evidence that the role of leptin during pregnancy is more than the hypothalamic regulation of appetite suppression. Alterations in foetal growth can occur due to the deregulation that is experienced in some pregnancies (Hauguel-de Mouzon et al. 2006). There is an indication that very little maternal leptin crosses the placenta due to the lack of association between maternal leptin concentrations and birth weight. However, umbilical leptin levels are correlated with foetal fat mass and ponderal index in neonates and that foetal leptin levels are a marker of foetal adiposity in the same way that it is a marker of obesity throughout life (Hauguel-de Mouzon et al. 2006).

2.13.1 Predictive Adaptive response & Foetal Origins of Adult disease

Leptin resistance is not irreversible and may be a normal seasonal response to a plentiful food supply enabling energy storage for periods of food shortages as has been observed in hibernating animals (Morrison and Berthoud, 2007). The metabolic and hormonal response to nutritional intake is very complex and evolved in early hunter-gatherers to maximise energy input when food was more available and minimise energy output that is minimal physical exertion. Thus, humans evolved to biologically adapt to food shortages and hunger but not to a continued abundance of food and over consumption, which in the developed world is unexceptional (Heitmann et al., 2012).

Pregnancy is a complex period of physiological change and maternal nutrition prior to and during this time is an important determinant of foetal growth and

development. Weight loss during pregnancy is not recommended as it is linked with increased rates of prematurity and stillbirth, intrauterine growth restriction (IUGR) (NICE 2010) and behavioural and /or mental health disorders have all been observed in women who have lost weight as a result of starvation either due to famine or hyperemesis gravidarum (HG) [excessive vomiting during pregnancy] (Fejzo et al. 2009). The Dutch national health care program during the Second World War provided longitudinal data from the famine region that could be compared with data from non-famine areas. There were differences in the pregnancy outcomes' depending on when the famine was experienced and relative to how advanced the pregnancy was. Increased rates of prematurity, stillbirths and central nervous system (CNS) abnormalities, such as neural tube defects (NTD), were observed if, during the first half of the pregnancy, energy intake was restricted to between 600 to 1500 kcals per day. Energy restriction experienced during the latter half of the pregnancy resulted in a lower recorded birth weight with no increase in stillbirth rates or prematurity (Johnson and Yancey 1996). Similarly, women who suffered severe weight loss as a result of HG experienced comparable outcomes (Fejzo et al 2009). However, in both these examples there was a severe and continued reduction in all nutrients, not just total energy intake. Furthermore, pre-pregnancy BMI was not considered, as such, it was not established whether any of these women were overweight or obese prior to conception. Foetal growth *in utero* requires a continuous supply of nutrients and it is postulated that the foetus may be exposed to insufficient or excessive amounts if the regulation is altered (Hauguel-de Mouzon et al. 2006). Epidemiological observations based on the Dutch famine and work carried out by David Barker in the 1980's and 90's have led to the hypothesis that birth

weight is linked to later adult disease (D. J. P. Barker 2007, Michels 2003) as a result of predictive adaptive responses (PAR). It is proposed that PAR's may provide a selective advantage, as one genotype can produce different phenotypes in response to environmental stimuli or insults. In most cases the appropriate phenotype is produced and the growing foetus is later matched into a postnatal environment conducive to its programmed phenotype. However, the postnatal environment may not always be advantageous to phenotype. Gluckman et al (2007) described PAR's as a type of developmental plasticity whereby the foetal development trajectory is compromised in response to an adverse intrauterine environment and there is an adaptation in gene expression altering phenotypical characteristics (Gluckman et al. 2005), which, when later mismatched into an obesogenic environment, increases susceptibility to obesity and obesity related diseases (Hanson et al. 2011). The development of the foetus and some of its organs can be compromised as energy and essential nutrients are conserved for cardiac function and neural development, (Gluckman et al. 2005). However, there is also evidence that foetal over-nutrition can result in the pre-programming of metabolic syndrome and obesity in late life, suggesting that the mechanisms are similar. This occurrence can be represented by a U-shaped curve, which shows an increased prevalence of later obesity in individuals who were of either a low or a high birth weight. This prevalence of later overweight and obesity has been linked to babies born to mothers with GDM, impaired glucose tolerance and type 2 diabetes (Vickers et al. 2007).

2.14 MACRONUTRIENTS - CONTRIBUTION TO TOTAL ENERGY

As previously described in section 2-3, the westernised diet has changed considerably over time. It is difficult to determine the optimum energy requirements but since the doubly-labelled water (DLW) method was introduced in the 1980's, it became possible to base energy requirements on total energy expenditure (TEE), measured by DLW (Rennie et al. 2007). This takes into account BMR, physical activity levels, thermogenesis and the energy cost attributed to synthesising new tissue (COMA 1991a). This method has since been improved upon and energy requirements have been updated. A factorial approach has been adopted where TEE is expressed as a multiple of basal metabolic rate (BMR) and physical activity level (PAL), thus TEE is equal to BMR x PAL (SACN, 2011).

Macronutrients contribute to total energy and consist of fat, carbohydrate and protein. The suggested proportion of macronutrients to energy contribution (not including alcohol) is in the ratio of 50% CHO, 35% total fat and the remaining 15% is made up of protein. Dietary fats can be further classified into saturated fatty acids (SFA), *cis*-monounsaturated fatty acids (MUFA), *cis*-polyunsaturated fatty acids (PUFA) and *trans* fatty acids. Dietary reference values (DRV) for adults as a percentage of total daily energy have been established. SFA's should account for no more that 11%, MUFA's 13%, PUFA's 6.5 % (with individual minimum targets of 0.2% ω3 1.0% ω6 fatty acids) and *trans* fatty acids should account for no more than 2%. Fatty acids total 32.5% of total energy, the remaining 2.5% supplied by glycerol. Carbohydrate can also be sub-divided into non-milk extrinsic sugars (NMES) and intrinsic, milk sugars and starch and DRV's are 11% NMES and 39% intrinsic, milk sugars and starch.

Non-starch polysaccharides (NSP) are the measurable fractions of dietary fibre and are the major components of plant cell walls and a DRV of 18-21g per day has been established as the population average (COMA 1991, SACN 2011). The amount of NSP in the diet characterises dietary patterns; a dietary intake high in NSP is reflective of higher intakes of fruit, vegetables and wholegrain cereals, and is likely to be low in fat and animal protein. Whereas dietary intakes low in NSP are suggestive of higher intakes of fat and refined CHO (Northstone et al. 2008). Foods rich in NSP tend to be less energy dense and induce greater postprandial satiety (Zhang et al. 2006). It is integral to normal bowel function as it acts as a substrate during fermentation by anaerobic gut flora and is degraded to short chain fatty acids, carbon dioxide, hydrogen and methane (COMA 1991). It is postulated that the net energy derived from NSP is associated with lower energy derived from the digestibility of fat and protein (COMA 1991). Therefore, dietary patterns characterised by increased intakes of NSP are recommended for the prevention or treatment of obesity. A meta-analysis by (Manuel et al. 2012) suggested that there was insufficient supporting evidence as to the efficacy of high fibre diets as a weight loss treatment, however, there was more evidence to suggest it plays a role in its prevention.

2.14.1 Protein

Following examination of isotopic data from Neanderthal and Upper Palaeolithic skeletons, it has been determined that protein intakes have declined substantially in comparison to intakes from early human diets (Cordain et al 2005). The criteria for protein intakes relate to the rate of growth or weight gain, the achievement of a positive nitrogen balance and the state of well-being

(COMA 1991). Current recommendations suggest a protein intake of 15% of total energy, which in the normally distributed population accounts for approximately 45g for women between 19 -50 years of age (COMA 1991). An increase of 6g/d to 51g/d has been recommended for normal weight pregnant women to meet demands for the conversion of dietary protein to foetal, placental and maternal tissues (Williamson 2006). Calculations were based on a total requirement of 925g for a woman gaining 12.5kg in weight, delivering a 3.3kg infant. However, protein requirements for the obese pregnant population have not been fully elucidated and currently remain the same as the normal population (SACN 2005).

It has been described by Cordain et al (2005) that in non-pregnant obese women, low energy diets high in protein improve insulin sensitivity and protect against lean tissue loss. Higher protein was defined as between 19-35% of total energy at the expense of CHO (22-40%), which has been observed in studies of indigenous hunter-gatherer populations. Furthermore, there is evidence to suggest that diets higher in protein may improve lipid profiles, reducing CVD risk (Wolfe and Piche 1999). This has also been observed in T2DM patients where an improved lipid profile has had a positive effect on glucose and insulin metabolism (Cordain et al 2005). During pregnancy, there is a reduction of approximately 10% in the amount of amino acids available for oxidation with the vast majority being utilised for protein synthesis. There is a higher turnover of protein synthesis, particularly in the 2nd and 3rd trimesters where demand for protein synthesis for foetal development and increased maternal tissue, such as, breast, liver and uterus, is greater. As yet it is unclear what impact obesity has on amino acid metabolism, but it is suggested that the anabolic response to

pregnancy may be impaired in the obese population, potentially limiting foetal growth (Nelson et al 2009). A study by (Blumfield et al. 2012), found that both maternal restriction and protein excess led to gluco-corticoid sensitivity in offspring, increasing the risk for metabolic syndrome via changes in gene expression through epigenetic alterations such as DNA methylation. It was further suggested that the macronutrient profile of pregnant women may influence foetal adiposity and distribution of adipose tissue as foetal abdominal subcutaneous fat was inversely related to %E of protein in the maternal diet (Blumfield et al. 2012).

2.14.2 Essential Fatty Acids

Dietary lipids have multiple functions over and above that as storage energy. They are involved in cell growth, the coordination of inter and intracellular communication and the modulation of gene expression regulating the metabolic environment and assimilation of nutrient substrates. Early diets consisted of high levels of the essential fatty acids (EFA) α-linoleic acid (ω3) and linoleic acid (ω6) that were predominantly derived from plant sources (Macé et al. 2006). These are long chain polyunsaturated fatty acids, both of which serve as precursors to arachadonic acid (AA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) via desaturation and chain elongation processes. These can be further converted to the eicosanoids i.e. prostaglandins, thromboxanes and leukotrienes (Muskiet et al. 2006) Eicosanoids function as signalling molecules and as regulators in the immune system and in particular the inflammatory response. Long chain PUFA's are integral to the brain development of foetus' and newborns and cognitive function, as well as the

metabolic and neuro-endocrine environments (Muskiet et al. 2006). As such they are implicated in the regulation of appetite and energy sensing as well as contributing to the regulation of genes involved in energy storage and oxidation (Innis 2011). Due to its properties and functions, α-linoleic acid (ALA) is not generally stored as adipose tissue, but is degraded to acetyl CoA for the generation of energy and *de-novo* synthesis of fatty acids and cholesterol. Therefore, the quality of maternal dietary fat intakes has a bearing on the quality of the fatty acids stored in the adipose tissue of infants (Innis 2011). The foetus is still dependent upon the quality of maternal intakes of fatty acids transferring across the placenta prior to delivery. Following birth, new-borns adapt to a milk diet where fatty acids provide approximately 50% of energy (Macé et al. 2006) and are now delivered via the intestines in chylomicrons, as opposed to via the umbilical cord into the foetal liver. However, breast milk fatty acid composition is dependent on maternal diet and a study by (Mäkelä et al. 2013b) found the breast milk of obese women to be higher in SFA (46.3 vs. 43.6%, p=.012) and lower in omega 3 (ω3) FA (2.2 vs. 2.7&, p=.010), in comparison to normal weight women. This was reflected in a strong correlation between SFA and offspring weight gain (r=.22, p=.04). It has been shown in animal studies that diets high in SFA and carbohydrates but relatively low in protein with deficiencies in vitamin intakes during gestation and lactation can result in 'reprogramming', affecting offspring cell division and differentiation and increasing the risk of developing the characteristic factors associated with metabolic syndrome (McMillen and Robinson 2005). The main characteristics of which are abdominal obesity, dyslipidaemia, hypertension, insulin resistance and glucose intolerance (Innis 2011). It has also been postulated by Innis

(2011) that it is increasing intakes of ω6 fatty acid linoleic acid with a lower intake proportionally of ω3, including DHA that may be implicated in the onset of metabolic syndrome and adiposity in the offspring, as intakes of SFA and animal derived fats have, in actual fact, declined in developed nations over the last 50 years with the predominance of refined vegetable oils (Innis 2011). Studies in animal models have suggested a link between high levels of LA in the maternal diet during gestation and during lactation in early infancy promotes adiposity and obesity, although causality in human infants has not yet been demonstrated (Macé et al. 2006). However, Mace et al (2006) did describe a study which evaluated the growth and body composition of premature infants, some of whom were fed formula milk supplemented with 0.42% ARA and 0.26% DHA against a control group who were fed non-supplemented formula. Comparisons at 12 months found that infants fed supplemented formula had similar body weight, length and head circumference than those fed non-supplemented but had a significantly improved lean tissue/fat mass ratio.

Levels of EFA's found in formulated infant feeds account for 1% of total energy, in contrast to levels found in human breast milk, which account for approximately 6% of its total energy (COMA 1991).

The current DRV's for EFA's have been derived on the basis of deficiency prevention as there is a paucity of evidence as to optimum intakes. However, it is speculated that intakes higher than those recommended to prevent deficiencies may modulate CVD risk (COMA, 1991).

2.14.3 Carbohydrate

The change in CHO profile has had the most dramatic effect on modern dietary patterns. The average recommended dietary intake of CHO now accounts for

approximately 50% of total energy (COMA, 1991). However, the NDNS found that mean intakes for women were 48.6% of total energy (Nelson et al. 2007). Dietary CHO is comprised of intrinsic sugars, milk sugars, and starch (39% of total energy) and NMES (11% of total energy). The main difference between intrinsic and extrinsic is characterised by how metabolically available they are. Intrinsic sugars are bound within the cellular structure of foods and are not as readily available as an energy source; by contrast extrinsic sugars which include processed sugars and sugars found in honey, are not bound within the cellular structure and are much more readily available (COMA 1991).

The amount of sugars consumed is indicative of dietary quality and data from the Low Income and Nutrition Survey, based on data from the NDNS, found that intakes of NMES were in excess of the DRV's for female adults in the 19-35 year age group and accounted for 15.6% of total energy and 12.6% in the 35-49 year age group. However, there is no specific dietary requirement for sugars in the diet as dietary CHO in the form of starch is sufficient to meet the demand for glucose (Nelson et al. 2007).

2.14.4 Glycaemic index/load

The development of the glycaemic index by Jenkins (1981) established the link between blood glucose levels, insulin concentrations and CHO in foods. The glycaemic index is a number attributed to an equal amount of CHO in a food and its blood glucose raising ability measured against pure glucose, arbitrarily set at 100, as a frame of reference (UK 2015). The glycaemic load was a much later concept (1997) and this was used to rank the CHO content of foods assessing the quantity and quality of CHO in an equal serving (Liu and Willett 2002). This is a more useful application as some foods scored very highly on

the index but low on the glycaemic load when taking the serving size into consideration. There is supportive evidence that a dietary intake that has a low GI/GL significantly reduces the glycaemic and insulinaemic postprandial response (CORDAIN et al 2010). The GI/GL approach has also been proposed as an effective weight loss method but a review by Esfahanni et al. *(*2011), which assessed on 20 studies of which 19 were controlled comparing a low GI diet to either a low fat diet or a high GI diet (controls), found that results were not conclusive. Only four found significant differences in weight loss between the methods, 10 low GI diets had favourable results compared to the controls but there were no statistically significant results. However, the effects of low GI/GL on postprandial glucose and insulin concentrations may prove significant when it comes to maternal diet particularly in the obese population. Insulin resistance is increased by as much as 40 - 50% during pregnancy; this promotes foetal growth by enabling metabolic fuels to pass to the foetus as glucose passes freely between the mother and foetus whereas insulin does not (Yogev & Visser 2009; Makela et al 2013). This metabolic adaptation makes the foetus increase its own insulin. Therefore, if the mother is exposed to higher concentrations of glucose then this applies also to the foetus. This has implications when there are elevated glucose concentrations as a result of excessive dietary intake and GDM may result. Pre-existing obesity and gestational weight gain exacerbate insulin resistance in pregnancy and other symptoms of metabolic syndrome may present, increasing the risks of developing GDM, pre-eclampsia and pre-term delivery (Rhodes et al 2010). Metabolic syndrome is characterised by hypertension, inflammation, dyslipidaemia and hyperglycaemia. These hallmarks are indicators of a future

predisposition to CVD if left untreated. A recent study by Makela et al (2013) reinforced the evidence that hyperglycaemia and adverse pregnancy outcomes including long term risk factors for disease in later life are associated with a lower diet quality and unfavourable lifestyle factors. In pregnancy, there are concerns about the use of drug therapies because of teratogenic effects on the foetus, as such, modifications in dietary intake is the primary treatment method (Mäkelä et al. 2013a). However, Metformin is now commonly used during pregnancy as well as or instead of insulin and the benefit from improved glycaemic control is thought to outweigh any potential risk (NICE 2008b).

2.15 MICRONUTRIENTS – COFACTORS AND COENZYMES

Macronutrients contribute to total energy intakes and are required in large amounts, but the quality of an individual's diet is not just characterised by the ratio of macronutrient intakes but micronutrient intakes as well. Micronutrients are defined as the vitamins and minerals and trace elements that are required in only very small amounts such as milligrams or micrograms per day, but have no calorific value (Bender 1995). The required amounts are variable at population level but for optimal health and the avoidance of deficiencies, dietary reference values (DRV) have been established for most of the nutrients (COMA, 1991).

Dietary reference values have also been established for pregnant women, the amounts recommended however, assume a normal distribution (COMA, 1991) and there is little evidence as to whether the recommended amounts for any nutrient are sufficient for the obese population and/or the obese pregnant

population. Overweight and obese individuals are known to have lower blood concentrations of vitamins and minerals compared to non-overweight/obese people, but it is not known if there is a causal relationship and if so, the direction of causality (Garcia et al. 2009). Despite this, recommendations for a number of micronutrients have been established. In some cases, physiological adaptations during pregnancy enhance absorption of certain minerals such as calcium, iron and iodine (Williamson and Wyness 2013). This reduces the need for incremental increases to meet the demands of an increased tissue mass; however, maternal status is dependent on an adequate supply delivered through either dietary or supplementary means. The use of supplements will be discussed later in section 2.17 of this chapter.

Women are advised to eat a varied diet during pregnancy to ensure optimum intakes of all nutrients and the 'Eatwell Plate' is used as a guide for the recommended ratios of food groups (DH 2009). Modern food manufacturing and secondary processing, however, can strip foods of unstable nutrients, such as the water soluble vitamins B_{12} and C. Therefore, the nearer a food remains to its original state, the more replete of nutrients it is likely to be (Skibsted et al. 2010).

2.15.1 Functions of micronutrients

Micronutrients have multiple functions; they act as 'co-factors' catalysing chemical reactions in living cells and metabolic pathways, they also serve as antioxidants, coenzymes and enzyme activators, constituents of structural or process molecules or precursors of structural or process molecules as well as having electro-chemical activity (Berti et al. 2011). They also have a role in

signal transduction and transcription pathways, biological functions and oxidative stress. However, the biological mechanisms or the level of micronutrient involvement in biological function; is still not completely understood (Berti et al. 2011). There is evidence that some micronutrients have additional function during pregnancy and are required at different times during gestation, influencing offspring metabolism, organ growth, development and function (Blumfield et al. 2013). Folate is a primary example of a nutrient with a specialist function during pregnancy, as it is integral to the closing of the neural tube at approximately 28 days after conception (Williamson 2006). The brain of the offspring undergoes critical periods of development and experiences 'brain growth spurts' during the last trimester of pregnancy and early infancy. This development is vulnerable when there is an inadequate supply of micronutrients that are integral to brain function such as iron (McCann and Ames 2007) and iodine which is essential for cognitive function (Skeaff 2012).

2.16 VITAMINS

Vitamins are classified as either fat soluble or water soluble and have differing properties and functions. The water soluble vitamins are the B complex which includes folate (B_9) and vitamin C. They are easily destroyed by high temperatures and oxidise rapidly when exposed to the atmosphere (Lean 2006a). They cannot be stored by the body in any appreciable amounts and must therefore be replenished on a daily basis. The fat soluble vitamins are A, D, E and K and conversely can be stored by the body in the adipose tissue or in the lipid component of the cells (Barasi 2003). Fat soluble vitamins can

accumulate in adipose tissue and the liver and can be harmful if consumed in too large amounts. Under normal circumstances it is unlikely that levels leading to toxicity would be achieved via dietary sources alone (Bandini and Flynn 2003). However, there is a recommendation for women to avoid liver and liver derivatives during pregnancy due to the high concentrations of vitamin A (between $13,000\mu g$ and $40,000\mu g/100g$ depending on the species of animal) and supplements containing retinol (Vitamin A). This is because retinol, one form of vitamin A, is teratogenic and high intakes greater than $3,300\mu g/d$ during pregnancy have been associated with birth defects in infants (COMA 1991). Conversely, it is suboptimal intakes of micronutrients that are of greater concern, particularly in the obese pregnant population, because they are more associated with adverse pregnancy outcomes (Berti et al. 2011).

2.16.1 The evidence

An advanced online publication presented a prospective case-control study by (Sen et al. 2013). Maternal blood was measured for vitamins A, B_6, C, E, the serum measurement of vitamin D, $[25 (OH)D_3]$ folate and zinc, as well as inflammatory markers, CRP, IL-6 and TNF-α and also oxidised and reduced glutathione. The measurements were taken between 24 and 28 weeks gestation in 15 obese pregnant women (BMI $\geq 30kg/m^2$) and 15 normal weight women (BMI $18\text{-}25kg/m^2$) and also from the cord blood at delivery. The study found that the obese pregnant women had statistically significantly lower levels of vitamins B_6, C, E and folate, but a higher ratio of oxidised to reduced glutathione and higher levels of CRP and TNF-α compared to normal weight women. Although there were no differences in micronutrient concentrations in the infants born to either obese mothers or normal weight mothers, there were

strong correlations for folate, B_6 and zinc between mothers and infants. The study concluded that obese pregnant women have increased oxidative stress and inflammation, but a lower antioxidant capacity, possibly contributing to the adverse outcomes associated with obesity in pregnancy. The most recent systematic review by Blumfield et al (2013) explored all studies reporting on the micronutrient intakes of pregnant women in developed countries, irrespective of design. Nutritional adequacy was measured relative to the dietary guidelines for adults of the respective country and relate to DRV's for comparable population groups. The review also commented on how nutrient recommendations take into account nutrient stores and physiological adaptations that enhance the uptake and absorption of some nutrients that are needed to meet increased metabolic demand during pregnancy. Dietary data from all the included studies was meta-analysed to produce single point estimates to control for between-study variation and to generalise the findings. The analyses were also stratified to trimester, SES and methodology used to collect the data, which included, FFQ, weighed food records, estimated food records, 24 hour recall and diet history's. The review excluded studies in animals, studies that included data related to supplementary intakes, studies that included health conditions that would affect or influence dietary intakes and studies that included a single micronutrient value. Results found that despite reported increases in energy intake and gestational weight gain, dietary intakes for iron, folate and vitamin D were below optimal recommendations in developed countries that included the UK, Europe USA/Canada, Australia/NZ and Japan (Blumfield et al. 2013).

2.16.2 Vitamin D

The vitamin D status of pregnant women and in particular obese pregnant women is potentially a cause for concern. Vitamin D is a pro-hormone which has both paracrine and endocrine actions (Meerza et al. 2010). It is involved in regulation of cell differentiation and proliferation, modulation of the immune response. It is also been associated with glucose metabolism and as such insulin resistance and metabolic syndrome due to the presence of vitamin D receptors on β-cells of the pancreas (Meerza et al. 2010). Vitamin D undergoes 2 hydroxylation's to arrive at its active form 1,25-dihydroxyvitamin D_3 [2,25(OH)D_3] (James 2008). Plasma concentrations are dependent on the amount of exposure to UVB light during the summer months which can vary depending on the amount of times spent outdoors, inclement weather, mobility and cultural influences (COMA 1991b). There are no dietary reference value (DRV) for adults in the UK who live a normal lifestyle, however for individuals with limited exposure to ultra-violet B, a recommended nutrient intake (RNI) of 10μg/day of vitamin D is recommended; this includes all pregnant and lactating women (COMA, 1991), (SACN 2007). However, it remains unclear what the actual vitamin D requirement is for pregnancy. Despite this, research suggests a subset of pregnant women are at risk of vitamin D insufficiency due to obesity, darker skin pigmentation and estimated delivery date in spring or summer (Dror and Allen 2010). Even though there is no increase in requirements for calcium during pregnancy, a positive maternal calcium balance is dependent on adequate circulating levels of 25-hydroxy vitamin D_3 [25(OH)D_3] (James 2008). Determining adequate circulating levels of 25(OH)D_3 is fraught as not all countries in the world have equal hours of sunshine. Measurements taken of

healthy individuals in locations of high sunshine, who spend prolonged hours outdoors either working or sunbathing with minimal clothing and without sunscreen, ranged from 54 - 90μg /L.

Specific biomarkers such as parathyroid hormone (PTH), bone mineral density (BMD) and calcium absorption indicate vitamin D deficiency as circulating levels of 25(OH)D$_3$ of ≤32μg/L. Current dietary recommendations are not sufficient enough to maintain these levels particularly during pregnancy and especially in the obese population (Hollis 2005). With evidence emerging as to the health implications of vitamin D, it is clinical practise at the Liverpool Women's Hospital to prescribe obese pregnant women with a BMI ≥40kg/m^2 who are referred to the bariatric clinic with a combination supplement of calcium and vitamin D in order to meet current requirements when booking in for ante natal care. Guidelines issued by NICE recommend that all women who are in need of additional care including women with a BMI ≥30kg/m^2 should receive a vitamin D supplement (NICE 2008a).

Long term shortage of vitamin D has deleterious consequences for bone health and foetal bone development; poor maternal vitamin D status is linked to reduced bone mass in offspring at age 9 (Javaid et al. 2006). Severe deficiencies in vitamin D can result in rickets, which was thought to be very rare in the UK; however, due to some lifestyle factors such as increased use of sunscreens, reduced exposure to UVB and more varied ethnicity, there has been an increase in the prevalence of rickets particularly in infants (Judd 2013). Many factors affect maternal transfer of calcium to the foetus; calcium intake, vitamin D status, calcium absorption and maternal bone turnover are all correlated with reduced bone mineral accrual in offspring (Javaid et al. 2006). In

addition to being essential for calcium homeostasis and bone health, vitamin D plays a much wider role in general health and disease prevention (Hollis 2006). Maternal outcomes such as gestational diabetes, pre-eclampsia and increased risk of caesarean section are all associated with low vitamin D status (Hollis 2006). The risks are compounded in obese pregnant women since obesity is linked to vitamin D deficiency, it has been shown that obese women have a 50% decreased bioavailability of cutaneous synthesised vitamin D_3 leading to lower circulating levels of $25(OH)_3$ compared to non-obese individuals (Wortsman et al. 2000). Furthermore, it is hypothesised that deficiency in vitamin D gives rise to metabolic syndrome and its associated diseases such as type 2 diabetes mellitus (T2DM) and cardiovascular disease, due to seasonal variation of glycaemic control as a result of a deviation in the adaptive winter response (Foss 2009). An inverse relationship between plasma levels of 25-(OH) D and glycaemia and presence of T2DM has been observed in a number of studies (Meerza et al. 2010). There are limited dietary sources of vitamin D; it is found naturally occurring in fish liver and fish oil and eggs and a range of fortified food such as margarines and milk.

2.16.3 Folate/Folic acid

Folate and folic acid are precursors for the active form tetrahydrofolate (THF), a coenzyme involved in single carbon transfer reactions in the metabolism of amino acids and DNA synthesis and therefore, cell division (Berti et al. 2011). Thus, it has been implicated in foetal development particularly with regard to neural tube development. The neural tube matures into the spine but defects can occur in the protective spinal column, typically occurring within 4 weeks of conception. The most common forms of neural tube defects (NTD) are

anencephaly which results in death in the perinatal period and spina bifida, the most well-known form of NTD. There are varying degrees of physical disability associated with spina bifida including partial or total paralysis (Williamson 2006). Randomised controlled trials have effectively shown that supplementation with folic acid can prevent NTD's (Cornel et al. 2005). However, a review by (Lassi et al. 2013) into folic acid supplementation during pregnancy to reduce incidence of preterm delivery and low birth weight could not find any conclusive evidence of any benefit in taking supplementary folic acid during pregnancy.

The RNI of 200μg/d of folate (derived from dietary sources) for the normal population is increased to 300μg/d in the pregnant population and it is also recommended that women take a 400μg supplement of folic acid for 3 months prior to conception and 12 weeks into the gestational period to reduce the risk for NTDs (as described in chapter 2:2.5). However, with 16.2% pregnancies unplanned and 29% described as ambivalent (Wellcome Trust, 2013), there is a need to meet requirements via dietary sources and that has resulted in call for the fortification of flour in the UK (SACN 2006). There is opposition to folic acid fortification based on unequivocal evidence that it is potentially implicated in an increased risk of cancer by promoting the progression of existing undiagnosed neoplastic lesions (Kim 2007). So, although there is compelling evidence as to the positive effects of folic acid on preventing NTD's there is a potential dose response issue. Contrary to this finding for the general population, there is evidence of a weakening of the protective effect of supplementary folic acid on NTD's in overweight and obese women as described in a study by (Wang et al.

2013). This reinforces the findings of other studies commented on in which the protective effects of folic acid supplements is only significant in the non-obese population. Interestingly, a case control study by (McMahon et al. 2013) found the opposite effect with a stronger protective effect in obese women when measured using intakes of daily intakes of folate from food. However, it would be fair to say that the optimum intakes of either dietary folate or folic acid supplementation have yet to be determined for overweight or obese women and further investigation is warranted.

2.17 MINERALS

Minerals are stratified into major mineral elements and trace elements, are essential to homeostasis and must be derived from dietary sources. Major minerals such as calcium, iron, sodium and magnesium are required in larger quantities relative to vitamins and trace elements. They have multiple functions including bone health, muscle contraction, nerve function, fluid balance and in the case of iron as an essential component of haemoglobin in red blood cells (Lean 2006a). Trace elements include copper, selenium, chromium and iodine and function mainly as co-factors for enzymes that catalyse metabolic reactions (Lean 2006b).

2.17.1 Calcium

The efficiency of calcium absorption improves during pregnancy, due to physiological adaptations, however, there are limitations, as the increase in calcium absorption is dependent on dietary intakes (Hacker et al. 2012).

Additional requirements for foetal growth and development are met through the mobilisation of stored calcium, particularly from bone which has diminished density during the first 3 months of pregnancy but is restored within 6 months (COMA 1991). Calcium retention is also enhanced through increased reabsorption via the kidney tubules. The mechanisms of how these adaptations occur, however, have not been fully elucidated. As such, there is no increased requirement for calcium during pregnancy and a DRV of 700mg/d has been established for pregnant women (Williamson 2006). Calcium status can be compromised in certain population subsets, such as, people who consume little or no dairy, vegans for instance (Theobold 2005). Calcium absorption can also be impaired in people who consume a very high fibre diet and in people who have a low vitamin D status (Williamson 2006).

Derbyshire (2008) reviewed a number of studies investigating dietary intakes of calcium during pregnancy, however, findings were conflicting and in most cases women were either just meeting or falling below UK recommendations (Derbyshire 2008). Low calcium intakes during pregnancy have been linked to a predisposition to hypertensive disorders (including pre-eclampsia), a potential reduction in foetal bone mineralisation and decreased concentrations of calcium in breast milk (Prentice 2000). There is also evidence to suggest an association with pre-term delivery and infant birth weight, but there are conflicting findings in the literature (Hacker et al. 2012). It is also implicated in the bone health of offspring, via a positive relationship between calcium intake and bone mineral content in offspring at aged 9 years (Hacker et al. 2012). This demonstrates the impact that maternal nutrition may have on foetal development in a direct way.

There is uncertainty as to whether maternal metabolism directly affects foetal bone development or whether independent regulation occurs within the foetus (Hacker et al. 2012). It is the potential inadequate intake of vitamin D that is likely to compromise the utilisation of calcium as opposed to a deficit in dietary intakes. Generic dietary advice meted out to all pregnant women is to ensure that the type of foods that provide a source of calcium are included in the diet (DH 2009). There are no safe upper limits set for calcium intakes because it is under close homeostatic control and an excessive accumulation in the blood and tissues is unknown (COMA 1991).

2.17.2 Iron

Iron deficiency is the most prevalent and widespread deficiency in the world and is still highly prevalent in industrialised and developed nations (Scholl 2011). The most common form of iron deficiency is anaemia, with estimates of nearly 50% of pregnant women worldwide thought to be anaemic and all pregnant women in industrialised world thought to be iron deficient to some degree (Brion et al. 2008). The main contributory factor to iron deficiency in pregnancy is due to low iron stores at conception. Iron requirements in early pregnancy are relatively low, but continue to increase as pregnancy progresses until the third trimester when demand is very high (Hallberg 2001). Iron requirements to support pregnancy are estimated to be 680mg and are usually met via a mobilisation of maternal iron stores and the cessation of menstruation (COMA 1991). Hallberg (2001) speculates that the diets of early ancestors were much higher in meat in comparison to the modern day equivalent, supplying an estimated iron store of approximately 500mg. This, in addition to normal dietary intake, would have been sufficient to support pregnancy requirements.

Similar to calcium, there is an increase in iron absorption to meet the demands for iron during pregnancy (Berti et al. 2011). Despite the increase in iron absorption, it is likely that requirements cannot be met via dietary intakes alone during the second half of pregnancy and is therefore dependent on iron stores. However, iron stores are dependent on adequate dietary intakes or supplementation prior to conception (Hallberg 2001). The bioavailability of iron differs between haem iron and non-haem iron because they are absorbed differently. Haem iron, in the form of animal protein, is the most bioavailable because haem solubility is significantly increased by the presence of protein (West and Oates 2008). Whereas the uptake of non-haem iron, found in plant sources such as spinach or broccoli and a whole range of fortified foods, is less readily available but is enhanced by ascorbic acid (vitamin C) (Hallberg 2001). Non-haem iron is thought to provide the majority of iron to the diet but bioavailability ranges from between 1 and 100% because of inhibition of absorbance by iron binding phenolic compounds, phytates, soy proteins and calcium (Conway et al. 2007). There is a suggestion that obesity itself also inhibits the absorption of iron possibly via an inflammatory mediated mechanism. Other hypotheses cited include, increased plasma volume (a definite occurrence during pregnancy), an increased consumption of energy dense, nutrient poor foods and chronic inflammation in response to excess adiposity (McClung and Karl 2009).

There is evidence that links iron deficiency with a number of adverse pregnancy outcomes including a two-fold increased risk of maternal death in the UK in women with moderate anaemia (Hercberg et al. 2000). Iron deficiencies are also implicated in the cognitive development of offspring; a higher prevalence of

IUGR, low birth weight and preterm delivery, changes in thermoregulation and alterations in lipid metabolism. Maternal iron status may also influence iron homeostasis in the offspring and predetermine iron deficiencies in later life regardless of adequate nutritional intakes (Mihaila et al. 2011). A study by Scholl (2011) states that the majority of women of child bearing age are entering into pregnancy with inadequate iron stores to support pregnancy and to ensure optimum foetal development. With reference to the National Health and Nutrition Examination Survey (NHANES) III (1988-1994), it was estimated that 90% of women had below the recommended intake of 22mg/d for pregnant women with a median intake of 14.7mg/d. References to the Camden study (2001-2007) showed similar findings with median intakes of 15mg/d and 83% below the recommended intake (Scholl 2011). In addition to the immediate obstetric risks to the neonate there is also increased risk for a number of obesity related conditions in later life. An adverse intrauterine environment can subject the foetus to developmental plasticity at critical periods, altering phenotypical characteristics which may predispose to obesity and obesity related disorders if exposed to a mismatched postnatal environment and beyond (Hanson et al. 2011). It has been postulated by Brenseke et al (2013) that maternal iron deficiency is implicated in metabolic syndrome in offspring in later life. Oxidative stress is believed to be the link between foetal growth and an increased risk for metabolic syndrome. Known factors related to oxidative stress include hypertension, pre-eclampsia, inflammation and infection. Additional factors are obesity and malnutrition, both of which are also implicated in low birth weight and pre-term birth. Pancreatic β-cells are sensitive to oxidative stress because of low antioxidant capacity and a diminution in insulin secretion has been

observed (Brenseke et al. 2013). In animal model studies, a link between mouse offspring born to mothers with induced iron deficiency and birth weight was observed. The offspring went on to develop glucose intolerance and high blood pressure which are characteristics of metabolic syndrome. It was also noted that although the birth weight of the offspring was lower than the controls, it soon caught up with controls following the introduction of a high fat diet during weaning; the implication being that the offspring of mothers with iron deficiency during the gestational period are pre-disposed to obesity if exposed to a high fat diet (Furuta et al. 2012). An overview of evidence by (McCann and Ames 2007) and supported by (Radlowski and Johnson 2013) cited studies including both human and animal models indicating that iron deficiency is associated with neurological development in offspring.

The current UK position relating to iron intakes and guidelines that relate to the management of iron deficiencies is that women should be advised on how to maximise dietary intakes for increased absorption of iron. Women perceived to be at risk of anaemia or diagnosed with anaemia (serum ferritin level <30µg/L) should be offered oral supplements (Pavord et al. 2012). Current practice is to investigate haemoglobin levels below 110g/100ml from blood count screening tests performed at 16 weeks gestation and to consider supplementary iron on an individual basis (NICE 2008a). The stance taken by (SACN 2010b) is that the optimum iron requirements of all women of reproductive years, and not just during pregnancy, should be met via nutritional strategies and dietary advice.

The position taken by NICE is that there is insufficient evidence to support the routine supplementation of iron or of having a specific DRV for iron during pregnancy or lactation and this is also supported by SACN. Therefore, there is no increase in the dietary requirement for iron which has been established as 14.8mg/d for women aged 19-50years (COMA 1991). This is likely to be because there are adverse pregnancy outcomes associated with both extremes of iron status and evidence exists to suggest that giving iron supplements to non-anaemic women can lead to an increase in haemoglobin (Hb). A U-shaped relationship has been observed between maternal Hb and birth weight. In a large scale study of over 54,382 pregnancies, prenatal death, low birth weight and pre term delivery were seen in women with Hb >132g/L compared to intermediary concentrations at 13-19 weeks gestation. Furthermore, women with Hb >143g/L a 42% had an increased risk for hypertension, which was observed in primiparous women (cited in (Pavord et al. 2012)). Upper safe limits for supplementary iron intakes have been established and are set at 17mg/d in addition to dietary intakes, this is to avoid the associated gastrointestinal effects of constipation, nausea, diarrhoea and vomiting seen in supplementary doses of 50-220mg/d (SACN 2010b). Furthermore, oxidative stress is also associated with excessive iron intakes. The placenta is susceptible to oxidative stress because it is highly vascular and is high in mitochondria. Significantly elevated levels of malondialdehyde, a marker for oxidative stress, have been found in the placentas of women supplemented with iron during pregnancy (Pavord et al. 2012).

2.17.3 Iodine

Iodine is essential for the production of the thyroid hormones triiodothyronin (T3) and thyroxin (T4) of which 70-80% are found in the thyroid gland. These hormones are essential for the regulation of the central nervous system, influencing neurological development including neuronal cell differentiation, maturation and migration; neuro-transmission and synaptic plasticity (Nyaradi et al. 2013). They also have a role in the maintenance of the skeletal system and energy metabolism (SACN 2013). The actual requirements for iodine are not known, although a RNI for iodine for adults in the UK has been set at 140μg/d. A LRNI has also been established for iodine and has been set at 70μg/d. The goitre is the endemic manifestation of iodine deficiency and has been observed in populations with iodine intakes <50μg/d. In response to observational studies, 70μg/d has been cited as the minimum necessary to avoid incidence of goitre (COMA, 1991). In contrast to UK recommendations, the IOM has set a recommended daily allowance (RDA) of 220μg/d and the WHO has advised an intake of 250μg/d for pregnant women. This is due to an increased requirement during pregnancy to support the increase in maternal T4 needed to maintain euthyroidism and transfer thyroid hormones to the foetus in early pregnancy. Thyroxin is necessary for the transfer of iodine to the foetus in late pregnancy and to also allow for an increase in renal iodine clearance (Zimmermann 2012). However, there is an adaptive response, whereby there is an increased efficiency of the utilisation of both absorbed and stored iodide (SACN 2013).

