Dietary Assessment of Pregnant Women in Sheffield, UK

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As a part of an on-going project to develop a dietary risk assessment tool for low income pregnant women, we evaluated the performance of a modified version of an existing semi-quantified food frequency questionnaire (FFQ) in terms of validity and assessed the nutrient intakes of a sample of English speaking, Caucasian pregnant women living in economically deprived and non-deprived electoral wards of Sheffield. Two statistical techniques were also applied to on energy-adjusted data for identification of discriminatory food items among women living in economically deprived wards.

A critical assessment of the influence of individual and social factors on food choice, of the dietary intakes of different socioeconomic groups, of the importance of nutrition prior and during pregnancy and of methods of dietary assessment and associated methodological concerns was undertaken.

One-hundred and twenty three pregnant women were recruited for the validation study, which were also included in the main study analysis together with another sub sample of 127 pregnant women. In total 250 pregnant women aged 15 to 43 years provided complete dietary information, of which 174 resided in the 40% most deprived electoral wards and 76 in other wards within Sheffield.

The validity of the FFQ was tested against two 24-hour recalls. The FFQ overestimated nutrient intakes but an acceptable agreement between the two assessment methods was observed. Macronutrient intakes of the Sheffield women were similar to other UK pregnancy studies. Mean intakes of calcium, iron, folate and vitamin C however, were relatively lower. Subgroup comparisons showed wide variations in nutrient intakes. The results of regression and discriminant analyses identified food items which might be of importance in the

evaluation of the habitual diet of the low income group of pregnant women in Sheffield.

The study findings confirm that the FFQ is a valid tool for categorising pregnant women according to dietary intake and that the diet of pregnant women in Sheffield is possibly characterised by low intakes of important nutrients for pregnancy. This study makes an important contribution to future planning and development of interventions for pregnant populations in Sheffield and similar conurbations.

I Dedicate the Thesis to my Wonderful

Parents- Charalabos and Anna-

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Chapter 5-Validation Study

Chapter 6-Main Study

Units

%	Percentage
g	Gram
Kcal	Kilocalorie
Kg	Kilogram
m	Meter
mg	Milligram
MJ	Mega joule
μg	Microgram

Abbreviations

24h-recall	24-hour Dietary Recalls
AA	Arachidonic Acid
ALSPAC	Avon Longitudinal Study of Parents and Children
BME	Black and Minority Ethnic
BMR	Basal Metabolic Rate
BMI	Body Mass Index
COMA	Committee of Medical Aspects of Food Policy (UK Department of Health)
CI	Confidence Intervals
CHD	Coronary Heart Disease
r	Correlation coefficient
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DoH	Department of Health (UK)
DQI	Diet Quality Index
DQI-P	Dietary Quality Index for Pregnancy
DRV	Dietary References Value

DHA	Docosahexaenoic Acid
EI	Energy intake
EFS	Expenditure and Food Survey
FFQ	Food Frequency Questionnaire
FSA	Food Standards Agency
HEI	Healthy Eating Index
IMD	Index of Multiple Deprivation
IOM	Institute of Medicine (USA)
IUGR	Intrauterine Growth Retardation
LOA	Limits of Agreement
LBW	Low Birth Weight
LRNI	Lower Recommended Nutrient Intakes
MRC	Medical Research Council (UK)
MAFF	Ministry of Agriculture, Fisheries and Food (UK)
NTD	Neural Tube Defects
PAL	Physical Activity Levels
PIH	Pregnancy-induced Hypertension
PCT	Primary Care Trust
PCA	Principal Component Analysis
RDA	Recommended Daily Amount
RNI	Recommended Nutrient Intake
RR	Relative Risk
PTB	Preterm birth
SES	Socio-economic Status
WIC	Special Supplemental Nutrition Program for Women, Infants and Children (USA)
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences

NDNS	The National Diet and Nutritional Survey (UK)
TEE	Total energy expenditure
WISP	Weighed Intake analysis Software Package
WHO	World Health Organisation

Chapter 1

1. Introduction

The contribution of nutrition to health inequalities is well established by a large amount of research evidence. Variations in health profiles might be partly explained by dietary differences between different socio-economic groups, which may be the result of the effect of several factors influencing food choices at individual level such as cultural or economic. Research findings highlight how the dietary intakes and dietary quality of low-income groups may be compromised as a result of economic constraint.

This is particularly of importance for women of childbearing age as the quality of the maternal diet during the peri- and postconceptional period is of significant importance because of its association to pregnancy outcomes. A small number of studies which describe the diet of pregnant women in the UK have been published. The majority of them report that a woman's dietary quality and quantity during pregnancy tends to fall with income. Additionally, mothers from low-income households who are nutritionally vulnerable may go short of food in order to feed their children.

Measuring dietary intake is a complex area however, as there are several methodological issues associated with the accuracy of dietary assessments. Methods of dietary risk assessment, which can be shown to be efficient and valid, could contribute to the identification of pregnant women at dietary risk and may help to reduce poor pregnancy outcomes such as low birth weight (LBW) (birth weight less than 2.5kg) in low-income women in Sheffield and elsewhere.

1.1 Inequalities in health

A body of research evidence has suggested a positive association between levels of social deprivation and differentials in adult and childhood mortality and morbidity rates (Gallobardes *et al* 2006; Petrou *et al* 2006; Baker *et al* 1998; Slogget and Joshi 1994). Analysis of the 2001 UK Census data for England, Wales and Scotland (Doran *et al* 2004) and of mortality data for England and Wales between 1981 and 1997 (Shaw *et al* 2000) confirmed large geographic and social-class health disparities.

In addition, meta-analysis of mortality by educational level and occupational class from national longitudinal studies in six Western European countries, including England and Wales, suggested rising rates of lung cancer, breast cancer, respiratory disease and gastrointestinal disease in low income groups. There was also a relatively slower decline in mortality rates from cardiovascular disease for most of the participating countries for men and women from the lower socioeconomic groups (Mackenbach *et al* 2003).

1.2 The role of nutrition in health inequalities

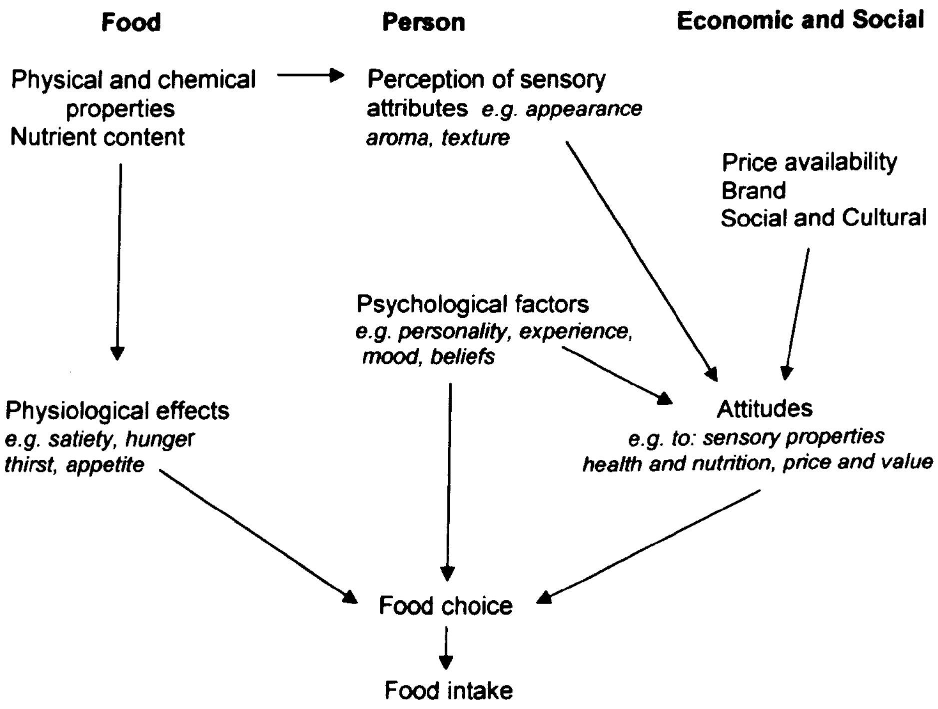
Nutrition is recognized as an important determinant of public health and as a potential area for policy implementation in order to tackle health inequalities. Epidemiological studies have described the contribution of nutrition to inequalities in health and have highlighted the adverse association between low fruit and vegetable consumption to cancer (Wallstorm *et al* 2000) and coronary heart disease (Joshipura *et al* 2001) as well as low consumption of wholegrain foods to coronary heart disease (Liu *et al* 1999), cancer and type 2 diabetes (Slavin *et al* 2001).

Several studies which examined and reviewed the association between socioeconomic status (SES) and nutrition at individual or at environmental level have concluded that the dietary differences might partly explain identified variations in health profiles between different socioeconomic groups. Prior to the presentation and interpretation of any finding however, some of the factors related to and affecting food choices will be addressed.