Maternal deficiencies in iodine are likely to result in iodine related disorders in the offspring. The main adverse outcome of severe iodine deficiency in pregnancy is cretinism in the offspring, the main characteristics of which are

mental retardation and speech and hearing impairment. Other deficiencies include; deficits in intellectual and motor function and congenital abnormalities (Jackson and Robinson 2001).

Measuring iodine deficiency or insufficiency in pregnancy has proved challenging. A cut off for urinary iodine concentrations (UIC) of 150μg/L were established by WHO in 2007, however, due to large within subject variation it can only be used to assess iodine status within groups. It has been reported however, that even in groups where inadequate iodine status was determined (a maternal UID of <38μg/L) concentrations of thyroid hormones fell within normal ranges and there were no adverse birth outcomes detected in offspring, who achieved developmental milestones during the first year of infancy (Skeaff 2012).

2.18 PHYTOCHEMICALS

The current recommendation for fruit and vegetable intake in the UK is to consume 5 portions (equivalent to approximately 80g per portion) of a variety of different fruits and vegetables every day (DH,1994). Five portions was perceived as being achievable to most people, however, the national average is only 4.1 portions per day (DH, 2012). This is in contrast to the USA with a recommendation of a minimum of 9 portions of fruit and vegetables a day and Australia who recommend 7 portions per day in the ratio of 2 fruit and 5 vegetables (Australian Bureau of Statistics, 2012). The WHO recommendations are equivalent to 400g/d (WHO 1990). By consuming increased amounts of fruit and vegetables in varying forms, for example, fresh, frozen, tinned, cooked and

dried, an individual is exposed to a wide range of bioactive compounds (BDA, 2011). These include vitamins, minerals and soluble plant fibres, but also a number of phytochemicals which include phenolic compounds, flavonoids and carotinoids (Li et al. 2012). There is emerging evidence that these compounds have an influence on trans-signalling pathways due to the additive and synergistic interactions (Liu 2013, Williams et al. 2013). Phytochemicals have been shown to possess chemo-preventive, anti-inflammatory and antioxidant potential and studies indicate they are influential is limiting the prevalence of a number of dietary related cancers via inhibition of cancer cell proliferation and promotion (Boivin et al. 2009) and T2DM via synergistic interactions between phytochemicals and dietary fibre that have antioxidant potential, thus reducing oxidative stress, a characteristic of metabolic syndrome and a precursor to T2DM (Belobrajdic and Bird 2013). Inflammation is a characteristic of obesity and evidence also shows that phytochemicals may have anti-obesity properties due to the anti-inflammatory potential and the ability to target different stages of the adipocyte lifecycle suppressing the growth of adipose tissue (Williams et al. 2013).

It is evident that micronutrients play an important role in both maternal and foetal health and that the optimum method of obtaining these nutrients is from dietary sources (vitamin D and folic acid being the exceptions to this). By measuring dietary intakes of micronutrients it is possible to assess the overall quality of maternal diet which is essential for optimum pregnancy and birth outcomes and for long term health.

2.19 SUPPLEMENTATION

Research into the use of nutritional supplements is ongoing. It has been demonstrated that folic acid taken prior to conception reduces incidences of NTD's and10μg/day dose of vitamin D is routinely prescribed to women with a BMI ≥35kg/m^2 to improve the absorbency of calcium. However, there are still question marks over the wholesale use of nutritional supplements as a substitution to a micronutrient rich diet. There is a wide variation in the composition of multivitamins and minerals (MVM) and concentrations may not always reflect the label values. Similar to nutritional food labels, MVM use composition databases for labelling purposes as opposed to analysed values (Yetley 2007). There is a paucity of information regarding bioavailability, bioequivalence, composition and drug interactions with MVM. The bioavailability of nutrients is variable due to potential factors that affect absorption. Additionally, the circulating concentrations of nutrients relative to the functional effects at the sites of action also vary amongst nutrients. Individual nutritional status may affect the absorption of nutrients because of homeostatic regulation, increased iron absorption in pregnancy, for example. It is postulated that homeostatic mechanisms may regulate circulating nutrients within a narrow range and may therefore be sensitive to increases in ingested amounts. A study into high maternal MVM supplement intake during pregnancy in animal models, found that glucose and fatty acid regulation was affected, increasing body weight and adiposity in the offspring via altered expression of the peroxisome-proliferator activated receptor (PPAR) genes. This was amplified further in the post-weaning stage when exposed to an 'obesogenic' dietary intake (Lopez et al. 2013).

Table 2-4: Summary of dietary related interventions

Author (year)	Type of study	Method	Sample size	Outcome measures	Results
Chung Yu Louie et al (2013)	Cohort All BMI ranges	3 day food diary randomised to low GI or HF modest GI	n=99 with GDM	Nutrient intake compared to Australian Nutrient Reference Values. Pregnancy outcomes, neonate anthropometry, maternal metabolic profile in GDM	Low GI diet achieved modestly lower GI than HF. Nothing of statistical significance related to pregnancy or birth outcomes.
Makela et al (2013)	Between samples comparison BMI ≤25kg/m^2 BMI ≥25kg/m^2	Index of Diet Quality (IDQ)	n=149 (82 OW & 67 NW)	Dietary intake, PA, GWG, pregnancy & birth outcomes	Statistically significant differences in glucose conc., BW, birth length, head circumference (p <0.01). NW women had better diet quality (p = 0.023)
Northstone et al (2008)	Cohort study, BMI not specified	FFQ	n=12053	Dietary patterns & associations with socio-demographic & lifestyle factors	5 dietary patterns established: Health conscious, traditional, processed, confectionary & vegetarian. Strong associations between socio-demographic variables & dietary patterns
Olafsdottir et al (2006)	Cohort study All BMI ranges	Semi Quantitative (SQ) FFQ Lifestyle Q	n=495	Changes in eating patterns, GWG, birth outcomes	34% gained weight in excess of Icelandic recommendations. Women with a BMI 25 – 29.9kg/m^2 gained most weight (p <0.001) with higher EI (p=0.017)
Rhodes et al (2010)	Pilot RCT BMI ≥25≤45kg/m^2	Randomly assigned to low fat or low GL diet	n=46	BW, GWG, infant anthropometric measurements, maternal metabolic parameters and gestational duration	Nothing of statistical significance but longer pregnancy duration, increased head circumference & improved maternal CV risk factors

On balance, there are many more studies designed to limit weight gain in the obese pregnant population than there are looking specifically at improving quality of diet. It is still unknown what the optimum diet is for pregnancies that are complicated by overweight and obesity (Rhodes et al. 2010). There are limited studies looking at the quality of diet in pregnant women, therefore studies looking at nutrient intakes in the obese pregnant women are even rarer. Table 2-4 summarises some of the studies that have explored the relationship between dietary intake and pregnancy outcomes. Those that do exist have very varied study designs. A large population cohort by Northstone et al (2008) looked at dietary patterns in association with socio-demographic factors in over 12, 000 pregnant women. The study identified 5 dietary patterns: the health conscious, the traditional, the processed, the confectionary and the vegetarian. Findings indicated that dietary patterns were influenced by social factors, for example, women who followed a health conscious dietary pattern tended to be older, with higher levels of education and more affluent. Conversely, women who corresponded with the processed dietary pattern were more likely to be of increasing parity, smokers, with decreasing levels of education living in council accommodation. The authors reported that their findings were consistent with studies investigating similar patterns. However, the study made no associations with pregnancy outcomes relative to dietary patterns and the BMI of the sample population was not established (Northstone et al. 2008).

A study by Olafsdottir et al (2006) set out to investigate the relationship between dietary factors, pregnancy weight gain and birth outcomes in women who

gained outside the recommended amount in Iceland. Dietary intakes were estimated using semi-quantitative FFQ's in 495 women. The FFQ's were completed between 11 and 15 weeks gestation and again between 34 and 37 weeks gestation. A questionnaire regarding lifestyle factors in the previous 3 months was also included. Both questionnaires were emailed to the participants to complete at home and were requested to bring or send the questionnaires back prior to a clinic visit. The study found 20% of NW (BMI ≤25kg/m^2) women at booking in gained in excess of recommendations (NW ≥18kg), whereas 55% of OW (BMI ≥25kg/m^2) women at booking in gained in excess of recommendations (OW ≥12kg). This was also associated with an increase in energy intakes with OW women increasing their energy % (E%) from fat (1.2 ± 6.3 E%) with a decrease in E% from CHO (-0.7 ± 6.4). In women whose weight was classed as suboptimal (NW ≤12kg, OW ≤7kg) this was reversed with significant increases in CHO (4.5 ± 7.6 E%, p = 0.03) and a significant decrease in E% from fat (-3.9 ± 5.7, p =0.015). Additionally, women who gained suboptimal weight gave birth to lower birth weight babies (p <0.001), were shorter (p =0.001), with smaller head circumferences (p =0.006), a lower placental weight (p =0.007) and with a shorter gestation (p <0.008) than women gaining optimal or excessive weight. This seems to support the theory that women should not lose weight during pregnancy. However, this only applied to NW women, by contrast, the only significant difference in the OW women was in birth weight (3594 ± 443 versus 3918 ± 526, p =0.029) whereas other birth outcome parameters were unaffected (Olafsdottir et al. 2006).

Only 2 of the studies looked at dietary intakes in women with a BMI ≥25kg/m^2. The study by Rhodes et al (2010) was a pilot RTC in which 46 women described as overweight or obese were randomly assigned to receive either a low fat diet or a low glycaemic load (GL) diet. The study was designed to determine the optimal dietary intake for pregnancy with a view to reducing insulin sensitivity and thus GWG. The study found that the duration of pregnancy was significantly longer in the low GL group than in the low fat group (mean ± SD 39.3 ± 1.1 vs 37.9 ± 3.1wks, p =0.05), adjusted infant head circumference was greater in the low GL group (35.0 ± 0.8 vs. 34.2 ± 1.3cm, p = 0.01) and women in the low GL group had smaller increases in triglycerides than the low fat [median, IQ range: 49 (19, 70) compared to 93, (34, 129mg/dL), p= 0.03]. There were no significant differences between birth weight and other infant body composition measures. However, the study observed that length was greater and all four skin-fold measurements were smaller in the group assigned to the low GI diet (Rhodes et al. 2010). By contrast, the study by Mäkelä et al (2013) was designed to determine whether maternal overweight and/or hyperglycaemia in combination with other lifestyle factors predisposed otherwise healthy women to adverse pregnancy/birth outcomes. Comparisons were made between women with a pre-pregnancy BMI ≥25kg/m^2 and women with a pre-pregnancy BMI <25kg/m^2 and dietary intake was assessed in the 3rd trimester only using the Index of Diet Quality (IDQ). The IDQ measures compliance with Finnish nutritional recommendations and promoted healthy diets. The study found that insulin resistance was higher and sensitivity lower in the overweight women (p <0.05) and the offspring of the overweight women were 273g heavier at birth and 700g heavier at 13 months old than the offspring

of normal weight women ($p < 0.001$). Dietary intake assessed using IDQ showed normal weight women had a preferable diet quality than the overweight women ($p = 0.023$) (Mäkelä et al. 2013a).

The general theme to emerge from the review of intervention studies is that regardless of whether there are any findings of statistical significance in any of the studies, changes or trends emerge to suggest what appears to be a positive response from the women to any intervention, with reductions in GWG, improved dietary behaviours and positive pregnancy and birth outcomes.

The systematic review by (Thangaratinam et al. 2012a) of RCT's that evaluated dietary or lifestyle interventions that could potentially effect positive pregnancy outcomes and/or maternal weight in the overweight or obese pregnant determined that dietary interventions were the most effective at reducing obstetric complications such pre-eclampsia, GDM, gestational hypertension and pre-term delivery. Moreover, there were reduced risks of shoulder dystocia to the foetus and importantly, there was no evidence of maternal or foetal harm following any of the interventions. However, there was less effect on foetal weight as a result of dietary or lifestyle interventions or rates of caesarean section or induction of labour (Thangaratinam et al. 2012b). Acknowledged limitations to the review were due to the quality of the reported findings in the studies. The review further asserted that interventions focusing on dietary interventions, as opposed to a combination of diet and physical activity, are more effective in reducing gestational weight gain and that a balanced low glycaemic diet with a ratio of 30% fat, 15-20% protein and 50-55% carbohydrate with total energy intake individualised to the requirements of the mother,

depending on pre-pregnancy BMI would be beneficial in improving outcomes. It also suggested that a regular nutritional input from dietetic services from early pregnancy, particularly in the overweight/obese pregnant population would benefit the most. Although the reasons are not fully elucidated, it is suggested that compliance in all aspects of a multiple component study may be reduced in some components and that the delivery of the intervention may not be consistent across the components. As a possible model for the dietary management of obese pregnant women it may be useful to explore the approach taken for the management of T2DM. Specific lifestyle interventions in the form of modified diet and increased levels of physical activity have been shown to have a positive impact in the non-pregnant population with reductions in weight, BMI and waist circumferences as well as plasma concentrations of glucose. A similar approach has been taken for the management of women diagnosed with GDM although dietary advice alone is insufficient and outcomes are usually improved if combined with Metformin. Furthermore, it is suggested that interventions for the weight management of obese pregnant women should adopt some of the dietary recommendations suggested for women with GDM (Abayomi and Charnley 2012, Nelson et al. 2010).

An account of a case study by Abayomi (2012) highlighted the positive effect of a low fat, low sugar diet that one particular patient, with a booking in BMI of 42.1kg/m^2 and weight of 103kg, had adopted in 2008 on the advice of the dietitian when diagnosed with GDM at 19 weeks gestation. At the point of delivery at 38 weeks gestation, there had been a small weight loss of 3.6kg equating to approx. 0.2kg per week since diagnosis and the baby was born

healthy with a birth-weight of 3.5kg. The same patient presented at antenatal clinic in 2010 with a booking in weight of 91kg and a BMI 37kg/m^2, a comparative reduction of 12kg (>10% of previous body weight) from the previous pregnancy by continuing with the eating plan devised by the dietitian (Abayomi and Charnley 2012).

2.21 THE CURRENT STANDARD OF NUTRITIONAL ADVICE GIVEN IN PREGNANCY

The NETMUMS survey (Russell et al. 2010) carried out in association with the Royal College of Midwives interviewed over 6000 women regarding their experiences during and after pregnancy. The survey highlighted disparities in the approach to care of obese pregnant women; with 64% of respondents feeling that midwives should play an active role in giving encouragement and advice on issues such as weight management and nutrition. Findings from the survey suggest that midwives would raise the issue of BMI and overweight at booking in but only 57% of the respondents were offered any nutritional advice by the midwives and only 12% of those identified as having a high BMI were referred to a dietitian or nutritionist. However, dietetic support is not always available. Research conducted by Abayomi (2007) found that no referrals were made from the antenatal clinic in respect of obesity during the study period. Dietetic provision at LWH was only 0.4 whole time equivalent (WTE) and considered totally inadequate to deal with all the maternity and obstetric nutritional needs. This included all the pregnancy related medical disorders such as cystic fibrosis, GDM and phenylketonuria (PKU). Conservative estimates indicated that to effectively support all those in need of dietetic input a

minimum of a 1.2WTE dietitian would be required. The lack of dietetic support persisted post-delivery where only 8% of those referred to a nutritionist were given any opportunity to discuss post-partum weight management with the midwives and given that 40% of these women went on to have a caesarean section there is a clear need for further guidance. Hestlehurst et al (2011) highlighted an absence of research evidence for effective strategies on how to tackle maternal obesity, as it is still classed as a relatively new phenomenon (Heslehurst et al. 2011). There is uncertainty among community midwives on how to raise such a sensitive issue, as once raised "where do you go with it?" There are other barriers associated with the discussion of obesity in pregnancy, Lee et al (2010) explored health promotion practices and found midwives viewed lifestyle and obesity as low priority. This is supported by a previous study by Hestlehurst et al (2007), who found discussions regarding weight were avoided due to a lack of resources, finance and equipment. Furthermore, there was a lack of consistency regarding available services and the type of advice that should be offered and that no clear guidelines were available. Moreover, the lack of consistency between maternity units where most of the advice, particularly dietary advice tends to be on an '*ad hoc'* basis leaves 'at risk' women with additional anxieties. A 2013 review by (Arrish et al. 2013) investigated the role of midwives in delivering nutritional education during pregnancy, regarding the amount of nutritional knowledge, attitudes and the communication skills required to impart nutritional advice in a number of countries including the UK. The review concluded that there is a basic lack of knowledge of nutritional requirements during pregnancy and midwives received inadequate nutritional education during training apparently due to the low

priority that nutrition is given. However, midwives do view nutrition as being very important during pregnancy and recognise the significant position they are in to advise women on dietary recommendations and intake. One study by Wills and Forster (2007) cited in the review speculated that even when midwives did offer nutritional advice that it lacked scientific evidence. In general, the majority of midwives, featured in all of the studies reviewed, had limited knowledge and lacked confidence in advising pregnant women on nutritional requirements (Arrish et al. 2013). Therefore, they are in a position to offer generic advice on 'healthy eating' but may not be able to give advice on specific nutrients, dietary sources, required amounts and potential inhibitors or promoters of micronutrient absorption (Barrowclough and Ford 2001).

The most recent UK study featured explored health promotion practices within maternity services in respect of guidelines published by RCOG and NICE. The study published by (Lee et al. 2010) comprised of an audit of health promotion strategies and interviews with a sample of 13 midwives drawn from 3 NHS trusts in North West England to elicit opinion of current practices and to determine what training and service changes are required to enable the midwives to confidently deliver health promotions and advice to pregnant women on a number of key issues, including nutritional education. The key findings of the study relating to nutritional information were that 'midwives were not confident discussing complex nutritional issues with pregnant women'. Moreover, the audit findings suggested that there was a paucity of documentation pertaining to discussions between midwives and 'at risk' women regarding weight, normal dietary intake and referrals to a dietitian, regardless of the (NICE 2010) recommending that all women with a BMI ≥35kg/m^2 be

referred to a dietitian. Nor was there any evidence that the women were provided with any literature, in the form of leaflets, regarding dietary advice.

To date and despite a thorough search of accessible databases, there was no further literature relating to the nutritional education and/or knowledge of midwives so it is not known if nutritional education and training for midwives has been improved upon.

2.22 SUMMARY AND RATIONALE FOR STUDY

The risks of adverse outcomes in pregnancies complicated by overweight and obesity are now well described and there are numerous studies, both reported and ongoing which have been designed to limit GWG in these pregnancies. The studies report back varying degrees of success. However, although healthy eating advice may have been offered, there were no measurements of dietary intakes reported. Additionally, to date, there are limited studies looking at the effects of dietary intervention on pregnancy and birth outcomes and none conducted here in Liverpool or elsewhere in the UK, making it difficult to generalise any findings to UK populations. There is a growing body of evidence from observational, epidemiological and animal model studies that suggest obesity and nutritional intakes may have long term implications for offspring health in terms of obesity, T2DM, CVD and some cancers. Liverpool is one of the most deprived areas in the UK, with high incidence rates of those health issues mentioned above which are likely to increase as the obese population increases. To address the effects of obesity in the long term and reverse the obesity trend, the question of whether the quality of nutritional intakes has on

the long term implications of health must be answered. This also needs to be considered alongside the negative aspects of being obese; such as, the humiliation and anxiety experienced by some women with obesity during pregnancy.

This current study was designed to observe dietary intakes in pregnant women with BMI ≥35kg/^{m2} from the Liverpool area, investigating the relationship of dietary intakes with pregnancy and birth outcomes. Furthermore, this study also explores lifestyle and the lived experience to gain an insight into what influences these women's behaviours and to make the food choices they do.

3 CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter is to discuss the theoretical, methodological and ethical considerations, which informed the methods employed by this study. The first part of the chapter begins with a section on the research study design where the methodological considerations are discussed and explains the rationale behind the study and its context in relation to the wider Fit for Birth study. This is followed by an explanation of the methods used to collect the data for the quantitative phase of the study and a justification of the reasons those methods were selected. Ethical issues are discussed next. Finally, the chapter includes overviews on the sampling strategy and analysis strategy used in this study.

3.2 FIT FOR BIRTH

Fit for Birth was a single centre longitudinal prospective observational cohort study nested in routine clinical care, which was designed to:

- Describe the process and feasibility of recruitment onto an assessment study that would form the basis of a definitive cohort study or a randomised control trial
- Investigate how variables relevant to maternal weight change, after booking in, are associated with pregnancy outcomes
- Explore those factors associated with weight change during pregnancy.

Fit for Birth plus (FFB+) was an additional arm to the study where a subset of women with a BMI ≥35kg/m^2 consented to a more detailed assessment relating to physical activity levels, quality of life, sleep apnoea and notably dietary intake. The focus of this study is the dietary intake and the other aspects aforementioned will be published elsewhere.

Inadequate intakes of essential nutrients are associated with an increased risk of dietary related diseases in adulthood (Ruxton and Derbyshire 2010). Therefore, it is necessary to assess the dietary intake of pregnant women to identify any sub-groups within the population with inadequate nutrition (Mendez and Kogevinas 2011) to enable the design of appropriate intervention programmes. The primary aim of the research was to estimate diet and nutrient intake and to determine any effects of inadequate dietary intake on weight change and pregnancy outcomes. Thus, short and long term health risks, for the pregnant woman and the developing foetus can be identified.

3.3 PHILOSOPHICAL APPROACH

Research studies set out to gather information and generate data that will answer research questions or test hypotheses. The design of a research project is therefore structured to enable the researcher to follow a clearly defined framework to increase the objectivity, reliability, validity and the rigour of the research to answer a research question (Rees 2011). Additionally, this framework informs the logistical decisions made by the researcher regarding the methods and the analysis used and the interpretation of the data (Creswell and Plano Clark 2007). This is guided by research paradigms which are

characterised by their ontological assumptions - beliefs about reality; their epistemological assumptions – the relationship between the researcher and what can be known (how can reality be known?) and methodological assumptions – how to carry out the research relative to the research questions and context (Houghton et al. 2011).

The methodology differs to methods in that it defines the philosophical principles and specifies how research questions should be asked and answered (Teddlie and Tashakkori 2009). Or put another way, it is the framework that relates to the entire process of the research (Creswell and Plano Clark 2007). Methods are the specific procedures and steps taken to implement the research where the sampling strategy, data analysis and the interpretation of the findings are defined (Teddlie and Tashakkori 2009).

Social sciences and health studies traditionally conduct research using one of three research paradigms; quantitative, qualitative or mixed methods. Creswell and Plano Clark (2007) state that quantitative and qualitative approaches both tend towards the same elements in the process of research in terms of intent of the research, how the literature is used, how data are collected, analysed and validated and the role of the researcher. The paradigms or worldviews that the researcher uses to influence how the study is designed and conducted also differ between quantitative and qualitative approaches (Creswell and Plano Clark 2007).

Quantitative research usually follows a confirmatory or exploratory model and tests hypotheses that are driven by theory using deductive reasoning. It is

typically numerical data that is collected and is associated with a [post] positivist paradigm (Teddlie and Tashakkori 2009) and is based in the conventional standards of scientific rigour, reliability, internal and external validity and objectivity (Guba and Lincoln 1994). Post positivism assumes that social research will reflect the natural sciences model of objective inquiry by providing clear results that lead to conclusive causes for certain social or psychological phenomena (Ryan 2006). The belief of the [post] positivist researcher is that there can only ever be an approximation of the truth of reality, which can never be explained completely because of the influence of cultural experiences and the biased perception of reality, that people tend towards (Onwuegbuzie et al. 2009).

In contrast, qualitative research employs inductive reasoning to generate theories that are grounded in narrative data and is associated with a constructivist paradigm (Teddlie and Tashakkori 2009). The constructivist stance is that multiple realities, or equally valid accounts of the same phenomenon, can exist (Onwuegbuzie et al. 2009). These multiple realities are the products of human intellect but are subject to change as the constructor becomes more knowledgeable or experienced (Ryan 2006). The goodness or quality criteria of the constructivist paradigm is that the research is both authentic in terms of fairness, knowledge and improved understanding of the constructions of others and that it stimulates and inspires action (Guba and Lincoln 1994) and that the research is trustworthy. Qualities that are accredited to trustworthiness reflect the goodness criteria attributed to quantitative criteria; that it has creditability, paralleling internal validity; it has transferability which

parallels external validity; dependability, paralleling reliability and confirm-ability, paralleling objectivity (Guba and Lincoln 1994).

It was thought that quantitative and qualitative research methodologies could not be effectively mixed due to the dichotomous nature of these two research paradigms. However, a branch of philosophers known as pragmatists argued that multiple paradigms can be used to address research questions and that the focus should be on the methods that are best suited to answering the research question rather than the researchers worldview (Cameron 2009). Mixed methods is a paradigm that has emerged with an approach that combines or integrates both quantitative and qualitative paradigms to gain a better understanding of the research problem (Creswell and Plano Clark 2007). It offsets the weaknesses and emphasises the strengths of both approaches, because independently neither approach is sufficient but when combined both methods complement each other offering a more robust interpretation of research findings (Ivankova 2006).

Guba and Lincoln (1994) describe paradigms as human constructs that represent the most informed and sophisticated way of responding to the ontological, epistemological and methodological questions. They argue that no one construction can be irrefutably right as they are inventions of the human mind and are therefore subject to error and that no construct is based on proof but must rely on utility and persuasiveness. Additionally, three stances relating to mixed methods approaches to be considered during the study design have been identified.

- Stance 1: Asserts that there is only one paradigm that fits mixed methods research and that is pragmatism, this view is supported by at least 13

authors according to Tashakkori and Teddlie (2003), cited in Creswell and Plano Clark (2007).

- Stance 2: States that researchers can use multiple worldviews in mixed methods studies as long as the researcher is explicit in their use. The suggestion being that all paradigms are valuable but are only partial worldviews (Teddlie and Tashakkori 2009).

- Stance 3: Advocates that worldviews can vary depending on the type of mixed methods design. This enables investigators to view mixed methods as more 'methods' and use one paradigm for one kind of study and another appropriate paradigm for another study (Teddlie and Tashakkori 2009).

Mixed methodologies are relatively new in terms of social and healthcare research in comparison to quantitative and qualitative methods, only really gaining popularity in the last 15 years or so (Onwuegbuzie and Leech 2009). Since then approximately forty-six different mixed methods research designs have been reported in the literature according to Tashakkori and Teddlie (2003) cited in Ivankova (2006). However, Creswell et al (2003) identified the triangulation design, embedded design, explanatory design and the exploratory design as the four major mixed methods research designs. The choice of research design is dependent upon its application as the choice of design will determine the methods, the sequence of data collection and how the data from the quantitative and qualitative phases are connected and the results integrated (Ivankova 2006).

3.4 STUDY DESIGN AND RATIONALE FOR USING A MIXED METHODS APPROACH

Health research including studies relating to nutrition and dietetics have largely been predominantly based in quantitative approaches (Swift and Tischler 2010). For example, objective measures such as nutritional status using clinical biomarkers or subjective measures of dietary intakes using food records or questionnaires can be generated and analysed using statistical analysis. However, as Swift and Tischler (2010) assert, a qualitative research approach can bridge the gap between food being viewed merely as an energy source that fulfils a biological need and the sociocultural context of food, identifying the role it plays in how human beings communicate within their social sphere. This is reflected in the experiences of dietitians and nutritionists in real life situations who work collaboratively with clients on how to make changes to their dietary intake and physical activity levels to improve health, reduce weight and the risk of non-communicable diseases and increase quality of life (Swift and Tischler 2010). Additionally, dietitians and other public health professionals may have to address the behaviours and influences that are the main determinants of obesity and other suboptimal health outcomes (Affenito et al. 2012). As such, the aims of health related research studies are to provide an holistic approach to the understanding of health related issues by drawing on other disciplines such as sociology, psychology and anthropology as these tend to focus on human behaviour in a sociocultural context (Green and Thorogood 2004).

The aims of this study were to explore the food choices of pregnant women with a BMI ≥35kg/m^2 relative to their eating behaviours. Key themes explored included the nutrient content of the food being eaten, what the underlying influences were that lead to individual food choices and eating behaviours and

how those choices ultimately impacted on pregnancy outcomes. By understanding the influences behind food choice, and thus the adequacy of nutritional intakes, the development of conceptual frameworks, which form the basis of more effective interventions, can begin. One of the most popular research designs that has found application in the social and behavioural science is that of the mixed methods sequential explanatory design. This is design is well characterised in the literature (Tashakorri and Teddlie 1998; Creswell et al 2003) cited in Ivankova (2006). This design adopts a sequential approach in which the qualitative phase helps to explain or build upon the results from the quantitative phase (Creswell and Plano Clark 2007).

In this study quantitative data were collected during phase one of the study using estimated food diaries. A [post] positivist approach was taken with this phase of the study, the data was collected in a scientific and objective manner and was initially collected in a narrative form as the participants estimated and described three days' worth of food intake. The food items were then coded and converted into a numerical form that could be analysed statistically. However, there is recognition of the limits to the research. The collection and aggregation of nutritional data enabled the researcher to assess nutrient intakes, which gave an overview of the quality of the diet being consumed. However, it did not give any indication as to why those food choices may have affected the quality of the diet and what the effects of a poor quality dietary intake had on weight change, pregnancy and birth outcomes. Therefore, more evidence was required to determine and understand the food choices and behaviours that influenced nutrient intakes (Ryan 2006).

This was followed by a qualitative second phase which took a constructivist worldview approach. Semi-structured interviews pertaining to food and lifestyle behaviours were undertaken with a sample of participants from the quantitative phase. The principle behind this methodology was to conduct research in a natural setting to determine the underlying meaning and purpose attributed to an individual's actions. Thus, the qualitative phase aimed to describe the issues that influenced particular food choices and eating behaviours in a subset of the population being studied. The purpose of the second phase is to connect the data and explain the results from the first phase. The research sets out to investigate how dietary intakes during pregnancy and subsequent pregnancy outcomes are influenced by the lifestyles and lived experience of pregnant women with obesity. This can be achieved by following a sequential approach in which the phases follow a chronological order (Teddlie and Tashakkori 2009). The purpose of a sequential mixed methods analysis is to use data from the first phase to inform the second phase and this can follow either an exploratory or an explanatory approach. In an exploratory approach the qualitative research precedes the quantitative phase in which the qualitative data may throw up a theoretical perspective that generates more specific questions or hypotheses (Teddlie and Tashakkori 2009). Conversely, the quantitative phase comes before the qualitative phase in an explanatory approach. In this instance, results generated from the analysis of quantitative data may not provide anything of significance or may be contrary to expectations in which case further explanation may be required (Creswell and Plano Clark 2007).

This study, therefore, followed a sequential explanatory mixed methods approach in which the quantitative data is emphasised as seen in figure 3.1.
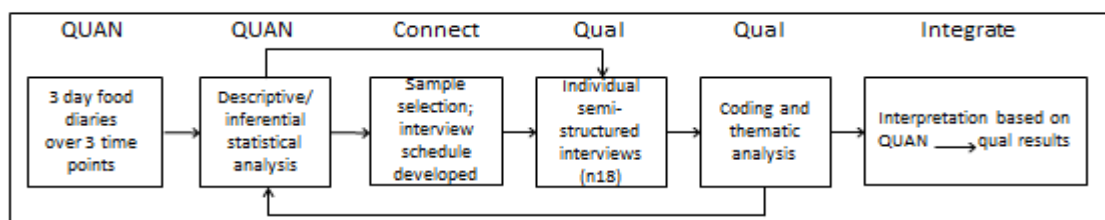
Figure 3-1: Mixed methods design - sequential explanatory model with emphasis on quantitative phase (Reprinted and adapted with permission from SAGE) (Ivankova 2014)

3.5 SAMPLING STRATEGY

The overall Fit for Birth study was a prospective observational cohort study designed to generate pilot data to inform further research design. Provisional sample size estimates suggested that 3200 participants would yield sufficient data to detect changes in primary outcomes. However, as it was a pilot/feasibility study in design no formal sample size calculations were required. The estimated 3200 participants were to include 3000 for the FFB weights only arm of the study and 200 participants to be included in the FFB+ arm of the study, where data pertaining to physical activity, quality of life, sleep apnoea and dietary intake was collected.

A pragmatic approach to the recruitment was taken where the target population of pregnant women with a BMI ≥35kg/m^2 who took part in FFB+ were recruited at the antenatal booking in appointment by community midwives and at various locations around Liverpool. This type of sampling is described as convenience sampling with a volunteering sample. In this instance the participants were easily accessible and those who consented were willing to take part (Teddlie and Yu 2007).

The community midwives, responsible for booking in pregnant women for antenatal care, were briefed on recruitment criteria and were provided with the relevant consent forms and information sheets. All pregnant women over the age of 18, with a singleton pregnancy and with a BMI ≥35kg/m^2 were eligible to participate regardless of pre-existing medical conditions. The women were recruited continually throughout the one year period between June 2009 and June 2010 onto the quantitative phase of the study. The women were provided with an information sheet and asked for their consent, enabling a research clinic appointment to be made. In the majority of cases there was somewhere between 2 and 6 weeks between the antenatal booking appointments and the first research clinic appointment at 16 weeks. This gave the women ample opportunity to withdraw at any time beforehand. However, not all the women who initially agreed to participate in FFB+ received appointments to the clinics as there was a limited capacity at each research clinic. Moreover, not all the women participated in all 3 research clinics, this could have been due to either some women choosing to withdraw, or that the clinic patient list had already reached maximum capacity.

The sampling strategy for the qualitative phase of the study was determined by the results from the quantitative study; as such the sample was drawn from the original sample invited to participate in the FFB+ phase. Creswell and Plano Clark (2007) suggest that it is common practice in sequential explanatory design for the sample to be much smaller in the qualitative phase than the quantitative phase, as the aim is not to compare the data but to explain further the quantitative results, therefore, equal sizes of sample are not required. Thus, the sample were purposively selected from the existing FFB+ sample and

invited to participate in semi-structured interviews. The initial aim was to recruit as many participants that would achieve saturation of themes. In thematic analysis, saturation point is deemed to have been met, when no new data or themes emerge from the sample (Francis et al. 2010). However, Francis et al (2010) questions the concept of data saturation and the lack of guidelines determining sample size prior to data collection and Guest (2006) suggests that saturation of themes is a difficult concept to determine in practice (Guest 2006). Both sets of authors suggest that when, interviews are conducted by the same researcher, of a homogenous group, in which the aim is to understand common perceptions, saturation is likely to be achieved within the first 12 interviews in 97% of cases.

3.6 MIXED METHODS DATA COLLECTION

This section discusses the decision making process regarding the method used to collect the data relating to nutritional intakes followed by the method employed to collect the data relating to the lived experience of the women who participated in FFB+. Although a number of mixed-methods typologies exist in which data can be triangulated or embedded, the data collection strategy employed for this mixed methods study adopted an sequential explanatory design using a combination of quantitative observation procedures followed by qualitative interviews (Teddlie and Tashakkori 2009).

3.6.1 Methods to determine nutritional status

Patterson and Pieitinen (2004) discuss four direct methods used at individual level to determine nutritional status. Anthropometrics, provide measurements of the dimensions and composition of the body *(ibid.)* biomarkers, which measure nutrient intakes or the impacts of nutrient intakes *(ibid.)* clinical assessment, to ascertain the clinical consequences of imbalanced nutrient intakes *(ibid.)* and lastly dietary assessment, which estimates food and nutrient intakes *(ibid.).* There are strengths and limitations to each of these methods in terms of cost, feasibility and suitability. For example, anthropometric measurements of pregnant women are unreliable due to changes in tissue composition and body mass *(ibid)* Biomarkers are a useful objective measure of dietary exposure, however, micronutrients such as calcium and iron are homeostatically regulated, and therefore, measures are not reflective of dietary intake (Vioque et al. 2013). There are also implications in terms of practicality and cost. In addition to laboratory facilities necessary for sample analysis, samples such as blood, urine and adipose tissue, require formal procedures to collect, process and store (Patterson and Peietinen 2004). Therefore, dietary assessment is the most relevant means by which data relating to nutritional intakes and food choices can be generated. The assessment and evaluation of dietary intake in specific population groups or in individuals is an essential part of nutritional surveillance and epidemiology (Ahmed and Tseng 2013). The appropriate dietary assessment methods used by nutritionists, dietitians and other public health workers required to collect information regarding dietary intake are dependent upon the objectives (Barasi 2003). The estimates of intake at population level using national nutritional surveys, household surveys, etc.

assess intakes of particular foods and nutrients in relation to RNI's, to determine changes over time. Dietary assessment has also been used to identify possible nutritional causes of certain diseases by comparing dietary intakes with disease rates in different countries and populations (Mann and Bingham 2012). Alternatively, the information may be used for developing modified diets for individuals with specific medical conditions, educating the general public about healthy eating or for research (Meltzer et al. 2008). Measuring dietary intake is not straightforward as there are a number of methods available, however, choosing the right one needs careful consideration because the method used needs to reflect the characteristics of the research question (Roberts and Flaherty 2010). The questions that need to be addressed when selecting an appropriate method relate to whether the data is being collected on individuals or populations, whether the data describes dietary patterns or nutrient intakes at specific time points or over a specified period time. The cost and time necessary to conduct the research and the 'burden' to both the participant and the researcher need consideration (Bingham et al. 1994). For the purpose of this study individual intakes at specific time points are what of interest. The methods used to collect this type of data also vary and need careful consideration.

There are a number of different methods used to collect dietary data at individual level including food frequency questionnaires, 24 hour recall and food diaries/records which can be either weighed or estimated. There is divided opinion over which methods are the most effective. A review by (Ortiz-Andrellucchi et al. 2009) evaluated 17 studies assessing micronutrient intakes

in pregnant women using varying dietary assessment methods, against each other and in some instances against biomarkers to determine the best method. FFQ's had been validated for use in 15 out of 17 of the studies, and 6 correlated favourably with estimated food records when used as a reference method. However, there was considerable variation in the methods of the studies presented and in the nutrients being measured. In contrast, (Stephen 2007) argued that estimated food diaries are preferable to FFQ's in longitudinal studies because they include more food detail. Although FFQ's are easier to administer, are lower in cost and with a lower participant burden, their ability to demonstrate a relationship between diet and disease was questioned (Stephen 2007).

The research team therefore, decided to collect dietary data using estimated 3 day food diaries. The data would be further validated during follow up interviews held at the weekly research clinic appointments. This is where there was an opportunity to scrutinise the diaries in detail, establish food portion sizes with the use of a food atlas (Nelson et al. 1996) and to determine shopping habits and cooking methods. The follow up interviews helped to ensure that the information contained in the food diaries was as accurate as possible.

3.6.2 Food Composition Databases

Food composition tables such as the McCance and Widdowson 6th edition (1996) are comprised of many chemically analysed foods eaten in the UK. These include composite foods such as homemade recipes and industrially processed foods of a similar nature; for example homemade lasagne versus retail versions. The tables can also be found as electronic databases e.g. Microdiet, DietPlan 6. They all differ in their application and some are more user

friendly than others, however in the UK they are all currently based the 6th edition McCance and Widdowson food composition tables. Liverpool John Moores University currently holds a licence for Microdiet, therefore data from the food diaries were inputted and analysed using Microdiet.

3.6.3 Interviews for the follow up qualitative phase

There are a number of different types of interviews conducted in research, which can yield varying depths of data. Interviews can contain closed questions, open questions or both and can be carried out in group settings such as focus groups or on an individual basis (one-to-one) (Draper and Swift 2011). They can be conducted in various settings including face-to-face, over the phone or via the internet. It is the research design that will influence which approach is adopted. However, according to Rees (2011) interviews have become the most common form of data collection in qualitative research. They are defined by, Tashakkori and Teddlie (2009), as a powerful data collection strategy when employed as a one-to-one interaction between the researcher and the interviewee. It provides the interviewer with the opportunity to ask for explanations of answers that appear vague or to provide clarification to the interviewee for unclear questions. Interviews can be categorised according to the degree of structure or format of the questions. They encompass both ends of the spectrum with structured interviews that have a specific order of questions with exact wording and all respondents are asked the same questions in an exact sequence (Tashakkori and Teddlie 2009). This approach however, lacks the opportunity for spontaneity and tends to be rather superficial (Rees 2011). At the other end of the spectrum are unstructured interviews that tend to use an interview guide but enable the participant to describe and elaborate on

what they see as relevant as opposed to what the researcher deems to be important. This generates an enriched depth of data that requires a considerable amount of time to analyse and code, therefore the number of questions and participants tend to be quite small (Rees 2011). A juxtaposition of these two approaches is the semi-structured interview, in which an interview guide is used and pre-defined questions relating to a topic yet has the flexibility to probe and explore issues that are deemed appropriate to the individual concerned (Rees 2011). Thus, semi-structured interviews enable the collection of rich narrative data that can provide a unique view of the experiences of those who are being interviewed. At the same time, the semi-structured approach enables the interviewer to maintain some control over the topics discussed and steer the interviewee back on course should the conversation deviate from the topic of interest (Draper and Swift 2011).

There are some disadvantages to the interviewing process that need to be considered. Firstly, interviewing is a costly method in terms of both time and expense. It is common practice to interview participants in a place and at a time that is convenient to them, hence there may travel expenses incurred for either the participant or the researcher. Additionally there is the time taken to travel to the chosen venue. Furthermore, the transcribing and analysing of the interviews can be a lengthy experience. It is estimated that one hour's worth of interview can take anywhere between 5 and 6 hours to transcribe (Bryman, 2001). Finally, the quality of the interview data is driven by the skills of the interviewer, which for a novice interviewer can develop over the course of the study period.

In this study an interview guide was developed to ask questions relating to aspects of body weight, dietary intake and health of some of the participants

that would enhance and explain some of the results that the quantitative phase generated.

3.7 ETHICAL CONSIDERATIONS

The ethical issues surrounding research involving pregnant women are very complex. There are international guidelines drawn up to protect pregnant women and the growing foetus from harm as a result of participating in research studies (CIOMS 2002). Blehar (2013) asserts that pregnant women, along with foetuses and neonates are considered to be vulnerable people. There is a fear of harm to the foetus, due to a complex physiology associated with pregnancy, which is not fully understood, and the threat of legal liability, which are cited as the main reasons why there is a reluctance to consider pregnant women as research participants. As a result, the clinical care of pregnant women is not always driven by evidence derived from pregnant populations because medical researchers have been reluctant to include them in clinical intervention studies (Blehar et al. 2013). Guidrey-Grimes and Victor (2012) concur, suggesting that researchers would need to provide proof of a significant probability of a direct benefit with minimal potential harm to both the woman and the foetus (Guidry-Grimes and Victor 2012). Lupton and Williams (2004) describe two main areas of medical research, that of therapeutic and non-therapeutic research. Non-therapeutic research, in which there is no immediate or direct benefit to either the foetus or pregnant women, is perceived as being harder to justify as the subject is altruistically participating for the benefit of science (Lupton and Williams 2004). However, the ethical implications regarding the participation of pregnant women in research, relate to clinical interventions and RCT's where

they may be a realistic possibility of foetal abnormality as a result of the pregnant women's participation in a research study.

These issues have created much debate in the literature, with arguments that the foetus is classed as a patient in obstetric practice and is therefore a foremost consideration in research on pregnant women (McCullough and Chervenak 2011). However, as there is a need to collect data on how to treat disease and illness in pregnancy (Lyerly et al. 2011) and in the relatively new phenomenon of how obesity affects both maternal and foetal outcomes, there is a clear need to determine how nutritional intakes impact on weight gain during pregnancy and subsequently maternal and foetal health.

Prior to the commencement of the data collection, the study protocol received rigorous scrutiny by the National Research Ethics Service (NRES 2014) North West Committee, which forms part of the NHS Health Research Authority (HRA). The authority sets out to protect the rights safety, dignity and well–being of research participants whilst facilitating and promoting ethical research that is of potential benefit to participants, science and society.

In this instance, the panel determined that the study posed no risk to the pregnant women or foetus and approval for the study was granted. Ethical standards were maintained throughout the duration of the study and ethical approval sought from NRES for any changes to the study protocol.

3.8 ANALYSIS STRATEGY

Mixed methods research designs involve the collection and analysis of both quantitative and qualitative data. Whether the data is analysed concurrently or sequentially will depend on which type of mixed methods research design is

adopted. In mixed methods sequential explanatory research design employed in this study, the data analysis is sequential in that quantitative data is collected and analysed first with the results informing the approach taken with the qualitative phase, see figure 3.2.

3.9 QUANTITATIVE PHASE ANALYSIS STRATEGY

As described earlier, estimated food diaries were selected as the most appropriate method of generating data regarding the nutrient intakes in the sample population. The participants were asked to complete a 3 day food diary prior to their visit to the research clinic at three intermittent time points. Interviews were conducted at the research clinics during which portion sizes were verified using a photographic atlas of food portion (see the methods chapter 4 (section 4.1.3) for detailed description of methods used). All food and drink items were coded and entered into the Microdiet database, as an estimated weight in grams, which provided a detailed nutrient analysis of both whole and composite foods consumed. Coding of the food and drink items ensured continuity as individual codes represented an analysed nutrient content of a specific item, for example one slice white bread would be coded as 11468 and this code would be entered each time a participant specified white bread in their diaries. The researcher selected the nutrients chosen for analysis. Macronutrients consisted of total fat; SFA, MUFA, PUFA; protein and carbohydrate including total sugars and NSP. The micronutrients selected for analysis consisted of calcium, iron, folate, vitamin D and iodine.

Mean values were generated from all the nutrients which were collected from the participants over a 3 days at 3 intermittent time points: 16, 28 and 36 weeks gestation. These mean values were then condensed down to provide mean intakes for the 3 days of all the selected nutrients for each participant and input into the Statistical Package for Social Scientists (SPSS) v21. Further variables relating to maternal characteristics, pregnancy and birth outcomes were also input into SPSS. These variables were generated as part of the wider FFB study and initially recorded by other members of the research team. Maternal characteristics include BMI, age, smoking status and parity. Pregnancy outcomes related to GDM, pre-eclampsia, hypertension and weight change. Birth outcomes relate to live birth, birth weight, delivery mode, APGAR score (1 min & 5 min) and admission to SCBU.

3.10 DESCRIPTIVE STATISTICS

Means, standard deviations and medians were calculated for macronutrient and micronutrient intakes for all 3 visits and were presented as a percentage of total energy and as a ratio of energy in MJ/d.

Frequency and percentage distributions of maternal characteristics, pregnancy and birth outcomes relative to nutrient intakes were generated.

It is a well-documented reality that obese people can under-report total energy intake by as much as 30% (Rennie et al. 2007), therefore, calculations to determine the level of misreporting of total energy intake were also undertaken using the Schofield equation to determine BMR and a Goldberg cutoff of 1.55 to

determine physical activity ratio (PAR). The relevance and limitations of this calculation are discussed in more detail in chapter 6 (section 6.4.4).

Comparisons of associated nutrients were also compared; for example iron intakes relative to protein, an indicator of the sources of protein, and vitamin D relative to calcium.

Descriptive statistics enabled the data to be tested for normal distribution, which is done to determine whether the variables meet the assumptions of parametric tests. The distribution is characterised by a bell-shaped curve and is reflective of the frequency distribution, with the greatest frequency of scores in the middle and fewer frequencies towards the extremes. Data demonstrates skew if the curve is not symmetrical or kurtosis if the curve has pointiness (Field 2009). A Kolmogorov-Smirnov (K-S) test compares the scores in the sample to a normally distributed set of scores with the same mean and standard deviation. Thus a K – S score of $p \leq 0.05$ denotes a significant difference and therefore the sample is said to be a non-normal distribution (Field 2009). (See table 1 appendix 4).

Data that were skewed were transformed; this involves modifying the data using mathematical formulas until the data appears more normal, the formula used is dependent upon the shape of the distribution (Pallant 2013). Explorations of outliers to skewed data determined that they were valid data points, which should be included in the analysis.

Both descriptive and inferential statistics were employed to study the relationships between the variables and to compare statistically significant differences between groups.

3.11 INFERENTIAL STATISTICS

Dietary data were compared to outcome variables using correlations, Chi Square, t-tests and ANOVA test to determine any associations.

3.11.1 Chi-square tests for independence

This test explores the relationship between two categorical variables (Pallant 2013). For the purposes of this study, continuous variables relating to maternal characteristics, pregnancy and birth outcomes and energy and nutrient intakes were categorised. The chi-square test was conducted to determine any association between BMI and achievement of nutritional recommendations. In addition, achievement of nutritional recommendations was explored in association with pregnancy and birth outcomes.

3.11.2 Correlations

Correlation analysis describes the linear relationship between two continuous variables in terms of both the strength and direction (Pallant 2013). In this study, the relationships between nutritional intakes and maternal weight change and infant birth weight were explored.

3.11.3 Independent samples T-test

This test is used to compare the mean scores of two different groups of people. In this study different groups related to micronutrient variables such as vitamin D and iron being compared to dichotomous pregnancy outcome variable such as pre-eclampsia or GDM.

3.11.4 Paired sample T-tests

This test is used to compare the mean scores for the same group but on different occasions or when you have matched pairs. In this study, both of these characteristics applied. The test was conducted on women who completed estimated food diaries at visit 1 (V1) and at visit 3 (V3). Matched pairs applied because 99 women completed a diary at V1 and 73 at V3 but not necessarily all that completed a diary at V1 completed one at V3.

3.11.5 ANOVA

This test is used to compare the mean score between more than two different groups (Pallant 2013) and in this study was used to compare nutritional intakes with participants according to BMI classification.

3.11.6 One Way Repeated measures ANOVA

A one way repeated measure ANOVA compares within subject scores over different time points (Pallant 2013). In this study it was used to determine if there were any statistically significant differences between nutritional intakes between the 3 visits.

3.12 QUALITATIVE PHASE – ANALYSIS STRATEGY

Attride-Stirling (2001) suggests that if qualitative research is to yield meaningful and useful analysis then the material must be scrutinised in a methodical manner. Qualitative research is seen as a highly complex, diverse and nuanced form of research (Braun and Clark 2006) and as such there are a diverse number of approaches to the analysis of qualitative data. Tashakkori and Teddlie (2009) identified three general types of qualitative data analysis strategies; categorical strategies, contextualising strategies and data displays. Although Gibbs (2007) states that the common strategy in all qualitative analysis is to code and categorise the data (Gibbs 2007). Categorical strategies include content analysis and grounded theory techniques, whereas phenomenological, narrative and ethnographical analyses and critical theory approaches fall within the contextualising or holistic approach. However, all approaches feature a form of thematic analysis in which data is scrutinised for emergent themes or patterns. Nevertheless, it is still considered a poorly branded method that is not often named as the main method of analysis in comparison to other forms of analysis (Braun and Clark 2006). It is however, used interchangeably with content analysis, as researchers often cannot always distinguish between the subtle differences between the two, which, mainly relates to the opportunity for the quantification of data found with content analysis. Conversely, thematic analysis provides a detailed and nuanced account of qualitative data (Vaismoradi et al. 2013). Braun and Clark (2006) describe thematic analysis as the foundation of qualitative analysis and a stand alone method. They argue against the opinion of Ryan and Bernard (2000) cited in Braun and Clark (2006) who assert that 'thematic coding can be located

within major analytic traditions rather than a specific approach in its own right'. They further argue that thematic analysis may go much further by interpreting various aspects of the research topic (Braun and Clark 2006). This is also reinforced by Boyatzis (1998) cited in Tashkkori and Teddlie (2009) who describes thematic analysis as a 'way of seeing' by moving the researcher through three phases of inquiry; seeing, encoding and interpreting. Thus, it enables the researcher to find out about the actual perceptions, behaviours and motives of the people being studied (Vaismoradi et al. 2013).

In the qualitative phase of the Fit for Birth Plus study, the intention was to draw upon the lived experience of the women to enhance and explain the findings of the quantitative phase. Thematic analysis is a form of qualitative analysis commonly used in health and social research. The analysis strategy adopted for the qualitative phase of this research is that of thematic analysis. Data was collected during one to one interviews with the women and recorded on Olympic digital voice recorders and transcribed verbatim by the researcher. This enabled the researcher to become familiar with the data to ensure effective analysis (Fade and Swift 2011). The transcripts were each given an identification code and the participants given a pseudonym to ensure anonymity and confidentiality.

3.13 SUMMARY

This chapter has described Fit for Birth plus (FFB+) and how it fits into the Fit for Birth (FFB) study in its wider context. Furthermore, it describes the methodology underpinning this research study. Additionally, it provides a clearly

defined justification of the data collection methods, analyses and approaches used for both the quantitative phase and the qualitative phase. This study used a sequential explanatory mixed methods design conducted over two distinct phases. In phase one data were collected relating to dietary intake in pregnant women with a BMI ≥35kg/m^2 and compared against pregnancy and birth outcome data that was collected as part of the wider FFB study. A convenience sample, of 225, were recruited at LWH to participate in FFB+ of which 140 completed at least one estimated food diary. Descriptive and inferential statistics were used to analyse this data. The second phase was conducted as follow up study in which a purposive sample was conveniently recruited to participate in semi-structured interviews. The aim was to explore the lifestyles and lived experience of some of the women to gain an understanding of their food choices and behaviours to help support and explain some the findings from the first phase. This data was analysed using thematic analysis. The data collection methods are described in more detail in the following chapter.

4 CHAPTER 4: METHODS

As previously described in chapter 3 (3.3), the study takes a sequential explanatory mixed methods approach with two distinct phases. Phase one involved the collection and analysis of quantitative data relating to dietary intake, this was followed by the second phase in which semi structured interviews took place. The qualitative data collected from these interviews enabled a more holistic overview of the factors that determined these women's eating behaviours and the varying influences that lead to the overweight and obesity in the first place. Using a mixed methods study design enables the weaknesses and strengths that apply to both quantitative and qualitative approaches to be offset as described in chapter 3 (section 3.3). Having an understanding of how these underlying factors influence eating behaviours could be a key determinant when it comes to the planning and design of future interventions to address the problem of obesity in pregnancy.

4.1 PHASE ONE – QUANTITATIVE STUDY

4.1.1 Recruitment

As described in chapter 3 (section 3.6) the sampling strategy employed by the FFB study took a pragmatic approach. Women were invited to participate in the Fit for Birth study at their antenatal booking in appointment, which normally occurs anytime between 10 to 14 weeks gestation. There are a number of booking in centres, in and around the Liverpool area from which the women were recruited and these are; LWH, AUH, the May Logan centre in Bootle, Kirkby Health Suite, Yew Tree Centre in Dovecot and 5 Centre in Speke. The

study was designed with 2 distinct arms. In the first arm of the study, women with a BMI ≥30kg/m^2 were asked to participate in intermittent weighing when attending routine antenatal appointments at participating centres. This data was collected and recorded by the community midwives in both the participant's medical record and in the handheld notes, retained by the participant's until presentation at the maternity wards for delivery.

The second arm of the study was to generate information in a subset of women recruited with a qualifying BMI ≥35kg/m^2 relating to lifestyle factors i.e. nutritional intake, physical activity levels, quality of life and sleep apnoea. A range of tools including validated questionnaires, direct measurements and estimated food records were used to collect the data.

The recruitment took place between June 2009 and June 2010, however, there was a lag period from recruitment of women in the last 3 months of recruitment until delivery resulting in an actual data collection period of 18 months. For the purposes of this thesis, only data relating to nutritional intakes will be reported and data that pertains to physical activity, quality of life and sleep apnoea is reported elsewhere.

Full ethical approval was sought and approved by IRAS and funding for the study, was provided by MerseyBeat and subsequently LivHIR; sub divisions of the Liverpool Health Inequalities Research Institute. The institute focuses on reducing health inequalities in the city of Liverpool and full consideration to the inclusion of pregnant women with obesity in research was fully deliberated, as described in chapter 3 (section 3-7). A collaborative alliance between the University of Liverpool, Liverpool PCT/CCG and Liverpool John Moores University was formed to complete this research project.

4.1.2   Inclusion Criteria

The inclusion criteria for FFB was a BMI ≥30kg/m^2 and BMI ≥35kg/m^2 for FFB+, singleton pregnancy and aged 18 years and over at the time of recruitment.

Figure 4-1 illustrates the process by which women's eligibility was determined.

Figure 4-1: Fit for Birth Eligibility Rates from LWH Population

Total number of women who were booked in for antenatal care at Liverpool Women's Hospital in 1 year period from June 09 – June 10 **8112**
LEVEL 1

Number of eligible women booked in with a BMI≥30kg/m² in same period **1541**

Number of eligible women who consented to extra weighings at booking **824**

Excluded women
Twins = **3**
Under 18 = **8**

Women who later dropped out = **7**

Deliveries that took place elsewhere therefore no recorded data = **42**

Number of eligible women who consented to Fit for Birth **764**
LEVEL 2

Number of women with a BMI≥35kg/m² who consented for Fit for Birth plus **221**
LEVEL 3

Number of eligible women who attended at least 1 Fit for Birth research clinic **151**

Number of women who completed at least 1 food diary **140**

Number of women who completed 3 food diaries **41**

113

4.1.3 Data collection

Women who formally consented to participate in the second arm of the study, FFB+, were invited to attend 3 research clinics at 16, 28 and 36 weeks gestation where information regarding the rationale for the study was explained in detail. Copies of the consent form were kept in the handheld notes that accompanied the women to antenatal appointments.

Data regarding nutritional intake were collected using 3 day estimated food diaries. A food diary was sent out by post ten days prior to appointments with a request to record 3 days food intake and to bring it to the research clinic. The women were not asked to keep weighed food diaries as it was felt that this would deter them from participating but they were asked to provide as much detail as possible including all snacks, drinks and condiments. A follow up interview took place at the research clinic where the diary was scrutinised and assessed. A photographic atlas of food portion sizes was used to estimate the portion size of a range of specific cooked foods including composite meals, Shepherd's Pie and Lasagne for example. A wide selection of variously cut and cooked vegetables are illustrated in the atlas and can be used to approximate portion sizes of similar vegetables (Nelson et al. 2002). Information regarding shopping habits and food preferences were also noted. Supermarket websites were accessed to calculate portion sizes of processed foods and the current weights of a range of consumables such as, confectionary, cakes, biscuits, tinned foods and packet foods.

Recipes of certain less familiar composite foods were collected and calculations to estimate portion size, water and weight loss during cooking, as well as normal wastage attributed to the preparation of home cooked foods, were made.

The data generated from the food diaries was then coded and input into Microdiet V1.1 as a weight in grams and analysed to determine the macro and micronutrient content of the inputted foods. Mean values were established for a range of nutrients selected by the researcher and included total energy in kcals and total fat, SFA, PUFA, MUFA, CHO, protein. The macronutrients were determined as weights in grams but also converted to kcals which enabled the contribution of CHO, total fat and protein to total energy to be established. Additionally, micronutrient intakes in either milligrams (mg) or micrograms (µg) were determined.

4.1.4 Microdiet

Ideally, foods in a food composition database such as Microdiet™ would be based on the same representative samples, but in reality they are subject to both inherent and acquired variability (Pennington 2008). This is likely to be because the values are not exact and are based on mean values of imputed foods. Additionally, the foods are subject to wide nutrient variation as the data is aggregated from different sources and reflect differing analytical methods, seasonal and environmental factors as well as differing processing, preservation and cooking methods (Sievert et al 1989). Therefore, the dietary results do not reflect the true nutritional status of the women, but offer an

estimation of dietary intake at a given time based largely on self-reported information provided by the participant.

4.1.5 Statistical Analysis

Data were collected for total energy intake, macronutrients and a number of micronutrients such as iron, calcium, iodine, folate and vitamin D. The food diary data was compared against pregnancy and birth outcome data, which were collected by midwives at the LWH as part of the routine antenatal care.

Pregnancy and birth outcome data were collated from the hospital database MEDITECH by the study administrator and recorded anonymously in the FFB study data set. Primary outcome data related to composite negative outcomes, represented by an uncomplicated pregnancy and delivery, and defined as an absence of the following: stillbirth, spontaneous abortion or termination, gestational hypertension or diabetes, labour induction or augmentation, caesarean section or operative vaginal delivery, shoulder dystocia, 3/4th degree tear, hospital stay over 3 days, birth before 37 completed weeks, birth weight > 90th centile or < 10th centile, antenatal and postpartum haemorrhage (>1000mls). Secondary negative outcomes related to the known pathological effects of obesity and were identified as: pre-eclampsia, macrosomia (bw >90th centile), IUGR (bw <10th centile), GDM and postdates pregnancy (defined as gestational age at delivery of over 41 weeks and 3 days) (Narayanan et al 2015). The results of FFB are reported elsewhere and only data from women who consented to FFB+ and completed at least one estimated food diary were included in this analysis.

The data was imported into IBM SPSS version 21 in order to statistically analyse.

4.1.5.1 Descriptive Analysis

The data were explored to provide a numerical description of maternal characteristics, pregnancy and birth outcomes and nutritional intakes. This data is presented in a series of graphs and tables in the following results chapter. The descriptive analysis provided the following descriptives:

- Frequencies of maternal characteristic according to BMI classification
    - Age, parity, smoking status, GW change at 36 weeks
- Frequencies of pregnancy and birth outcomes according to BMI classification
    - Hypertension, pre-eclampsia, gestational diabetes, live birth, induction of labour, mode of delivery, admitted to SCBU, APGAR score 1min, APGAR score 5 minutes, birth weight
- Frequencies of total energy according to BMI classification relative to visit 1, 2 or 3
- Mean intakes of total energy (kcals), macronutrients and micronutrients relative to visit 1, 2 or 3
- Macronutrient intake as a percentage of total energy
- Micronutrient intake as a percentage of total energy
- Mean ratio's of macronutrients as a ratio of MJ/d
- Comparisons of iron relative to protein and vitamin D relative to calcium

- Determination of misreporting of total energy intake using the Schofield equation and Goldberg cut off of 1.55 PAR.

Many of the continuous variables collected during phase 1 were collapsed into groups to generate categorical variables to enable the following statistical testing. The results of these tests are described alongside the tables and graphs that illustrate the descriptive analysis. A more detailed description of the tests used to provide inferential statistics is provided in chapter 3 (section 3-12).

4.1.5.2 Inferential statistics

- Chi-squared tests for independence
- Independent samples t-tests
- Paired samples t-tests
- One-way ANOVA
- One-way repeated measures ANOVA
- Pearson's Correlation Coefficient.

4.2 PHASE 2 – QUALITATIVE STUDY

4.2.1 Recruitment

A pragmatic approach was taken to the recruitment of FFB+ as described in chapter 3 (section 3.6), as such a purposive sample of women was conveniently recruited from the existing Fit for Birth Plus (FFB+) dataset. The women were located from the FFB+ data set and approached via the telephone. There was between a 1 to 2 year time lapse between participation in FFB+ and the qualitative interviews. The intention was to recruit women who had consented to FFB+ and include women who had participated as well as those who had not, to determine the reasons why. The nature of the qualitative research was made explicit to the women during recruitment to ensure that anyone sensitive to the issues would not feel obliged to participate. Following discussion with the supervisory team it was decided that all women from that subset should be included in the recruitment regardless of pregnancy outcome. Due to the sensitivity of this criterion inclusion, recruitment took place at Liverpool Women's Hospital which enabled access to the women's maternity records, thereby reducing the chances of further distress to potential participants, this was in compliance with the ethical considerations as described in chapter 3 (section 3.8). During the recruitment process, checks were made for each participant to determine pregnancy outcome prior to making the call. In the event, two of the women who agreed to participate in the follow up study had spontaneously aborted at 24 and 26 weeks respectively during FFB+ 1st phase.

Of the FFB+ women, 140 women attended at least 1 research clinic appointment and 143 women who initially consented, did not attend any clinic

appointments. After postcode checks at least 65 women were found to be ineligible as they lived outside the Liverpool area. Women who lived outside the Liverpool PCT were not included in this part of the study as a condition of the funding. A report to LivHIR was included to determine the barriers and drivers to the uptake of maternity services within the Liverpool PCT. However, postcodes were not checked for 52/143 women drawn from the non-attenders as the researcher had recruited a sufficient sample.

The recruitment took place between July 2011 and March 2012 and was conducted periodically to ensure appointments were made within the shortest possible timeframe from the initial call. A further call or text message was made by the researcher a day or two before the appointment to check the participant was still available and happy to proceed.

The recruitment process proved to be challenging; many attempts to contact potential participants were met with answer phone messages some of which screened unknown numbers and many calls remained unanswered. There were also many numbers that had ceased to exist. Therefore, permission was sought and granted from North West Research Ethics Committee to contact the 'hard to reach' women via letter. Thirty-five such letters were posted out to women inviting them to participate but this received a zero response. Of the eligible women with whom contact was made, 12 declined to participate any further in the study. The main reasons cited were, a return to work or too long a time lapse between original involvement in FFB+ and the follow up. Twenty-two women accepted the invitation (including 2 women who had lost their babies

during the second trimester) and appointments were arranged. On two separate occasions on arrival at the participant's homes at the appointed time, the researcher found no one home. The researcher made one further attempt to contact them but on receiving no response treated them as withdrawals from the study. The ethics agreement clearly stated that if the women chose to withdraw for any reason then no further contact would be made, this was to ensure that there would be no perceived change in clinical treatment now or at any time in the future. Two further withdrawals occurred when the participants failed to respond to texts or calls just prior to the appointment time. In total data were collected from 18 participants. Although this is lower than the number originally proposed, it was felt that every effort was made to recruit the sample.

The women were provided with an information sheet, on arrival at the agreed venue prior to the interview, detailing the aims and objectives of the research and were given the opportunity to withdraw at any point in the interview (Appendix 6).

4.3 THEMATIC ANALYSIS

The research took the form of semi-structured interviews using an interview guided approach. The interviews took place in the participants own home or in a place of their choosing, for example one interview was conducted at the interviewee's place of work. As described in chapter 3 (section 3.7.3) the choice of semi-structured questions enabled an open, direct dialogue between interviewer and interviewee, built around a set of predetermined questions, to elicit a detailed narrative (Whiting 2008). Pre-determined questions allowed for

the interviewer to maintain an element of control over the dialogue, thus preventing the interviewee from diverting too far from the subject themes while enabling flexibility to the order of the questions, so as not to interrupt the natural flow of dialogue (Nicholls 2009). It was important that the interviewer adopted a reciprocal and reflective approach so that participants felt that their voices could be heard and that it was not just a data collecting exercise (Whiting 2008). The women who consented to participate in the follow up interviews also gave consent for the interviews to be recorded. This was done using 2 Olympus digital voice recorders. The questions in the interview guide were devised to elicit responses relating to a number of research questions. The questions were designed to explore the women's experiences and the perceptions they had regarding diet, weight and health. The interviews varied in length from between 30 minutes to 50 minutes and all were conducted face to face. Following the interviews the recordings were manually transcribed, verbatim by the researcher who conducted the interviews. This ensured that the researcher remained familiar with the contents of the recordings and was able to interpret the emotional context and meaning of certain aspects of the dialogue. The transcripts were prepared with wider margins to facilitate the coding and theming of the text. The transcripts were given an identification number and the participant a pseudonym to ensure complete anonymity and confidentiality. In qualitative research thematic analysis is used to identify patterns or themes that emerge from the data (Braun and Clark 2006) using coding. Coding is also referred to as theming, indexing and categorising (Gibbs 2007) and can be defined as a label attached to narrative data which can be applied to one word, a group of words, a whole sentence or even a paragraph (Fade and Swift

2011). For this study, once the recordings were transcribed, the transcripts were read and reread. The transcripts also underwent rigorous reading and re-reading by independent researchers to determine themes. Gibbs (2007) suggests that intensive reading of the transcript enables the researcher to decide what it is about by identifying chunks of text and coding it in a way that is theoretical and analytical, as opposed to being merely descriptive. The researcher applied this technique during the first order coding in which initial themes were identified. This was achieved using highlighter pens and writing the first order codes in the margins of the transcripts. Emergent themes were then colour coded according to generalised categories relating to subject themes (see appendix 10). Following initial coding, second order coding was applied to the text in which sub-themes were identified using tables. Finally, third order coding enabled the over-arching themes to emerge from the narrative data.

4.4   INTEGRATED RESULTS

Results from the quantitative data and the qualitative data are presented in the next chapter. Quantitative data is presented in tables and graphs with description of what tests were performed and the findings from the qualitative data are presented in a narrative form.

5 CHAPTER 5: RESULTS SECTION

5.1 INTRODUCTION

The purpose of this chapter is to present; firstly, analysed quantitative data that was collected at the LWH in the form of estimated food diaries. And secondly to present the findings of the qualitative study, which took the form of semi-structured interviews and were conducted at a place chosen by the participant. In the quantitative phase of the study, primary outcomes regarding total energy intake and total fat intake relative to birth outcome and maternal weight change, in addition to maternal BMI and birth weight of the baby, were assessed. Other data regarding micronutrient intake was also assessed in relation to maternal outcomes, as well as BMI and birth weight. The aims of the qualitative study were to explore lifestyle and the lived experience of a subset of the original cohort to support and explain the findings from the quantitative study.

5.2 PHASE 1: QUANTITATIVE RESULTS – ESTIMATED FOOD DIARIES

5.2.1 Characteristics of participants

Pregnancy outcome data was recorded for 140 women who completed at least one food diary. Available data regarding recorded maternal weights were variable and declined over time. Weight change data commensurate with nutritional intake data applied to 37 women and tests to determine association relate to weights recorded at approximately 36 weeks gestation. There was insufficient weight change data beyond 36 weeks to extrapolate or to derive any further measurable associations. The numbers of participants for the specific variables that are being tested are highlighted in table 5-1.

Table 5-1: Participant numbers for variable categories

Variable categories	Number of participants
Booking in BMI	140
Birth and pregnancy outcome data	140
Weight change at 36 weeks	39
Visit 1 16 – 20 weeks	93
Visit 2 28 weeks	99
Visit 3 36 weeks	73
2 completed diaries V1 & V3	46
3 completed diaries V1, V2 & V3	37

Time points are referred to as visits 1, 2 & 3. The timing of the visits would ideally have reflected differences in the 3 trimesters, however, booking in for antenatal care usually occurs between 10 and 14 weeks. Therefore, the earliest opportunities for appointments to the research clinic were between 16 weeks and 20 weeks. Those women whose first appointment was around the 20 week mark were recruited directly from the bariatric clinic. Subsequent appointments were scheduled for 28 and 36 weeks gestation.

The women were categorised according to BMI classifications of obesity at the time of booking in. The maternal characteristics highlighted in table 5-2 are presented according to BMI category.

Table 5-2: Maternal characteristics according to BMI classification

	Body Mass Index* (n140)			
	35-39.9 kg/m^2	40-44.9 kg/m^2	45-49.9 kg/m^2	50+ kg/m^2
Age (n140)				
18-24	15 (11)	4 (3)	4 (3)	1 (1)
25-29	32 (23)	13 (9)	6 (4)	4 (3)
30-39	27 (19)	16 (12)	4 (3)	3 (2)
40+	6 (4)	4 (3)	1 (1)	0
Parity (n140)				
Primip	32 (23)	10 (7)	6 (4)	5 (4)
Multip	47 (34)	27 (19)	8 (6)	3 (2)
Missing	1 (1)	0	1 (1)	0
Smoking status (n140)				
Given up	9 (7)	7 (5)	0	1 (1)
Smoker	8 (6)	6 (4)	4 (3)	0
Non-smoker	62 (44)	24 (17)	10 (7)	7 (5)
Missing	1 (1)	0	1 (1)	0
Gestational wt change at 36wks (kg) (n39)				
Less than 0	2 (5)	4 (11)	1 (3)	0
0-4.9kg	9 (23)	4 (10)	1 (3)	0
5-9kg	7 (19)	2 (5)	0	0
9kg+	7 (19)	1 (3)	1 (3)	0

Key: number of subjects within the range (% of subjects within the range)

Over half of the women (57%) have a BMI between 35 and 39.9kg/m^2 with the highest percentage in the 25 – 29 years age group. Just over 60% of the women were multiparous in all BMI ranges and 73% of all the women declared themselves as non-smokers.

5.2.2 Pregnancy and birth outcome characteristics

Maternal weights recorded at 36 weeks were categorised according to BMI and are presented in figure 5-1
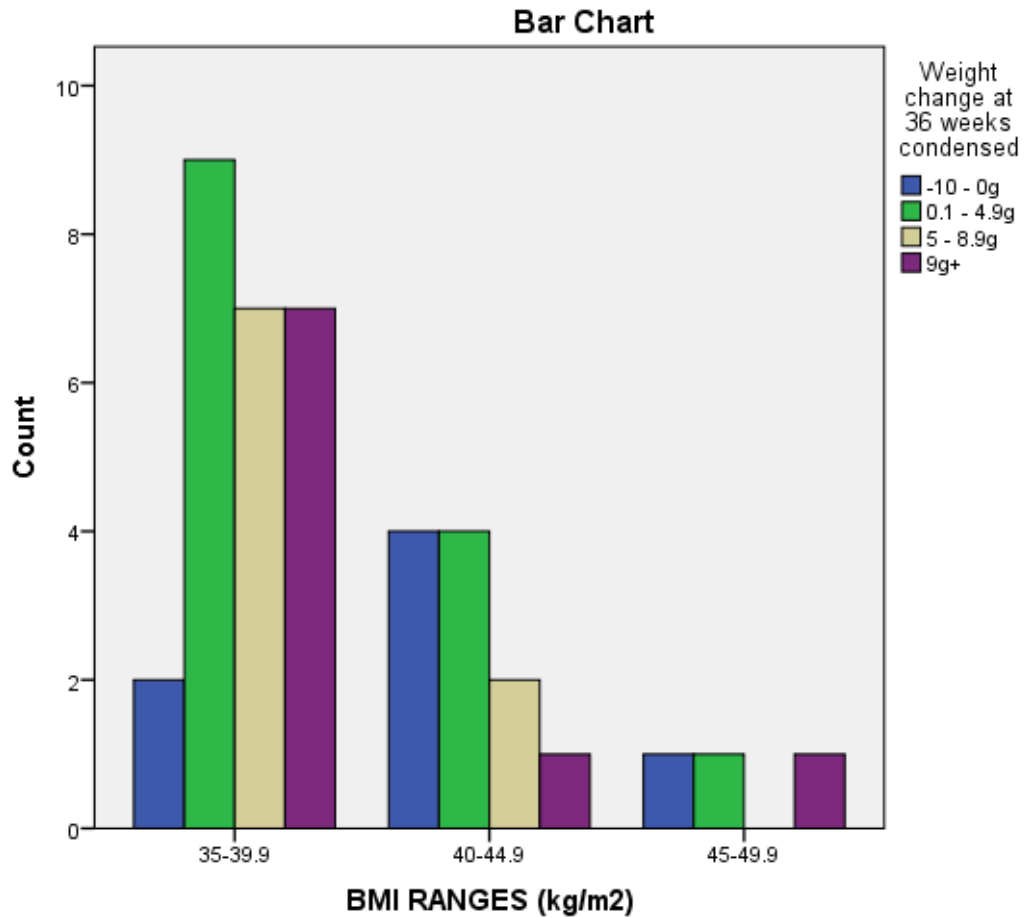
Figure 5-1: Weight gain at 36 weeks relative to BMI (n39)

Chi square tests for independence revealed no statistical associations between BMI and weight change at 36 weeks (p >0.05), however, 19% of the women who gained weight in excess of US IOM recommendations had a BMI 35-39.9kg/m^2 and a further 19% of women with BMI 35-39.9kg/m^2 gained weight within the IOM recommendations of 5-9kgs.

Pregnancy and birth outcomes are presented in table 5-3 outcomes for each

BMI category.

Table-5-3: Pregnancy and birth outcomes according to BMI classification

	Body Mass Index*			
	35-39.9 **80 (56%)**	**40-44.9** **37 (26%)**	**45-49.9** **15 (10.5%)**	**50+** **8 (5.6%)**
Hypertension Yes No	 7 (5.3) 69 (51.5)	 1 (0.8) 35 (26.3)	 2 (1.5) 12 (9)	 2 (1.5) 6 (4.5)
Pre-eclampsia Yes No	 10 (7.5) 66 (49.3)	 3 (2.3) 33 (24.8)	 3 (2.3) 11 (8.3)	 0 8 (6)
Gestational Diabetes Yes No	 6 (4.5) 70 (52.2)	 4 (3) 32 (24.1)	 1 (0.8) 13 (9.8)	 0 8 (6)
Birth outcome Live birth Stillborn	 75 (56) 1 (0.8)	 36 (27.1) 0	 14 (10.5) 0	 8 (6) 0
Induction of labour No Yes	 52 (38.8) 24 (18)	 24 (18) 12 (9)	 8 (6) 6 (4.5)	 5 (3.8) 3 (2.3)
Mode of delivery Vaginal Instrumental Elective caesarean Emergency caesarean (EmC) EmC with failure to progress	 39 (29.1) 6 (4.5) 13 (9.8) 14 (10.5) 4 (3)	 16 (12) 2 (1.5) 8 (6) 8 (6) 2 (1.5)	 7 (5.3) 2 (1.5) 2 (1.5) 3 (2.3) 0	 3 (2.3) 0 2 (1.5) 2 (1.5) 2 (0.8)
Admitted to SCBU No Yes	 67 (50.4) 8 (6.1)	 34 (25.8) 2 (1.5)	 13 (9.8) 1 (0.8)	 7 (5.3) 1 (0.8)
APGAR score 1 minute Critically low 0-3 Low 4-6 Normal 7-10	 3 (2.3) 11 (8.3) 61 (45.9)	 3 (2.3) 4 (3) 29 (22)	 1 (0.8) 4 (3) 9 (6.8)	 0 3 (2.3) 5 (3.8)
APGAR score 5 minutes Low 4-6 Normal 7-10	 2 (1.5) 73 (54.9)	 3 (2.3) 33 (25)	 0 14 (10.6)	 0 8 (6.1)
Birth weight (kg) 0.1-2.49 2.5-4.49 4.5-6.00	 6 (4.5) 67 (50) 3 (2.3)	 1 (0.8) 33 (24.8) 2 (1.5)	 1 (0.8) 12 (9) 1 (0.8)	 1 (0.8) 6 (4.5) 1 (0.8)

Key: number of subjects within the range (% of subjects within the range)

Chi-square tests for independence indicated that there were no significant associations with BMI and pregnancy and birth outcomes (p >0.05). However, some pregnancy and birth outcomes were significantly correlated. Induction of labour was negatively correlated to parity (r = -.256, p =0.003) suggesting that multiparous women are less likely to be induced. Additionally, parity was associated with incidence of pre-eclampsia (r = -.280, p =0.001), suggesting that primiparous women were more likely to develop pre-eclampsia and positively correlated to birth weight (r = .258, p =0.003) suggesting that multiparous women are more likely to have higher birth-weight babies.