1.2.1 Food choice

There are various interpretations and meanings of the phrase 'food choice' including the action of choosing, the power, right or faculty of choosing and the abundance and variety to choose from (Murcott, 1998). The Food Standards Agency (FSA) in their *Food Choice and Acceptability Programme* defined food choice as *'the selection of foods for consumption, which results from the competing, reinforcing and interacting influences of a variety of factors* (British Nutrition Foundation, 2004). A popular model used to illustrate the variety of factors affecting food choice is shown in the following figure 1.

Figure 1. Shepherd's model on factors affecting food choice and intake (Shepherd, 1999)



This model suggests that food choice is influenced by many factors and that is not determined only by physiological/biological factors but from social and cultural factors also. Factors influencing food choice are categorised as those related to the food, the person and to the economic and social environment upon which choices are made and can be interrelated and affect food choice at individual and social level (Sheperd, 1999). An overview of some of the factors is given in the following sections.

1.2.1.1 Food choice-individual level

Biological factors

At individual level hunger and satiety, palatability and the sensory aspects are some of the physiological factors likely to have an influence on food intake through sensory stimulation (e.g., smell, taste of food), gastrointestinal signals and circulating factors and chemical signals (e.g., glucose, insulin). The sensory aspect which refers to the taste is reported to have a major influence on food behaviour (Clark, 1998) and is the sum of all sensory stimulation (taste, smell, appearance and texture of food) that is produced by the ingestion of a food.

As described and summarised by Gibney *et al* (2004), at individual level food behaviour might be influenced early in life by taste, flavours, textures, energy intake and meal size, familiarity and exposure frequency early in life etc but is also develops through experiences and is susceptible to personality traits and attitudes, expectations and information and food and mood.

Personal attitudes and beliefs

Personal beliefs and nutrition knowledge appear to have an effect on food choices. The results of the PanEuropean Survey of Consumer Attitudes to Food, Nutrition and Health suggested that 'quality and freshness' (74%), 'price' (43%), 'taste' (38%), 'trying to eat healthy' (32%) and 'what my family wants to eat' (29%) were the top five influences on food choice in 15 European member states. The survey also suggested stronger variations in the influences of food choice by demographic factors than culture (country) For instance, 'family preferences were more important for females compared to 'habit' for males (Lennernas *et al* 1997).

The results of another study conducted on a large sample of young adults from 23 countries investigated possible explanatory mechanisms for gender differences in food choices suggested that women's greater weight control involvement and their stronger beliefs in healthy eating might partly explain differences in food choices. The women in the study were more likely to report avoiding high-fat foods, eating fruit and fibre, and limiting salt (Wardle *et al* 2004).

Similarly, in another study of 1024 older adults attending population-based cancer screening across the UK investigating processes underlying gender differences in fruit and vegetable consumption, the results indicated that low consumption of fruit and vegetables was related to the men's poorer nutrition knowledge of the recommendations for fruit and vegetable consumption as well as the benefits of consumption (Baker & Wardle 2003).

Psychosocial

Psychological stress, anxiety, mood are some of the known psychosocial factors affecting food choice. The influence of stress on food choice is complex and its effect on food choice depends on the individual, the stressor and the circumstances and in general, some people eat more and some eat less than normal when experiencing stress (Oliver & Wardle 1999). One of the few studies investigating the effect of psychosocial factors on dietary patterns and intakes during pregnancy is the study conducted by Hurley *et al* (2005) on 134 non-smoking, predominantly white, well educated women with low-risk pregnancies. Increased maternal age and multiparity were significant associated with psychosocial factors and the findings suggested that stress, fatigue and anxiety were related with increased intakes of carbohydrate, fats and protein and decreased intakes of micronutrient intakes. Stress was associated with higher intakes of bread, snacks and sweets. Anxiety was associated with higher intakes of foods from the fat and oils, sweets and snack food groups. Findings remained significant after adjustments for age, parity, education and BMI. The authors however, pointed out that in a less homogenous group the association observed might have been weaker.

1.2.1.2 Food choice-economic and social environment

"Food is almost always generally considered to be major significant part of culture, and culture is considered to be the major influence upon food choice, specifically, a culture shares certain food choice" (Gibney *et al* 2004). Cultural factors affecting food choice include social, psychological and behavioral factors i.e. health beliefs, weight control, and nutritional knowledge.

Food accessibility

Dowler (2001) suggested that the concepts of accessibility, affordability and practicality need to be taken into account when relating findings to food choice, nutrient intakes, dietary quality and consequently to unhealthy lifestyles. Concerns over this relationship have been expressed in the UK and Government public health policies are focusing on improving access to and affordability of those socially disadvantaged. The use of "food deserts" has been used widely referring to urban or rural settings where people have physical and financial difficulties in buying healthy food.

The evidence however for the existence of "food deserts" and the effects of food access and availability in the UK are conflicted and sometimes inconclusive. Cummins and McIntyre (2002) suggested that the statement that "food deserts" exist in the UK is a factoid (assumptions and speculations reported and repeated until they are considered true) and suggested that improvements in diet and subsequently reduction in health inequalities can be achieved through the use of approaches that take into account both access and knowledge rather to access alone (Cummings *et al* 2005).

Motivational, psychosocial or lifestyle factors were the big barriers to healthy eating for a low-income sample in East Anglia, UK and not physical access to super-markets (Dibsdall *et al* 2003). A study conducted by Pearson *et al* (2005) suggested that age and sex were significantly associated with fruit and vegetable consumption. Fruits and vegetable prices, deprivation and distance to the supermarket were not significantly associated with either fruit or vegetable consumption.

On the other hand in their paper Donkin *et al* (2000) supported the concept of continuing geographical polarisation of income inequalities and presented price and availability indices for describing and mapping of cost and availability of food within an area. They suggested that such indices when linked to geographical and economic local data could provide snapshots of areas most at risk of limited affordable food access and range of foods.

Studies conducted on pregnant population in the US have reported a positive relationship between accessibility, affordability and availability and dietary quality and food choice. For example a study on a population of pregnant women (*n*=918) in the USA investigated the effect of accessibility to supermarkets, groceries and convenience stores on the overall diet quality using data obtained from a FFQ, which were used to develop a Dietary Quality Index for Pregnancy (DQI-P). Despite the reported study limitations e.g. lack of information on transportation, changes in food retail environment the authors suggested a significant association between increased distance to super-markets with a lower mean DQI-P score. There was a 3-fold probability of falling into the lowest DQI-P tertile for participants living more than 4 miles distant from the supermarket. Location and proximity to food outlets had an effect on the overall composite dietary score of the pregnant women (Laraia *et al* 2004).

Extrapolation from findings in the USA to the UK needs to be cautious however, because relationships or comparisons might not be valid. Ethnic and cultural differences are some of the factors that might not allow direct comparisons.

Socio-economic variations

In general, low SES is associated with less healthy food choices and less balanced diets. Quantitative and qualitative research evidence investigating the association has highlighted the effect of economic constraint to the dietary intakes and dietary quality of low-income families (McIntyre *et al* 2003; Darmon *et al* 2002). This relationship has been documented by the use of several indicators. Some surveys used indicators derived by the occupational social class, highest educational attainment of the head of the household and others, residential area socioeconomic measures. This lack of a common indicator for measuring socioeconomic position however, makes difficult the interpretation and comparison of the reported results within and between countries.

An analysis conducted by Cade *et al* (1999) on data obtained for the UK Women's Cohort study, amongst other factors e.g. being older, being vegetarian spending more money in food purchasing were strong dependent predictors of a healthy diet. Further analysis of the results of two national dietary surveys in the UK have shown marked differences in whole-grain food consumption, with those from non-manual occupational social class being more likely to be whole-grain food consumers (Lang *et al* 2003).

Similarly, in an investigation of the independent association between individuals and area based socioeconomic measures in a cross-sectional population study in the UK Norfolk cohort of the European Prospective Investigation into Cancer significantly lower intakes of fruit and vegetables were identified in those with low educational level and those in manual occupational social classes. Living in a residentially deprived area affected again those with low educational level and those in manual occupational social classes possibly as a result of the characteristics of the area itself e.g. limited availability and high cost of fruit and vegetables and high availability processed bulk foods (Shohaimi *et al* 2004).

An Australian study however, examining the effect of area and individual level SES to food purchasing behaviour failed to identify a significant association and the authors concluded that household income rather than residential area explained food purchasing behaviour in that sample of households (n=1,000) (Turrel *et al* 2004).

The importance of the social and other influences on the diet has been highlighted by the FSA commissioned survey of the diet of low-income consumers with the purpose *to provide for the first time robust, nationally representative, baseline data on food consumption, nutrient intake and nutritional status and factors affecting these in low-income/materially-deprived consumers*. Data collection started in November 2003 and the results are expected to be published in 2007 (FSA, 2007).