5.2.3 Macronutrient intakes

Mean values, standard deviations and medians determined for self-reported measures of total energy, total fat, protein, CHO and CHO fractions are presented in table 5-4. Mean values for total energy suggest energy intakes commensurate or just below recommended intakes for women aged between 19 and 50 years. There is, however, a wide dispersion around the mean and an extensive range of intakes, reflecting a normal population distribution. Suitable reference body weight ranges consistent with long term good health are used to calculate energy reference values to account for the increase in overweight and obese individuals. Therefore, the calculation equates to the 50th centile for UK-WHO growth standards for adults at a BMI of 22kg/m^{2} (SACN 2010a).

Table 5-4: Reported macronutrient intake from 3 day estimated food diaries

Macronutrient	VISIT 1(16-20WKS) (n93)			VISIT 2 (28WKS) (n99)			VISIT 3 (36WKS) (n73)		
	Mean ± SD	Median	Range	Mean ± SD	Median	Range	Mean ± SD	Median	Range
ENERGY kcals	1849 ± 591	1751	764 - 4142	1984 ± 526	1917	870 - 3966	2066 ± 587	2027	483 - 3610
ENERGY kJ	7770 ± 2488	7343	3209 - 17493	8344 ± 2209	8088	3657 - 16624	8673 ± 2464	8501	1995 - 15064
PROTEIN (g)	71.8 ± 21.5	70	29 - 128	78.7 ± 21.3	77	30 - 141	83.8 ± 24	78.2	27 - 134
CHO (g)	252.2 ± 105	232	106 - 766	260.5 ± 84.3	249.4	99 - 526	259.7 ± 81.7	254.1	52 - 535
TOTAL FAT (g)	68.3 ± 25	65.6	26 - 157	76.6 ± 25	73.5	28 - 176	83 ± 31.2	78.1	19 - 156
TOTAL SUGARS (g)	116.5 ± 98	N/A	6.8- 711	123 ± 86	N/A	4.9 - 702	111.1 ± 77	N/A	6.1 - 556
STARCH (g)	128 ± 56	N/A	36.4 - 496	135 ± 50	N/A	8.7 - 317	142 ± 50	N/A	16.2-288
NSP (g)	12.8 ± 5.2	12.4	2.7 – 33.5	12.8 ± 4.1	12.9	4.6 - 26.4	12.8 ± 4.1	12.5	4 - 23

Mean intakes of total fat, protein and carbohydrate also showed a wide dispersion around the mean values but the overall means are proportionate to EAR's.

One-way repeated measures ANOVA's were conducted to compare mean scores for total energy, total fat, protein and CHO over all 3 visits (n37) but there was no statistical significance determined (P >0.05). However, paired samples t-tests conducted to compare the mean scores for macronutrients between visit 1 and visit 3 (n46) revealed significant increase in protein, total fat, SFA and MUFA suggesting intakes of these macronutrients increased significantly over time. These are shown in table 5-5 below. There were no significant scores for total energy, CHO or PUFA (P >0.05).

Table 5-5: Paired T-test comparing means between V1 & V3 (n46)

	V1 mean (SD)	V3 mean (SD)	Mean increase	95% CI of difference	Sig. (2-tailed)
Protein	74.4 (21.3)	81.2 (23.6)	6.8	0.9 - 12.6	0.025
Total fat	69 (26.3)	80 (31.2)	10.9	2.7 – 18.9	0.001
SFA	24.3 (10.8)	30.2 (14.1)	5.9	2.6 – 9.1	0.013
MUFA	22.1 (9.9)	26.1 (11.1)	4.0	0.9 - 7.2	0.021

5.2.4 Comparing BMI with macronutrient intakes

Energy intakes were classified according to BMI range. One way between groups ANOVA's were conducted to explore the differences in dietary intakes between participants in each BMI range in accordance with WHO (2013) BMI classification. Group 1: BMI 35 – 39.9kg/m^2; group 2: BMI 40 – 44.99kg/m^2; group 3: BMI 45 – 49.99kg/m^2 and group 4: BMI≥ 50kg/m^2. There was no statistical difference between the groups (p >0.05), however, a difference in intakes of CHO between group 2 and group 4: $F_{(3, 89)}$ = 3.74, p =0.014 was detected. Mean intakes of CHO were found to be higher in group 2 (BMI 40 – 44.9kg/m^2). However, a higher proportion of women across 3 out of the 4 BMI ranges did not achieve EAR for energy at visit 1 (see figure 5-2).
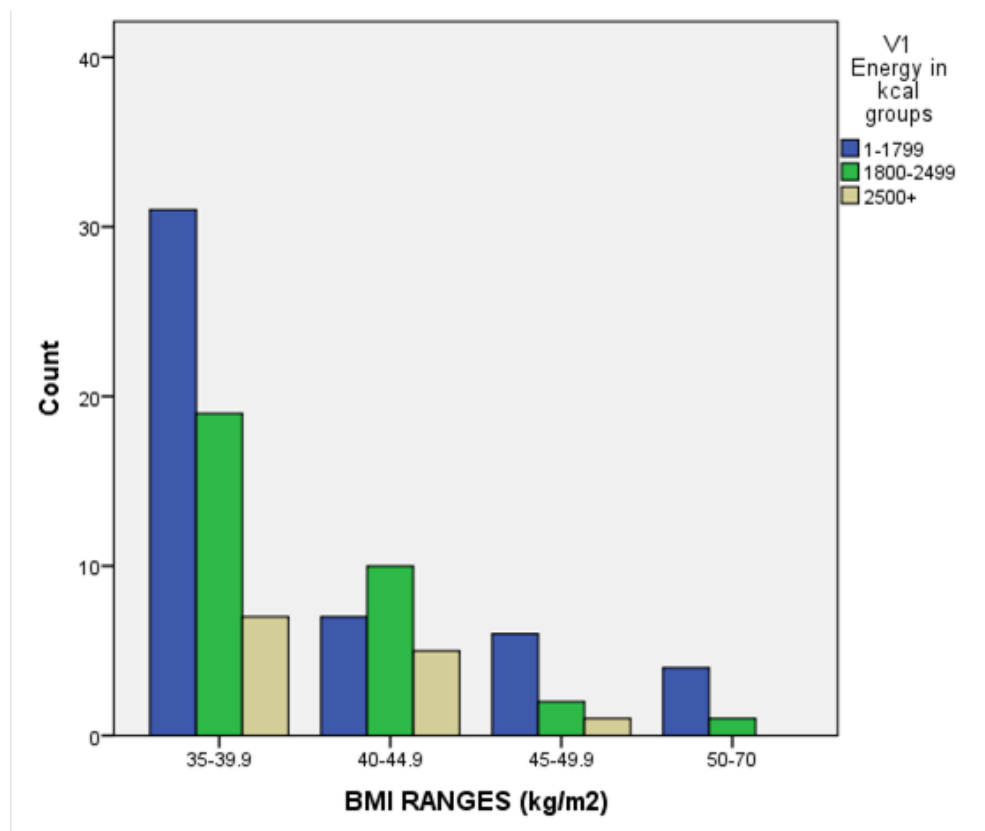
Figure 5-2: Energy intakes according to BMI range (V1)

The proportion of women achieving EAR for energy increased during visit 2 (see fig. 5-3) particularly in the 35-39.9 BMI range, however there were no statistical differences between the groups (p >0.05).
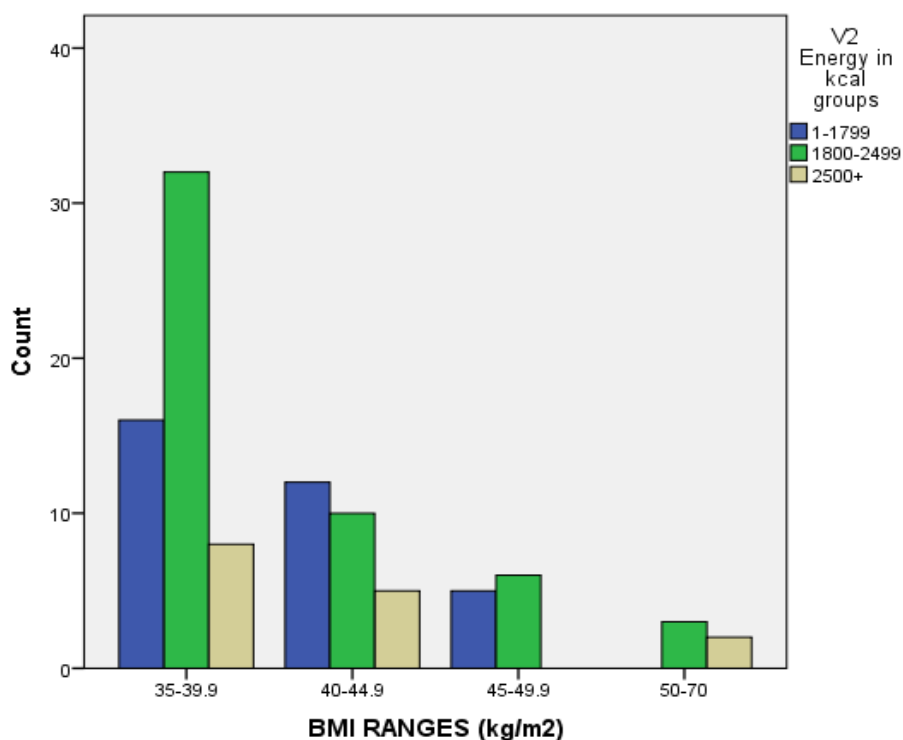
Figure 5-3: Energy intakes according to BMI range (V2)

Although, at visit 2, there were differences found between group 4 and the other groups for MUFA: $F_{(3, 95)} = 3.69$, (p= 0.015) and also for PUFA: $F_{(3, 95)} = 6.84$, (p=0.000), with mean intakes in group 4 (BMI ≥50kg/m^2) being considerably higher for both. There were no differences detected between groups 1, 2 and 3 (p >0.05).

The proportion of women achieving EAR for energy at visit 3 had also increased and there was also an increase in energy intakes in excess of 2500kcals/d but the increases were not statistically significant (p >0.05) (see fig. 5-4).
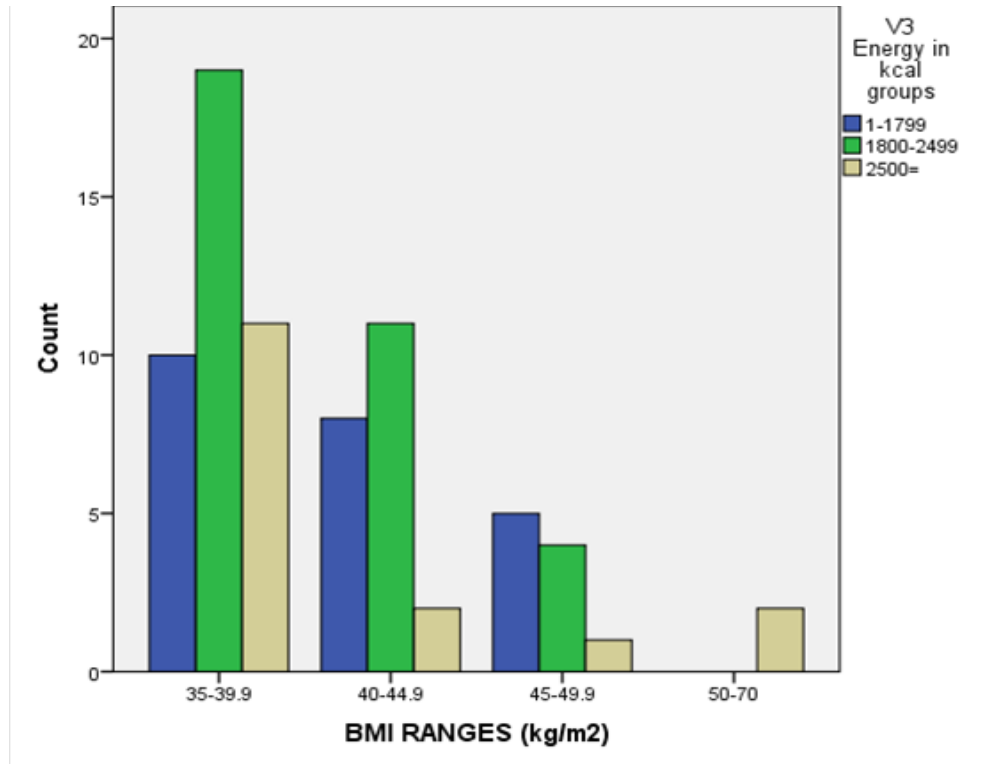
Figure 5-4: Energy intakes according to BMI range (V3)

There were statistically significant differences between V3 total energy between group 4 and those in group 3: $F_{(3, 69)} = 3.51$, $P = 0.02$ with mean intakes in group 4 significantly higher than the other groups, however, the numbers in this group were far fewer so it would be questionable to generalise this to the population.

Additionally, there were differences between group 4 and groups, 1, 2 and 3 for V3 total fat intakes $F_{(3, 69)} = 2.83$, $P = 0.045$, although, there was no difference with each other for groups 1, 2 and 3. This finding also applied for V3 MUFA $F_{(3, 69)} = 3.57$, $P = 0.18$.

5.2.5 Comparing birth weight with V3 macronutrient intakes

The relationship between birth weight and macronutrient intakes at visit 3 were investigated using Pearson's correlation coefficient. There were statistically significant negative correlations between birth weight and total energy ($r = -0.285$, $p = 0.014$), total fat ($r = -0.272$, $p = 0.020$) and total CHO ($r = -0.249$, $p = 0.034$). This implies that birth weight decreases as energy intakes increases.

5.2.6 Macronutrient intakes and quality of diet

Mean intakes for macronutrients in grams were converted into kcals based on standardised measures. Thus, CHO = 3.75kcals/g, protein = 4kcals/g and fat = 9kcals/g. This enabled the macronutrients to be calculated as a percentage of total energy, see table 5-6 below

Table 5-6: Reported macronutrient intakes as a percentage of total energy

	VISIT 1 (16-20WKS) (n93)	VISIT 2 (28WKS) (n99)	VISIT 3 (36WKS) (n73)	One-way repeated measure ANOVA (n37)
Macronutrient	Mean ± SD	Mean ± SD	Mean ± SD	
Total Energy (kcals)	↓1849 ± 591	↑1984 ± 526	↓2066 ± 587	P >0.05
Protein %E	↑16.0 ± 3	↑16.2 ± 3.4	↑16.6 ± 3.3	P >0.05
Fat %E	↓33.4 ± 6.8	↓34.8 ± 6.2	↑35.7 ± 6.2	P >0.05
SFA %E	↑12.0 ± 3.3	↑12.9 ± 3.2	↑13.3 ± 3.2	P = 0.038*
MUFA %E	↑10.7 ± 3.1	↑11.3 ± 2.9	↑11.5 ± 2.6	P >0.05
PUFA %E	↓5.6 ± 2.4	↓5.65 ± 2.1	↓5.8 ±2.1	P >0.05
P:S Ratio	↓0.51 ± 0.26	↓0.47 ± 0.23	↓0.46 ± 0.21	P >0.05
CHO %E	↑50.7 ± 7.5	↓48.9 ± 6.6	↓47.3 ± 6.8	P >0.05
NSP	↓12.8 ± 5.2	↓12.8 ± 4.1	↓12.8 ± 4.1	P >0.05
SUGARS %E	23.5	24.9	22.5	P >0.05
STARCH %E	26	27	28	P >0.05

↓↑The arrows indicate whether intakes were below or in excess of DRV's for pregnant women

Macronutrients were calculated as a percentage of total energy and the mean values of total fat, CHO and protein suggest the ratios were also consistent with EAR's. There is an increase in protein of 3.75% between visit 1 and visit 3 but intakes were in excess of the DRV of 51g per day for pregnancy. There was an increase in total fat of 6.9%, however, the increases were disproportionate between SFA, MUFA and PUFA with increases of 10.8%, 7.5% and 3.6% respectively, this is reflected in a 9.8% decrease in P:S ratio. There was decrease in CHO of 6.7% between visits 1 and 3 with a decrease of 4.2% in total sugars and 7.7% increase in starch. The mean intake of NSP remained at 12.8g/d for all 3 visits. Macronutrient values were proportionate to respective energy intakes at all 3 visits. One-way repeated measures ANOVA's were conducted to compare the macronutrients as ratios of energy across all 3 time points. There was a significant difference between SFA at V1 and V2, Wilks' Lambda = 0.83, $F_{(2, 35)}$ = 3.6, p= 0.038, where SFA as a percentage of total energy is much higher at V2. However, intakes are still in excess of the EAR for SFA.

A downward trend in P:S ratio suggests that the sources of dietary fat were not from healthier options but likely derived from unhealthy sources but this was not statistically significant. To fully appreciate the quality of dietary intakes, further measurements of macronutrient intakes as a ratio of energy per MJ/d were made between visits 1 & 3, as opposed to stand alone mean values, these are shown in table 5-7. This table reflects trends in the quality of diet over time and reinforces findings that the quality of dietary intake is not consistent.

Table 5-7: Comparison of mean ratio of macronutrients per MJ/d between V1 & V3

	Energy intake 8.1/8.13*	Total Fat g/d	SFA g/d	MUFA g/d	PUFA g/d	CHO g/d	Protein g/d	NSP g/d	Starch g/d	Sugars g/d
Visit 1	7.8MJ	8.8	3.2	2.8	1.47	32.5	9.2	1.64	15	16.5
Visit 2	8.3MJ	9.2	3.4	3.0	1.48	31.2	9.4	1.53	14.7	16.1
Visit 3	8.7MJ	9.6	3.6	3.1	1.54	29.9	9.7	1.48	12.9	16.5
% change	+11.5	+9.1	+12.5	+10.7	+4.8	-8.0	+5.4	-9.8	-14.0	NC

Macronutrient intake was measured relative to total energy intakes to determine whether participants had achieved EAR's. As described earlier the ratio for macronutrients intake as a percentage of total energy is approximately 50:35:15 CHO, fat and protein, based on CHO standardised to 3.75kcals/g, fat 9kcals/g and protein 4kcals/g. Protein has a RNI of 51g/d during pregnancy. A positive correlation between energy intake and macronutrient intake was demonstrated for all 3 visits. The following graphs (fig 5-5 to 5.7) demonstrate this relationship at 36 weeks gestation. This time-point coincides with the 3rd visit (n=73) to the research clinic and the last set of recorded weights that yielded sufficient data for analysis (n=39).

The relationships between total energy and protein, total fat and CHO were investigated using Pearson's correlation coefficient. Figure 5-5 shows a strong positive correlation (r= .789, p <0.001) between energy intake and protein however, there is a higher proportion of participants that under achieve both energy and protein requirements at 36 weeks gestation than those who achieve Figure 5-6 demonstrates a similar relationship with total energy and total fat (r = .878, p <0.001, but again, there are a higher proportion of participants that did not meet requirements for either energy or fat and the same applies to total energy and CHO (r = .868, p <0.001) see figure 5-7 which also illustrates a failure to achieve energy and CHO requirements.

The bold lines on the following graphs indicate the EAR's for total energy and the relative macronutrient intake.
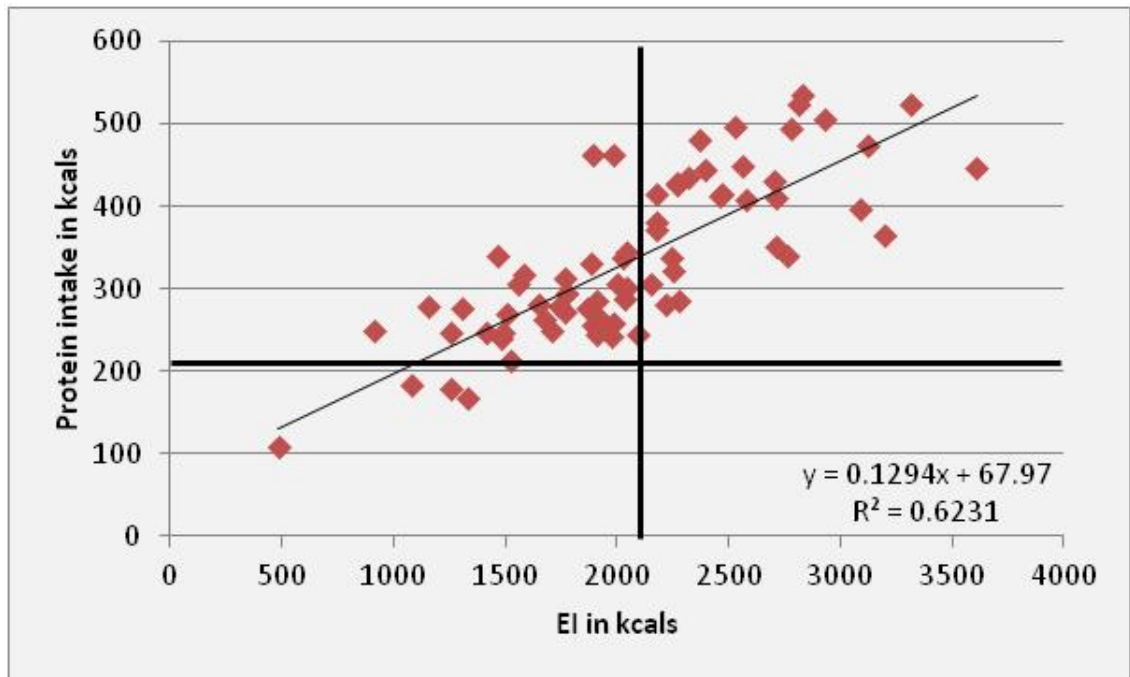
Figure 5-5: Protein intake in kcals relative to EI at 36 weeks
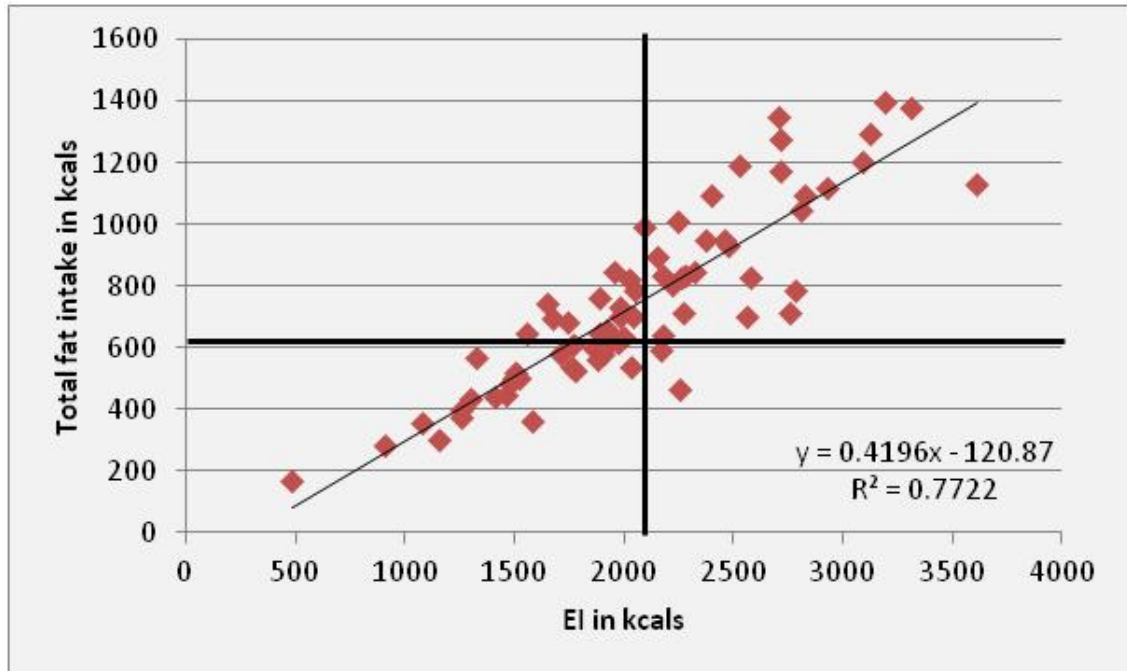
Figure 5-6: Fat intake in kcals relative to EI at 36 weeks
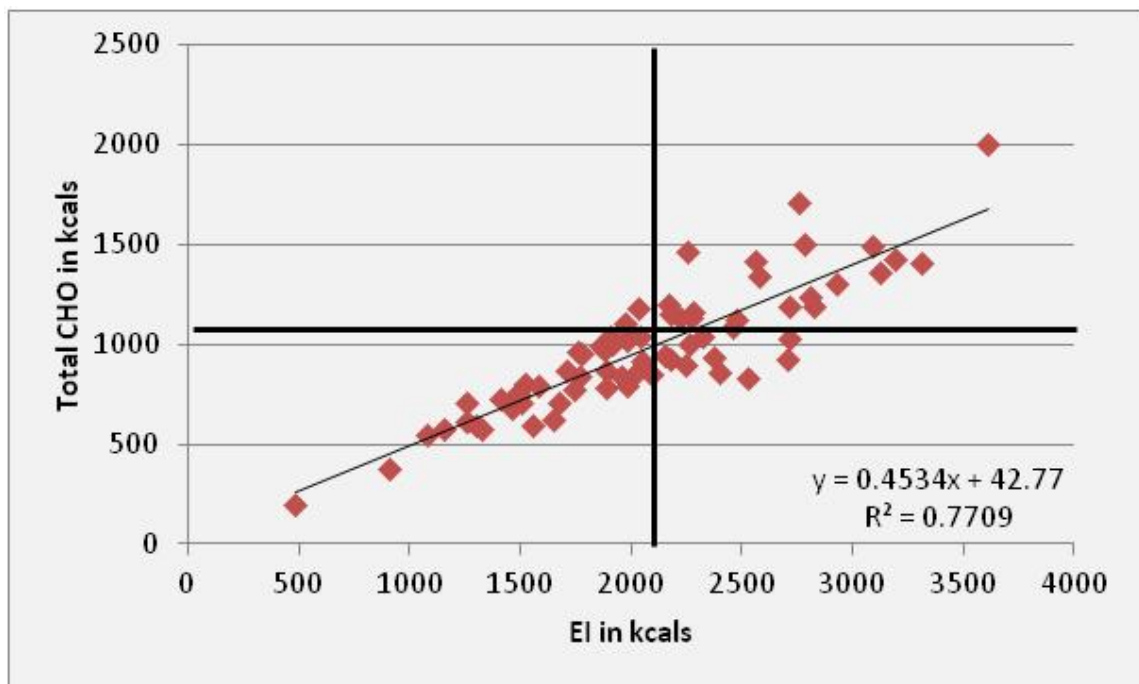
Figure 5-7: CHO intake in kcals relative to EI at 36 weeks

Calculations were then made to estimate levels of underreporting using the Schofield equation described in the methodology and a Goldberg cut off 1.55. The cut off was selected to reflect a sedentary lifestyle that may be assumed for pregnant women with a BMI ≥35kg/m^2. Results are presented in table 5-8 and estimate mean underreporting to be approximately 37% below EAR for energy at visit 1, 34% at visit 2 and 32% at visit 3.

Table 5-8: Characteristics to determine levels of mis-reporting of energy intake

	VISIT 1 (16-20WKS)			VISIT 2 (28WKS)			VISIT 3 (3WKS)		
	(n)	Mean±SD	Range	(n)	Mean± SD	Range	(n)	Mean ± SD	Range
Total energy in kcals	93	1849±591	764-4142	99	1984±526	870-3966	73	2066±587	483-3610
BMR	129	1957±268	1498-2828	115	1983±263	1558-2783	39	1956±220	1626-2489
EAR energy *	129	3033±415	2322-4383	115	3273±407	2615-4514	39	3233±342	2720-4057
EI as a % of EAR	86	63.5±22.7	21-128	82	61.4±16.8	27 - 112	29	65.6±16.3	14 - 91
EI:BMR	86	0.98±0.35	0.3–2.0	82	1.0 ± 0.3	0.4 – 1.8	29	1.1 ± 0.3	0.2 – 1.5

*Calculated using Goldberg cutoff of 1.55
Mean baseline BMI was calculated and recorded at initial booking in appointment (n140) 40.4 (SD 5.1)
Mean baseline BMR calculated from booking in weights using Schofield equation (n140) 1952 (SD 269)   Range 1520-2694
% of underreporting calculated by (EI:BMR/1.55) *100

5.2.7 Total energy intake and maternal weight

Energy intakes at 36 weeks were compared to maternal weight in the women at 36 weeks. Figure 5-8 suggests that there is little association between weight gain and energy intakes at 36 weeks and similar tests on data for visits 1 and 2 revealed no statistical significance between energy intake and weight change ($p > 0.05$).

The chart shows the trend line equation: $y = 0.0039x + 108.39$ and $R^2 = 0.0204$
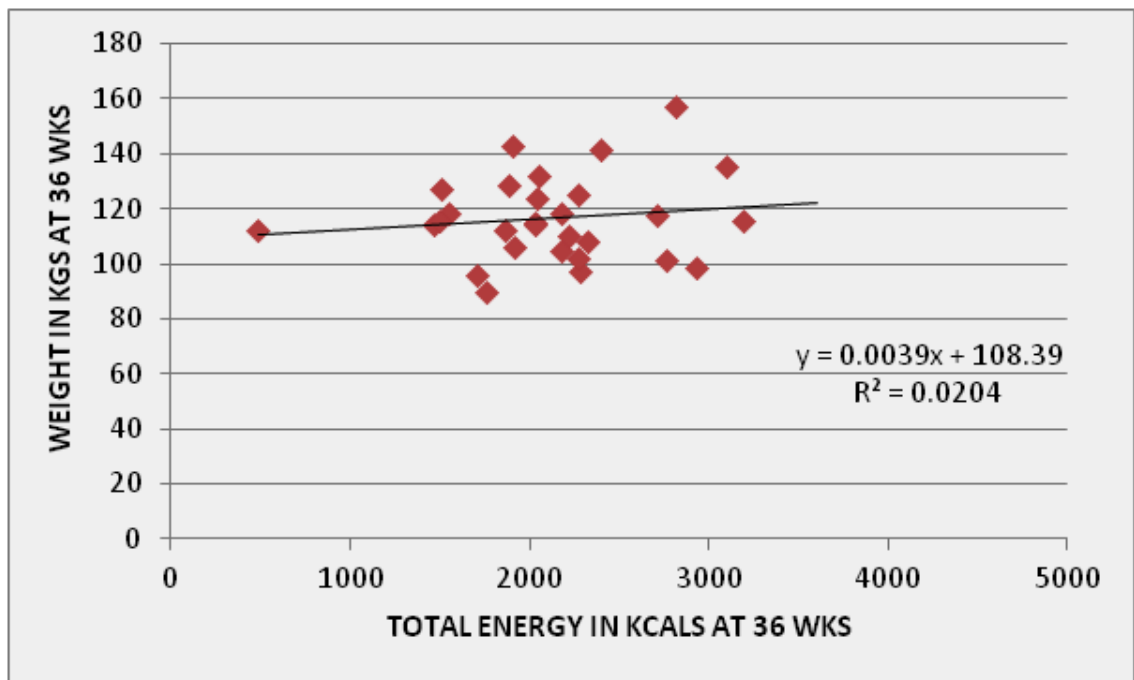
Figure 5-8: Association between EI and maternal weight at 36 weeks

The final maternal weight recorded at 36 weeks change shows a positive association with BMI. Figure 5-9 illustrates the relationship between BMI and maternal weight at 36 weeks gestation (Pearsons r =.739, p <0.001) however, data is clustered in the range BMI 35-39.9kg/m^2, showing a higher frequency of women in that category in comparison to frequency of women in the higher ranges.
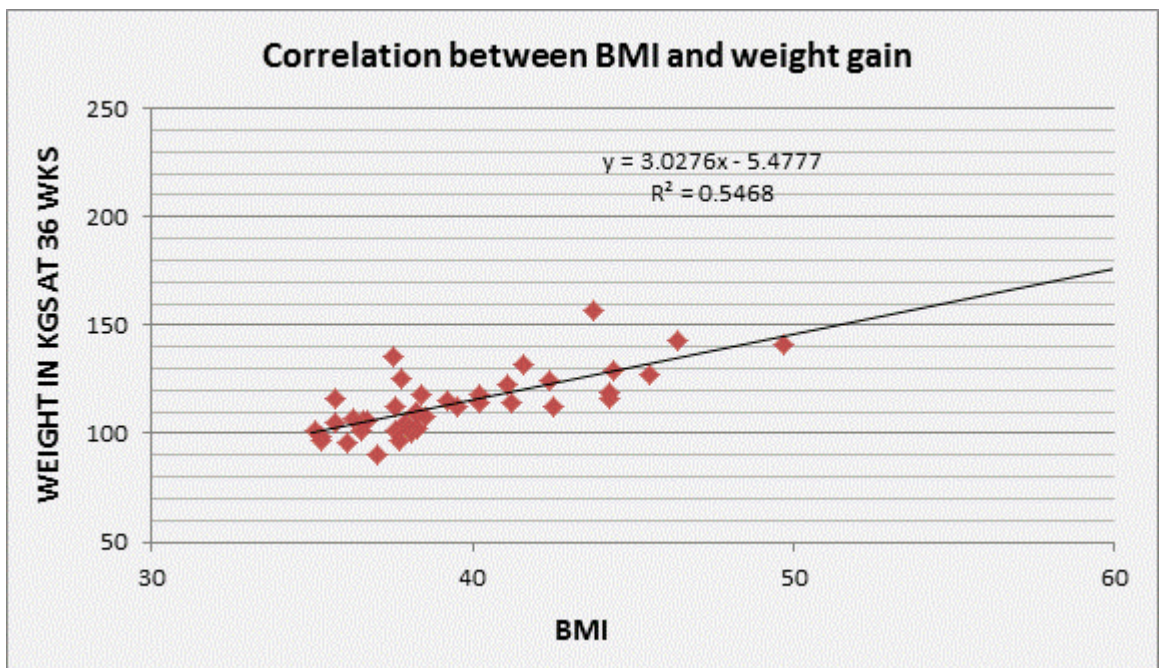
Figure 5-9: Correlation between BMI and maternal weight (n39)

All of the women included in FFB+ were weighed intermittently throughout gestation and figure 5-10 illustrates this data and includes the number of week's gestation and the number of women who had a weight recorded at the given time-point. It demonstrates an average increase in weight of 4kg from a mean booking in weight of 110kg during week 11 to 114.9kg during week 31. However, the numbers of women who had their weight recorded had decreased from 140 at week 11 to 99 at week 31. This figure had decreased to 39 by week 36 where the mean weight was 113.9kg.
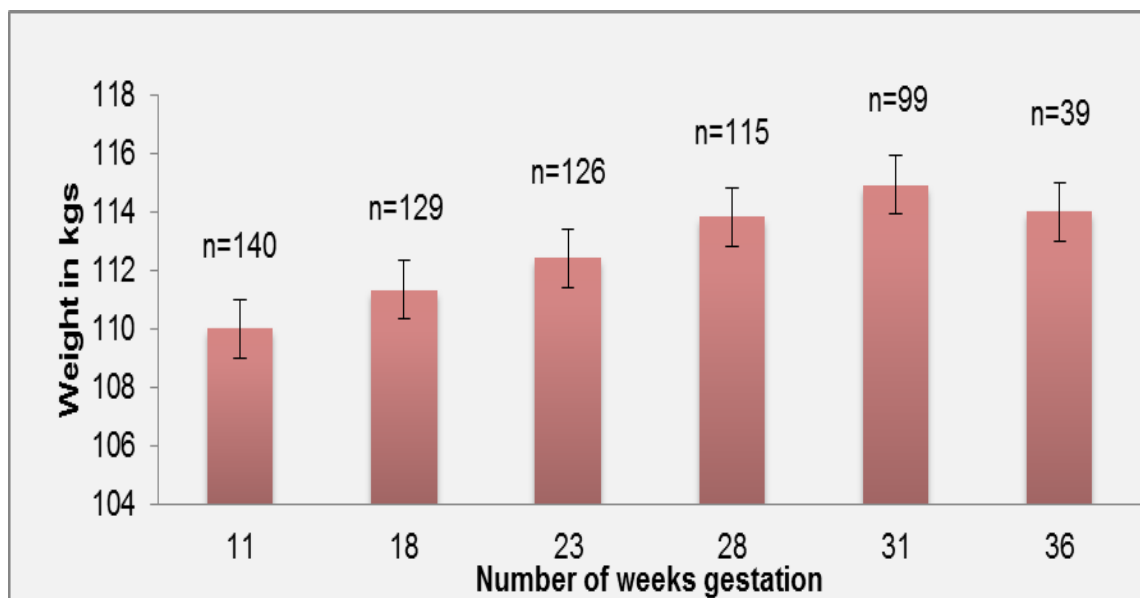
Figure 5-10: Maternal mean weight gain recorded at intermittent intervals

Figure 5-11 by comparison shows the recorded weight history of the women who were weighed at 36 weeks showing the trajectory of weight gain. Data shows a downward trajectory of those women who were weighed at 36 weeks (mean weight gain of 4kgs) in comparison to mean weight gain of 4.9kgs at week 31.
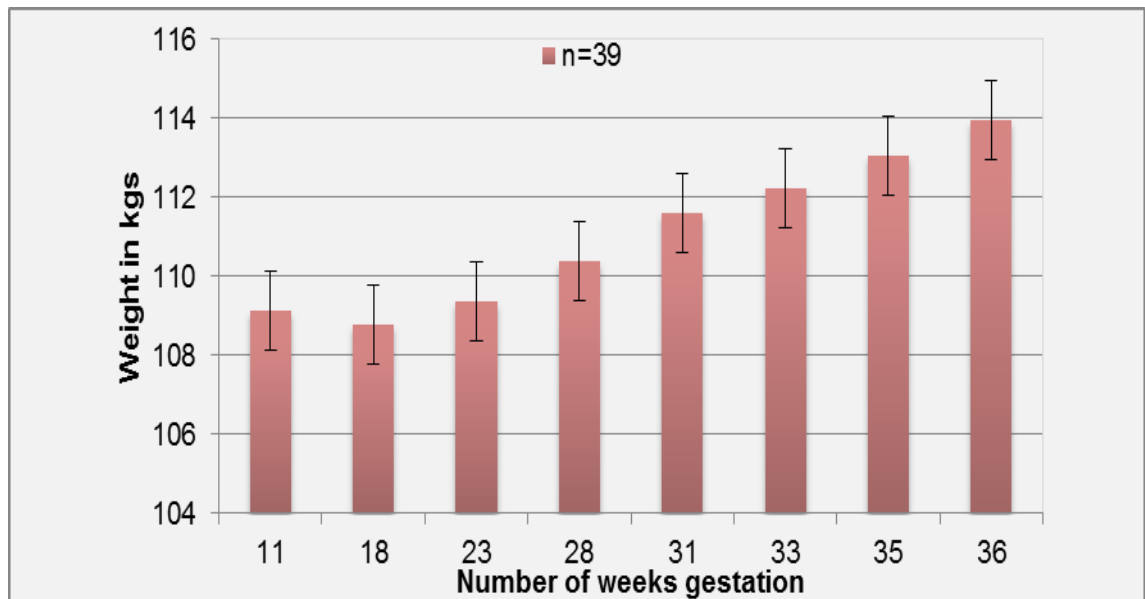
Figure 5-11: Mean weight gain of subset of women weighed intermittently throughout pregnancy

The overall weight change in the subset of women weighed at 36 weeks is illustrated in figure 5-12 and shows that not all of the women gained weight. The mean difference in weight change was 4.8kg (SD 5.4) reflecting a wide dispersion. Some of the women lost weight, 13.5% of women lost as much as 9kgs and 51% of women gained weight below the IOM recommendations of 5-9kg. A further 24% gained weight within the IOM recommendations for weight gain in women with a BMI $\geq30kgs/m^2$ with 24% gaining in excess of recommendations.
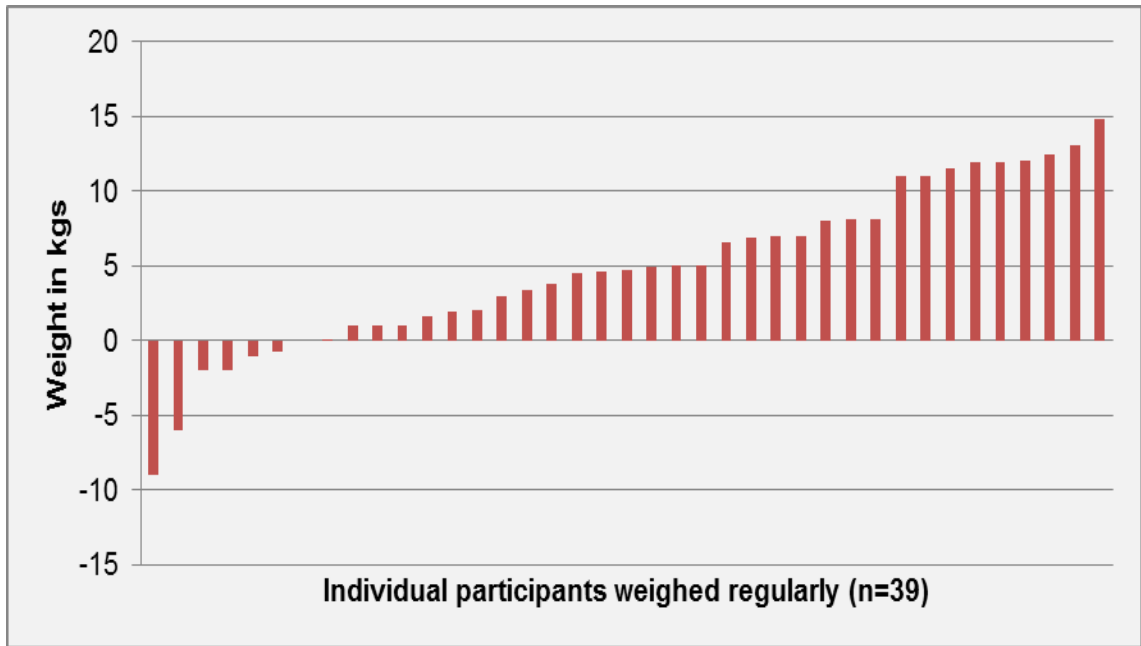
Figure 5-12: Individual weight change in subset of women pregnant women with BMI 35 + at 36 weeks

5.2.8 Results for micronutrient intake

The analysis of micronutrient intakes was undertaken using Microdiet for windows v1.1 and was statistically analysed using SPSS v21. Where possible, foods were analysed in the state that they were consumed, either raw of cooked. The cooked status of the micronutrients can impact on concentration levels, particularly those of water soluble vitamins such as folate.

For the purposes of this study the data values related to micronutrient content of food pertains to dietary and food intakes only. The study has not accounted for supplements in the form of multivitamin and mineral intakes although foods that have been fortified and are included in the food composition database have been accounted for. Data regarding the use of vitamin/mineral supplements were not collected as the focus of the study was on overall quality of dietary intake and not status. The biological status of micronutrients has not been assessed either, therefore it is not possible to accurately determine nutritional insufficiencies or deficiencies. The exception being a small subset of women of ethnic origin who's plasma $25(OH)D_3$ levels were recorded on the LWH medical database Meditech.

The results are presented as means of intakes per visit and are not representative of individual intakes. Statistical analysis of nutrients compared to pregnancy and birth outcomes are matched pairwise.

Five micronutrients, folate, vitamin D, iron, calcium and iodine, integral to an optimal pregnancy were assessed against a range of primary pregnancy and birth outcomes.

5.2.9   Mean intakes of micronutrients

The mean intakes of these micronutrients measured over the 3 visits are presented in table 5-9, however the data is shown at face value and is relative to the number of women who provided data at each visit.

Table 5-9: Reported micronutrient intakes from estimated 3 day food diaries

| | VISIT 1(16-20WKS) | | VISIT 2 (28WKS) | | VISIT 3 (3WKS) | |
| | (n93) | | (n99) | | (n73) | |
	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range
Vitamin D (10μg)	2.6 ± 2.5	0.1–10.9	2.5 ± 2	0 – 12.8	2.7 ± 2.5	0 - 17
Calcium (700mg)	875±334	206-1958	949±357	159-1765	1009±441	300-2854
Iron (14.8mg)	10.6±4.3	4.8–25.1	10.6±3.7	5 – 25.7	11.6 ± 3.9	4.6 - 23
Folate (300μg)	270±138	94–1086	263±114	112 - 743	276 ± 103	112 - 639
Iodine (140μg)	126 ± 66	19 - 340	142 ± 84	19.1-381	164 ± 93	29 - 629

The data in table 8 are presented as mean ± SD were analysed using one-factor repeated measures ANOVA with pairwise comparisons and for data related to vitamin D, calcium, iron and folate there was no statistical difference between the mean values ($p > 0.05$).

5.2.10 Micronutrient intakes and quality of diet

However, a pairwise samples t-test was conducted on all micronutrients being assessed and revealed nothing of significance (P >0.05) other than for iodine which revealed a significant increase in mean intakes between visit 1 (M=130.4µg, SD72.8) and visit 3 (M=155µg, SD79.7), *t* (45) = 2.4, P=0.021 (2-tailed). The mean increase in iodine scores was 24.5 with a 95% CI between 3.9 - 45.1. This would indicate that iodine intakes improved considerably as pregnancy progressed but when expressed as a ratio of energy intake in MJ/d, iodine intakes in actual fact decreased by 6.7% between visit 1 and visit 3. Similar patterns emerged when calcium, iron, vitamin D and folate intakes were also calculated as a ratio of energy intake with percentage decreases of 17.1%, 10.7%, 27% and 26.3% respectively, see table 5-10

Table 5-10: Mean ratio of micronutrients per MJ/d

	Energy intake 8.1/8.13*	*Calcium 700mg/d*	*Vitamin D 10µg /d***	*Iron 14.8mg/d*	*Folate 300µg /d***	*Iodine 140µg /d*
Visit 1	7.8MJ	123mg	0.37µg	1.5mg	38µg	17.8µg
Visit 2	8.3MJ	106mg	0.27µg	1.17mg	29µg	15.9µg
Visit 3	8.7MJ	102mg	0.27µg	1.34mg	28µg	16.6µg
% change	+11.5	-17.1	-27.0	-10.7	-26.3	-6.7

- Mean ratio of micronutrients per MJ/day
- * EAR for energy in 3rd trimester only
- ** RNI for pregnant women

Frequency data for mean intakes of iron showed that only 14% of women achieved RNI for iron at visit 1 with 31% not achieving LRNI. Iron intakes measured at visit 3 showed that more women (19%) achieved RNI and women

failing to achieve LRNI had decreased to nearly 18%, see table 5-11. The other notable micronutrient that the women failed to achieve RNI for was vitamin D although no LRNI has been established for vitamin D only a tiny minority achieved RNI at any of the 3 visits. However, normal population distribution describes the numbers of percentage of population that should be achieving LRNI as >97.5% and EAR >50% this suggests that low nutrient intakes in a small number of women are sufficient to meet metabolic needs and does not always require the EAR that are recommended for over 50% (Younger 2002).

Table 5-11: Percentage of women achieving either RNI or LRNI

Micronutrient	DRV	Ranges	Visit 1 % achieved	Visit 2 % achieved	Visit 3 % achieved
Iron	<LRNI	<7.99	31.2	23.2	17.8
	LRNI	8.0-14.7	54.8	66.7	63.0
	RNI	≥14.8	14.0	10.1	19.2
Calcium	<LRNI	<399.9	5.4	2.0	5.5
	LRNI	400-699.9	28.0	23.2	15.1
	RNI	≥700	66.7	74.7	79.5
Iodine	<LRNI	<69.9	18.3	13.1	8.2
	LRNI	70-139.9	50.5	51.5	35.6
	RNI	≥140	31.2	35.4	56.2
Vitamin D	<RNI	<9.99	96.8	98.0	98.6
	RNI	≥10	3.2	2.0	1.4
Folate	<LRNI	<99.9	1.1	0	0
	LRNI	100-299.9	66.7	73.7	65.8
	RNI	≥300	32.3	26.3	34.2

Chi Square tests for independence revealed no statistical association between BMI and achievement of either RNI or LRNI of micronutrients.

Protein intakes were found to be in excess of the DRV of 51g/d during pregnancy however, mean iron intakes were found to be approximately 28% below RNI at visit 1 and 22% below at visit 3.

The primary sources of haem iron are animal proteins such as red meat, poultry and fish. Figures 5-13 to 5-15 illustrate dietary souces of iron relative to protein at visits 1, 2 and 3. The bold vertical lines that cut through the graphs indicate the DRV of 51g/d for protein and the bold horizontal the RNI of 14.8mg/d for iron. It is clear to see that at all three visits, protein requirements were met by the vast majority of women whereas the majority of women failed to achieve the RNI for iron. At visit 1, there was also a significant number of women who failed to achieve the recommended intakes for both protein and iron with over 31% failing to achieve LRNI for iron at visit 1 and 17.8% failing to achieve LRNI for iron at visit 3.

The bold lines on the following graphs indicate the EAR's for total energy and the RNI of relative micronutrient intake.
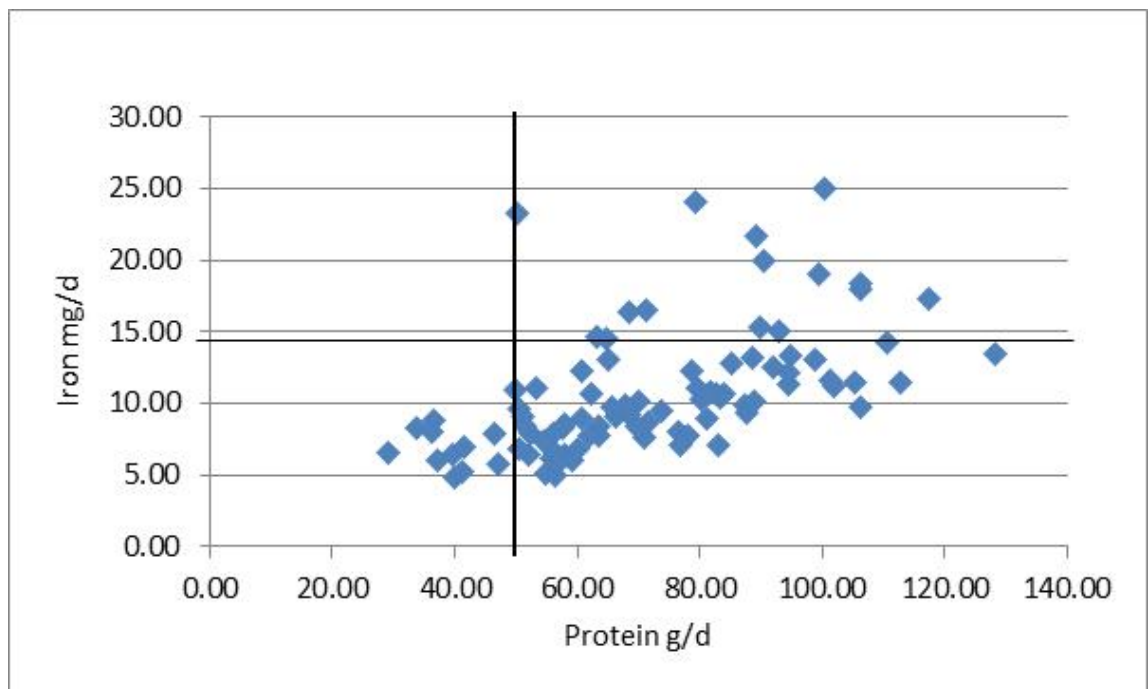
Figure 5-13: Dietary intake of iron relative to protein intakes V1 (n93)

The relationship between protein and iron was also investigated using Pearson's correlation coefficient. A positive correlation was found at all 3 visits with V1 (r= .555, p = <0.01), V2 (r = .610, p = <0.01) and V3 (R = .596, p = <0.01).
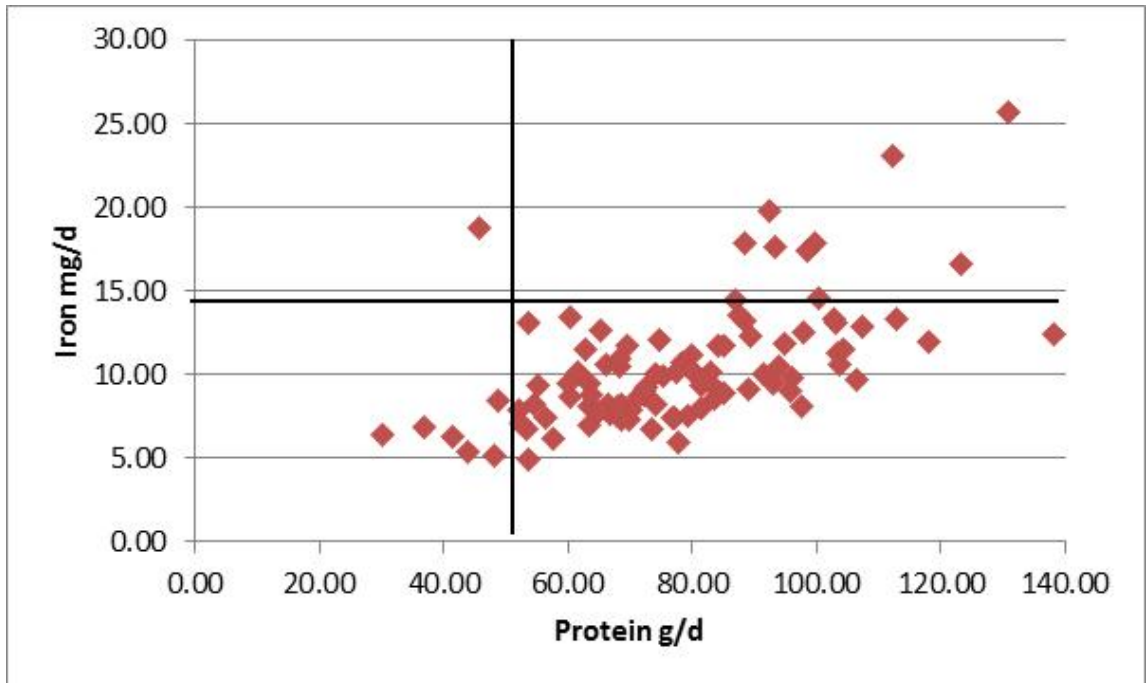
Figure 5-14: Dietary intake of iron relative to protein intake V2 (n99)
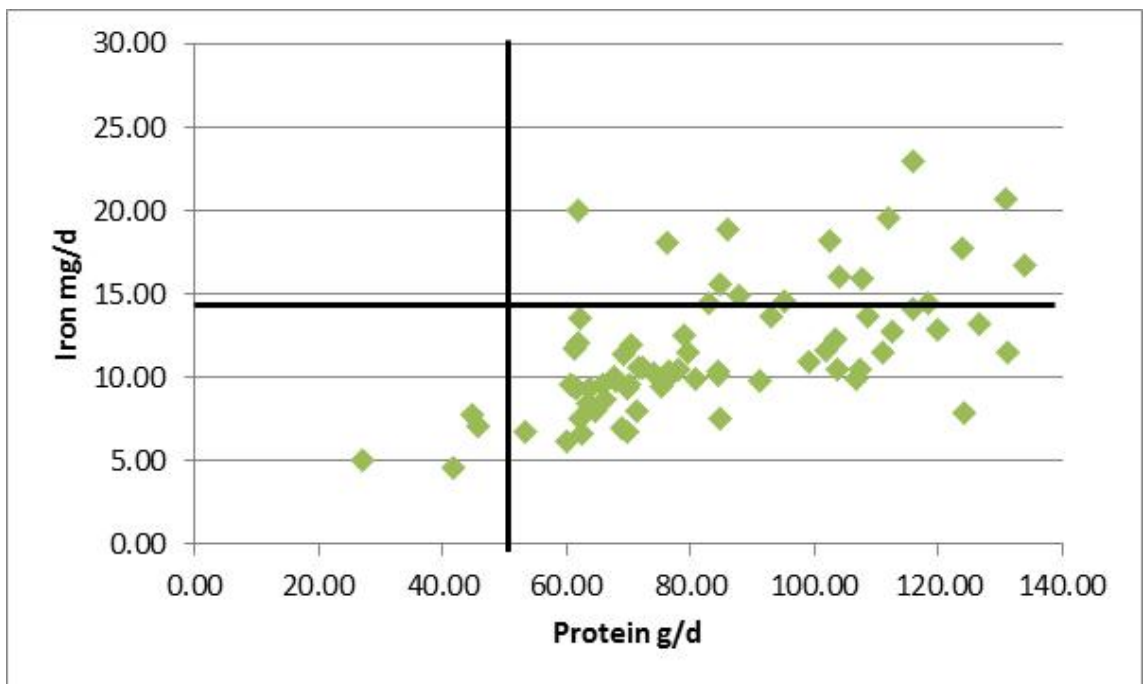
Figure 5-15: Dietary intake of iron relative to protein intakes V3 (n73)

Vitamin D is renowned for having limited dietary sources and the next series of graphs, figures 5-16 to 5-18, illustrates the difficulty that the participants had in achieving the RNI of 10µg /d with only a minority succeeding at any of the visits, mainly due to the consumption of oily fish and margarines fortified with vitamin D. In these instances intakes of vitamin D were assessed relative to calcium intakes with the bold vertical line cutting through the graph representing the RNI for vitamin D and the bold horizontal line representing the RNI for calcium.
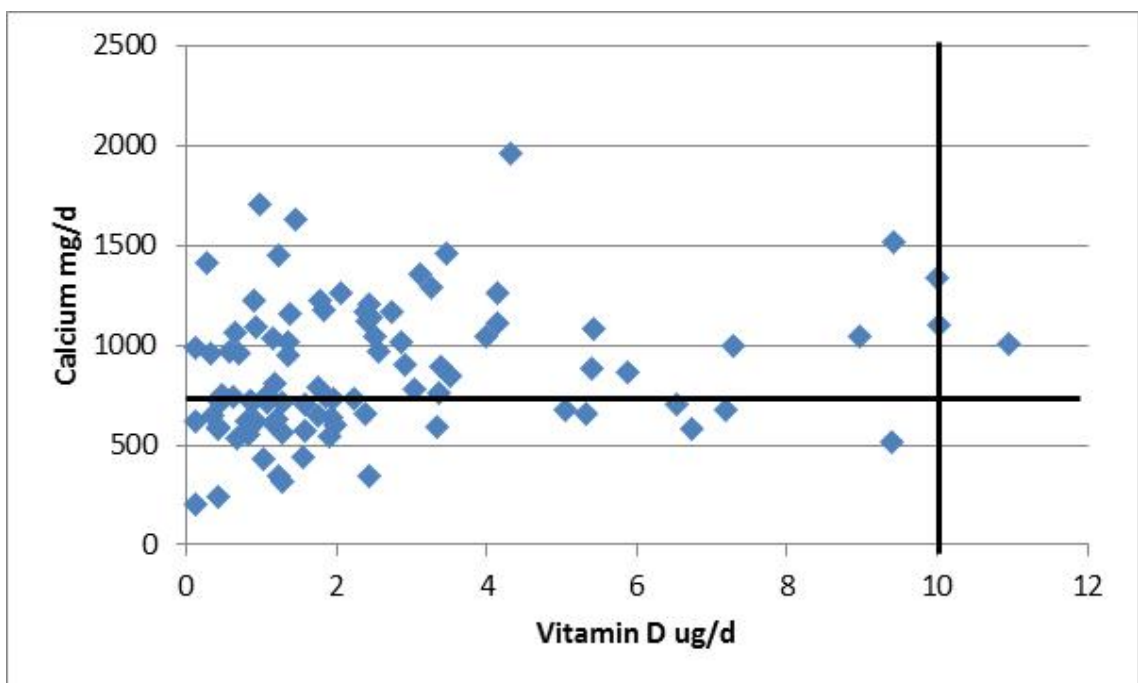
Figure 5-16: Vitamin D intake relative to calcium intake V1 (n93)

In addition to the failure of meeting RNI for vitamin D in 97% of women at any visit, there is also a high proportion of women (33.4%) that failed to meet the RNI for calcium at visit 1, decreasing marginally (25.2% & 20.6% respectively) at visits 2 and 3. The relationship between vitamin D and calcium was also investigated using Pearson's correlation coefficient, a statistically significant

association was found at visit's 1 (r= .231, P = 0.026) and visit 2 (r = .274, p = 0.006) but no significance at visit 3 (p >0.005).
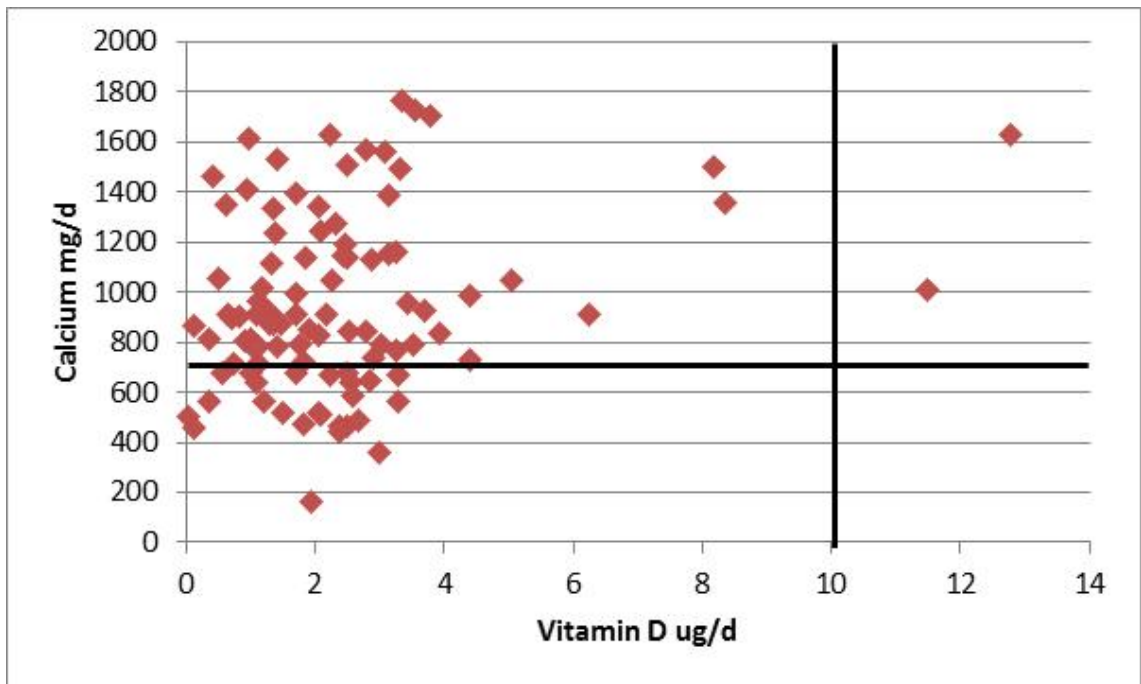
Figure 5-17: Vitamin D intake relative to calcium intakes V2 (n99)
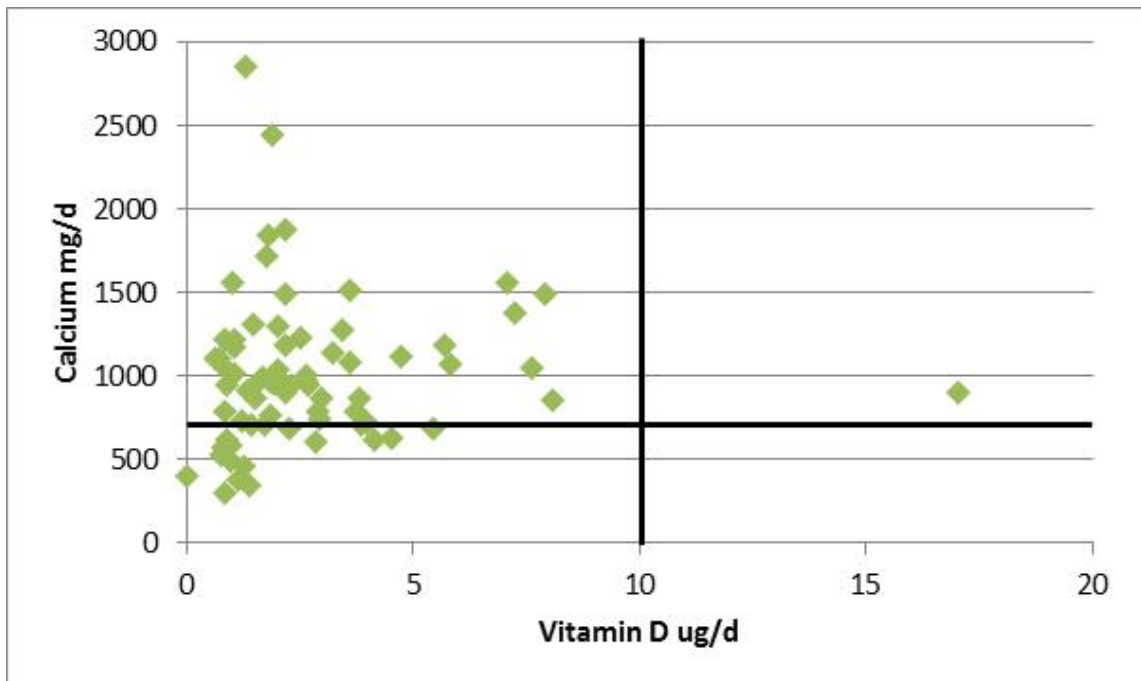
Figure 5-18: Vitamin D intake relative to calcium V3 (n73)

In addition to measuring intakes of micronutrients in relation to total energy and to other nutrients, intakes were also measured against a range of outcome variables. Independent samples t-tests were conducted to compare the mean intakes of vitamin D, calcium, iron, dietary folate and iodine against pregnancy related outcomes such as hypertension, pre-eclampsia and GDM. Surprisingly, there were statistically significant positive differences in mean intakes for calcium (p = 0.008), dietary folate (p = 0.012) and iodine (p =0.042) at visit 2 in women with pre-eclampsia compared to those without. However, there was a statistically significant negative difference in calcium intakes at visit 3 (p =0.016) in women diagnosed with GDM compared to those without.

Data regarding circulating levels of $25(OH)D_3$ were only routinely recorded for women of ethnic origin (n=7) at booking in at LWH. Circulating levels were found to be insufficient or deficient and ranged from 5.6μg/L to 28.7μg/L as compared to observed levels of circulating $25(OH)D_3$ of between 54-90μg/L in populations who have adequate to good exposure to sunlight (Hollis 2005). Specific biomarkers such as parathyroid hormone (PTH), BMD and calcium absorption, indicate vitamin D deficiency as circulating levels of $25(OH)D_3$ of ≤32μg/L (80nmols/L) (Hollis 2006).

5.3   PHASE 2: QUALITATIVE RESULTS - INTERVIEWS

The second phase of the study was intended to explore the lifestyles and behaviours of a subset of the women who participated in the first phase of the study. Women who had originally consented to take part in the quantitative study but for some reason had failed to do so were also invited to participate in the interviews. It was hoped that their reasons for not participating could be explained for the purposes of future study designs. The participants were randomly sampled from the FFB+ sample, those who had participated and those who had not.

5.3.1   Aim of the research

The aim of this phase of the research was to explore the impact of lifestyle and the lived experience of these women on food choices and eating behaviours to support the findings from the quantitative phase. This may help to inform future guidelines for the care and management of obesity in pregnancy.

5.3.1.1 Research Question

The research question relates to the behaviours and perceptions underpinning the health related experiences of pregnant women with obesity in Liverpool?
To answer this question it will be necessary to:

- Investigate the socio-cultural factors underpinning lifestyle choices with an emphasis on diet and food

- Explore the behaviours and lifestyle of these women

- Explore their perceptions of their own health, weight and eating behaviours.

5.3.2 Findings from the interviews

The women who participated in the interviews were asked a number of semi structured questions related to pre-determined topics reflecting the research questions. The questions related to weight, diet, health and physical activity both in terms of their historical significance and how they related to current experiences particularly when pregnant (Question schedule appendix 7 & 8).

Table 5-12: Characteristics of respondents

Pseudonym	Age	BMI	Parity	FFB+	Ethnicity
Laura	35	40	P	Y	WBr
Cathy	31	36	M	Y	WBr
Nerita	27	43	M	Y	ASIAN
Lois	21	46	M	Y	WBr
Pamela	26	51	M	Y	WBr
Odette	32	40	P	N	BI-AFR
Kylie	30	38	M	Y	WBr
Kara	40	44	M	Y	WBr
Maxine	28	38	P	Y	WBr
Rhianne	34	35	M	Y	WBr
Michaela	38	44	M	Y	WBr
Jessica	25	46	P	Y	WBr
Amira	29	44	M	Y	M.EAST
Sonia	27	39	M	N	WBr
Serena	39	44	M	N	WBr
Eliza	26	43	P	N	WBr
Leah	23	41	M	N	WBr
Susan	23	47	M	N	WBr

The semi-structured interviews yielded data on the following 4 major themes

Themes from interviews			
Diet	**Weight**	**Health**	**Services**
• Childhood • Transition to adulthood • During pregnancy	• Perceptions of weight • Weight loss methods • Weight cycling • Social/cultural issues • Barriers to change • Emotional responses	• Perceptions of health status • Pre-existing health issues • Pregnancy related health issues • Emotional issues • Barriers to physical activity	• Fit for Birth • Antenatal services • Dietetic services • Access to services • Barriers to services

Figure 5-19: Themes generated from semi-structured interviews

The overarching themes that emerged related to

- The contribution of childhood eating behaviours to pre-pregnancy obesity

- The influences that lead to weight gain and obesity

- The emotional issues that have affect current eating behaviours.

The first theme explores the changes experienced by the participants over time with regard to their weight and dietary intake and eating behaviours. These changes potentially inform their perceptions relating to their physical health and emotional well-being and helped to explain the eating behaviours adopted during pregnancy and post-partum. The final theme relates to the emotional issues experienced by the women as a result of their obesity and how these issues either inhibit the women or drive them to change.

5.3.3 Diet history – including changes in eating habits over time

The women were given the opportunity to talk in depth about their dietary intake, how it evolved over time and the differences in their dietary intake in adulthood compared to that of their childhood, and about their current relationship with food. In most instances dietary intake during childhood followed a traditional route. Food was homemade and cooked from scratch using fresh ingredients. Convenience foods and readymade meals were kept to a minimum. Typically, the regionally recognised dish Scouse was a family staple, as well as the traditional Sunday roast with all the trimmings; the 'trimmings' being potatoes, vegetables, Yorkshire pudding and gravy etc as illustrated by Susan who stated

> *"we had everything, we had pasta bake, loads of fish, loads of vegetables, Scouse, soups…all homemade stuff".*

Three of the women who participated were of ethnic origin, all of whom were immigrants to the UK and all of differing nationalities, i.e. African, Indian and Middle Eastern. These women also recalled their childhood diet being predominantly traditional with dishes being based on cultural and religious influences. Amira said

> *"our food is very rich, lots of sweets like baklava, we love rice and eat it every day with our meals"*

However, all 3 women, once they had taken up residency in the UK substituted some of their traditional foods for less wholesome westernised options, particularly the sort of foods found widely available in fast food and takeaway outlets.

The traditionally held view that the mother is mostly responsible for meal provision was contradicted by a small number of women who stated that it was their fathers who were the better cooks. In most instances, regardless of which parent cooked the meal, either, or, of the parents was described as being capable of cooking a meal from scratch and any meals provided by the non-cooking parent would most likely be convenience foods that required no preparation and could be placed straight into the oven from the fridge or freezer. The generational difference between many of the women and their parents was apparent. It was suggested by a number of the women that some of the guilt and negative relationships they have with food stems from childhood and the attitude of their parents towards food and food waste. Kylie and Eliza both had childhood recollections of having to eat everything on the plate *"because there are kids starving in Africa"* particularly when it came to eating less preferred foods such as vegetables. Eliza, who came from a big family where food was seen as celebratory, described her mother as 'a bit of a feeder' who offered food to anyone that entered the house and provided more than enough for 'seconds'. This was echoed by Odette who associated food with happy times like Christmas and always went for 'seconds' as a child. However, this relationship food wasn't always a positive one and she admitted that she still struggled with portion sizes and often mindlessly picked when bored. Cathy also enjoyed the social side of food, people coming together and eating a meal. However, there was an acknowledgement of greed, preferences for junk food and an over indulgence of snack foods and sweets. For example, Lois remembered eating very traditional foods, cooked by her 'nan' who brought her up, to excess but then *"having all the junk food when I was in school"*.

What came across quite strongly throughout the interviews was that eating behaviours that followed a traditional path in childhood and adolescence became more erratic once the women became autonomous. Work and family commitments and available time influenced when and how much the women ate. Many of the women cooked different things at different times for their children without sitting down to eat with them. This often led on to late night snacking once the children were in bed and is summarised by Lois who stated

"I cook me kids Shepherd's Pie, roast dinners and things like that but when it comes to me sitting down and having a meal I'm like 'I can't be bothered cooking at this time of night' and I'll just get a takeaway" and Laura who said *"you know you feed the kids and that but if there's a packet of biscuits there…rather than go and make a meal, I'll eat the biscuits".*

5.3.4 Eating behaviours during pregnancy

There were considerable differences in the eating behaviours experienced by the women during pregnancy. Many of the women experienced intense morning sickness during the earlier stages of pregnancy. Sonia and Susan both experienced severe morning sickness and vomiting, Susan described how she

"doesn't do pregnancy very well, I just had morning sickness straight through...the thought or the smell of anything being cooked turned me sick, I'd eat and then a few hours later..."

and Leah who said

*"I just lived on toast and that's all I ate when I was pregnant with ****".*

Some of the women cited how participation in FFB+ had affected their eating behaviours, Kylie stated

'I didn't actually put much pregnancy weight on cos I was eating really healthy when I was pregnant...it probably started with coming to see yourself'

and Pamela who was trying to monitor her portion sizes as a result of attendance at the FFB+ research clinic but still struggled saying

"but then you think ''well I can have that cos I'm pregnant'''.

This was echoed by Eliza who although she didn't feel like she ate anymore when pregnant said

"I wanted to eat more fattening things and in my head I think "oh I can cos I am pregnant"".

Nerita also struggled admitting that

"when I was pregnant, I couldn't stop eating, I didn't feel like going out, I was like sitting down".

5.3.5 Weight history

Pregnancy is probably the transitional point during the life-course where women are most likely to gain weight. Research by Scholl et al (1995) indicates that nulliparous women who are of normal weight, prior to conception, are likely to gain the most weight during pregnancy and retain it post-partum, often pushing them into the overweight BMI category. All of the women who participated in the interviews, regardless of parity, already had a BMI ≥35kg/m² when they were recruited onto the original FFB+ study. Over 60% of the women were multiparous and cited previous pregnancies as a time when they 'piled on the weight' as stated by Lois who described her weight *as*

"up and down…it's always been up and down. Since having the kids, it's been more up than down".

Therefore, it could be argued that intervention is important in women with a 'normal' BMI during their first pregnancy to ensure that excessive weight is not gained.

When asked to consider their own weight history retrospectively, the women's perception of their weight in childhood and adolescence was often skewed. Many of them recognised on reflection that during their adolescence they were not formally overweight but they acknowledged that there was a perception of overweight when comparing themselves to their peers. This is summed up by Eliza who said

> "*I've always been overweight really…when I was in school I was always bigger but I was more developed than fat…now when I look back I wasn't fat at all but cos all me friends were like little kids…I had big boobs and all that so I've always felt bigger*".

However, erroneous weight perceptions in adolescence often triggered changes in eating behaviours and weight loss attempts. According to many of the comments and insights offered by the women during the course of the interviews, weight gain appears to tie in with transitional points during the life-course. Marriage and relationships proved to be a pivotal point, as previous research suggests entering into marriage is more likely to effect a weight gain as the need to attract a partner has been accomplished (Sobal et al. 2003, Wilson 2012). The adoption of new eating behaviours brought by a partner to a new relationship or alternatively new behaviours created by the couple can influence weight gain. For example; Eliza increased her consumption of takeaway food because of her boyfriend's frequent intake of takeaway meals; behaviours that were formed during his own upbringing. He also had a liking for

chocolate which influenced Eliza's chocolate consumption. She described her partner as being

> "dead thin but will think nothing of eating a handful of chocolate bars one after the other…so that influences you doesn't it but cos you've only eaten two you feel like you're alright but really you've just eaten two bars of chocolate".

Furthermore, novel eating behaviours developed in response to changes in lifestyle; the arrival of the first baby in some instances, where 'nights out' were replaced by 'nights in' and an introduction of compensatory treats, referred to by Kara as "Saturday night Scooby snacks". The courtship aspect of new relationships saw many couples regularly 'eating out' with a commensurate increase in alcohol consumption and matched portion sizes. Portion sizes were also a factor for Rhianne who stated

> "Since I've been married the portion sizes have been the same and that's wrong cos we're supposed to have less"

And also Odette who as a child always went for 'seconds' and commented thus

> "I do struggle with meal sizes still".

The advent of new relationships is often coupled with a decline in physical activity levels; giving up participation in sporting activities or other physically active pursuits. A reduction in physical activity is also seen as a result of changes in employment and transport status i.e. the purchase of a car for instance or use of public transport. These experiences were cited by Kara and Sonia as a trigger for weight gain.

A number of weight loss methods were described by the women, from fad diets, slimming clubs and exercise regimes (see table 5-13).

Table 5-13: Attempted methods of weight loss used by participants of phase two

Weight loss methods		
Fad diets	Slimming clubs	Exercise
Cabbage soup diet Rapid weight loss for surgery diet Liter Life™ Slimming pills Atkins Diet Appetite suppressants	Weight Watchers Slimming World Rosemary Conley	Gym I fit (power plate) Zumba

All of the women had at some point engaged in weight loss attempts and in most cases had made multiple and varying attempts to lose weight. Some of the initial weight loss attempts, particularly those attempted during adolescence tended to be fad diets of the sort typically found in popular literature, for example, the cabbage soup diet. One participant went so far as to attempt a rapid weight loss for surgery diet. Some of the other measures included appetite suppressants and slimming pills as well as some of the more controversial weight loss programmes such as Liter Life™ and the Atkins diet.

By far the most common weight loss methods involved attendance at slimming clubs such as Weight Watchers, Slimming World or Rosemary Conley. There would be some weight loss success followed by a gain in weight and a change in slimming club. The commonality between the methods attempted is their apparent long term ineffectuality as all of the women had/have failed to sustain the weight loss for any length of time and were all classified as clinically or morbidly obese at the time of FFB+. However, at the time of the interview, Cathy, Rhianne and Leah had all re-engaged with a slimming club, were switched in to positive dieting mode and were making concerted efforts to lose weight. Cathy explained

"I've recently joined Slimming World…that looks more at lifestyle change, I'm enjoying that one and I think it's better".

In contrast though, some of the women who had previously attempted slimming clubs in the past were less positive about the long term impact of attending slimming clubs. Lois' stated

"I've tried everything, I mean with Weight Watchers, I lost 4 stone and then I stopped and then it just started creeping back up again even though I'm doing the exact same…nothing works".

Serena was even more critical stating

"I've been on every single diet in the world but I don't think they work though cos they're just there to weigh you…you have a little discussion and all that but they're just there to get your money off you".

Autonomy and financial independence can also be determinants of weight gain. Parental restriction of certain foods during childhood can often lead to an overconsumption of denied foods; this often coincided with a change in financial status. Employment was cited as a major determinant of weight gain in many of the women. It was felt that employment obligations impacted on many areas of domestic life and the issue of time emerged as a key factor.