Age and gender

Differences in food choice between age groups and gender have been described by several studies. Differences in food choice between men and women can be partly explained by women' placing greater emphasis on healthy eating and weight control and dieting or eating behaviour restraint (Westenhoefer, 2005; Wardle et *al* 2004).

Education and occupation data from the UK Health Education Authority's Health and Lifestyle Survey 1993 used to characterize the demographic and behavioural characteristics of the low fruit and vegetable consumers shown that the best predictors of low fruit and vegetable consumption were age (being aged between 19-24), gender (being a male) and smoking status (current smoker) (Thompson *et al* 1999). Differences have been observed and reported at a different range of ages. For example description of the diet of seven years old schoolchildren living in the South-west of England using food diaries showed dietary adequacy for most of the nutrients for both boys and girls but differences between food and nutrient intakes by gender. For instance, boys had higher mean energy and iron intakes and were significantly less likely to eat fruit and vegetables and significantly more likely to consume breakfast cereals (Glynn *et al* 2005). Variations in food consumption patterns between boys and girls as well as differences in the level of under reporting may explain some of the observed differences.

The results of analysis for the identification of dietary patterns of a representative sample of people aged 65 years and over living in the UK also showed differences between sexes. The authors reported that women ate more butter, full-fat milk and certain beverages, cakes, apples, pears and bananas and that men ate more eggs, sugar, certain meat products and drank more alcoholic drinks, especially beer and lager (Bates *et al* 1999).

Age differences in food consumption have also been observed. These differences can be attributed to biological, social, behavioural and psychological factors (Gibney *et al* 2004). At national representative level the National Diet and Nutritional Survey (NDNS), provided a comprehensive picture of the types of foods consumed and differences by age groups. Age categories included; 19-24, 25-34, 35-49 and 50-64 years of age. The report suggested differences by gender and age. Greater differences were observed between the 19-24 years and 50- 64 years both for men and women. In particular, women aged 19-24 years were significantly more likely to consume carbonated drinks, burgers and kebabs, coated chicken and turkey. On the other hand, women in the 50-64 age group were significantly more likely to consume leafy green vegetables, wholemeal bread, oily fish, eggs, cream and apples and pears (Henderson *et al* 2002).

1.3 Findings on diet and nutrition inequalities

1.3.1 Dietary trends and food expenditure

In December 2005 the results from the latest UK Expenditure and Food Survey (EFS) were published (National Statistics 2005). The EFS was established in

2001 and is in fact a combination of the National Food Survey and the Family Expenditure Survey. The report measured household food and drink consumption (all food and drink brought into the household, including takeaways foods brought home) rather than consumption by individuals. The report's coverage was extended to include out-of-home consumption data and historical estimates of in-house consumption between 1974 and 2003-2004.

The results showed that average household consumption between 1974 and 2003-2004 increased by over 60% for fresh fruits, and fruit juice purchases increased ten-fold over what they were in 1974. Consumption of milk, eggs, potatoes and bread has fallen since 1974 (38% for milk consumption, 28% for bread and over 50% for eggs and potatoes). On the other hand consumption of wholemeal bread was five times higher in 2003-2004 compared to 1974, and purchase of processed potatoes has doubled.

Over the time, fresh vegetable consumption has changed little, but a 37% decrease in green fresh vegetable consumption was followed by an increase consumption of frozen and other vegetables within that period. The consumption of fats, oil, table sugar, syrup and preserves has fallen, possibly indicating an increase in the consumption of processed and ready-made food.

Average household energy intakes have gradually declined from 2534 kcal in 1974 to 2077 kcal per person per day in 2003-04. Since 1975, average intakes of fat, carbohydrate calcium, iron and folate have declined also, possibly reflecting reductions in overall energy intake. Demographic analysis of intakes from all food and drinks consumed was also covered in the report (2001-2004). Households were split into five income quintiles (quintile 5 had the highest income) each one representing 20% of the population of households.

Table 1 reports selected mean nutrient intakes from foods and drinks consumed by income quintiles, in an attempt to highlight possible differences in nutrient intakes across income groups. For most of the nutrients intakes were similar across the income quintiles and very small differences were observed.

Table 1. Income quintile analysis of intakes from all food and drink (average April 2001 to March 2004)*

INCOME QUINTILES		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Lower boundary (gross weekly household income £)		**0.00**	**193.00**	**351.00**	**559.00**	**828.00**
Total Energy and Nutrient Intakes[a]		*intakes per person per day*				
Energy	kcal	2269	2402	2298	2191	2279
Total Protein	g	75.4	80.5	77.1	74.2	78.5
Fat	g	94	99	93	88	92
Carbohydrate [b]	g	284	299	287	272	279
Fibre [c]	g	13.5	14.8	14.1	13.5	14.3
Alcohol	g	8	9	11	12	13
Calcium	mg	1007	1050	992	946	970
Iron	mg	11.7	12.4	12.1	11.7	12.3
Sodium [d]	g	2.90	3.01	2.98	2.93	3.03
Folate	µg	277	298	288	275	292
Vitamin C	mg	64	72	71	71	80
Vitamin E	mg	12.33	13.41	12.40	11.71	12.05

*Source: Table adapted and customized from National Statistics 2005
(a) Contributions from pharmaceutical sources are not recorded by the survey
(b) Available carbohydrate, calculated as monosaccharide
(c) As non-starch polysaccharides
(d) (i) Excludes sodium from table salt

According to the report, members of the quintile one households (2003-2004) purchased the largest amounts of non-carcase meat, other meat products, sugar and preserves but quintile 5 had the highest purchases of cheese, fruit and alcoholic drinks. Compared to quintile 5, quintile 1 purchased larger amounts of milk, fish, 'other meat products', eggs, fats and oils, potatoes, total cereals and confectionary. Finally, quintile 1 households had the lowest purchases and expenditure of food and drink eaten outside the home (20.7% compared to 32.5% in 5th quintile households) and spent 13.3% less than the UK average on household food and drink.

1.3.2 Dietary differences according to SES

The NDNS provided comprehensive information on food and nutrient intakes of British adults aged 16-64 years living in private households (Henderson *et al* 2002). Dietary information obtained using a 7 day dietary record and each item consumed over the seven days of the recording period was listed, including its description, the brand name and method of preparation. Data were weighted to correct for differential sampling probability and for differential non-response.

The NDNS also provided analysis on the variation in the foods eaten and nutrient intakes by households in receipt, or not, of benefits (those where someone in the respondents household was currently receiving Working Families Tax Credit or had, in the past 14 days drawn Income Support or Job Seeker's Allowances). Members of households in receipt of benefits were statistically less likely to consume a wide variety of foods, including fruit and vegetables (compared to an average of 3.1 portions a day for women of non-benefit households, women in benefit households consumed 1.9 portions a day (P=0.01).

Table 2, presents the percentage of the respondents consuming different types of foods by households in receipt or not of benefits. Differences need to be interpreted with caution as they may suggest differences or associations arise by chance due to large sample size. Differences by households in receipt or not of benefits in the proportion of consumers were narrow for some of the food items presented in the table i.e. chips, pizza, semi-skimmed milk, meat, pies and pastries, savoury snacks and fizzy drinks and wider for others i.e. carbonated soft drinks, yogurt, oily fish, whole milk.

Table 2. Percentage of consumers and total quantities (grams) of food consumed in seven days by whether someone in respondent's household was receiving certain benefits: women consumers

Type of food	Receiving benefits		Not receiving benefits	
	Mean (g)	% consumers	Mean (g)	% consumers
Pizza	311	22	233	25
Wholemeal bread	258	22	234	43
Whole grain & high fibre breakfast cereals	197	36	285	53
Buns, cakes & pastries	173	49	193	64
Whole milk	1086	49	797	32
Semi-skimmed milk	998	64	1097	74
Yogurt	293	25	418	43
Meat pies & pastries	223	44	189	30
Coated and/or fried white fish	162	33	162	33
Oily fish	164	27	193	51
Other raw & salad vegetables	136	66	206	84
Potato chips	370	75	276	66
Savoury snacks	85	61	78	56
Apples & pears	359	42	395	56
Table sugar	186	58	97	46
Carbonated soft drinks	1336	49	931	40

*Source: Table adapted and customized from Henderson *et al* 2002

In general, women respondents in benefit households were statistically less likely to have been consumed soft grain and other bread, whole grain and high fibre cereals, cream, cottage cheese, yogurt, oil fish, salad and green leafy vegetables and vegetables dishes compared to respondents in benefit households.