5.3.5.1 Emotional response to weight

Overweight and obesity are inextricably linked to psychological and emotional issues and is a reciprocal relationship. Guilt and disappointment are emotions experienced by the women as a result of their overweight, but their overweight may occur as a result of depression or anxiety. Some of the comments expressed by many of the women when referring to their relationship with food

were often bound up in the guilty emotions they experience because of their overweight. Jessica described her inner battle by saying

"I go to bed at night and I lie down and I think 'in the morning I'm gonna to be dead good and I'm just gonna have me cereal and nothing else and then me dinner and nothing else and then me tea and that's it' then I get up the next morning and I'm like…"

This guilt was expressed both in terms of eating foods deemed unhealthy and also because of a 'failure' to control their eating behaviours, to lose weight or sustain weight loss. . This relationship was described by Nerita who said

"sometimes when I get upset I have chocolate…and afterwards I feel horrible cos I've put more calories inside".

Terms such as 'being good', 'naughty', 'behaving myself' and 'I can't have that' are all indicative of the terminology that exists within the dieting culture and reflects a constant inner battle that the women face. These terms were expressed by Pamela who said

"I tend to eat more sweet stuff and crisps but I have been really good and I haven't been eating crisps"

Or Michaela who stated that

"before I had the kids I could go on a diet and lose loads of weight…now it's very hard to diet and stick to it and behave meself"

And Amira who admitted

"I love carbs which is horrible and is a big problem and I love anything naughty like chocolate, crisps, that kind of stuff".

5.3.5.2 Personal, social and media influences

The guilt, anxiety and other negative emotions expressed by the women as a result of their overweight during the course of the interviews is influenced by their perceptions of what others think about them. This included family members who without possibly realising added to the self-reproachment felt by many of the women as expressed Kylie and Amira below:

> "*if I go anywhere, even his mum's, I never take me coat off…I just didn't want to reveal myself*" (Kylie)

> "*I always say to people who love me and care about me and who say that I need to lose weight…I say to them 'it's very hard, it's another weight you are adding on top of everything else*" (Amira)

This is not exclusive to family, friends and other personal associates but extends to society in general and public opinion expressed via mediums such as newspapers and magazines. Some of the anxieties experienced during pregnancy revolved around media reporting of obesity related health issues and celebrity pregnancies. News reports, which coincided with a time when some of the women were participating in FFB+, were related to two celebrity pregnancies both ending in stillbirth; neither of the two celebrities involved were overweight which underlines the risks that still exist in pregnancy.

Because the women were informed during antenatal booking in of the associated risks of obesity during pregnancy, the chances of experiencing an anxiety disorder were increased. This was illustrated by both Pamela and Rhianne who said:

> "*you hear that people are 7 months pregnant and are losing babies…like Amanda Holden and Lily Allen and it's cos there is nothing there…it would*

be better if they had a scan at like 7 months just so you've got something in the middle to reassure you that everything's still fine" (Pamela)

And

"knowing that I was overweight…with everything you read in the media and you think 'oh I'm going to get diabetes…I'm gonna die during labour cos I'm so huge' which were the worries I did have" (Rhianne).

5.3.6 The effects of overweight on health in pregnancy

The women were asked how they perceived their health to be before, during and after pregnancy and the responses in most cases, initially, were positive in respect of their general health, which they perceived to be good. However, issues regarding deteriorating mobility, increasing tiredness and exacerbated existing conditions during their pregnancies emerged during the interviews. Kara explained her experiences saying

> *"I did struggle a lot more…more sluggish; I didn't feel as if I had much energy. I'd literally come in from work and I'd be totally exhausted. I carried on doing what I was doing but I was just a lot slower doing it…I felt as though it did take up a lot more energy doing things that I was normally ok doing before".*

Some of the women experienced physical difficulties which proved to be debilitating and restrictive, preventing them from leaving the house and leading to enforced rest in some cases. This was often followed by subsequent gain in weight, exacerbating the problem as described by Serena who said

> *"because I'm back to back…me baby's on me back, there's more pressure there down below, it's proper agony. I'm usually out all the time*

but because of this I've been stuck in the last few weeks and I think that's

why I've put more weight on, I can't walk, it's painful to walk".

Some of the mobility issues the women had related to back and knee problems. Sciatica and symphysis pubis dysfunction were the most severe physical difficulties that were experienced in 3 women, affecting their ability to participate in normal domestic and family activities.

Tiredness and fatigue became more prevalent as pregnancy progressed and those women with pre-existing asthma found the condition worsened over the gestational period making them more breathless. However, this was not exclusive to those with pre-existing asthma and many of the women experienced breathlessness as their weight increased during the gestational period irrespective of asthma.

Some minor conditions related to common pregnancy complaints such as morning sickness, heartburn and difficulties in sleeping were also experienced by the majority of the women.

5.3.7 Explanations for weight gain

Autonomy and financial independence can also be determinants of weight gain. This was explored by Serena who remembered it as being a negative experience saying

"It all started when I was about 18 or 19 when I went into the workplace

and I lost confidence, it was a horrible experience in work really and I

started eating and stuff…I started eating for comfort. I was buying things

because yeah…I had me [sic] own money".

Kara's experiences related to her time at university

> *"I think I put more weight on when I did my degree, towards the end of my degree the studying got more intense so then I got a car and from there my activity levels started dipping but then if you continue to eat at the same rate then you're gonna put on weight, then I met ****, that's when I kind of put weight on…you know when you are going through a new relationship and you're having lots of meals out".*

5.3.7.1 Time

Time was one of the main factors other than their weight that women felt that they had lost control over; from not participating in physical activities, to not sitting down to a proper meal. It was cited as the reason why eating behaviours were so erratic. Intrusions into normal routine because of situations arising can result in erratic eating behaviours as experienced by Kara whose new relationship with her partner coincided with her having to care for her dying father stating

> *"it was the two combinations together, caring for me dad…it was not so much a case of thinking about what you were going to eat, it was kind of grabbing things as you were going along and unless you plan and it's organised you can guarantee it's always going to be unhealthy stuff you're grabbing".*

Children were also cited by Nerita, Lois and Leah as reason's why eating habits became so inconsistent

> *"I did enjoy cooking for everyone but since I had him I don't have time for myself,I don't do cooking now" (Nerita)*

And Lois who stated

> "…I eat at the wrong times, I don't eat all day and then once the kids are in bed at say 8 – 9 o'clock, I start picking…I can't be bothered cooking at this time of night and I just get a takeaway"

And Leah who said

> "when you've got children you pick more or I'll not eat cos I don't have time".

Alternatively there is the admission by Serena who stated that

> "I'm putting weight on cos I'm eating the wrong things at the wrong times".

Employment was cited as a major determinant of weight gain by some of the women. It was felt that employment obligations impacted on many areas of domestic life and time as described by Amira who said

> "…but it's been very hard for me to find time to exercise, by the time I've finished work and the kids are asleep and I need to start studying so it's just impossible".

There were also those who found it extremely difficult to develop regular eating habits as illustrated by Susan who said

> "I do shift work and my shifts change constantly…if I eat before I go to work I'm dead slow and stodgy…it's really tough to get a proper meal routine cos of me work schedule".

5.3.8 FFB and other service providers

The women were asked about what the perceived benefits were to taking part in the FFB+ study, their reasons for doing it and if the experience of participating in such a study had had any long term impact.

The reasons for participation were twofold; they either saw it as an opportunity to help others as they were aware that the study would not impact them directly but understood that the LWH is a research hospital and appreciated the positive aspects of research in the long term. Lois appeared not to give it any due consideration as she had participated in other research studies stating:

> *"I was quite willing to do it…I took part in quite a few".*

This was also the case with Michaela who said:

> *"everybody's got to learn and they've got to find out new things about pregnant women being overweight".*

She then went on to say:

> *"I suppose in a way it helped me a little bit, it helped me realise that I needed to eat better".*

Alternatively, it was seen as an opportunity to self-regulate due to the research clinic appointments and additional weighing that formed part of the data collection as illustrated by many of the women who participated:

> *"it was gonna be a support mechanism , for the fact you are overweight" (Cathy)*

> *"it was just try something different, you know cos they told you to write down what you eat…I was putting more weight on" (Nerita)*

"I wanted the study so I could monitor my weight so I don't put on too much weight" (Odette)

"it's probably a good idea cos it will keep an eye on me weight…it did make me think about what I was eating" (Kylie)

"when I found out about the diabetes I was devastated cos I thought 'I've not been dead, dead good' so I thought 'I may as well take part and see what benefits I can get out of it and I actually lost weight in the end" (Jessica)

"well you helped you know when you were checking my food and things" (Amira)

"I was aware of my weight and being older…if I take part in FFB I will be better looked after…I was at the hospital quite a lot but I felt as if I need that care" (Kara)

"I found keeping the food diary helped…it was good to have the extra midwife check as well" (Rhianne)

"to keep you on track and keep you healthy cos you want to be healthy don't you…I was thinking someone's watching me and that would be good" (Eliza).

There were, however, 2 women who took part in the follow up interviews who although had consented to take part in the study were never sent an appointment from the LWH to attend any of the research clinics.

"I said to them 'I'm under the dietitian you know' and she said 'I know but it's just research that's going on' so I said I would do it" (Serena)

"I thought it was a really good idea because people are different to me and have different experiences… I just didn't get any appointments that

was the only reason cos I did sign up for it and I was really interested"

(Sonia).

All those who had participated in the original FFB+ study felt it was a positive experience despite there being no intervention during it, with the exception of one women who when asked how she felt about being asked to take part in the study described her initial response as

"well it just basically made me feel 'oh she's big, fat and pregnant' you

know what I mean…but for the sake of the baby" (Laura).

In the majority of cases however, participation in the study meant reassurance and extra care; they received additional contact with a midwife and other maternity services over and above their normal antenatal care and they felt they were being more closely monitored in terms of their dietary intake and weight gain.

5.4 LEGACY

The women were keenly aware that their weight issues were responsible for much of the emotional turmoil and self-reproachment experienced on a daily basis, but one of the sentiments expressed by many of the women was with regard to their children and their desire that they shouldn't have the same negative experiences; this was particularly expressed by multi-parous women:

"I personally think that if you deprive them of these things then they are

gonna crave it more cos that's what I was like when I was younger" (Lois)

"now he's started school I'm adamant I won't put crisps in his packed

lunch cos I don't want my kids to turn out like me, I want them to be

healthy…I don't want them growing up with weight and having issues like

what I had" (Pamela)

"I think with having children, you're very much aware of your own eating pattern and you don't want them to pick up your bad habits" (Kara)

"I don't want my daughters, you know, having the same problems" (Rhianne)

"my diet is really poor but we're trying our best with the baby as well, not to make her follow in our lead because I don't want her to end up looking like me" (Jessica)

"one of me daughters…she was starting to put a bit of weight on and I said to her 'don't start going down that road, that's the road I went down…(Serena).

6 CHAPTER 6: DISCUSSION AND SYNTHESIS OF FINDINGS

6.1 INTRODUCTION

This chapter aims to provide a comprehensive discussion of the key study findings. The chapter will comprise of 4 sections beginning with a discussion of the findings from the food diary analysis relative to pregnancy and birth outcomes. The next section will discuss the findings of the dietary analysis relative to its quality. The following section will be a synthesis which will connect the results from phase 1 of the study with narrative qualitative data collected during phase 2. The final section will close the thesis and consist of a discussion of the study limitations and a conclusion which will include recommendations for further research and practice.

This study set out to examine the nutrient intakes and quality of diet in pregnant women with a BMI ≥35kg/^{2} in Liverpool to determine and compare intakes with pregnancy and birth outcomes and to explore how lifestyle and the lived experience of these women influenced food choice and behaviours. The following objectives were used to achieve these aims

- The dietary intake of pregnant women with a BMI ≥35kg/m^2 were assessed using estimated food diaries

- The relationship between quality of diet and pregnancy outcomes were investigated using a range of statistical tests

- The diet and weight histories of these women were explored using semi-structured interviews. Questions related to changes in eating behaviours over time, weight history and weight loss attempts

- The perceptions of these women as to how their obesity impacted on their health and emotions with particular reference to pregnancy were revealed

- The lived experiences of these women were drawn on to enhance and explain the data collected from the food diaries.

6.2 MATERNAL CHARACTERISTICS

There were 225 women recruited to FFB+ over a 12 month period who participated in at least one aspect of the study, see chapter 4 (fig 4-1). Questionnaires relating to physical activity, quality of life and sleep apnoea and completed estimated 3 day food diaries at 3 time points during pregnancy, at approximately 16-20 (V1), 28 (V2) and 36 (V3) weeks gestation. The constituent relating to dietary and nutritional intakes is treated as a standalone study and findings pertaining to physical activity, quality of life and sleep apnoea are reported elsewhere.

Data regarding maternal characteristics including BMI, parity, pregnancy outcomes and birth outcomes is included for 140 women see chapter 5 (table 5-1). This data was routinely collected by both community midwives and midwives at LWH, was collated into the FFB study database by other researchers and relevant data extracted for examination in comparison to dietary data collected by the author of this thesis.

The following tables (6-1 and 6-2) summarise the main findings from this study. These findings provide the focus of further detailed discussion and comparison

to secondary research in the sections as described in the introduction to this

chapter

Table 6-1: Summary of quantitative findings from FFB+ study

Variable	Outcome	P value
Maternal characteristics Pregnancy outcomes Birth outcomes	Parity negatively associated with pre-eclampsia & birth weight	P =0.001 P =0.003
BMI 35- 39.9kg/m^2	Associated with GWG above IOM 5-9kg EI in excess of EAR at 36wks	P > 0.05 P > 0.05
Overall GWG (n39)	41% gained below IOM 5-9kg 18% gained within IOM 5-9kg	P > 0.05 P > 0.05
Macronutrients **(total EI)** Total EI as %MJ/d	No significant increase in total EI between V1 & V3 Total EI ↑ 11.5% V1 – V3	P > 0.05 P > 0.05
Protein Total fat SFA MUFA	Significant increases in Protein V1 – V3 Total fat V1 – V3 SFA V1 – V3 MUFA V1 – V3	P = 0.025 P = 0.001 P = 0.013 P = 0.021
CHO fractions as %MJ/d Between V1 & V3	Total CHO ↓ 8% Starch ↓ 14% NSP ↓ 9.8%	P > 0.05 P > 0.05 P > 0.05
Micronutrients	No significant differences in micronutrient intakes V1 & V3	P > 0.05
When expressed as %MJ/d Calcium Vitamin D Iron Folate Iodine	↓ 17.1% V1 – V3 ↓ 27% V1 – V3 ↓ 10.7% V1 – V3 ↓ 26.3% V1 – V3 ↓ 6.7% V1 – V3	P > 0.05 P > 0.05 P > 0.05 P > 0.05 P > 0.05

Table 6-2: Summary of qualitative from semi-structured interviews

Theme	Key points
Dietary intake	Dietary intakes changed considerably over time between childhood and adulthood where daily traditional and home cooked meals replaced regularly with an increase in takeaway/convenience foods.
	Morning sickness was a key factor for lower dietary intakes during gestation but pregnancy was also viewed as a time to relax eating behaviours because of the associated weight gain.
Weight change	Pregnancy viewed as the time when women were most likely to gain weight but other transitional points in life were cited as reasons for weight gain.
	All of the women had engaged with commercial slimming clubs and had tried other various weight loss methods but all had a BMI $\geq 35 \text{kg/m}^2$ when booking in regardless of parity.
	Negative terminology regarding eating behaviours and weight were commonly used by the women and all experienced negative emotions such as depression and anxiety because of their weight.
Perceptions of health	Initial perceptions of good health during pregnancy but pre-existing disorders such as asthma exacerbated and chronic disorders such as Pubis Symphysis and mobility difficulties associated with GWG developed. A lack of energy and above normal feelings of tiredness persisted throughout.
Access to services	Participation in FFB+ study was perceived positively. It was viewed as an opportunity to be monitored more regularly and used as a means to self-regulate dietary intakes and keep their weight in check.

6.3 Dietary intake relative to pregnancy and birth outcomes

Findings from the main Fit for Birth study demonstrated a relationship between weight gain and poor pregnancy outcomes, When weight gain was categorised as less than 5kg, 5-9kg and over 9kg each category was associated with increased odds for incurring a negative composite outcome as described in chapter 2 (fig 2-2). Women who gained in excess of IOM recommendation of 9kg were most at risk (Narayanan et al. 2015).

The dietary constituent of FFB+ set out to determine the effects of dietary intakes and weight change on pregnancy outcomes. This study revealed a number of findings which may have implications for the care of obese pregnant

women, particularly in the current economic climate. Presently, only women with a BMI ≥40kg/m^2 are being referred to the bariatric clinic at LWH with no dietetic referral. Although not statistically significant, 19% of the women who had weights recorded at 36 weeks and had gained weight in excess of US IOM guidelines of 5-9kg had a BMI 35-39.9kg/m^2; women with a BMI ≥40kg/m^2 gained the least or lost weight in comparison, this is illustrated in chapter 5 (fig 5-1). In addition to excessive weight gain, women in the BMI 35-39.9kg/m^2 category also had the highest increases in total energy consumption in excess of EAR at 36 weeks, (fig 5-4). This suggests that women in this BMI range are most at risk of GWG as a result of excessive energy intakes and are therefore potentially more at risk of adverse pregnancy outcomes than women in higher BMI ≥40kg/m^2 categories.

Birth weight was negatively associated with total energy, total CHO and total fat intakes at 36 weeks, see chapter 5 (5.2.5). The correlation implies that as energy intakes increase, birth weight decreases. This would indicate that the quality of dietary intake was poor with a high energy density but lacking in essential nutrients to support foetal development. This may be explained by a change in the ratio of fatty acids over the gestational period with an increase in SFA and a reduction in PUFA's relative to total energy intake reflected in a decreased P:S ratio, see chapter 5 (table 5-8). Although the correlation is quite weak, this suggests that dietary intakes are implicated with birth outcomes and warrants further investigation.

The women with a BMI 35-39.9kg/m^2 also had proportionally higher incidences of hypertension, pre-eclampsia, induction of labour, a baby admitted to SCBU and deliver a SGA baby, although there was nothing of statistical significance

(p>.05). Pre-eclampsia was negatively associated with parity, suggesting in this instance that primiparous women were more likely to develop pre-eclampsia. This is consistent with reports that suggest primiparous women have a 3-fold higher risk of developing pre-eclampsia than multiparous (Hutcheon et al. 2011). Birth weight was also associated with parity; in this case a higher birth weight was positively correlated with multiparous women.

However, these findings have implications for the care of women in this BMI classification. Guidelines published by NICE and CMACE/RCOG specify that women with a BMI $\geq 30kg/m^2$ are classed as high risk and should receive additional care and a referral to a dietitian or other appropriately qualified persons for personalised dietary advice (Modder 2010, NICE 2010). However, due to the current economic climate and limited resources, NHS services are mainly targeted at women with a BMI $\geq 40kg/m^2$ leaving women who are perceived to be at risk without the additional monitoring and care and at increased risk of adverse pregnancy outcomes. Furthermore, the numbers of women who are booking in for antenatal care with BMI $30-40kg^2$ are considerably greater that those booking in with a BMI $\geq 40kg/m^2$. This is also reflected in the frequencies of women in the BMI $35-39kg/m^2$ compared to the frequencies of women with BMI$\geq 40kg/m^2$ who participated in FFB+, see chapter 5 (fig 5-1).

6.4   THE QUALITY OF DIETARY INTAKE

Although there were limited statistically significant findings in terms of nutrient intakes, trends emerged regarding dietary intakes. These trends are suggestive of changes to maternal eating patterns over the duration of pregnancy and as such are indicators to the quality of diet being consumed by the women.

6.4.1 Macronutrients

The findings of this study showed that mean energy intakes were slightly below the UK recommendations for energy intakes during pregnancy for the normally distributed population (COMA 1991b). However, the results show that although total energy increased by 11% between visits 1 and 3, see chapter 5 (table 5-7), mean intakes were still slightly below the recommended intake of 2,145 kcals during the third trimester. Furthermore, there were significant changes in the macronutrients that contribute to total energy.

Protein intakes were in excess of the RNI of 51g per day which is recommended during pregnancy and mean intakes increased significantly between visits 1 and 3 (p =0.025), see chapter 5 (table 5-5). This is reflected as a 5.4% increase between visits 1 and 3 when calculated as a ratio of total energy in MJ/d, (table 5-7).

Although there was nothing of statistical significance (p >0.05), there were changes in the ratio of CHO fractions. Total CHO intakes decreased by 8% between visits 1 and 3 but total sugar remained the same. By contrast, there was a reduction in starch of 14% and NSP of 9.8% relative to total energy. The decrease in starches and NSP is indicative of a dilution of these CHO fractions over time. While there is no change in contribution of total sugars relative to

energy, this suggests a relative increase. Thus, it could be argued that the foods contributing to total CHO intakes are higher in SFA and sugar and low in dietary fibre and complex starches.

Statistically significant differences in the intakes of total fat (p =0.001), SFA (p = 0.013) and MUFA's (p =0.021) were observed between visit 1 and visit 3 (table 5-5). There was a mean increase of 10.9g of total fat, 5.9g of SFA and 4g increase in MUFA, see chapter 5 (table 5-5). When calculated as a ratio of MJ/d this reflected a 9.1% increase in total fat, a 12.5% increase in SFA and a 10.7% increase in MUFA between visit 1 and visit 3, see chapter 5 (table 5-7).

These findings indicate deterioration in the overall quality of diet as pregnancy progresses, suggesting changes in the foods being consumed. The decreases in starch and NSP as a ratio of total energy in MJ/d imply a reduction in the amount of fruit and vegetables and other foods high in dietary fibre. Moreover, the increases in total fat, SFA and MUFA in association with the changes in CHO fractions suggest that foods higher in fat with a high GI are being consumed.

These findings support previous studies looking at the quality of dietary intake during pregnancy. An Australian study by (Moran et al. 2013) used food frequency questionnaires (FFQ) at 10-20 weeks, 28 and 36 weeks gestation and 4 months postpartum in a cohort of 301 overweight or obese pregnant women. The study concluded that diet quality deteriorated over the duration of pregnancy and continued into the postpartum phase. The differences in macronutrient intakes between early pregnancy and late pregnancy is also concerning as dietary intake in early pregnancy can be compromised as a result of nausea and vomiting, therefore once this common pregnancy occurrence had

settled then it could be assumed that an improvement in the quality of diet being consumed would be seen but this is not the case. Poor diet quality was found in a US study by (Rifas-Shiman et al. 2009) as part of the Project Viva where 1,777 women completed FFQ in first trimester of pregnancy. In this study it was younger multiparous women with a higher BMI and lower educational attainment that had poorer quality diets. In a previous study by the same author as part of the same project, a comparison was made between dietary intakes in the first and second trimesters of pregnancy and mean energy intakes were found to be similar, 2046 kcals and 2137 kcals respectively (Rifas-Shiman et al. 2006).

6.4.2 Micronutrients

It is recommended that optimum dietary intakes of micronutrients are achieved pre-conceptually as well as in the first trimester to reduce the risk of adverse pre-programming during critical periods of foetal development (Jackson and Robinson 2001, Langley-Evans 2009). Dietary intakes of iron are often insufficient to cope with the high demand for iron in later pregnancy and are dependent on the bodies existing iron stores (Hallberg 2001). Data relating to maternal iron stores was not used as part of this study but results regarding dietary intakes of iron, show that mean intakes did not meet RNI in 86% of women at visit 1 and this had decreased to 80.8% by visit 3, see chapter 5, (table 5-11). Iron intakes are also shown in association with protein, see chapter 5 (fig. 5-13 to 5-15), this shows a positive correlation between iron and protein intakes at all 3 visits, however, these figures demonstrate that whilst the majority of women were achieving the RNI of 51g per day of protein, the majority of women were failing to achieve the RNI of 14.8mg per day for iron.

Normal distribution suggests that 97.5% of women aged 19-50 years of age should be achieving a RNI of 14.8mg/d to reduce the risk of deficiency, however, a LRNI of 8mg/d maybe sufficient enough to reduce the risk of deficiency for 2.5% in the same group (COMA 1991b). In this study the mean intake of iron for visits 1 and 2 was 10.6mg/d and visit 3 11.6mg/d. Mean values at visits 1 and 2 also fall short of the EAR of 11.4mg/d which 50% of women aged 19-50 years should be aiming for to reduce the risk of deficiencies. Furthermore, results indicate that 31% of women had failed to achieve the LRNI of 8mg/d at visit 1; this had improved by visit 3 where 17.8% of women had failed to achieve see chapter 5 (table 5-11). However, it is suggested that even mild maternal iron deficiencies can reduce foetal iron stores, which has been linked to impaired cognitive development in the offspring (Radlowski and Johnson 2013).

Vitamin D and calcium are integral to bone development in offspring (Javaid et al. 2006) and dietary intakes of vitamin D were wholly inadequate in this study. Maternal vitamin D status is not routinely measured in pregnant women with the exception of some ethnic minorities because of the perception that most women will be subject to normal UVB exposure in the UK. However, the question remains as to the actual requirements of vitamin D in pregnancy and whether obesity affects the absorption of pro-vitamin D_3. Because an obese woman's vitamin D status can be potentially compromised, women who book in for antenatal care at the LWH and have a BMI ≥40kg/m^2 are prescribed a combination supplement, which provides the requisite RNI's of calcium and vitamin D. However, the supplementary amount of vitamin D may be insufficient in the obese pregnant population based on more recent research. The COMA

panel established DRV's based on available evidence at general population level in 1991 and is the process of re-evaluating recommendations based on up to date evidence. Interestingly, a study looking at vitamin D status of post-menopausal women (mean age 61 and mean BMI 26.7kg/m^2) in Brazil with increased exposure to UVB found that a 10μg supplement of vitamin D incrementally increased circulating levels of 25(OH)D$_3$, the serum levels were still suboptimal (Pignotti et al. 2010). The suggestion being that there are even question marks over optimum levels in individuals living in sunnier climates and with a normal weight. There has been suggestion that obese individuals may have limited exposure to UVB because of body image issues and a reluctance to expose much skin (Anon 2000) but this has been refuted in a study by (Wortsman et al. 2000) who measured serum levels following supplementation in obese individuals and a normal weight control group and found after 24 hours serum levels of 25(OH)D$_3$ were higher in the control group. There has been some suggestion that vitamin D deficiency may give rise to obesity and an improvement in Vitamin D status may reverse the prevalence (Foss 2009). However, more recent findings suggest that vitamin D insufficiency or deficiency is as a result of obesity (Vimaleswaran et al. 2013).

Dietary intakes of iodine are difficult to measure using traditional dietary assessment methods which include estimated food diaries. This is because determining the used of iodised salt used in cooking or added at the table is impossible to quantify, also iodine in soil can vary widely (Skeaff 2012). Iodine has been positively associated with pre-eclampsia; a Turkish study by (Gulaboglu et al. 2010) measured the urinary iodine levels in women with severe eclampsia and found levels to be 4.25+/-2.7μg/dL lower than 20.89+/-

μg/dL found in normal healthy pregnant women, the authors concluded that urinary iodine concentrations may be a useful marker for diagnosing pre-eclampsia and iodine therapy a potential treatment. In this study no statistically significant associations were made between iodine and pre-eclampsia. There are no incremental increases in the recommendation for iodine during pregnancy, thus the RNI is140μg/d in adult women aged between 19 and 50 and the LRNI is 70μg/d. In this study 18.3% of the participants failed to achieve LRNI at visit 1 whereas 31.2% achieved RNI. By visit 3 those who had failed to achieve LRNI had decreased to 8.2% and those achieving RNI had increased to 56.2%, see chapter 5 (table 5-11), however, it was noted that iodine intake when measured as a ratio of MJ/d decreased by 6.7% between visit 1 and visit 3 see chapter 5 (table 5-10).

Folate is required pre-conceptually and in the first trimester to ensure the closure of the neural tube however, requirements continue throughout pregnancy hence the 100μg /d increment recommended throughout the entire duration (Williamson 2006). Maternal folate status is also associated with other adverse pregnancy outcomes such as pre-eclampsia, foetal growth restriction and preterm delivery (Sengpiel et al. 2014). The numbers of participants in this study were insufficient to detect any statistical relationship between folate intakes and pregnancy outcomes. However, the mean dietary intake of folate of the women in this study a fell short of the recommended RNI during pregnancy of 300μg /d at all 3 visits. Although there were very few women who failed to achieve LRNI of 100μg/d (not including the additional 100μg/d recommended for pregnancy) two-thirds of the women only achieved LRNI at visits 1 and 3,

see chapter 5 (table 5-11) in and when calculated as a ratio of MJ/d there was a decrease of 26.3% in dietary intake.

The findings of this study are consistent with findings in other studies, see (Blumfield et al. 2013). Dietary intakes of iron, folate and vitamin D in the normally distributed pregnant population are below the recommended guidelines in the majority of developed countries including the UK. There is also gathering evidence that micronutrient status is impaired in the obese population contributing to associated comorbidities (Garcia et al. 2009).

The decline in micronutrient intakes as a ratio of total energy between visits 1 and 3, see chapter 5 (table 5-10), further suggests a dilution of nutrients and that increases in energy are being met via energy dense, nutrient poor foods 'empty calories', rather than from nutrient dense food.

If these findings are representative of the obese pregnant population in general then it suggests that energy intakes may be consistent with recommendations but contributions to total energy are from SFA and MUFA and simple CHO and intakes of micronutrient are inadequate.

6.4.3 Supplements

Supplement use was not measured in this cohort as the focus was about meeting dietary recommendations through the adequacy of dietary intakes. Until sufficient evidence exists that human beings can be adequately nourished through supplementation, then it would be beneficial for pregnant women and particularly obese pregnant women to have a nutrient rich diet (Bekker 2009) prescribed for them to ensure optimum foetal development and to reduce the risks associated with foetal programming and PAR (Hanson et al. 2011). There is conflicting evidence for the use of supplements in pregnancy. A review of

intervention studies determined that for women who live in low to middle income countries, supplementation with multiple micronutrients particularly in respect of iron, iodine and folic acid was a cost effective way to improve birth weight rates and there was evidence of an 18% reduction in SGA babies in women with a BMI ≥20kg/m2 and a good nutritional status at baseline. Conversely, there was also evidence to suggest that multi-micronutrient supplementation was associated with an increased risk for perinatal and neonatal mortality via birth asphyxia in heavier babies but this finding was limited to only 2 studies and was not statistically significant (Haider and Bhutta 2012). There is supporting evidence that fortifying foods and beverages aimed at pregnant women in developing countries is associated with reductions in anaemia and iron deficiency. Furthermore, increases in mean birth weight of 60-73g have been observed in studies where supplementary foods containing milk and/or fatty acids have been used (Yang and Huffman 2011).

Folic acid supplementation has been proven to significantly reduce incidence of NTD but for optimum outcomes the supplement needs to be taken for at least 3 months in the pre-conceptual period and for the first 12 weeks of gestation (SACN 2006). The evidence for the protective effects of folic acid on NTD's was so overwhelming that it has become policy in the USA and Canada to fortify flour with folic acid improve the folate status of pregnant women. However, it has become apparent that folic acid may be implicated in the promotion and progression of existing neoplastic lesions (Kim 2007), although there is no evidence from RCT's (SACN 2006). Folic acid supplementation is also contra-indicated with anti- inflammatory medications as well as negatively affecting

zinc status. Some animal model studies have suggested that iron deficiency may cause folate depletion (EVM 2003).

It has been argued that 'there is too much of a good thing' with many supplements containing higher than recommended amounts, particularly micronutrients that have antioxidant capacity such as vitamins C & E. (Stanner 2000). As with folate, excessive intakes of some nutrients can interact with some pharmaceutical drugs and other nutrients (Yetley 2007). The Expert Group on Vitamins and Minerals in the UK (EVM 2003) have reported on known interactions for all vitamins and minerals. Iron is thought to interact with other metals that are close to it in the periodic table, such as copper, manganese, zinc and chromium and animal model studies have shown iron supplementation associated with impaired zinc absorption which may also translate to humans. The absorption of calcium is known to be affected by phytates found in seeds, nuts and grains but conversely, calcium is known to inhibit the absorption of iron even at low levels and the absorption of zinc at high levels (EVM 2003).

With the exception of folic acid and vitamin D supplementation, there is still insufficient evidence of any conferred benefit to pregnant women in developed countries from nutritional supplements (Picciano 2003) and the consensus is that all women of reproductive age should be made aware of the importance of a nutrient rich dietary intake during pregnancy to ensure optimal pregnancy outcomes (Williamson and Wyness 2013).

6.4.4 Underreporting

Previous research suggests that overweight and obese people can misreport energy intake by as much as 30% (Poslusna et al. 2009); overreporting intakes of fruit and vegetables and underreporting energy dense foods such as snack

foods and confectionary (Mendez et al. 2011). It is likely that foods that were underreported in this study will have been the energy dense, nutrient poor foods, effectively diluting micronutrient intakes as a ratio of energy intakes even further. However, the estimation of dietary intake during pregnancy is problematic. Therefore, there are many limitations associated with the assessment of nutritional status both at population and individual level.

The under-estimation of energy intake, by as much as 30% in the obese population, is renowned in self-reported dietary evaluation and can lead to systematic bias (Rennie et al. 2007). This was also observed in the study, calculations using the Goldberg cut off of 1.55 to validate energy intakes were based on data provided. The level of underreporting was estimated to be 37% at visit 1 and 29% at visit 3 see chapter 5 (table 5-8). However, limitations with the Goldberg cut off include difficulty assessing invalid reporting at individual level and inability to identify minor levels or varying degrees of reporting (Black 2000) The Goldberg cut off is expressed as the ratio of reported energy intake and estimated or measured basal metabolic rate (BMR) (Livingstone and Black 2003). When no measurable BMR is available it can be calculated from weight alone using the Schofield equations, which are modified to provide equations based on age ranges and coefficients of variation.

Below are the calculations based on the formula for non-pregnant, non-obese weight women:-

BMR (kJ day-1)

15 – 17 years BMR = 13.3 x W + 690   SEE = 112

18 – 29 years BMR = 14.8 x W + 485   SEE = 120

30 – 59 years BMR = 8.1 x W + 842   SEE = 112

W = body weight in kilograms   SEE = Standard error of estimation. (O'Riordan et al 2010)

The use of predictive equations for the purpose of estimating misreporting of energy intakes assumes a stable weight, which in the pregnant population is unlikely. BMR is thought to fluctuate at different rates during each trimester and by as much as 20% making the predictive equations unreliable (Horgan and Stubbs 2003). The basis of current recommendations for energy intake in pregnant women is still based on a theoretical model developed by Hytten and Chamberlain (cited in (Hronek et al. 2009), in which the model assumes an average gestational weight gain of 12.5kg composed of fat (3.8kg) water (7.8kg) and the remainder protein. Gestational weight gain and body fat are important determinants of BMR in pregnancy and longitudinal studies support the theory that there are marked increases in BMR during pregnancy (Lof et al. 2005). It has been established that the clinical practice for the estimation of BMR in pregnancy is inaccurate therefore Hronek et al (2009) set about determining a new equation for the prediction of BMR in pregnancy. However, only healthy women with a normal BMI were included in the study and up to now no equations have been validated for obese pregnant women therefore, levels of underreporting in this study are debatable.

Despite this, it is clear that excessive dietary intake is implicated in overweight and obesity. Alterations in macronutrient composition and an excessive intake of total energy may also have a profound effect on gestational weight gain, adverse pregnancy outcomes and birth weight, all of which are implicated in long term health risks for both mother and child. Therefore, it is essential that

any potential risk that is associated with dietary intake is identified and measures taken to reduce risk.

6.5 A SYNTHESIS OF THE FINDINGS OF THIS STUDY

To gain some understanding of why the quality of diet deteriorated during pregnancy and what the influences of lifestyle and eating behaviours had on this, this thesis employed a sequential explanatory mixed methods design. This enabled the findings of both quantitative and qualitative research to be connected. They utilise very different approaches but the results yielded can complement each other. In this study the findings from the qualitative phase were used to support and explain some of the findings from the quantitative phase.

6.5.1 Connecting the results

The quantitative phase of the study illustrated a marked deterioration in the quality of diet over the duration of the pregnancy with intakes of essential nutrients, optimum to pregnancy outcomes, declining in contrast to an increased intake of total fat SFA and MUFA. It is evident that the additional calories that contributed to total energy intakes were provided by more energy dense/nutrient poor foods. What is also apparent from this study is that there are multiple factors that influence the food choices that pregnant women with obesity make. The quantitative findings are supported by the qualitative study, which found that the women who participated in the qualitative arm of the study often had negative pre-existing eating behaviours that were exacerbated, particularly in the final weeks of pregnancy when they were experiencing extreme tiredness

and mobility difficulties. This in turn influenced food choices, which were more likely to be convenient, takeaway or snack foods, all of which are more energy dense and lack vital nutrients. Many of the women freely admitted to consuming 'empty calories' such as crisps and chocolate, often at the expense of regular meals. There were higher intakes of fast food and takeaway meals as the physical symptoms of pregnancy, such as increased tiredness and limited mobility, were experienced. However, many of the women also stated that their appetites were diminished during early pregnancy as a result of pregnancy sickness, whilst others made a concerted effort to eat more healthily throughout. This could explain why the mean total energy intakes were equal to or slightly below EAR for energy during pregnancy. Additionally, the final weights recorded at 36 weeks gestation suggest a modest mean weight gain of 4.8kg, slightly below IOM recommendations of between 5-9kg. Of the women who had their weight recorded at 36 weeks gestations (n39), 41% had gained below the IOM recommendations of 5-9kg weight gain for women with a BMI ≥30kg/m^2 and 18% had gained within IOM recommendations. Conversely, 15% of these women also lost weight, see chapter 5 (fig 5-12). However, it must be emphasised that the women who participated in FFB+ received no dietary advice as the study was observational in design. As such, the reasons for the weight loss are not known. However, during statistical analysis no inverse relationships between maternal weight change and pregnancy or birth outcomes were flagged up.

Some of the women who took part in the follow up phase suggested that they participated in the FFB+ study to help them to modify their eating behaviours and adopt a more healthy diet because their food intakes were being scrutinised

although no dietary advice was being given. There was agreement in the women's views that regular monitoring of their weight would help them to moderate the amount of GWG. Pregnancy is a major transitional point where many of the women agreed that their weight increased significantly as a result of their first pregnancy and continued to increase with each subsequent pregnancy. This is consistent with other studies, indicating that pregnancy is a key stage for weight gain (Gunderson et al. 2000, Melzer and Schutz 2010, Rössner and Ohlin 1995).

There were appreciable physical and emotional constraints that many of the women experienced as a result of overweight and obesity. Some physical symptoms prevented the women from participating in family and/or physical activities. Tiredness and breathlessness as well as sciatica, symphysis pubis and joint problems were all exacerbated during pregnancy. These findings were supported in a study by (Evenson et al. 2009), where health related issues such as tiredness and back pain were identified as barriers to physical activity. This also supports the findings from the quantitative phase in which dietary quality declined as pregnancy progressed due to the reasons aforementioned.

There was a dichotomy in the perceptions of overweight and obesity experienced by the women who participated in FFB+. On the one hand, these women gained weight intermittently and had at points successfully reduced their weight to a perceived acceptable level. Many admitted that during these periods of 'normal weight' they felt much better for it; being more mobile, more sociable and feeling altogether healthier, but ultimately they were unable to sustain the weight loss and often as a result of a transitional period regained the weight, moving their weight set point upwards. This effected emotional responses, often

frustration, guilt and disappointment at the apparent 'failure' to keep the weight off and comfort eating or mindless eating often ensued. The psychological effects of weight cycling were reviewed in research by (Foster et al. 1997) and the negative emotions experienced by the women as a result of their weight regain are consistent with findings in other studies. Many of the women in the FFB+ study who are caught up in this weight cycling existence described it as being in a 'vicious circle' that they feel powerless to break free from. They were bound by a negative language, common to the women, where terms related to eating behaviours such as 'being good' or 'naughty' and 'behaving' themselves were expressed.