Variations in macro-nutrient and micro-nutrient intakes between women living in households in receipt of benefits or not were reported by the authors. Mean energy (P=0.05), protein (P=0.01), carbohydrate (non-starch polysaccharides) (P=0.01), alcohol (P=0.01) and total dietary fat (P=0.05) intakes were lower for women in households in receipt of benefits. For the majority of vitamins mean daily intakes from food sources were significantly lower for in households in receipt of benefits specifically for vitamin B_6, vitamin B_{12}, riboflavin, folate, vitamin C and vitamin E (P=0.05). Ninety-three percent of the women respondents aged 19-24 years, 99% of the women aged 25-34 and 85% of women living in benefit households had mean folate intake less than 400µg/day.

This is of concern since the Department of Health (DoH) (1991) recommended a periconceptional folate intake of 700µg/day (300µg/day from dietary sources and 400µg/day from supplements) for those women who could become pregnant because of its ability to prevent with Neural Tube Defects (NTD) (Medical Research Council (MRC) Vitamin Study Research Group (MRC) 1991). Mean daily intakes of minerals from food sources were significantly lower for women living in benefits households except for haem iron. Mean total iron intake was 8.8mg/day and 10.3mg respectively for women living in benefit households or not.

Whilst interpreting the above findings, the results of the correlations between the dietary intakes and blood analytes i.e. haemoglobin concentration, plasma vitamin C, red cell folate for women living in households in receipt of benefits, or not, need to be taken into consideration. There were no significant differences by women's household benefit status in mean concentrations of any of the haematology analytes or measures of iron status, serum vitamin B12, mean serum folate and mean concentration of blood lipids. On the other hand, mean concentrations of plasma vitamin C and red cell folate were significantly lower for women living in benefit households compared with those living in non-benefit households. For example, mean plasma vitamin C concentration for women living in benefit households was 49.4µmol/l, compared with 63.7µmol/l for those in non-benefit households ($p<0.05$). The authors noted that even though some statistically significant differences were observed in blood analytes between the groups, in general, correlations observed between measured dietary intakes and blood analytes were low.

1.3.3 Dietary differences in pregnancy

Despite the considerable amount of scientific evidence in relation to SES and nutritional status in general populations; there are few reported data of nutrient intakes of pregnant women of different socioeconomic groups in the UK. Women with limited financial resources may face particular challenges in achieving healthy nutrition. For example, biochemical measures of nutritional status i.e. haemoglobin, serum folate in the first trimester of pregnancy in an ethnically diverse population in London, UK showed that women in the non-manual occupational group had significantly higher means of haemoglobin and red cell folate than women in the manual and unwaged occupational groups (Rees *et al* 2005a).

One of the earliest studies conducted in the UK is the study by Doyle and colleagues (1982), assessing the diet of 76 low-income pregnant women during the three pregnancy trimesters using a 7-day weighted record. Within the three trimesters the authors reported low maternal energy intakes and that only 6% of the participants met the Recommended Daily Amount (RDA) for energy in any one of the trimesters. Protein, iron and vitamin C intakes were relatively high; however 70% of the women had mean folate, and 95% vitamin D intakes, below the RDA. The authors suggested that the high proportion of mothers failed to meet the energy requirements observed could be either because the RDA for energy substantially overestimate intakes or because nutritional inadequacies are a real problem associated with low-income.

Similar evidence indicating variation in mean nutrient intakes in different social groups was obtained from a dietary survey of 265 pregnant women living in London and Edinburgh, twice during pregnancy and once post partum (Schofield *et al* 1989). Nutrient intakes were assessed using food records. Mean daily calcium and iron intakes were below the RDA, and social class comparisons showed nutrient variations, with women from the non-manual classes having higher intakes. A study of 513 pregnant women in London found women from lower SES groups consumed less wholegrain, fruit and vegetables and dairy products. These women had an increased incidence of still-birth and LBW babies (Wynn *et al* 1994).

Finally, another study which investigated the relationship between financial difficulties and composition of diet of a population of pregnant women conducted in the South-west of England, reported a strong relationship between affordability of food and dietary quality (Rogers *et al* 1998a). The study looked at the nutrient intakes of 11,833 pregnant women from April 1991 to December 1992 using a semi quantified FFQ at 32 weeks of gestation. Increasing levels of reported difficulty in affording foods (no difficulty, slight difficulty, fairly difficult and very difficult) were related with less healthy diets, and statistically significant differences were observed for most the nutrient examined except for riboflavin, vitamin E and calcium in smokers and non-smokers. Differences were also observed in frequencies of consumption of the food items included in the FFQ; difficulty in affording foods was associated with more frequent consumption of chips and biscuits and less frequent consumption of white and oily fish, fruits, fruit juice and green leafy vegetables. Some of the observed differences however, could be attributed to energy under reporting; 37% to 44% women in each group were identified as under reporters, and to the effect of using a self-assessed measure of difficulty in food affordability, rather that a more a subjective measure e.g. partner's employment status.

1.4 Summary of the findings

In this chapter, the effect of different factors on food choice and possible barriers to healthy eating including food access and food budgeting have been examined. Findings from studies conducted on UK and non-UK population have been reported in an attempt to provide a more complete picture of the factors related to food choices not only in the UK but also worldwide. Any attempt to generalise findings need to be cautious because of ethnic, cultural and lifestyle differences between and within populations in different countries.

Trends of household food and drinks consumption of British adults from 1974 up to 2004 have been reported. These trends shown a variation in dietary quality between different socioeconomic groups similarly to information offered by the findings of latest NDNS, indicating differences in food and nutrient intakes by participants living in households in receipt of benefits or not. Both reports suggested that the diet of low socioeconomic groups was characterised by lower intakes of 'healthy foods' i.e. whole grain foods, low fat products, fruits and vegetables and that households in receipt of benefits tended to have the lower mean micronutrient intakes. Preliminary analysis of data from the Low Income Diet Methods Study suggested however, that differences between income groups may be partly accounted for differential under reporting of the lowest income groups as well as differences in age, gender and ethnic distribution (Nelson *et al* 2002).

Finally, findings of studies examining the dietary intakes of UK pregnant women are reported. Data on nutrient intakes of pregnant women of different SES in the UK are limited and most of the reported studies recorded some dietary differences. Factors like sample size, research design and methods of dietary assessment used, population characteristics need to be taken into consideration however, because they can affect the interpretation, generalisability and comparability of findings.

Chapter 2

2. Pregnancy outcome and maternal nutritional status

2.1 Low Birth Weight

In developed and developing countries LBW is an important indicator of neonatal morbidity and mortality. LBW is the outcome of two distinct adverse processes during pregnancy: Preterm birth (PTB) (gestational age at delivery less than 37 weeks) or intrauterine growth retardation (IUGR) (birth weight less than the 10th percentile weight-for-gestational) (Kramer, 1987).

2.1.1 Etiological determinants and consequences of LBW

Birth weight is a complex interaction of genetic and environmental aetiological determinants and research evidence suggests that the aetiological determinants of preterm-birth and IUGR vary. Figures 2 and 3 reviewed by Kramer *et al* (2000) presented an up-to-date version of the well established etiological determinants of IUGR and preterm-birth respectively in a developed country in which 25% of the women smoke during pregnancy and a substantial minority are non-white. The authors have pointed out however, that the figures should be interpreted with caution and not to be perceived as a complete representation of all causes of IUGR and preterm-birth.

The etiological determinants of IUGR (figure 2) with the higher relative risks (RR) included cigarette smoking and pregnancy induced hypertension (PIH). Other risks factors included: low weight gain, low pre-pregnancy Body Mass Index (BMI), short stature, primiparity, ethnic origin, alcohol and drugs misuse.

Genito-urinary infection and multiple birth were the two of highest prevalence aetiological factors for PTB (figure 3) followed by other determinants such as low pre-pregnancy BMI, PIH, incompetent cervix, placental abruption and cigarette smoking.

Figure 2. Etiological determinants of IUGR in a developed country in which 25% of the women smoke during pregnancy and a substantial minority are non-white (Kramer *et al* 2000)

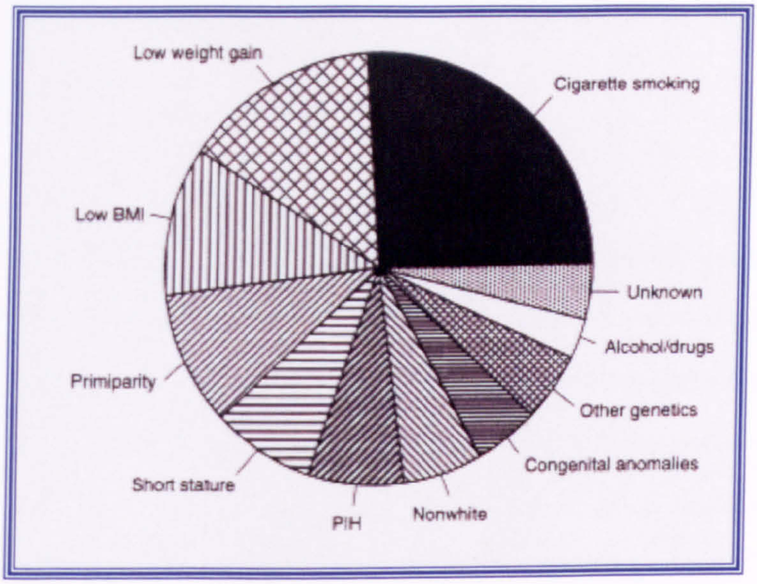
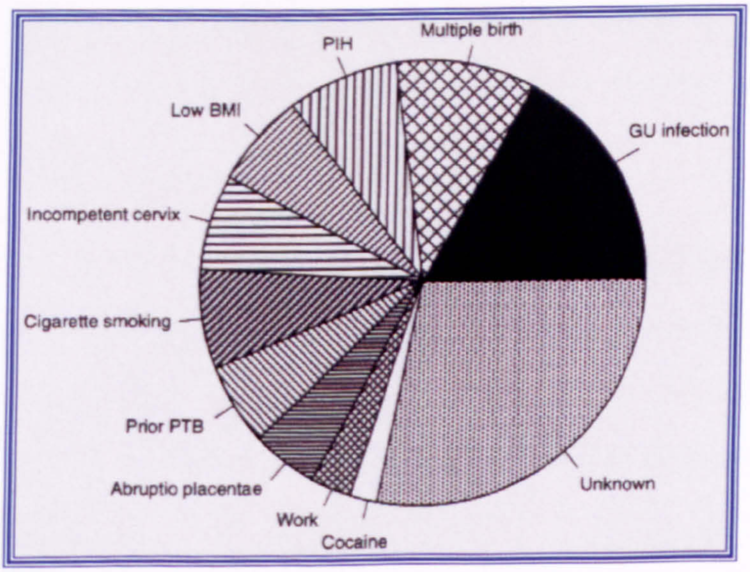


Figure 3. Etiological determinants of PTB in a developed country in which 25% of the women smoke during pregnancy and a substantial minority are non-white (Kramer *et al* 2000)



LBW is a major cause of infant mortality in the developed world including the UK, and is also associated with short and long term infant morbidity. The health consequences for babies born less than 2.5Kg include inhibited growth, impaired cognitive development and chronic illnesses (United Nations Children's Fund and World Health Organization 2004).

Over the recent years, the theory that adult disease patterns may have their origins *in utero* has led to much research and debate. The fetal origin hypothesis states that *"alternations in fetal nutrition and endocrine status result in developmental adaptations that permanently change structure, physiology and metabolism, thereby predisposing to cardiovascular, metabolic and endocrine disease in adult life"* (Godfrey & Barker, 2001). This became known as the Barker Hypothesis, or the Early Life Origins of Disease Hypothesis.

Hales & Barker, (2001) suggested that programming of disease is the result of an adaptive mechanism, whereby the human fetus adopts a 'thrifty phenotype'. The developing fetus makes adaptations *in utero* in response to an inadequate, maternally determined environment i.e. under nutrition. Possible consequences include reduction in growth of some organs or the whole body. These adaptations result in the child thriving in a deprived environment but becoming compromised in an enriched environment.

Early evidence from retrospective cohort studies of body proportions at birth and cardiovascular disease reported associations between LBW and increased levels of Coronary Heart Disease (CHD). One of the studies was based on birth records of men and women born in six districts of Hertfordshire, UK during 1911-1930 where birth weight was the only measurement recorded. Analysis of causes of death in relation to birth weight and weight at one year was conducted. The results suggested that men with the lowest weight at birth and at year one had the highest death rates from ischaemic heart disease and this association appeared stronger with weight at year one than weight at birth. On the other hand, for women the risk was strongly related to birth weight and the highest proportion of deaths from CHD was observed among those with below average birth weight (Osmond *et al* 1993).

In a study of 1586 men born in Sheffield UK, during 1907-1925, analysis of causes of death in relation to anthropometric measurements at birth suggested increased mortality from CHD as a result of reduced fetal growth. Unlike the Hertfordshire study which did not include measurement of body size at birth other than birth weight the Sheffield study included more detailed measurements i.e. birth weight, length from crown to heel, placental weight. The results of this study showed that it was men who were small at birth as a result of growth retardation were at increased risk of cardiovascular disease compared to those born prematurely (Barker *et al* 1993).

This association between LBW and CHD has been confirmed in other large scale studies of men in Uppsala, Sweden (Leon *et al* 1998), in Helsinki, Finland (Eriksson *et al* 2001; Forsen *et al* 1997) and men in Caerphilly, Wales (Frankel *et al* 1996) which similarly investigated the relationship between restricted growth and CHD using detailed measurements.

Law & Sheill (1996) published a systematic review based on 34 studies of more than 66000 people aged 0-71 years describing the relationship of blood pressure with birth weight. The authors suggested a decrease in blood pressure with increasing birth weight in the majority of studies in children and adults but less consistent associations in studies of adolescents. Likewise, the results of two other large scale studies (Nurses' Health Study, Health Professionals Follow-up Study) conducted on US adult populations, investigated the association between LBW and chronic diseases including hypertension and diabetes mellitus provided evidence to support the association (Curham *et al* 1996a ; Curham *et al* 1996b).

In their paper Godfrey and Barker (2001) suggested that the programming phenomenon can be carried through to several generations. The authors pointed out that evidence from animal model studies indicated *"a cumulative effect of under nutrition on the reproductive performance over several generations"* and described that experiments on rats fed a protein deficient diet over twelve generations resulted in a gradual increase of fetal growth retardation. The authors also suggested that strong evidence exists supporting an intergenerational effect of the maternal' birth weight on the birth weight of her offspring and potential mechanisms underlying this effect include alternation in the systemic vasculature, programmed changes in maternal metabolic status and impaired placentation.

The validity of the conclusions and suggestions of studies investigating the Barker hypothesis however, has been met with scepticism partly because of the nature of the studies used to confirm some aspects of the hypothesis i.e. largely observational and cross-sectional as opposed to experimental and/or intervention designs and the effect of selection bias (Symonds *et al* 2006).

Others failed to identify any relationship and provided no evidence to support the hypothesis i.e. (Huxley & Neil, 2004; Lauren *et al* 2003; Huxley *et al* 2002). The quality and completeness of the information on measurements is another concern because they vary by study and are based on historical records.

Finally, another concern is related to the relatively crude nature of the association and the lack of adjustment for possible confounders. Critics suggest that the same factors that might cause reduced fetal growth and development might also predispose adult disease. For instance, the association between size at birth and chronic diseases may be due to socioeconomic confounding and that reduced size at birth reflects poor maternal socioeconomic conditions that predict relative deprivation in adult life which in turn increases the risk of chronic diseases (Kimm, 2004). In other studies in which data on lifestyle variables were available like social class, the authors claimed however that socioeconomic confounding did not explain the dependent relationship between birth weight and CHD (Leon et *al* 1998).

2.1.2 Prevalence of LBW

According to the report produced by the United Nations Children's Fund and World Health Organization (2004) more than 20 million infants per year worldwide are of LBW. There are significant geographical variations in rates of LBW ranging from 7% to 18.6% (Table 3). Over 95% of the LBW infants are born in developing countries, with the sub region of South-Central Asia having the highest incidence 27.1% (nearly 70% of all lbw births occur in Asia) and Europe the lowest incidence (6.4%).

Table 3. Percentage and number of LBW infants by United Nations Regions, 2000

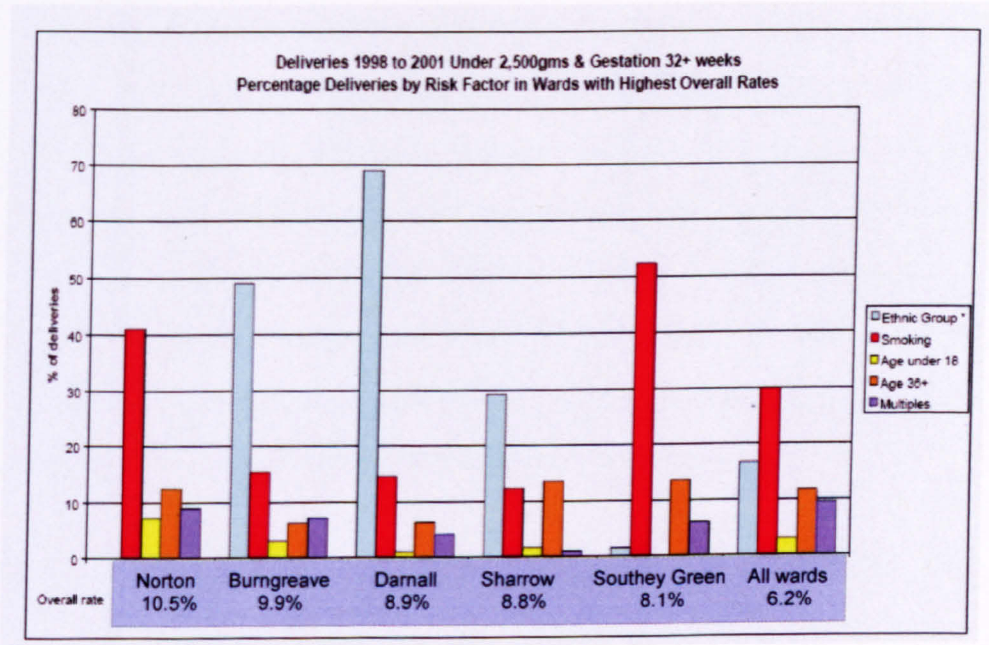
	% LBW infants	Number LBW infants (1,000s)	Number of live births (1,000s)
World	15.5	20,629	132,882
More developed	7.0	916	13,160
Less developed	16.5	19,713	119,721
Least developed countries	18.6	4,968	26,639