Indications from the phase 2 results are that the women's weight gains are intermittent, attributable to specific times throughout their lives and are associated with transitional points. Puberty, autonomy, friends, family and relationships were major influences on weight and eating behaviours and a strong media influence resulted in negative self-perceptions among many of the women. A study by (Grant and Boersma 2005) also found that family and emotions were strong underlying factors that influenced weight gain in a cohort of 11 participants, 9 of whom were female. The women in this study describing how eating behaviours and relationships with food were developed in childhood as a result of family interactions, some of which were nurturing and some in which mealtimes were more like battlegrounds. The women in the FFB+ study very often turned to food for comfort at times of stress and the term 'comfort food' as defined by Wansink and Sangerman cited in (Locher et al. 2005) as a 'specific food consumed under a specific situation to obtain psychological comfort'. This was strongly reflected in the experiences of this cohort.

6.5.2 Challenges to the NHS

Obesity is a problem that can affect women at any stage in the lifecycle and it has been established that there are higher rates of obesity in women than there are in men in the developed world (Ryan 2007). There has been a significant rise in maternal obesity and rates were predicted to have risen to 22% by 2010 (Heslehurst et al. 2007a). Obesity in pregnancy poses a number of problems both physiological in terms of maternal risk, foetal health and long term maternal and offspring health but also in terms of the cost implications involved in reducing risk and additional care (Galtier-Dereure et al. 2000). Therefore, there is now a substantial body of work that set out to ascertain the scale of the problem including (Abayomi et al. 2007, Heslehurst et al. 2010), and to design interventions to address the problem; including physical activity interventions (Moholdt et al. 2011, Sui et al. 2012) and lifestyle interventions (Claesson et al. 2008, Guelinckx et al. 2010, Kinnunen et al. 2008). However, dietary intake is one of the most complex aspects of weight management. In most instances when applying techniques to effect a behavioural change, there is a requirement to abstain from the effectors' i.e. alcohol, narcotics or cigarettes but this is not as easily done when it comes to the diet. The majority of studies are looking at weight management by way of healthy eating, physical activities and goal setting, with the emphasis on weight. Many women find the issue of weight to be positively associated with low self-esteem and a negative emotional state as described previously. Participants in the qualitative study expressed negative emotions when it came to society's perceptions of overweight and obesity and felt that there was too much emphasis on weight, even from a medical

perspective with one participant stating *"I think the thing with doctors is that they put everything down to the weight part of you"*.

A change in strategy, away from the stigma of weight and the negative consequences associated with it and a focus on maternal and foetal health. Thus promoting healthy eating for good health as opposed to a regulation of weight could have a more positive effect. Opinion is emerging that suggests a paradigm shift away from weight loss and onto health as the most positive method of tackling long term obesity particularly in women with a history of weight cycling (Cadenhead et al. 2012, Smith and Lavender 2011). This may be a useful approach due to the difficulties midwives have in approaching the subject of weight with obese pregnant women at booking in. Midwives are duty bound to inform obese pregnant women of the risks to themselves and to the infant of obesity during pregnancy and to advise them on the role of healthy eating and lifestyle in order to reduce the risk of GDM (NICE 2010). However, in the absence of official guidelines as to recommended weight gain/loss in obese pregnant women (Warren et al. 2012), communication difficulties regarding the sensitive nature of weight (Smith et al. 2012) and a lack of nutritional knowledge (Arrish et al. 2013), midwives are faced with a major challenge over the issue of gestational obesity.

Furthermore, due to the current economic climate and the austerity measures implemented by the present government, there have been large cutbacks in health care staff including the dietitians and midwives needed to implement the recommended guidelines for the care of pregnant women with a BMI $\geq 30 kg/m^2$ (Royal College of Midwives (RCM), 2012). It is estimated that there is a shortfall of approximately 5000 FTE midwives in England, coinciding with an increased

growth in birth rates which is outpacing the growth in midwife recruitment (RCM, 2012). Recent figures suggest the maternal mortality ratio (MMR) in the London area has risen from 9.1 per 100,000 live births in 2005-2006 to 21.6 per 100,000 live births in 2010-2011 largely due to the shortage of midwives and the issues facing maternity services (Silva, 2013). At the LWH alone, approximately 19% of women who booked in for antenatal care between June 2009 and June 2010 had a BMI ≥ 30kg/m^2 and if this increase in MMR is representative of a nationwide increase, many more women are being put at risk. This has subsequently impacted on the quality of care midwives are able to offer. A poll conducted by RCM of over 2000 midwives found that 89% of midwives felt unable to give women all the care and support needed and 87% were frequently or always working over and above their contracted hours (RCM, 2012). Dietetic provision has also been affected, the LWH has no dietetic care pathway in place for women (BMI ≥ 40kg/m^2) booked into the bariatric clinic and only had 0.4FTE in 2007 for all maternity provision including medical disorders of pregnancy and hyperemesis (Abayomi et al 2007). There are weight management services available in Liverpool; Aintree LOSS (Liverpool Obesity Support Services) is a multidisciplinary programme offering tailored advice from dietitians, physiotherapists, psychotherapists and health care support workers to obese people on an individual basis and/or as part of group appointments. An agreement, between LWH and Aintree University hospital, is in place to refer pregnant women with a BMI ≥ 35kg/m^2 into this service. However, very few women have accessed this service with personal communications revealing that only 10 women with a BMI ≥ 35kg/m^2 have been referred to LOSS in the past 12 months.

However, there have been other strategies that have been developed. In place of appropriate professional nutritional advice, an alliance between the RCM and Slimming World has been introduced to help obese pregnant women adopt a healthy diet and manage their weight (RCM, 2012). Slimming World is the only commercial weight loss organisation that actively works with pregnant and breastfeeding women and is backed by midwives and GP's. This is despite a systematic review offering evidence that slimming clubs have limited long term effectiveness, (Tsai and Wadden 2005). A study by (Ikeda et al. 2004) presented data on the self-reported dieting experiences of women with a BMI≥30kg/m^2 and similar to the qualitative findings of this study, found that women with high BMI's had made far more attempts at dieting than women with normal BMI's and tended to start dieting before the age of 14 and additionally had more negative memories of dieting, far outweighing the positive or neutral ones. Furthermore, a UK study by (Green and Buckroyd 2008) exploring the effects of successful weight loss in individuals who had attended commercial weight loss clubs found elevated levels of disordered eating cognitions and behaviours. There was also evidence of higher rates of depressive symptoms, body dissatisfaction and psychosocial impairment in addition to increased bouts of binge eating in those who had joined commercial slimming groups. These findings are supported by the findings of this study; women that participated in the qualitative arm, described a chequered history of weight loss attempts using commercial slimming clubs and continued to have disordered eating behaviours, with frequent binging episodes and comfort eating. They also described low levels of self-esteem and depression. Moreover, it is likely that the reported success rates of slimming clubs are diluted by the high attrition

rates, a view supported by a representative from the National Obesity Forum (NOF) who was quoted as saying that they were 'quick fixes' and not addressing the real problem (Campbell, BBC Newsbeat 2011). It has been shown that up to 90% of individuals who diet and lose 25lbs or more will regain the weight within 2 to 5 years (Kensinger et al. 1998). A review of studies into long term outcomes of weight loss treatments found similar results with up to 83% of individuals regaining more weight than had been lost. The authors concluded that there was insufficient evidence in support of dieting leading to sustainable weight loss or health benefits (Mann et al. 2007). This could be due to the focus of commercial slimming clubs being weight loss, the measurable outcome of successful slimming; as opposed to an emphasis on health and the quality of dietary intake. This is left to the club members themselves to self-regulate and therefore success is entirely dependent on the self-efficacy, motivation and emotional status of the individual. This is reinforced by the findings in this study which support the view that commercial slimming clubs may actually promote feelings of failure and perpetuate weight cycling. Furthermore, there is opinion to suggest that dieting actually makes people gain weight (Hill 2007) and that weight cycling is implicated in increased health risks including hypertension (Field et al. 1999) and cardiovascular risk factors (Montani et al. 2006). However, evidence is inconsistent (Graci et al. 2004) and individuals should not be deterred from weight loss but weight regain should be avoided. This was also reinforced by the women who participated in the qualitative study, who had all attempted on numerous occasions to lose weight by joining commercial weight loss clubs such as Weight Watchers, Slimming World and Rosemary Conley, with many of the women expressing both

negative and positive attitudes towards these clubs. Some felt that the clubs were just there to weigh them and take their money whereas others had re-engaged with a weight loss club and were making renewed attempts to lose weight. However, it is notable that they all booked in for antenatal care with a BMI ≥35kg/m^2. This suggests that the long term effectiveness of these organisations is questionable. This is potentially of major concern due to the alliance between RCM and Slimming World.

6.6 THE CONSEQUENCES OF OBESITY IN PREGNANCY

The implications of obesity in pregnancy have far reaching consequences at a number of levels. There is a personal cost to the women and offspring, both in terms of health risk and the social stigma that exists around overweight. The stigma of obesity is reinforced at most levels of society by the media, the fashion industry (Lewis et al. 2011), the health care profession (Schwartz et al. 2003) and not least by the weight loss industry itself (Karasu 2012). This leads to the self-objectification of girls and women where a psychological link exists between self-objectification and the well-being of women. Body guilt and feelings of shame ensue which mediate disordered eating (Calogero and Pina 2011). Furthermore, depression and anxiety in obese individuals can lead to negative eating behaviours such as binge eating and/or comfort eating increasing depressive symptoms even further (Schneider et al. 2012) and the potential for weight cycling. This was evident in the women who participated in the qualitative study, as previously described, many of the women admitting to binge eating, comforting eating and snacking between meals or sometimes

instead of regular meals. This is supported by comments from some of the women who said *"you know you feed the kids and that but if there's a packet of biscuits there…rather than go and make a meal, I'll eat the biscuits"* and *"sometimes when I get upset I have chocolate…and afterwards I feel horrible cos I've put more calories inside"*

However, this may be a reciprocal association and it is weight cycling that has adverse effects on self-esteem, body image and eating behaviours. These negative effects may also impact on an individual's self-efficacy about weight control, creating potential barriers to weight loss amid the fear and shame of subsequent regain in a society that overvalues thinness (Foster et al. 1997). The findings of this study also supports these views as many of the women spoke of a long term battle or 'vicious circle' relating to weight, leading to feelings of anxiety and guilt and using a negative terminology when describing a relationship with food. These psychological issues can unwittingly be passed on to offspring because of the strength of maternal influence on early child feeding practices. This is the subject of a review by McPhie et al (2012), which considers personal characteristics and psychopathology as factors related to a mother's influence on child feeding practices. The review found a number of studies suggesting a negative correlation between maternal weight and the communication of knowledge regarding nutritional balance and variety in the offspring diet or the modelling of healthy eating behaviours (McPhie et al. 2012).

Pregnancy is viewed as an ideal opportunity or a 'teachable moment' (Phelan 2010) to encourage women to adopt new dietary behaviours, due to the concern and anxiety they have in relation to infant health and development.

Interventions that help to improve dietary intakes, to ensure optimum foetal development and reduce the risk of obesity and predisposition to obesity related disease such as T2DM in the offspring are need. Possibly, the most direct way to influence maternal health, offspring health and subsequently weight is related to quality of dietary intake. Public health messages regarding the dangers of smoking and consuming alcohol during pregnancy have had a positive effect on those behaviours with significant reductions but there is still evidence to suggest that dietary intake, particularly in respect of fruit and vegetable consumption changes very little (Crozier et al. 2009). Women living in areas of low socio-economic status such as Liverpool, with lower levels of education are more likely to over consume energy dense, nutritionally poor foods leading to gestational weight gain, poor pregnancy outcomes and post-partum weight retention (Chang et al. 2008, Nelson et al. 2007). Understanding and comprehension of nutritional advice and the impact of poor food behaviours on pregnancy outcomes may be compromised. Cognitive ability may fall below national standards for literacy and there may be disconnect between nutritional knowledge and health outcomes (Dammann and Smith 2009). Therefore, it is important that nutritional knowledge is ascertained. Simple questionnaires could be introduced at booking in to identify those women in greater need of nutritional advice and support and those found in need of additional support could receive nutritional education, which has had some success in other countries (Fallah et al. 2013).

6.7 CONCLUSION & RECOMMENDATIONS

The final section of this thesis presents the conclusions and recommendations of the research study. It commences with the limitations associated with the study and is followed by the recommendations for further research and practice and finishes with the concluding remarks.

6.7.1 Limitations

The findings of this study may be limited by the convenience sampling method adopted by the wider FFB study. As such, the women who consented to participate may not have been fully representative of the obese pregnant population. All women who booked in for antenatal care with a BMI ≥35kg/m^2 were invited to participate in FFB+ but given the commitment required, only women who had either the time or a perception of benefit to themselves or to others in the future would be likely to consent.

Attrition rates also are a problem in any study, pregnant women can be sensitive about weight gain (Furber and McGowan 2011) and women who are already overweight or obese who are undergoing scrutiny, during a time when further weight may be gained, are likely to be ultra-sensitive and drop out of the study if there is a failure to comply with the study protocol. A systematic review by (Moroshko et al. 2011) found that low self-efficacy regarding weight management, eating behaviours, psychological health and physical activity levels were all contributory factors to high attrition rates. The women who consented to participate in FFB+ and in the wider FFB study also agreed to be weighed throughout gestation at routine antenatal appointments and at

additional research clinic appointments. However, there were many inconsistencies in this part of the study resulting in intermittent and incomplete data. As such, sufficient data pertaining to gestational weight change that could be matched statistically to dietary intake data only exists for 39 women and relates to weights recorded at 36 weeks gestation.

Limitations in respect of the recruitment to the qualitative phase were also evident. The sample was purposively selected, in that they had to have consented to FFB+, however, a convenience sampling method was also applied to phase 2 and therefore the qualitative sample of 18 women may not have been representative of the population who participated in phase one. The time lapse between phase 1 and 2 was between 1 and 2 years. This means that the memories the women had of being pregnant during phase 1 may not have been remembered with accuracy.

Research into the effects of nutritional epigenetics and developmental plasticity is on-going and the effect of specific nutrients on pregnancy outcomes remains unclear. Therefore, caution should be exercised during the design and development of any intervention based around these assumptions. Although there is an abundance of epidemiological observations and animal model experimental evidence, this does not necessarily directly translate to human experience.

Limitations exist in all aspects of the data collection, from the dietary assessment method, time restrictions during the validation of the food diaries, as well as methods used to assess levels of misreporting. There are also limitations in food composition databases, not all foods are represented, specifically some composite foods which needed to be broken down into the

component parts before analysis. Estimated food diaries were chosen as the most advantageous way to collect daily food intakes in this study. Weighed food diaries are probably more precise in terms of the actual weight of the food being entered into the software; however, the disadvantages outweigh the advantages. The participant burden is initially higher, where all food items including snacks and drinks would have to be weighed. There are differences in the weight and nutrient contents of raw and cooked foods that have to be accounted for and there would not have been the same need for the follow up interview. In contrast, estimated food diaries may lack precision but were probably more accurate as a food atlas was used to verify portion sizes at a follow up interview. The follow up verification interviews also proved to be beneficial for prompting and reminding participants of food items that may have been omitted, such as condiments, drinks and snacks eaten in between meals.

Food diaries give an insight into a typical day's food intake which accounts for all food items and includes drinks, snacks and condiments and allows for mean estimates of energy, macro and micronutrient intakes. However, food intake can be modified during the reporting period and/or under or over reporting of certain foods can cause systematic bias in the results. One of the limitations of using estimated dietary records is that the associated software generated estimated measures of the macro and micronutrient content of individual food lists but it was unable to generate a general food list for the sample population. Therefore, dietary patterns could not be established during this study.

Dietary data were collected for 140 women overall, however, the number of women who completed all 3 food diaries and had a weight recorded at 36 weeks only accounted for 39 participants, resulting in limited statistical power.

6.7.2 Conclusions

The relationship between total energy intake, energy expenditure, maternal weight gain and birth-weight is a complex one (Blumfield et al 2012) and the measurement of nutrient intakes in pregnant women difficult (Nowicki et al. 2011). There are limited studies looking at the quality of dietary intake in obese pregnant women but it is an area that requires much more research. Existing studies also indicate that diet quality deteriorates throughout the duration of pregnancy, increasing the risk of adverse outcomes.

Individual intakes of micronutrients cannot be considered in isolation, meaning that an inadequate intake of one micronutrient is likely to be associated with inadequate intakes in others. This is indicative of a nutritionally inadequate diet which was illustrated by the findings of this study. Supplements may be useful for the correction of diagnosed deficiencies of specific nutrients but cannot be relied upon to meet the requirements of all essential nutrients. There are always exceptions to the rule and this applies to supplementary forms of vitamin D and folic acid; vitamin D because recommended intakes are unachievable from dietary sources alone and folic acid due to the protective effects of NTD's. Combined multivitamin and mineral supplements recommended for pregnant women are no substitution for a high quality dietary intake. Pregnant women with obesity may be compromised in terms of micronutrient intakes and further research should attempt to determine optimum amounts of micronutrients for the obese pregnant population. Although the use of micronutrient supplementation may be of benefit to women with an inadequate nutritional status, a reliance on supplements will impact negatively on the nutritional status of the offspring if maternal nutritional knowledge is lacking. The likelihood of the

infant being introduced to an energy dense, nutritionally inadequate diet is increased. It is therefore, of great importance that all women of reproductive age are informed of the significance of eating a diet rich in essential micronutrients and phytochemicals to support pregnancy and provide the optimum environment for foetal growth at critical stages of development (Sui et al 2013). This should be done via qualified dietitians and nutritionists who have in-depth nutritional knowledge and can advise on and/or prescribe diet plans, to suit all budgets, that incorporate a wide range of foods that would supply the optimum nutrients and energy to sustain a healthy pregnancy whilst limiting gestational weight gain. This should also equip pregnant women with obesity for the future and influence breast-feeding and infant weaning practices. Research is needed to explore the acceptability of a prescriptive diet driven intervention in pregnancy.

The 'five-a-day' campaign, while worthy, is insufficient guidance on maternal diet, particularly in the obese population. Fruit and vegetables also supply minerals and trace elements as well as phytochemicals and non-starch polysaccharide (NSP) therefore pregnant women should be advised to consume over and above the current recommendation. The 'Eatwell' plate provides a rudimentary depiction of the approximate ratio of intakes relative to specific food groups but this and the dietary sources for certain micronutrients need qualifying by appropriately trained professionals.

6.7.3 Recommendations

Based on the findings of this study the following recommendations are required to address the gaps that currently exist in nutritional knowledge.

- For further study it would be useful to generate data that illustrated overall dietary patterns in pregnant women with obesity as well as the measurement of nutrients so that more prescriptive or tailored advice can be given to specific populations.

- There is a need to identify women's nutritional knowledge and eating habits, this could be done via nutritional scales or questionnaires at booking in (Kim 2009) and women identified as having low nutritional knowledge should be referred to a qualified dietitian or nutritionist for a detailed assessment of dietary intake and appropriate dietary advice.

- Women should be advised of the associations of low quality dietary intakes and offspring health in addition to the advice they receive regarding the risks that obesity poses to themselves and offspring in the short term.

- Additional focus should be given to nutrition and the nutritional needs of all pregnant women during midwifery training. Ideally this should be provided by qualified nutritionists or dietitians. The Nutrition Task Force Project Team (DH;1994) stated that all health care professionals should have an understanding of the general principles of diet, nutrition and health requiring 18 hours of instruction along with practical experience. (Barrowclough and Ford 2001). However, this statement from 1994 is outdated and insights and understanding of the pivotal role that nutrition plays in foetal development and long term health, necessitates a higher

priority given to it in midwifery training. This would aid the midwife in identifying low nutritional knowledge in the patients in their care and enable them to direct them towards the appropriate care pathway.

- Pregnant women with a BMI ≥40kg/m^2 are likely to have complex problems including GDM and/or psychological issues which present a challenge to fully qualified and experienced dietitians. Increased investment in dietetic services would enable compliance with NICE guidelines. Dietitians are the most qualified people to deliver nutritional education and advice, both to other HCP's and to high risk women rather than relying on the cheaper option of inexperienced and unqualified staff.

- The introduction of routine weighing at antenatal appointments and on presentation for delivery as a tool for monitoring weight gain in pregnant women. A 2009 study showed that GWG was reduced in pregnant women who were overweight, in the absence of any other lifestyle intervention, when weight was monitored throughout (Jeffries et al. 2009).

6.7.4 Future research ideas

A bid has been submitted for a Research for Patient Benefit grant to secure funding to undertake a feasibility study to determine the uptake and acceptability of referring obese pregnant women into an existing weight management service known as Liverpool Obesity Support Services (LOSS).

The aim is to enable the direct referral of women, deemed eligible at booking in, into the service with a commencement at approximately 16 weeks gestation. The study will look at the effectiveness of a multidisciplinary healthy eating programme in improving quality of dietary intake and reducing pregnancy risk in obese pregnant women.

A bid to secure funding to explore the current nutritional education and knowledge of practicing and student midwives, in a qualitative study, is being considered.

6.7.5 Concluding comments

The nutritional status of all pregnant women is of paramount importance and is a primary factor when it comes to addressing the obesity epidemic. This is supported by the findings of this study which found that women with a BMI 35-39kg/m^2 gained the most weight and proportionally had more adverse outcomes such as pre-eclampsia, hypertension and SGA. They also had more babies admitted to SCBU in comparison to women with a BMI ≥40kg/m^2. This has implications for the care of pregnant women with obesity as women with a BMI 30-39.9kg/m^2 are still a high risk group but receive no additional care above routine care because of limited resources thus their level of care is compromised which could potentially prove fatal. The same group of women also had the greatest increase in their total energy intakes above EAR, which would be a main determinant of GWG. Quality of diet has a significant influence on weight gain, pregnancy and birth outcomes and is an area that requires much more research. It is possible that nutritional status is the greater determinant of adverse pregnancy outcomes as opposed to weight, as weight gain is a consequence of excessive energy intakes often at the expense of

essential micronutrient intakes. Appropriate nutritional advice is essential for high risk women and should be delivered by appropriately qualified and experienced nutritional professionals such as dietitians.

Nutrition and dietary intake is the foundation of good health. Weisburger (2000) stated that 'most of the chronic diseases in the world have an important nutritional component by directly causing a disease, enhancing the risk through phenomena of promotion, exerting a beneficial effect by decreasing risk or preventing the disease' (Weisburger 2000). This is not a new theory as the influence of food on health was recognised by Hippocrates (460-377BC), the father of medicine, who the saying 'let thy food be thy medicine and thy medicine be thy food' is attributed to!

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7.1 PUBLICATIONS

M. S. Charnley, A. F. Hackett and J. C. Abayomi (2011) Energy intake and weight gain of morbidly obese pregnant women in Liverpool *Proceedings of the Nutrition Society* **70**:E17
doi:10.1017/S0029665111000322

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Liverpool Women's

Fit for Birth

Name……………………………………… Unit No……………………………………………...

Antenatal Care   Height (cm)………. Weight (kg)………. BMI………. Hb……….
Blood Group………. Rhesus……….

Date	Gestation	Blood Pressure	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being		Risk Assessment High/Low Risk?			Signature	
Fit for Birth Weight: _____ kg *						

Comments, advice or actions

See Continuation Sheet Number……

Date	Gestation	Blood Pressure	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being		Risk Assessment High/Low Risk?			Signature	
Fit for Birth Weight: _____ kg *						

Comments, advice or actions

See Continuation Sheet Number……

Date	Gestation	Date	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being		Risk Assessment High/Low Risk?			Signature	
Fit for Birth Weight: _____ kg *						

Comments, advice or actions

Fit for Birth   * Also please fill in page 23 about medication and illnesses

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Fit for Birth

ID Label

Date	Gestation	Blood Pressure	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being	Risk Assessment High/Low Risk?		Signature
Fit for Birth Weight: _____ kg *			

Comments, advice or actions

See Continuation Sheet Number……

Date	Gestation	Blood Pressure	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being	Risk Assessment High/Low Risk?		Signature
Fit for Birth Weight: _____ kg *			

Comments, advice or actions

See Continuation Sheet Number……

Date	Gestation	Blood Pressure	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being	Risk Assessment High/Low Risk?		Signature
Fit for Birth Weight: _____ kg *			

Comments, advice or actions

See Continuation Sheet Number……

Date	Gestation	Blood Pressure	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being	Risk Assessment High/Low Risk?		Signature
Fit for Birth Weight: _____ kg *			

Comments, advice or actions

See Continuation Sheet Number……

Fit for Birth   * Also please fill in page 23 about medication and illnesses

Liverpool Women's

Fit for Birth

ID Label

Date	Gestation	Blood Pressure	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being	Risk Assessment High/Low Risk?		Signature
Fit for Birth Weight: _____ kg *			

Comments, advice or actions

See Continuation Sheet Number……

Date	Gestation	Blood Pressure	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being	Risk Assessment High/Low Risk?		Signature
Fit for Birth Weight: _____ kg *			

Comments, advice or actions

See Continuation Sheet Number……

Date	Gestation	Blood Pressure	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being	Risk Assessment High/Low Risk?		Signature
Fit for Birth Weight: _____ kg *			

Comments, advice or actions

See Continuation Sheet Number……

Date	Gestation	Blood Pressure	Urine	Fundal Height	Position & presentation	Relation to brim	Fetal heart

Social & emotional well being	Risk Assessment High/Low Risk?		Signature
Fit for Birth Weight: _____ kg *			

Comments, advice or actions

See Continuation Sheet Number……

Fit for Birth   * Also please fill in page 23 about medication and illnesses   19

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Liverpool Women's

Fit for Birth

ID Label

Name…………………………. Unit number……………………………….

Continuation sheet

Date/time	Comments	Signature

Liverpool Women's

Fit for Birth

Fit for Birth

ID Label

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Your birth plan

We would like to know your plans for the delivery for your baby's birth, so please feel free to make a note of any preferences you have.

You may wish to consider the following points when completing you birth plan:
Where you would like to give birth
Mobility during labour
Use of the birthing pool for labour or labour and birth.
Pain relief in labour
Epidural analgesia
Fetal monitoring
The third stage of labour
Vitamin K for you baby
Birth partners / companion

Discussed	With Whom	Date

Liverpool NHS Foundation Trust

Liverpool Women's

Fit for Birth

Liverpool Women's Hospital, Crown Street, Liverpool L8 7SS
Tel 0151 702 4101

Principal Investigators: Dr Siobhan Quenby & Dr Andrew Weeks

ID Label

Illnesses in your pregnancy *

Date started	Date finished	Type of illness

Medicines and remedies in your pregnancy *

Date started	Date finished	Medication with dose and frequency

Organised activities in your pregnancy (e.g. aqua natal, pram push, etc) *

Date started	Date finished	Organiser (eg council, GP surgery…)	Type of activity

* continue overleaf if necessary

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Fit for Birth

ID Label

23

Continuation sheet

Date started	Date finished	

Liverpool Women's

Fit for Birth

ID Label

'Fit for Birth' is a study of the effect of diet and weight on pregnancy outcomes.

In the first part of the study we are asking all pregnant women with a body mass index (BMI) of over 30 (approximately 75kg or 12 stone) to help us.

There are 3 ways in which you can help us:

1. **Do nothing!** Your care will be exactly as normal and we will simply collect data from the hospital at the end of the year and see what the relationship is between fitness and eventual outcome.

2. **'Fit for Birth'.** Have your normal care in pregnancy, but allow us to weigh you at your antenatal clinic visits. We would also ask you to tell us about any illnesses or medication that you use in pregnancy. This will tell us about what is the ideal amount of weight to put on in pregnancy.

3. **'Fit for Birth PLUS'.** This study will look in a lot more detail at your health, diet and exercise during pregnancy. We will spend a morning with you at the Women's Hospital 3 times during your pregnancy, collecting information about your diet, assessing your exercise levels using a questionnaire and pedometer and (for some) your sleep (using an oxygen monitor overnight). After your delivery we will collect and study your placenta to look at how healthy it is. The assessments are simple and will give us a lot of time to fully assess your health. A specialist group of a midwife, doctor and dietician will be on hand to discuss any particular problems that you might have. The assessments will be repeated following your delivery.

More detail about the studies in general and about how we deal with the data about you are on the next page.

Which of the studies, if any, are you willing to take part in (please tick the box)?

1. 'Fit for Birth' (extra weights only) ☐
2. 'Fit for Birth PLUS' (detailed health assessments and examination of placenta) ☐

Please now read the full info sheet and

Sign on page 28 if you want to take part

Liverpool Women's Hospital, Crown Street, Liverpool L8 7SS
Tel 0151 702 4101

Principal Investigators: Dr Siobhan Quenby & Dr Andrew Weeks

INFORMATION SHEET

We would like to invite you to take part in a research study.

First you should understand why the research is being done and what it would mean for you.

Please take time to read this information carefully and discuss it with others if you like.

Ask us if there is anything that is not clear.

Take time to decide whether or not you wish to take part.

Why are we doing this research?

The aim of this project is to improve the care of pregnant women in Liverpool so that there are fewer complications during pregnancy and improvements in long term health.

Initially we are looking at all women who have a body mass index of over 30 (over about 75kg or 12 stone). Larger women are thought to be at increased of complications because of their weight. However, it is not known how risky a pregnancy is compared to smaller women, how it affects their long term health, or whether weight loss during pregnancy is good or bad.

'Fit for Birth' study: In this study we are therefore going to follow 3000 women through pregnancy, looking at how much weight is gained or lost by them and how it affects their health.

'Fit for Birth PLUS' study: For an extra 200 women we are going to do much more detailed assessments of their fitness levels. This will take place at the Women's Hospital on three occasions during pregnancy, and one after birth. At these visits we will assess your diet, exercise levels, sleep and quality of life of the cohort.

The data from this study will help us to understand the effect of fitness and weight on pregnancy, as well as helping us to improve the NHS services for women.

Why have I been chosen?

You have been chosen to take part because your body mass index is over 35. This increases your risk during pregnancy.

Do I have to take part?

No, it is up to you to decide. You are still free to change your mind at any time and without giving a reason. This would not affect your care – you would receive normal care.

What will happen if I take part?

'Fit for Birth' study: the only thing extra that will happen to you will be that we will weigh you at each visit. However, we would also like your permission to look at all the data held about you on the hospital records – this will tell us how you delivered and any complications that developed.

'Fit for Birth PLUS' study: in this study we would still weigh you at every visit, but we would ask you to come up to the Women's Hospital 4 times during pregnancy for detailed assessments. We will ask you to fill in questionnaires to assess your diet, exercise level, quality of life and sleep quality. We will also ask you to wear a pedometer to Measure your activity for one week. If your sleep questionnaire indicates that you may have sleep apnoea, we will arrange further test to confirm this. A dietician will assist you in filling in a diary of your food intake. We will also look in detail at your placenta in the laboratory after birth to see how healthy it is. A special trained midwife would like to measure round your baby's arm and also to measure the thickness of a fold of skin.
We estimate that each of these visits will take one to two hours.

What are the possible disadvantages of taking part?

'Fit for Birth' study: there are no potential disadvantages except for the time that it takes to weigh you at each visit.

'Fit for Birth PLUS' study: this will take up some of your time both for the assessments at the Women's Hospital, and for the home assessments of exercise, diet and sleep.

What are the possible advantages of taking part?

During the study you will have access to a special clinic on a Friday morning at the Liverpool Women's Hospital. This is run by the research staff, including a doctor, specialist midwife and nutritionist. If you are part of the *'Fit for Birth PLUS'* study, then you will get a detailed assessment of your fitness levels and health. This will help you to understand your body and ways in which you could improve your fitness and diet. This may have important long term benefits on your health.

What if something goes wrong?

In the unlikely event of anything going wrong with the treatment, or if you wish to complain, or have any concerns about the way you have been approached or treated during the course of this study, then the normal NHS complaints system will be available to you. If you are harmed due to someone's negligence, then you may have grounds for a legal action. There are, however, no special compensation arrangements in place in case of problems with the research.

Will my details be kept confidential?

All information that is collected about you during the course of the research will be kept confidential. The completed forms with your name on them will be kept in the central trial office in Liverpool and your name will be removed before the data is transferred to the computer database

for analysis. If you agree to take part in the research, the researching doctors may look at any of your medical records to analyse the results. They may also be read by people from regulatory authorities to check that the study is being carried out correctly.

What will happen to the results?

The study is planned to finish in late 2010. The results will then be analysed and published in a medical journal. You will not be identified in any publication. If you would like to receive a copy of the final publication, then please indicate this on the consent form.

Who is funding the research?

The research is funded by Liverpool Primary Care Trust through MerseyBeat, a project of the University of Liverpool. The doctors conducting the research are not being paid any extra for it.

Who has approved the study?

This study has been approved by the Liverpool Women's Hospital Research and Development Department, and the Liverpool Adult Research Ethics Committee.

Contact for Further Information

For further information about the study please contact:

Mr David Rycroft, Fit for Birth administrator, School of Reproductive and Developmental Medicine,

Liverpool Women's Hospital, Crown Street, Liverpool L8 7SS

Tel: 0151 702 4179; e-mail David.Rycroft@liv.ac.uk

Liverpool NHS Foundation Trust

Liverpool Women's

Fit for Birth

ID Label

Liverpool Women's Hospital, Crown Street, Liverpool L8 7SS
Tel 0151 702 4101

Principal Investigators: Dr Siobhan Quenby & Dr Andrew Weeks

Patient Hospital Number:

CONSENT FORM

Title of Project: Fit for Birth: a prospective cohort study.

Name of Researchers: Dr Siobhan Quenby & Dr Andrew Weeks, University of Liverpool

Please initial box

1. I confirm that I have read and understand the information sheet dated Feb 2009.

2. I understand that my participation is voluntary and that I am free to withdraw at any time without my medical care or legal rights being affected.

3. I understand that sections of my medical notes and data collected during the study may be looked at by individuals from the University of Liverpool, from regulatory bodies or from the NHS Trust where it is relevant to my taking part in this research. I give my permission for these individuals to have access to my, and my baby's, records.

4. I agree to take part in the above study.

5. I agree to my GP being informed of my participation in the study.

6. Which of the studies, if any, are you willing to take part in (please tick the box)?

   - '**Fit for Birth**' (extra weights only)

   - '**Fit for Birth PLUS**' (detailed health assessments and examination of your placenta and baby)

7. Do you wish to receive a final copy of the results when they are published?   Yes / No

_____   _____   _____
Name of Patient   Date   Signature

_____   _____   _____
Researcher   Date   Signature

1 copy to be kept with handheld notes, 1 copy to be kept in brown hospital notes

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Liverpool (Adult) Research Ethics Committee
Bishop Goss Complex
Victoria Building
Rose Place
Liverpool
L3 3AN

Telephone: 0151 330 2077
Facsimile: 0151 330 2075

01 June 2009

Dr Siobhan Quenby
Reader/Honorary Consultant
University of Liverpool/Liverpool Women's Hospital
University of Liverpool Department
Liverpool Women's Hospital
Crown Street
L8 7SS

Dear Dr Quenby

Study Title:	**Fit for birth: a prospective cohort study**
REC reference number:	**09/H1005/23**
Protocol number:	**2**

Thank you for your letter of 18 May 2009, responding to the Committee's request for further information on the above research [and submitting revised documentation], subject to the conditions specified below.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation [as revised].

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

For NHS research sites only, management permission for research ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission for research is

available in the Integrated Research Application System or at http://www.rdforum.nhs.uk. *Where the only involvement of the NHS organisation is as a Participant Identification Centre, management permission for research is not required but the R&D office should be notified of the study. Guidance should be sought from the R&D office where necessary.*

Sponsors are not required to notify the Committee of approvals from host organisations.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	Version	Date
Response to Request for Further Information		18 May 2009
Covering Letter		18 May 2009
Letter to GP	1	15 May 2009
C.V. for Supervisor		
Participant Consent Form	2	05 May 2009
Participant Information Sheet: FFB	2	05 May 2009
GP/Consultant Information Sheets		
Letter of invitation to participant		
Questionnaire: Food frequency questionnaire	1	05 May 2009
Letter from Sponsor		
Covering Letter		16 February 2009
Protocol	2	05 May 2009
Investigator CV		
Application	2.0	18 May 2009

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Service website > After Review

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

09/H1005/23	**Please quote this number on all correspondence**

Yours sincerely

Professor Sobhan Vinjamuri
Chair

Email: Ronald.Wall@liverpoolpct.nhs.uk

Enclosures: "After ethical review – guidance for researchers"

Copy to: *Mrs Gillian Vernon, R & D, LWH*

NRES Committee North West –Liverpool Central

3rd Floor
Barlow House
4 Minshull Street
Manchester
M1 3DZ

Telephone: 0161 625 7434

20 June 2012

Dr Andrew Weeks
Senior Lecturere/ Honorary Consultant Obstetrician
University of Liverpool/Liverpool Women's NHS Foundation Trust
Liverpool Women's Hospital
Crown Street
Liverpool
L8 7SS

Dear Dr Weeks

Study title:	**Fit for birth: a prospective cohort study**
REC reference:	**09/H1005/23**
Amendment number:	**7**
Amendment date:	**13 June 2012**

Amendment to Protocol.

The above amendment was reviewed by the Sub-Committee in correspondence.

Ethical opinion

The members of the Committee taking part in the review gave a favourable ethical opinion of the amendment on the basis described in the notice of amendment form and supporting documentation.

Approved documents

The documents reviewed and approved at the meeting were:

Document	Version	Date
Protocol	3.0	01 May 2012
Notice of Substantial Amendment (non-CTIMPs)	7	13 June 2012

Membership of the Committee

The members of the Committee who took part in the review are listed on the attached sheet.

R&D approval

All investigators and research collaborators in the NHS should notify the R&D office for the relevant NHS care organisation of this amendment and check whether it affects R&D approval of the research.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

09/H1005/23:	Please quote this number on all correspondence

Yours sincerely

Mrs Julie Brake
Chair

E-mail: anna.bannister@northwest.nhs.uk

Enclosures: *List of names and professions of members who took part in the review*

Copy to: *Mrs Gillian Vernon, Liverpool Women's NHS Foundation Trust*

NRES Committee North West - Liverpool Central

Attendance at Sub-Committee of the REC meeting on 22 June 2012

Name	Profession	Capacity
Mrs Julie Brake	Specialist Diabetes Nurse / Vice Chair	Expert
Dr Lyvonne Tume	Lecturer Practitioner of Paediatric ICU	Expert

PLEASE RETURN TO:-

Dietetic Department
Liverpool Women's Hospital
Crown Street
Liverpool
L8 7SS

THANK YOU

FOOD DIARY

Please use this diary to record **everything** you eat and drink over the next 3 days. (2 days should be week days and 1 weekend day)

Name …………………………………….
Date ………………..

HOW TO USE THE DIARY

- **You need to record everything that you** eat and drink

- Try, if you can, to estimate amounts
e.g. If you have a piece of cake, was it 1/4 or a 1/3 of the cake ?
If you have vegetables was it 2 tablespoons or 4 tablespoons?
Were the vegetables raw or cooked?
How was the meal prepared; did you fry, grill or bake?
Did you add any fats or oils?
Include all sauces, gravies, and condiments
Don't forget to include all your drinks and snacks including biscuits, crisps, nuts and fruit.

- It will be much easier for you if you record what you have had to eat after each meal.