* Table adapted and summarised by United Nations Children's Fund and World Health Organization, (2004)

Reducing health inequalities is a government priority. The report '*Tackling health inequalities: a programme for action*' published by the Department of Health (DoH) (2003a) included the aim "*by 2010 to reduce inequalities in health outcomes by 10 per cent as measured by infant mortality and life expectancy at birth*". In Sheffield, the locally agreed target as part of reducing inequalities in infant mortality is to reduce the proportion of LBW babies and no ward in Sheffield to have more than 10% of births weighing less than 2.5kg.

The incidence of LBW in Sheffield has risen from 7.7% in 1993 to 8.8% in the year 2003 (95% Confidence Interval (CI) = 8.1 to 9.6). This is not statistically significantly different to the rate for South Yorkshire of 8.7% (CI = 8.2 to 9.1), but it is significantly higher than the rate for England as a whole at 8.0% (CI = 8.0 to 8.1). For the period 2000 to 2004, ten of the twenty-eight electoral wards in Sheffield have had a rate of 10% or higher, nine of these being the most deprived wards in the Sheffield (Sheffield South East PCT, 2004). Ethnicity and age of mother and smoking during pregnancy are some of the factors that have an effect on the number of LBW babies in any ward (Figure 4).

Figure 4. Factors including ethnicity of mother, age of mother and smoking during pregnancy affecting the number of LBW babies in any ward and different preponderance of them in different wards (Sheffield South East PCT, 2004)



2.1.3 Mediating determinants of socioeconomic disparities in pregnancy outcome

Research evidence suggests social class variations in the incidence of LBW. In England and Wales the gap has widened between 1993 and 2000 (Moser *et al* 2003) and even though mean birth weight has increased, the disparities in LBW between groups have not diminished over this time (Fairley, 2005). The study conducted by Moser *et al* (2003) examined social inequalities and rates of LBW by comparing birth data of manual and non-manual occupational groups. The authors reported significant differences in relative ratios between manual and non-manual groups (RR 1.22 and 1.35) and claimed that an estimated 6.5% of LBW in 2000 in the manual group might have been avoided if risk factors such as low educational attainment in that group had been absent.

Many studies have suggested that socially deprived mothers give birth to smaller babies. For example an analysis of birth weight data in West Midlands Health Region estimated that nearly 30% of the estimated proportion of births less than 2.5Kg was statistically attributable to social inequality (Spencer *et al* 1999). The results of this study were further supported by Bambang *et al* (2000), as the analysis of the same data showed a positive linear trend in perinatal deaths for all causes of deaths and suggested that social inequality contributed to approximately 30% of deaths. Likewise, an analysis of birth registration of 471,411 births in England and Wales demonstrated that joint and sole registrants in social classes IV and V were at higher risk of giving birth to a LBW baby than the more affluent social classes (Pattenden *et al* 1999).

Although the relationship of low SES and incidence of LBW by the use of different socioeconomic indicators e.g. income, residential area, education, social class has been extensively investigated, the lack of universal social gradient indicators, small sample sizes, grouping of different individuals and the practice of comparing lower occupational status to higher might distort the actual situation. This needs to be taken into consideration prior to interpretation of the evidence (Reime *et al* 2006).

Even though much is known about the high prevalence of LBW among deprived groups, the effect of the mediating determinants is complex and difficult to understand. Kramer and colleagues (2000) summarised existing evidence in relation to the possible mediating factors between LBW and SES (table 4).

Table 4. Association between potential mediating factors of LBW and SES

Potential mediator	Link with SES
Anthropometry/ Nutrition	Short stature, low pre-pregnancy BMI, low gestational weight gain more common in low SES women
Micronutrients	Low dietary intakes more common in low SES women
Cigarette smoking	Higher rates and heavier smoking more common in low SES women
Substance use/abuse	Use of Cocaine, marijuana, high alcohol and caffeine consumption more common in low SES women
Work/physical activity	Strenuous work and prolonged standing more common in low SES women, leisure exercise less common
Prenatal care	Inadequate initiation and frequency of care more common in low SES women
Bacterial vaginosis	more common in low SES women
Multiple birth	less common in low SES women
Psychological factors	Stressful life events, depression, physical abuse, low level of social support and unwanted pregnancy more common in low SES women

*Table from adapted and customised by Kramer *et al* (2000)

As described in table 4 maternal anthropometry, micronutrient intakes, lifestyle factors such as cigarette smoking, alcohol consumption and drug use, attendance for antenatal care, bacterial vaginosis and psychological factors are determinants believed to play a role in the socioeconomic disparities in the incidence of LBW.

2.2 Anthropometrical and nutritional factors

2.2.1 Maternal anthropometry

Low pre-pregnancy BMI and low gestational weight gain are more common amongst women of low SES as seen in figure 2 (page 22). A WHO collaborative study of maternal anthropometry and pregnancy outcomes (WHO, 1995) analysed 25 data sets obtained in different country settings, which provided information on over 111,000 births worldwide. This analysis proposed maternal pre-pregnancy weight gain and pregnancy weight gain as strong predictors of LBW and fetal risk.

The quality of the maternal diet should receive particular attention prior to conception because of the relation between pre-pregnancy maternal BMI and infant weight. Women with low pre-pregnancy BMI tend to give birth to infants with lower mean birth weights, and women with higher pre-pregnancy BMI tend to deliver infants with higher mean birth weights. Women pre-pregnancy weight less than 49.5 Kg had an 84% increase in risk of IUGR and a 25% increase in risk of PTB (Bull *et al* 2003).

In order to assess the effect of pregnancy weight gain on birth weight multiple regression analysis was used by Abrams *et al* (1986) in a sample of 2946 pregnant women, and the results demonstrated a statistically significant linear association between pre-pregnancy BMI and birth weight (P=0.001). For every increase of one unit of pre-pregnancy BMI a statistically significant 15.9g increase in birth weight was observed. Findings of a retrospective cohort study conducted by Ehrenberg *et al* (2003) suggested a positive association between low maternal gestational weight gain (<0.27Kg per a week) with LBW (RR, 1.23, 95% CI 1.03-1.45) based on analysis of maternal and perinatal data in 15,196 deliveries and concluded LBW, prematurity and maternal delivery complications were associated with low weight and subsequently low BMI at conception or delivery and low maternal weight gain during pregnancy.

Conversely, research evidence from studies of women who gain more than the recommended amount of weight are at higher risk of pregnancy and delivery complications such as hypertensive disorders, gestational diabetes, caesarean sections and prolonged labour. Evidence also suggests that maternal obesity is related to increased risk of obesity in the long term and that it might also affect the health of the offspring in a negative way i.e. increased macrosomia and perinatal mortality (Krishnamoorthy *et al* 2006; Yu *et al* 2006; Linné, 2004).

The possible causal sequence of maternal nutrition on weight gain and infant birth weight needs further investigation as the relationship between anthropometrical measurements and pregnancy outcomes is mainly based on observational research designs. Experimental research designs conducted on animal models might improve our understanding of this complex relationship (Susser, 1991).

A systematic review conducted by Abrams *et al* (2000) concluded than weight gains within the recommended ranges are more strongly related to positive pregnancy outcomes than weight gains outside the recommended ranges- below or above. There are no specific UK recommendations for weight gain in pregnancy. In the US in 1990 the Institute of Medicine (IOM) (1990) published recommended weight gains by pre-pregnancy BMI (table 5).

Table 5. Recommended total weight-gain ranges for pregnant women by pre-pregnancy BMI* (IOM, 1990)

BMI‡ Category	BMI Range	Recommended total weight gain	
		Pounds	Kg
Low	<19.8	28.0-40.0	12.5-18.0
Normal	19.8-26.0	25.0-35.0	11.5-16.0
High	>26.0-29.0†	15.0-25.0	7.0-11.5

* BMI is weight in kg/(height in metres^2)
† For women with BMI >29, the recommended target weight gain is at least 6.0 kg

2.2.2 Maternal nutrition

Periconceptional nutrition

There is limited evidence relating periconceptional diet to pregnancy outcome and most of the reported studies usually focus on the effect of pre-pregnancy BMI on pregnancy outcome or in the prevention of NTD (Jackson and Robinson 2001). The positive effect of folic acid supplementation in the reduction of NTD and other birth defects especially in children of women at high risk because of a previous pregnancy affected by NTD is well established, but the effect of multivitamins without folic acid supplementation is controversial.

For example, a Cochrane systematic review on the effect of folic and/or multi-vitamins supplementation on prevention of NTD reported that periconceptional multivitamin supplementation without folic acid (results from two clinical trials) was not associated with prevention of NTDs and did not offer further preventive effects when given with folate. Periconceptional folate supplementation however, resulted in a strong protective effect and reduced the incidence of neural tube defects (RR 0.28, 95% CI 0.13 to 0.58) (Lumley *et al* 2001).

Similarly, the results of randomised double-blind prevention trial conducted by the MRC in order to determine whether supplementation with folate or multivitamins around the time of conception could prevent NTD suggested that folic acid rather than any other of the multivitamins was responsible for preventing NDT recurrence. The authors proposed folic acid supplementation of all women who have had an affected pregnancy and the development of public health strategies in order to ensure that the diet of pregnant women contains adequate amounts of folic acid (MRC Vitamin Study Research Group, 1991).

On the other hand, comparison of the results of the Hungarian randomized and two controlled trials on periconceptional multivitamin supplementation for the prevention of all congenital abnormalities have showed that multivitamins containing folic acid were more effective against NTD than high dose folic acid alone due to a possible additive and/or synergetic effect of the other B vitamins. In addition to the demonstrated effect on NTD reduction, the authors suggested a consistent effect of the periconceptional multivitamin and folic acid supplements on the overall reduction of congenital abnormalities and recommended daily use of multivitamin supplements containing 0.4-0.8mg of folic acid for a woman with a healthy diet and lifestyle (Czeizel, 2004).

The rate of use of pre- and periconceptional folic acid supplement usage could be affected by a range of factors. For example, a systematic review carried out by Ray *et al* (2004), investigated the characteristics associated with low rates of use and the effect of public campaigns on higher folic acid. Fifty-two studies were included in the final analysis; 34 studies reported preconceptional usage. Forty-nine studies reported that rates of periconceptional folic acid supplement usage varied from 0.5% to 52%. Low educational attainment, immigrant status, young reproductive age, lack of partner and unplanned pregnancy were the commonest associations with non-use. Finally, the results from the 4 studies investigating the effect of public campaigns reported a significant increase in the rates of periconceptional folic acid use (rate ratio: 1.7 to 7.2).

2.2.2.1 Nutritional requirements during pregnancy

The nutritional requirements of pregnancy are dictated by the growth needs of both mother and fetus. Pregnancy is a state of continuous physiological change. The maternal metabolism adjusts, mediated by the changes in key reproductive hormones like human chorionic gonadotropin, prolactin, cortisol etc. Blood volume and composition and renal function are also affected. Changes in the nutrient metabolism varies widely from woman to woman depending on her pre-pregnancy nutritional status, genetic make up, lifestyle, pregnancy weight gain and dietary intake (King, 2000). Nutritional requirements are raised during pregnancy in order to sustain the growth and development of the placenta and fetus and of the maternal reproductive organs, blood volume and fat depots (Picciano, 2003).

In 1991 the Committee of Medical Aspects of Food Policy (COMA) (COMA, 1991) published the Dietary References Values (DRVs) for energy, and certain macro-nutrients and vitamins during pregnancy (table 6). DRVs apply to groups of healthy people and include a series of estimates of the amount of energy and nutrients needed by different groups. Within this definition there are three types of estimates: Reference Nutrient Intakes (RNIs), Estimated Average Requirements (EARs) and Lower Reference Nutrient Intakes (LRNIs). The EAR, is used as an estimate of energy or nutrient requirements which approximately 50% of a group of people will require less, and 50% will require more assuming normal distribution of variability. The RNI is the amount of a nutrient that is enough to ensure that the needs of nearly all the group (97.5%) are being met. By definition, many within the group will need less. The LRNI estimates the amount of a nutrient which is enough for only the small number of people who have low requirements (2.5%).The majority within the group will need more.

Energy and macronutrient requirements

The COMA panel estimated the average additional energetic cost of pregnancy to be approximately 77,000 kcal (321 MJ) for a woman with a pre-pregnant weight of 60kg, depositing 2 to 2.4 kg of fat during pregnancy and recommended an increase of 200 kcal (0.91MJ) per day during the third trimester only (table 6).

Table 6. Increments in the average daily requirements for energy and reference nutrients intakes for women aged 19-50 years (COMA, 1991)

	Non-pregnant (19-50years)	Pregnant
Energy (kcal)	1940	+200*
Protein (g)	45	+6
Iron (mg)	11.4	**
Riboflavin (mg)	1.1	+0.3
Folate (μg)	200	+100
Vitamin C (mg)	40	+10*
Vitamin A (μg)	600	+100
Thiamine (mg)	0.8	+0.1*

*3rd trimester only
** No increments

A widely cited example demonstrating the adverse effects of energy restriction on fetal development is the Dutch famine winter of 1944 -1945, where during a five month period some parts of the Netherlands faced severe food shortages and a decrease in energy intakes from 1400 Kcal (6.37MJ) in October 1944 to 400-800 Kcal (1.82-3.64MJ) in April 1945. Painter *et al* (2005) reviewed the effects of exposure to the famine during gestation and health in later life from the findings of a cohort study of 2414 adult born around the time of the Dutch famine and suggested a link between maternal undernutrition during pregnancy and increased risk of CHD, raised lipids and obesity after exposure to famine in early gestation, obstructive airways disease and microalbuminuria after exposure in mid gestation, and decreased glucose tolerance after exposure in late gestation.

The COMA panel for protein intake recommended an average increase of 6g/day. No increment for carbohydrates (starch, sugar, fibre) during pregnancy is advised however, women with low intakes of dietary fibre might benefit from increased intakes, along with increased fluid intakes to avoid constipation.

No added requirement for fat intake during pregnancy is specified by the COMA panel. Adequate intakes of essential fatty acids and their long-chain derivatives, arachidonic acid (AA) Docosahexaenoic acid (DHA) are advised however, by the FSA because they are important structural components of cell membranes and therefore essential to new tissue formation (Williamson, 2006; Theobald, 2003).

The DoH recommends consumption of at least two portions of fish per a week one of which should be oily (DoH, 1994). Epidemiological studies suggested a positive association between fish intake and prolonged gestation (Olsen *et al* 1986) supported by results from randomised control trial on 533 healthy Danish women (Olsen *et al* 1992). An observational study looking at the effect of fish oil supplementation also reported higher birth weights and a reduction in LBW of mothers consuming liquid cod liver oil in early pregnancy (Olafsdottir *et al* 2005).

Mineral and vitamin requirements

Requirements during pregnancy increase for some but not all of vitamins, minerals and trace elements. Low vitamin and mineral levels are often related to women's lack of knowledge of adequate pre-conceptional nutrition, to inadequate intakes or health problems as well as to cultural influences and personal choices (Lapido, 2000).

Minerals and trace elements

No increments for minerals during pregnancy were recommended by the COMA panel, mainly because of more effective utilisation and absorption of nutrients occurring during pregnancy due to physiological and metabolic changes (COMA, 1991).

Calcium

The RNI for calcium is 700mg/day and no increment during pregnancy is suggested by the panel (COMA, 1991). Increased calcium intakes is advisable however, to individuals who consume little or milk or milk products, vegan women, adolescents and Asian women with low vitamin D status and increased dietary fibre intakes (Williamson, 2006).

The effect of calcium supplementation on birth weight has been reviewed by Bull *et al* (2003) suggesting that there is evidence supporting the effectiveness of calcium supplementation for reducing the incidence of LBW. In fact the review pointed out that calcium supplements were the only nutrient supplements having a clear and positive effect on the reduction of pre-term birth and incidence of LBW especially to those women at high risk of hypertensive disorders, compared to other nutritional supplements reviewed.

Iron

The COMA panel did not establish any increment of iron requirements during pregnancy, as extra requirements are considered to be met through the cessation of menstrual losses, increased intestinal absorption and mobilisation of maternal iron stores. Pregnant women however, are advised to consume iron-rich foods and in some case iron supplementation may be necessary. Iron-deficiency anaemia is the result of exhaustion of iron stores and results in a compromised supply of iron to the tissues. The Expert Group on Vitamins and Minerals (2003) identified as vulnerable groups for iron deficiency infants over 6 months, toddlers, pregnant women and adolescents (due to high requirements), older people and menstruating women with pathological blood loss.