EXAMPLE

Day 1

7.00am	Cup of tea made with skimmed milk
8:30am	Banana, cup of tea
11:00am	Cup of coffee made with semi skimmed milk
11:30am	2 pieces of toast with butter and jam
1:00pm	Can of diet coke Tin of vegetable soup 200mls Low fat yoghurt 2 biscuits Banana
3:00pm	Cup of tea
6:00pm	1/4 slice of chicken and ham pie Medium portion of fried chips 2 tablespoons of baked beans 2 pieces of bread Cup of tea
9:00pm	Cup of ovaltine Teacake with jam

2

DAY THREE

TIME	WHAT I ATE AND DRANK

DAY ONE

TIME	WHAT I ATE AND DRANK

DAY TWO

TIME	WHAT I ATE AND DRANK

Margaret Charnley

Appendix 4 - Statistical Analysis – Plan

Descriptive Analysis –

- Frequencies of maternal characteristic according to BMI classification
  - Age, parity, smoking status, GW change at 36 weeks
- Frequencies of pregnancy and birth outcomes according to BMI classification
  - Hypertension, pre-eclampsia, gestational diabetes, live birth, induction of labour, mode of delivery, admitted to SCBU, APGAR score 1min, APGAR score 5 mins, birth weight
- Frequencies of total energy according to BMI classification relative to visit 1, 2 or 3
- Mean intakes of total energy (kcals), macronutrients and micronutrients relative to visit 1, 2 or 3
- Macronutrient intake as a percentage of total energy
- Micronutrient intake as a percentage of total energy
- Mean ratio's of macronutrients as a ratio of MJ/d
- Comparisons of iron relative to protein and vit D relative to calcium
- Determination of misreporting of total energy intake using the Schofield equation and Goldberg cutoff of 1.5 PAR

Tests for significance

- Test for normality
  - If normally distributed →parametric tests
    - Repeated measures ANOVA
    - On nutrients to compare changes in intake between visit 1 and visit 3
  - If data skewed
    - Transform data (sqrt or log10)
    - Friedmans test → k-related samples → if $P < 0.05$
    - Post hoc tests – Wilcoxon Signed Rank test inc Bonferroni adjustment to $P= 0.05/3 \rightarrow P=0.17$
- Present data as median and IQR if data not normally distributed

- Correlations for associations between pregnancy outcomes, weight change and nutrient intakes
  - Normal distribution → Pearson's coefficient
  - Skewed distribution → Spearman's rank
- Chi-square tests for independence
  - Maternal characteristics
  - Pregnancy and birth outcomes
  - Micronutrient (achievement of RNI - Y/N)
  - Total energy (grouped categories)

Margaret Charnley

Stats test checklist

Variable	Kolmogorov-Smirnov <0.05 TRANSFORMATION >0.05		Parametric	Non-parametric
Energy kcals V1	0.008 SQRT 0.069	SQRT	Yes	
Energy kcals V2	0.200 SQRT 0.200	SQRT	Yes	
Energy kcals V3	0.200 SQRT 0.200	SQRT	Yes	
Protein V1	0.200 Lg10 0.200 SQRT 0.200	Both	Yes	
Protein V2	0.200 Lg10 0.200 SQRT 0.200	Both	Yes	
Protein V3	0.031 Lg10 0.069 SQRT 0.194	Both	Yes	
Total fat V1	0.200	Both	Yes	
Total fat V2	0.200	Both	Yes	
Total fat V3	0.076	Both	Yes	
CHO V1	0 Lg10 0.200 SQRT 0.054	Both	Yes	
CHO V2	0.010 Lg10 0.200 SQRT 0.200	Both	Yes	
CHO V3	0.200 Lg10 0.200 SQRT 0.200	Both	Yes	
SFA V1	0.200 Lg10 0.107 SQRT 0.200	Both	Yes	
SFA V2	0.053 Lg10 0.180 SQRT 0.200	Both	Yes	
SFA V3	0.013 Lg10 0.075 SQRT 0.200	Both	Yes	
MUFA V1	0.004 Lg10 0.132 SQRT 0.200	Both	Yes	
MUFA V2	0.036 Lg10 0.200 SQRT 0.200	Both	Yes	
MUFA V3	0.066 Lg10 0.200 SQRT 0.200	Both	Yes	
PUFA V1	0.005 Lg10 0.200 SQRT x	LG10	Yes	
PUFA V2	0.001 Lg10 0.200 SQRT x	LG10	Yes	
PUFA V3	0 Lg10 0.200 SQRT x	LG10	Yes	
Vit D V1	0 Lg10 0.200 SQRT x	NEITHER		Yes
Vit D V2	0 Lg10 0.006 SQRT x	NEITHER		Yes
Vit D V3	0 Lg10 0.020 SQRT x	NEITHER		Yes
Calcium V1	0.002 Lg10 0.161 SQRT 0.062	Both	Yes	
Calcium V2	0.001 Lg10 0.200 SQRT 0.090	Both	Yes	
Calcium V3	0.018 Lg10 0.200 SQRT 0.200	Both	Yes	
Iron V1	0 Lg10 0.200 SQRT 0.059	LG10		Yes
Iron V2	0 Lg10 0.200 SQRT 0.016	LG10		Yes
Iron V3	0.002 Lg10 0.172 SQRT 0.032	LG10		Yes
Folate V1	0.002 Lg10 0.200 SQRT x	LG10	Yes	
Folate V2	0.001 Lg10 0.200 SQRT x	LG10	Yes	
Folate V3	0.061 Lg10 0.200 SQRT x	LG10	Yes	
Iodine V1	0.001 SQRT 0.133	SQRT		Yes
Iodine V2	0 SQRT 0.005	SQRT		Yes
Iodine V3	00.2 SQRT 0.200	SQRT		Yes
NSP V1	0.006 Lg10 0.200 SQRT 0.200	Both	Yes	
NSP V2	0.200 Lg10 0.112 SQRT 0.200	Both	Yes	
NSP V3	0.200 Lg10 0.200 SQRT 0.200	Both	Yes	

Fit for Birth

Liverpool Women's NHS
NHS Foundation Trust

Crown Street
Liverpool
L8 7SS

Tel: 0151 708 9988
www.lwh.nhs.uk

Date:

Dear

Thank you for your recent participation in the Fit for Birth study, the information that you provided was very important and useful.

We are about to embark on a further phase of the study where we are trying to investigate pregnant women's (with a BMI of 35 and over) experiences and views of community and maternity services in the Liverpool area. We would also like to explore the lifestyles of this group of pregnant women with a particular focus on food, diet and health and try to reveal the social and cultural factors that influence their lifestyle choices. The aim is to review the care and services to overweight, pregnant women to ensure that future provision is acceptable but also reduces any risk to mother and baby that may arise as a result of being overweight.

We would be very interested to hear your views on these matters and you are therefore invited to participate. The study will be conducted by Margaret Charnley (Research Nutritionist) and will take the form of a short interview of no more than 1 hour in duration.

The interview will take place in your own home or an alternative venue suitable for you (to be agreed upon). The interview will be recorded and the information you provide will be treated in the strictest confidence and the data stored securely with restricted access. All recordings will be destroyed on completion of the study. You will not be identifiable by your name and your name will not be published; however quotes from the interview will be used in reports and publications pertinent to the study.

There are no risks attached to participating in the study however there is a sensitive nature to some of the questions and should any issues arise during the interviews that cause distress or upset and you need to seek further counsel then we will endeavour to arrange this for you.

You will be free to withdraw from the study at any time without affecting any care or treatment that you may be having now or in the future at the Liverpool Women's Hospital. . If you do not want to participate in the next phase of the study you do not need to respond and, we will not contact you again.

The study is being conducted under the direction of Prof. Andrew Weeks (Consultant Obstetrician). Email aweeks@liverpool.ac.uk, Tel 0151 702 4101 and Dr Julie Abayomi (Specialist Dietician). Email J.C.Abayomi@ljmu.ac.uk Tel 0151 231 5394.

If you wish to participate in the study please call Margaret Charnley on 0151 231 5271 or 07837837842 or alternatively email to M.Charnley@2006.ljmu.ac.uk

Yours sincerely

Margaret Charnley

Version 1.0   03.10.2011

Liverpool Women's

Margaret Charnley
Postgraduate Researcher
Liverpool John Moores University/Liverpool Women's Hospital
Tel. 0151 231 5271
Email M.Charnley@2006.ljmu.ac.uk
Supervisor – Dr Julie Abayomi
Email J.C.Abayomi@ljmu.ac.uk

About this research…..

We are trying to investigate pregnant women (with a BMI of 35 and over) and their experiences and views of available community and maternity services in the Liverpool area. We also want to reveal the feelings and lifestyles of this group of pregnant women and explore the social and cultural aspects behind their lifestyle choices regarding food and diet.

The aim is to provide a level of care and service to overweight, pregnant women that is acceptable whilst also reducing any risk to mother and baby that may arise as a result of being overweight.

What we are asking you to do…..

Allow us to interview you in your own home or a place of your choosing
Allow us to audio record the interview
Allow us to keep the information you provide on an electronic database and to analyse it for research purposes
Allow us to quote from your interview in reports and publications on our study

Any information you provide will be treated in the strictest confidence and the data will be stored securely with restricted access. You will not be identifiable by your name and your name will not be published.

There is a sensitive nature to parts of this research and you are free to withdraw at any time (this will not affect any care or treatment that you may now be having at the Liverpool Women's Hospital or may have in the future).
However, should any issues or problems arise during the interviews that cause distress or upset and you feel you need to seek further counsel I would be happy to try and arrange that for you.

Signed…………………………………............... Date…………………

Margaret Charnley

<p align="center">**INTERVIEW GUIDE**</p>

Research question:

What are the perceptions and attitudes underpinning health related experiences of obese pregnant women in Liverpool?

To answer this question it will be necessary to:

- investigate obese pregnant women's perceptions of service provision during pregnancy
- explore the attitudes and lifestyle of obese pregnant women
- explore the socio-cultural factors underpinning obese pregnant women's lifestyle choices with an emphasis on diet and food.

Tell me about your antenatal experiences, how did it make you feel?

Health care professionals, advice given

How did you feel when you were asked to participate in the Fit for Birth study?

What did you expect from the study?

Tell me about your weight history – before, during and since your pregnancy?

Including any weight loss attempts, changes in diet (i.e. does it differ from your childhood/adolescence)

Tell me what food means to you?

Issues, cultural, comfort, fuel, emotional

Can you describe ways that your weight inhibits you?

i.e. preventing you from participating in activities that you may once have taken part in, or participating in new activities

Describe any of the community services provided for pregnant women that you participated in?

i.e. aquanatal classes, pram pushing

Tell me about how your diet has changed as a result of your weight – before, during and since your pregnancy?

Margaret Charnley

<p align="center">**INTERVIEW GUIDE**</p>

Research question:

What are the perceptions and attitudes underpinning health related experiences of obese pregnant women in Liverpool?

To answer this question it will be necessary to:

- investigate obese pregnant women's perceptions of service provision during pregnancy
- explore the attitudes and lifestyle of obese pregnant women
- explore the socio-cultural factors underpinning obese pregnant women's lifestyle choices with an emphasis on diet and food.

Tell me about your health before you became pregnant – ie did you have any weight related health problems before, did this change through pregnancy

Tell me about your antenatal experiences, how did it make you feel?

I.e. Health care professionals, Doctors etc. were they any different towards you once you became pregnant

How did you feel about being asked to take part in Fit for Birth and what stopped you from attending?

How was the delivery…did it go according to plan?

Tell me about your weight history – before, during and since your pregnancy?

Including any weight loss attempts, changes in diet (i.e. does it differ from your childhood/adolescence)

Can you describe ways that your weight inhibits you?

i.e. preventing you from participating in activities that you may once have taken part in, or participating in new activities

Tell me what food means to you?

Issues, cultural, comfort, fuel, emotional

Tell me about how your diet has changed as a result of your weight – before, during and since your pregnancy? If not, why not

Describe any of the community services provided for pregnant women that you participated in?

i.e. aquanatal classes, pram pushing, yoga etc

M – hello Kara... tell me about your health, tell me about what you think of your health in general anyway and before you were pregnant and what the differences were when you were pregnant

K – well before I was pregnant my husband and I had tried for a couple of years before for 4 years really to kind of have a baby, and it had never happened so we were both concerned about our weight so what had actually happened before I was pregnant...I joined a slimming club and I had lost about a stone hence the reason I fell pregnant with ***** really

M – right so it was because you lost a little weight

K – yeah but I was aware that I kinda needed to lose weight...but then when I was pregnant with ***** the difference between my second pregnancy to my first pregnancy was I was a lot heavier in the second pregnancy and I did struggle a lot more

M – right...in what way

K– ...just physically more than anything...more sluggish, felt more tired quite a lot of the time, I didn't feel as if I had much energy...I'd literally come in from work and I'd be totally exhausted and that would be it for the rest of the evening I kind of didn't want to do any more and I was sort of looking forward to the weekend so I wouldn't have to do anything

M – so you took full advantage of the weekend did you...right, so did it impact on your physicality in any sort of way in terms of stopping you from doing stuff

K – ...no I don't think so...I still carried on doing what I was doing but I was just a lot slower doing it...I felt as though it did take up a lot more energy doing things that I was normally ok doing before

M – ok... so what's that been like since you had her then, what's your energy levels been like then...

K – it's quite difficult to tell really cos obviously you've got sleep deprivation as well kind of added into it erm I don't think I'm kind of back to the way I was before with regards to energy...but I do think...I'm kind of 70% there really

M – right, that's kind of easy to understand cos as you say you do have sleep deprivation (both laughing) so in terms of sleep deprivation and your weight...the difference between having ***** and having your older one...can you remember back to when you had *****

K - ***** yeah but there's a 10 year age gap as well...I was a lot heavier when I had ***** but also there was a big 10 year age gap so I felt as if I had a lot less more energy...I felt as if when I first had *****...I don't know if it was the effect of having a C-

section as well I just about managed to get through and obviously you know there was two of us but it felt almost like survival

M – right

K – but I suppose it feels like that for a lot of other people as well doesn't it cos I'd actually forgotten what it was like when I had me first baby erm and as I say with having more weight and also 10 years older it made it harder

M – yeah...so when you booked in with ***** for your ante natal care and when the midwives invited you to take part in the FFB study what did you think about that

K – (indecipherable) because I was aware of my weight and being older as well and I felt as if... with me first pregnancy cos when I was in labour because it was such a bad labour really at least if I take part in FFB I almost felt as if I would be better looked after through the process and it did feel as if I was really

M – you did feel like that then did you?

K – yes I think...well I suppose I can only surmise really but if I hadn't taken part in it I probably... there was...it was almost as if people took a bit more time to explain things to me...probably asked more questions...but you know kind of 'this is how it is' and explaining how things were going wrong in the first labour and you know what options, what options to me there were giving birth the second time so I felt as if I was kinda looked after really

M – right

K – it was difficult... I was at the hospital quite a lot but I felt as if I needed that care

M – right... did you feel...did you make changes because of it at all during your pregnancy do you think

K– ...yeah I did...I made some kind of minor changes as much as I could really at that time but obviously it was the diabetes that kind of like knocked me for six

M – right...were you diagnosed at 28 weeks...was that the GTT was it

K – yeah yeah so they diagnosed that but then I think when I was diagnosed I think what happened was she give me the glucose drink and then I had to wait round obviously to have a test well it was a case of 'ok you have this diabetes' (noise disturbance from musical toy drowns out dialogue) but it almost led me to think when I went away from the hospital that I didn't know that you could get diabetes during pregnancy

M – well yeah (tone suggests I'm afraid so)

K– I didn't know you could get diabetes

M – it's a different kind of diabetes...it doesn't have any long term consequences, it's just for the duration of the pregnancy but it does er you know...it increases the risks of

having a big baby and that's probably why they were a little bit concerned about her growth, it does affect your insulin levels and things like that...so how did you find all the doctors and medical professionals whilst you were going through this pregnancy then...

K – well no cos I was asked if I wanted to take part in it and obviously I agreed to that so I kind of created me own questions to be honest

M – Ok

K– and that was part of plus and that was part of taking part in it anyway and the research so no I didn't mind at all

M – no?

K – cos it's quite obvious that if your BMI is at a certain amount and I think for me the benefits for me...I think it's important that you take part in research so I felt for me (has coughing fit) sorry...as if I had...as if I would be taken better care of

M – yeah

K– that's why I did do it

M – and obviously positive that you did feel like you had been looked after a little bit more...

 K– it's almost reassurance

M – yes it's reassurance yeah and do you it is because you were carrying more weight and there are associated risks surrounding weight in pregnancy, is it because of the weight or is that women are actually more anxious during pregnancy anyway?

K– no...I think...I can only speak from personal experience but with me I didn't realise how much an effect weight could have during pregnancy really

M – right

K – ...so no I don't think I was particularly...I did think it was because of the weight that I was more anxious but I do think from my own personal experience apart from the FFB I think the experiences from the midwives was atrocious really

M – really!!

K – especially when I come home from hospital bearing in mind I had a C-section

M – you had a C-section

K– yeah I had a C-section and during the time I was home due to the bad weather I had no visit from the midwife...in fact I've got me notes (noise disturbance from little girl) so they were never collected really so I think apart from taking part in this research I don't think I would have had much involvement at all with professionals at all really...I don't think I would have felt like I knew what was going on

M – right...ok...

K – no

M – I think that is something that can go back...I can take back

K– there was just no follow up all...I mean I have...I've got me discharge notes here with me and I think that's quite bad really considering as well I had a caesarean section so there is always a chance of infection isn't there and I did suffer with it afterwards

M – yeah

K – but even kinda like on the ward there was no consistency with midwives and I realise that their shift pattern changes but there seemed to be no consistency and when you had to ask for medication you know that's kind of quite bad really isn't it

M – yeah yeah...that's really useful, that's really helpful that...thanks ***** yeah...so changing the subject slightly...well not really it's still related to your weight but tell me about your weight in general...your sort of childhood and your teenage years...how your weight...what your weight changes have been like

K - ...my weight changes really...I think...as a child I was kind of always...I wasn't erm...I wasn't slim but I wasn't chubby I was almost...you know when you're almost kind of inbetween

M – solid (laughing)

K– yeah solid(laughing) heavy boned but when I was in me teens I was kind of quite slim...kind of a size 12ish and I think really to try...I think I started to put weight on more when I was about 15 or 16 and I don't know why...there was nothing significant to say why I was putting weight on at that time...and I kind of remembered from about 16 or 17 almost...it was almost the culture to try and lose weight

M – yeah yeah

K – it's kind of you know...that peer pressure erm so I remember joining several slimming clubs and stuff at the time but looking back now at photographs I thought at 16/17 I was quite heavy but I wasn't

M – (laughing) noo and isn't that always the way

K– (coughing fit) sorry...I think it was the weight...I wish I had enjoyed it more rather than worry about my weight...then when I had my first chill...I think I was around 14 stone at that point...I think I put on more weight when I did my degree and I think what had happened was ...I was very active before then cos when I did access to social work before then...4 nights a week I was swimming 40 lengths...I was very active

M – did you....sorry to interrupt...before *** or after *** you did your degree

K – before *****...I was round about 24 when I was doing my degree I think erm so what I would do is...when we would leave uni I would go swimming 4 nights a week and I would do 40 lengths in 40 minutes

M – wow

K – (noise disturbance from little girl so next bit indecipherable)...but I also had a bike...I used to go everywhere on me bike then towards the end of my degree because obviously the studying got more intense so then I got a car and then from there really me activity levels started dipping but then really if you continue to eat at the same rate then you're just gonna put on weight

M – yeah exactly...I can completely empathise with that really..cos when you decrease your activity levels especially when you're in your kind of teenage years and you've gone along with these dieting patterns which teenage girls go through because of peer pressure (interruption from little girl...K attends to her) no that's quite alright...she comes first

K – sorry...shortly after I had done my degree I got into work... I was probably about 14 stone at that point and not long after I fell pregnant with ***** and then I think I was...after I had had ***** I kind of remained around 14 stone but then when I met *** that's *****'S dad...that's when I kind of put weight on...you know when you are going through a new relationship and you're having a lot of meals out and

M – yeah...enjoying yourself

K – yeah you do really and then me dad at the time...he was dying from cancer so it was kind of the two combinations together I think plus I was caring for me dad so it was a case of not so much thinking about what you eat it was kind of grabbing things as you were going along and unless you plan and it's organised you can guarantee it's always going to be unhealthy stuff that your grabbing

M – yeah it is

K – so it wasn't a priority at that time really...so and then I was obviously having ***** and the realisation was when I we were trying to have ***** because my husband was also quite heavy but really that could have been one of the things that was preventing ***** coming along really

M – yes I see

K – erm so then we both kind of started losing weight and I joined a slimming club and had lost just over a stone and a bit but it was Rosemary Conley you know where you do all the activity and stuff...so you start feeling a bit better

M – yeah yeah

K – and then I fell pregnant with ***** so it was getting into a bit of a pattern but since then I've not really had...I don't feel as if...now it feels as if...she's 2 and things are

starting to settle down so I'm thinking about doing some activity now...I'd really like to take ***** swimming now, she'd love swimming

M – right...she's getting to that age isn't she....so what was your weight gain like during pregnancy...how much did you put on...you know ish

K– ...ish...actually it was probably not as much as I did the first time erm I think it was probably about 3 stone I think

M – right

K – but then afterwards it was probably about a stone and a half heavier but then after ***** was born after about 3 – 6 months I'd kind of lost that so had gone back to what I was pre-pregnancy really

M – right...I wonder if the gestational diabetes might have had something to do with it as well

K– yeah...she's busying herself (referring to little girl)

M – aww yes she's very busy...it's good to see that she is very busy (laughing)

K – (laughing) ahh you like to keep yourself busy don't you

M – yeah (pause) so...apart from slimming world beforehand then have you done in your teenage years then...what sort of things would you do in your teens then

K – oh everything

M – did you follow actual...kind of magazine diets then

K– yeah they were very kind of faddy diets ...oh the cabbage soup diet...that was a lovely one... there was one diet that was particularly horrible...I think it was erm...I think it was supposed to be devised for patients who needed to lose weight rapidly for surgery

M – (laughing) right...ok

K– and literally it...it was so disgusting it was a five day specific thing that you had to do so I kind of followed that and the idea was that I'd lose 10lb over 5 days and you think 'that's not very good for you' but you do though

M – so did you find then that it fluctuated quite a lot then...did you go up and down quite a bit

K– yeah

M – right...so what kind of weight are you talking about cos obviously you know...like you say in your teenage years when you look back you didn't have a problem really you didn't know what your problem was but what kind of weight loss are you talking about back then

K – erm when I had the faddy diets

M – yes

K – erm...no more than a couple of stone really but it was in a short amount of time and that was the problem cos obviously it can't be sustained then can it cos once you start eating properly...my friend even was trying to...I think I drew the line at liter life she was trying to kind of like persuade me cos she'd done it and she looked fabulous but then I thought well if you're not going to eat and it's about your relationship with food erm...and she found that very difficult

M – right

K – so that's where I did draw the line cos as I've got older now it's just common sense really isn't it and I know now...I know what the food groups are and everything

M – right... so what do you feel about your relationship with food now and how has it been over the years then do you think

K – erm...I think I'm still very much a comfort eater more than anything...I know when I want to be I can be very organised you know and kind of eat very good things but sometimes it's when you go out or when you are in work it's like 'oh go on have that' and you think people aren't trying to push a piece of fruit on you it's usually a piece of cake (laughing)

M – (laughing) yeah I suppose it is

K – you know it sounds kind of appetizing too...I think probably quite difficult really cos I am very much a comfort eater but then I am more aware of my own weight as well so I do struggle with it but in some ways being a mum as well so I tend to think 'put that to the back burner' and you kind of get on with other things don't you but I think with having children you know you're very much aware of your own eating pattern and you don't want them to pick up your bad habits

M – yeah

K – so er...things have had to change...so things have had to change that way really cos you don't want to...especially with me older one at the moment..he's very conscious of his weight and he's very slim but he eats things like...you know rather than have a bag of crisps he'll have a piece of fruit

M – oh ok yeah

K – whereas if we try and do that it'll be like 'well why didn't you have a banana' which is quite right cos he is educated in school and you know the right things to do but I suppose it's leading by example

M – right yeah...so do you not feel like you do that so much then...or you try to do it or...

K – I try to do it but if I know I'm going to comfort eat I'll usually wait until he's in bed

M – yeah ok

R – one of the things we did do...I know it sounds daft but one of the really bad habits me husband introduced was...he calls it Scooby snacks...having a Scooby snack on a Saturday night but it wasn't just a (emphasized) packet of crisps it would be like big bags of crisps and bars of chocolate which is not a good thing and we've had to break that habit as well

M – right

K– but things become habits very easily don't they

M – yes that's true and also it's like you have an opportunity....(noise disturbance) and I suppose it's like you say...you can introduce habits very easily and they become habits very quickly but when you think back... to you know...earlier on maybe in your relationship with your husband it might have been then, it might just have been going out an eating meals out but you have to change things when you have your children don't you cos you can't go out the same but you want to enjoy yourself in just the same kind of way and food is social isn't it and that's the problem with it

K – it is and it's an enjoyable activity whether it's kind of healthy food or not but I just think...I don't know whether I've got to the point now where I automatically mind things or if I need a snack...we've obviously got like a big bowl of fruit and IO won't have the fruit I'll have a big packet of...or you know I'll eat a packet of crisps and sometimes I'll eat it without even thinking about it

M – yeah yeah...so what sort of foods were you brought up on then like when you were a child and you were living with your own you know...

K– ... very much kind of meat and two veg kind of really...there wasn't a lot of...sweets were very much a treat and I think it was only really when I got older that I got a bit more control over me own diet and things started going a bit wrong for me

M – yeah that's quite a common thing as well you know...so how do you...sort of impose those sort of values on your own children then...how do think about sweets and treats and crisps in terms of your own children

K – ...with regards to crisps for example with ***** we don't give her the ordinary crisps it's either the Goodies (brand name) or organic crisps and I limit it as well I wouldn't give her the packet it's half at a time really and with regards to sweets its things like...well *** will say...like for example last night was Halloween and I know that he would have sat there well like 'no really...do you realise the amount of sugar that's in sweets and you're going to bed and that sugar's on your teeth' and I kind of impose it that way really...we do limit it whereas at one point we had a goodie cupboard... we stopped it because even ***** knew where the goodie cupboard was and she had started to go in...like passing the fruit bowl and going in 'oh no I'll go there' so we just got rid of it all together so we always try and introduce a kind of healthier alternative and limit it as well

M – yeah....and do you cook yourself...do you do stuff from scratch

K– well me husband does most of the cooking

M – does he

K – yeah he does most of the cooking and he's very much kind of meat and to veg...the only thing being is he's very much a dessert man as well

M – right...ok

K– ok...when you think...we never had that kind of thing when we were kids, you just kind of had your dinner and that was it and I have had to sy to him 'actually we don't really need that, we have just sat down and ate a full meal so we don't really need that sponge pudding' and he's very much a feeder and that's kind of the way he was brought up as well

M – right

K– you know you kind of feed people up

M – so do you think sometimes it's a case of a mixture of....well a combination of traditional sort of values in terms of diet with you know your meat and two veg and then obviously like...I mean we used to have a pudding on a Sunday but just on a Sunday maybe and not during the week

K– well we used to have Sunday tea

M – yeah or maybe it's crept in onto other days but then it's fortified with just a little extra.....junk

K – yeah it is...well you know when I was little we used to have a Sunday tea when that's when you'd have your little sandwiches and your penguin biscuit but that's it you wouldn't see anything else during the week...you'd have your meals and that would be it really

M - no

K– you were very much limited but you would look forward to Sunday tea (noise disturbance next bit indecipherable)...but that has very much crept in and I think portion size as well...I mean it's kind of with *** I know he's very much a growing boy ***'s a man and sometimes he'll try and give me the same size portion and I can't eat that (noise disturbance from little girl)

M – so what's ... like you know with your comfort eating then is that more at night time...when you say the children have gone to bed...what sort of things then

K – ...it depends really on what's in the cupboards...quite often I come down after putting ***** down and you've done all your jobs for the next day...me husband will make a cup of tea and I'll feel like a chocolate bar or a packet of crisps which you

probably wouldn't have got automatically...or biscuits but kind of having a cup of coffee with a packet of biscuits is very dangerous cos you never have the amount you intended to have do you

M – no (laughing)

K - they're always half gone

M – yeah

R – but you've never ate them (laughing)

M – yeah

K – that's another habit we tried to put a stop to...me husbands been recently diagnosed with type 2 diabetes so that's something we've had to take on board so we're currently trying to stop that altogether

M – right

K– it's not good...you're not hungry...it's just a case of 'the kids are in bed' you know...I suppose other people will have wine but we'll have a packet of crisps or something so...

M – yeah...it's a tricky one isn't it especially if you have been diagnosed with T2D...it's obviously...it's definitely controlled with diet isn't it...T2D so erm...yeah...how often does he go to see erm...people for that...does he have regular check ups

K– yeah he has...er...he was only diagnosed in...I think it was in July...he has sleep apnoea as well

M – oh ok

K– so obviously the solution to sleep apnoea is to lose weight and again he kind of put weight on when he was studying as well cos as I say he was be erm kind of very fit to say the least and as regards to his diabetes he sees them every coupke of weeks he has to go back to the doctor (next bit indecipherable as noise disturbance from little girl)

M – ...does he monitor his own blood glucose levels

K – er yeah

M – what with one of those little monitor things

K – yeah although he actually uses (indecipherable) but they didn't recommend that he use that because I think one if the nurse practitioners said you could get hung up on that really and it was felt you had to learn how to use it properly as well so no he doesn't...he kind of uses it on and off

M – right yeah

K– but he knows himself

M – cos I suppose you get to the point where you recognise the signs as well don't you really...so is he controlling it with diet...mainly with diet at the moment

K – yeah and he's on Metformin as well

M – oh ok is he getting on alright

K– yeah he's fine (laughing as little girl is playing)

M – (also laughing at little girls antics)...well when you were pregnant then with ***** were you informed of any kind of like services in the community for any over weight...were you informed about any aqua-natal classes or were you informed of anything going on in your local sort of children's centres or in your local community centres...did you know of any of the stuff that was going on

K – no...I mean I knew there was an aqua-natal class but that was just something I'd known of (indecipherable) the first (indecipherable) always recommended that swimming was the best exercise really so no I didn't even down to parental classes I didn't know you know...be better to go to the children's centres them self really to see what was on but it was never a convenient time really

M – right...were you working...did you carry on working

K – yeah I was working...I actually started my maternity leave the day before she was born

M – right...so you went right to the wire then (laughing)

K– although I did go to baby massage when she was born

M – so, so you had a look yourself but you weren't advised of anything in particular

K– no

M – and it was mainly because...you didn't take part in anything mainly because of time constraints and stuff like that

K – yeah cos obviously I still continued to work and it was just that they weren't on the best days for me really and I suppose they can't consider all individual needs can they

M – no no

K– and they have to do on mass I suppose

M – would you have considered it if the timing had been a bit better for you

K– yeah I think possibly if it had been of an evening...if there had been like an evening class I would of but as far as I was aware there wasn't any evening classes

M – right...so that's another option isn't it you know

Appendix 9 - Transcription FFB0124 Kara

K – well just think if you're working full time and most people tend to (noise disturbance from little girl) work obviously in the day and if there was an evening class then yeah I'd kind of welcomed the opportunity really to have gone to one...I think as well ...it might sound daft but even to have met up with other expectant mums who were kind of in the same boat really just to say 'how are you finding it' cos there were some points when it was very confusing especially when I was diagnosed with diabetes it was right 'ok' and you're told 'it happens in your pregnancy' but then your given no information and you know 'you need to go along to the Royal and you'll speak to the nurse then' but the time gap was about 4 or 5 days to a week (not sure...noise disturbance from child) and no information (further disturbance)

M – ahh...(directed to little girl) I'm nearly finished and I'll be going very soon and you can have mummy all to yourself (laughs followed by personal chat re little girl and child rearing) ....so your thinking of taking up some activities in the not too distant..when the times right

K – yeah I think for me... I couldn't just kind of take part in an activity that I don't like and for me it was either on me bike or swimming and I'm thinking the reality of being on your bike as much as....

M – a bit scary yeah

K – so really it's kind of like...we've got some really nice sports centres opened up as well in Knowsley

M – oh right ok

K- yeah cos they've knocked a few down and opened up new ones

M – right

K – and with me son as well...when he was kind of 4 or 5 we did used to go swimming very regular erm but obviously my working pattern was changing and that stopped (personal chat as little girls wants to drink some of mums coffee)....so I do think swimming in the future really you know not too much like an aqua class but swimming...I like being able to swim up and down cos it's about relaxaton as well isn't it

M – yeah Mmmmm

K – so I think that's gonna be a on the cards in the future or as we planned to...it's not called the new Huyton Leisure Centre...I keep equating it to that...cos they've got some adult only sessions and we're trying to go as it's just adults...a bit later at night

M – yeah

K– possibly a bit quieter...so I'd probably like that as we were thinking about going on a Saturday or Sunday morning with the kids but apparently at the moment cos it's a new leisure centre it's very busy so I think we'll wait for that to die down

M – die down a little bit

K– because with ***** I'd taken her...I'd started taking her around about this time last year you know...she just became ill...lots of chest infections and then in January this year she ended up in hospital with pneumonia

M – Ahhh

K– so erm...I'm just being very cautious with her

M – yes of course that's understandable

K – but she's a bit older now and her immune system's developed a bit more

M – does she go to any kind of play groupy things

K – well she goes to nursery 3 days a week

M – oh right yeah

K – and that's really kind of brought her out

M – yeah and it'll help with their immunity as well cos it builds....

K– yeah they catch everything don't they (laughs)

M – (laughs) yeah they go through the works don't they

K– yeah...chicken pox is rife at the moment and we were hoping to get it...not yet...it would always happen when it's not the most convenient time

M – yeah probably Christmas (both burst out laughing) yeah so it's alternate...good Christmas...rubbish Christmas...good Christmas...rubbish Christmas

K– yes she had impetigo last Christmas

M – oh no oh dear

K – we're not doin too good cos last year wasn't too good either

M – oh dear (personal chat re little girl getting sleepy...well I shall finish up then and let you get her down so you can have a little bit of piece and quiet then...that is brilliant..thank you very much

(conversation after tape switched off led to talk about depression so recorder switched back on)

K– no I've never been diagnosed with depression at all but when I had ***** I kind of...I don't know whether I had a kind of extended baby blues or whether she or whether she was in special care but I found the first couple of months...emotionally...very difficult

M – well it was probably quite a traumatic time giving birth to her really...I mean you've had a section... you've had essentially had sort of... proper surgery...you know quite invasive surgery ...where you've been cut and you've had general anaesthetic you know...did you have an epidural or a general

K- a spinal...general

M – a spinal...were you knocked out...were you unconscious

K – no

M – I know...yeah yeah yeah...but spinal s... they can take quite a while...they can knock you for six a little bit and then like you say you're in shock

K– because she's in special care really as well...I didn't expect that...thinking...in hindsight...now...me friend is a neo-natal nurse in the Women's..and I think it was about a week before ***** was born and she said to me 'oh I hope she doesn't end up on our unit' and she kind of said it quite jokingly and I said 'well why would she end up....' I hadn't even... I hadn't equated and I suppose it's the most obvious thing that obviously she would of but I just didn't realise and I suppose probably people didn't mention it to me because they knew...you know that it would happen

M – yeah (sympathetically)

K – I didn't equate it cos no I had me first baby obviously me diabetes was gonna go...it's the most obvious, logical thing but I hadn't even thought that process through

M – right

K– so when they did kind of come and take her to special care it was a bit of a big shock really and I was like...'no I want to...I want to be there' really so that was a bit...so no I did find it quite difficult especially the first couple of months more than anything and I was a bit worried about myself...I was thinking 'now have I got post natal depression' but no I think it was just an accumulation of everything that had happened

M – right...but you do...I suppose it's that separation (indecipherable due to noise disturbance from the little girl)...you've got that sort of slight separation haven't you really where...

K – yeah cos I literally just wanted to(indecipherable due to noise disturbance from little girl) and then I think a s well when you go to a special csre unit when you've not had any involvement...some of the babies...

M – it's heartbreaking

K – their like little sparrows

M – yeah

K – and I think ***** when she was born (indecipherable due to noise disturbance) erm so she was quite big when she was born compared to some of the little babies in there

M – yeah yeah

K – and kind of seeing some of the parents and how they were coping with that... I think the worst experience was on Christmas morning (indecipherable due to noise disturbance from little girl) then on Christmas morning there were some volunteers who came round to give presents to all the mums and unless you went you could hear all the mums kind of sniffing over that cos they were all kind of really sad that they were there at Christmas but they were just trying to make things better for them

M – yeah mmmm

R – but no one can make it better for them

M – no no not at all....ahhh are you tired (directed to little girl) shall I go...

Interview ended
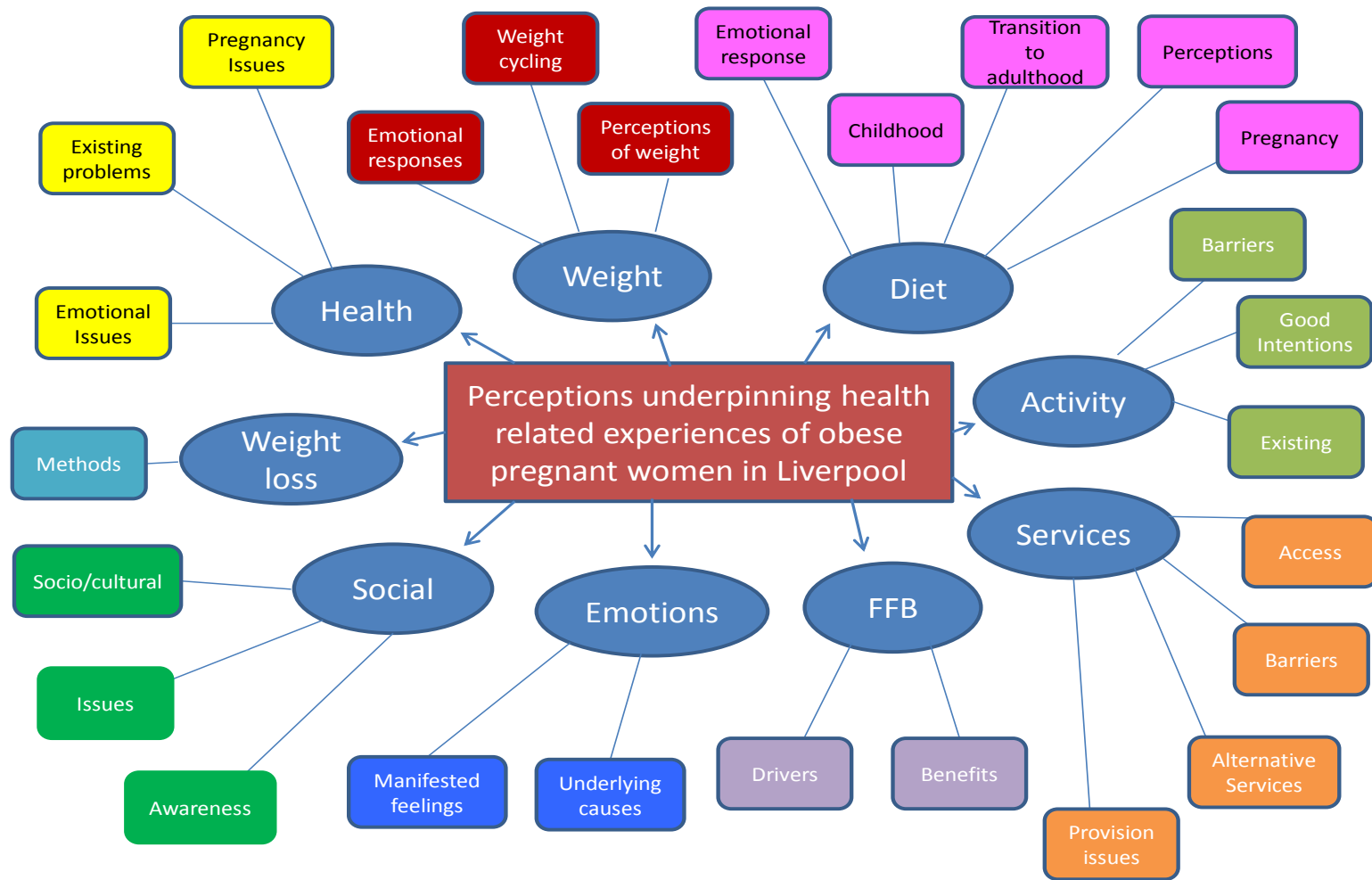
Appendix 10: Overview of themes generated from interview transcripts