Godfrey *et al* (1991) performed a retrospective analysis on 8,684 routine obstetric and haematological data in order to examine the effect of maternal influences on placental weight to infant weight ratio, which is a known association with elevated adult blood pressure. The findings suggested an association between maternal anaemia and iron deficiency with high ratio of placental weight to birth weight. A review of available evidence conducted by Allen (2000) of maternal iron deficiency and anaemia suggested a relationship with LBW, PTB and infant health and proposed administration of routine iron supplementation to all pregnant women whether the individual was anaemic or not.

The effect of maternal iron supplementation on reducing adverse pregnancy outcomes is questionable (Scholl and Reily 2000) but evidence from controlled trials in the developed world have shown an improvement in haematological status following iron supplementation. In developing countries where anaemia is a major health problem, results from controlled trials of routine iron and folate supplementation and iron supplementation have suggested that routine supplementation prevents low haemoglobin level (Mahomed, 2000; Mahomed, 1998). Deficiencies of other minerals such as magnesium, selenium, copper and calcium have also been associated with complications of pregnancy, childbirth or fetal development in developing countries (Black, 2001).

Vitamins

The COMA panel advised increases for vitamin A, C and D, thiamine, riboflavin and folic acid (COMA, 1991). The RNI for vitamin A for non-pregnant women aged 19-50 years is 600μg/day and an additional increment of 100μg/day during pregnancy is advised because of its role to fetal growth and maintenance as well as for fetal stores and maternal tissue growth. The increment in riboflavin and thiamine intakes is 0.1mg/day and 0.3mg/day (last trimester only) respectively.

As has been mentioned before pre- and periconceptional folic acid supplementation up to 12 weeks of pregnancy is advised. Additionally, extra folate is needed throughout pregnancy for the prevention of megaloblastic anaemia (Williamson, 2006). The RNI for non-pregnant women is 300μg/day and increment of 100μg/day is recommended for the duration of the pregnancy.

Vitamin C requirements also increase by 10mg/day during the last trimester of pregnancy, in order to maintain maternal vitamin C stores and because of the role of vitamin C in enhancing the absorption of non-haem sources of iron (Williamson, 2006).

2.2.2.2 Dietary surveys of pregnant women

Diet and pregnancy outcome

Pregnant women represent a vulnerable group with particular dietary requirements because of the direct effect of their diet on their and their baby's health. A broad range of epidemiological evidence has indicated an association between maternal diet and LBW, infant mortality and morbidity.

A study conducted by Doyle *et al* (1989) on 419 singleton pregnancies in East London examined the relationship between diet and birth weight by comparing the nutrient intakes of the mothers at the end of the first trimester and grouped the participants into four categories. The first group were classified mothers of infants of birth weight <2.5Kg and the fourth or 'reference' group were mothers of infants of birth weight between 3.5-4.5Kg. The authors observed that mothers of LBW infants have had the lowest intakes of most of the nutrients studied compared to other groups e.g. energy, calcium, iron, thiamine.

Dietary composition in relation to the size of the baby at birth was studied in 557 Australian pregnant women (Moore *et al* 2004). Multiple linear regression analysis revealed a positive link between dietary quality in early pregnancy and size at birth independent of energy intake and weight gain. In particular the percentage of energy from protein was positively associated to birth and placental weight, unlike the percentage of energy from carbohydrate which was negatively associated with ponderal index of the baby.

Micronutrient intakes have also been shown to be related to birth size (especially intakes of vitamin E, pantothenic acid and sodium) (Lagiou *et al* 2004) as well as dietary folate intakes (Neggers *et al* 1997). A number of prospective cohort studies in the UK however, failed to observe a positive relation between birth weight and intakes of any macro- and micronutrient and concluded that maternal nutrition at least in industrialised countries has only a small effect (Langley-Evans and Langley-Evans 2003; Mathews *et al* 1999).

Dietary intake surveys during pregnancy

Few large-scale dietary surveys which focus on pregnant populations have been reported. Several of these studies however, have identified nutrient inadequacies. A prospective study of 2,247 pregnant women taking part in the Pregnancy, Infection and Nutrition Study in North Carolina, USA (Bodnar and Siega-Riz 2002) suggested that approximately 30% of the participants met the recommended iron intakes from dietary sources only, 60% and less than 50% of the participants had met the recommended intakes for folate and dietary fibre respectively. The authors however, pointed out that around 12% of the sample grossly over- or underestimated their intakes.

In another study the authors compared the nutrient intakes of pregnant adolescent and adult women and suggested low intakes of selected nutrients. Nutrients that were found to be limited in the participants' diet included calcium, magnesium, zinc, iron, fibre, folate, vitamins D and E (Giddens *et al* 2000). Likewise, in a population of 200 Greek pregnant women, low intakes of folic acid and iron were reported (Petrakos *et al* 2005). Concerns are also related to dietary quality rather to dietary quantity. For example the study conducted by Bodnar and Siega-Riz (2002) suggested that biscuits, muffins, French fries and fried potatoes and whole milk were amongst the top 10 contributors to energy and fried potatoes and French fries to dietary fibre intakes.

In the UK, there are limited published data on nutrient intakes of pregnant women and most of the studies have reported low iron and folate intakes. For example a study conducted by Mathews and Neil (1998) investigated the dietary intake of 774 nulliparous pregnant women in the South of England using a 7-day semi-quantitative food diary and compared the results against the RNI.

The study findings showed that for over 65% of the nutrients studied women achieved the RNI values with exception for vitamin D, folate, iron and selenium. Statistical analysis of the behavioural characteristics of the participants revealed that 24.3% had taken dietary supplements for at least 1 day during the recording period. Iron containing supplements were taken only by 7.8%, and as a result in combination with low consumption of foods rich in iron content approximately 83% did not reached the RNI for iron and finally 66% of the women had folate intakes from food sources of under 300μg/day.

One of the largest-scale surveys that have been conducted in a UK pregnant population is the Avon Longitudinal Study of Parents and Children (ALSPAC) conducted by Rogers *et al* (1998b) describing the diet of 11923 pregnant women in the South-west of England, between April 1991 to December 1992. The authors used a self-completion un-quantified FFQ to assess maternal nutrient intakes of women at 32 weeks of gestation. Similarly to the study of Mathews and Neil (1998) their survey findings were compared to the RNI and to the nutrient intakes for all women aged 16-64 that have participated in the Nutritional and Dietary Survey of British Adults (NDSBA). It was estimated that 38% of the sample underreported their intakes.

Nutrient intakes were closely compared to the results of the NDSBA, with the exception of sugar, folate, calcium and Vitamin C; the Avon participants had higher intakes. The results were also closely related to the RNI with the exception of mean energy, iron, potassium, magnesium and folate intakes which were below the RNI. The authors raised concerns about the small proportion of women taking folic acid supplements (9% at 18 weeks of gestation and 18% at 32 weeks of gestation) and concluded that pregnant women in the UK were likely to have adequate amounts of most of the nutrients with the commonest exceptions being iron, potassium, magnesium and folate.

2.2.2.3 Nutritional Interventions

Evidence has shown that the dietary quality and quantity of pregnant women in the UK can be influenced by physical symptoms e.g. nausea, heartburn, social factors e.g. income, environmental factors e.g. new kitchen and cooker and emotional factors e.g. depression, anxiety (Tuffery and Scriven 2005). Results of nutritional intervention programmes in the form of dietary counselling, or advice, report an increase in women's' nutritional knowledge and awareness of healthier eating during pregnancy. Surprisingly this resulted in no effect observed on nutrient intakes and RNI achieved (Fowles, 2002; Anderson *et al* 1995).

A study conducted by Doyle *et al* (1999) on mothers of LBW babies in an inner city area of England argued that dietary counselling during the inter-pregnancy interval on its own seemed unlikely to improve nutritional status of pregnant women. Research evidence suggest a need for development and implementation of nutritional interventions programmes prior and during pregnancy but also emphasises associated problems regarding recruitment, participation and evaluation of such programs (Weerd *et al* 2003; Wrieden and Symon 2003; Doyle *et al* 2001).

A review of the effectiveness of nutritional interventions on the prevention of LBW conducted by Bull *et al* (2003) on behalf of the Health Development Agency highlighted the lack of high quality systematic review-level regarding interventions can prevent LBW. The exception was calcium supplementation interventions which were found to be effective by the authors (especially for women at risk of hypertension). Evidence on the usefulness of dietary advice, fish oil, balanced protein/energy, folate, iron, zinc, vitamin D and magnesium supplementation is either lacking, conflicting or of low quality and the authors did not recommend further research within the UK of specific nutritional interventions focusing on individuals' nutrients in terms of preventing LBW but encouraged appropriate combinations of nutritional interventions.

Research into other ways of improving the general diet of pregnant women at risk however, e.g. Special Supplemental Nutrition Program for Women, Infants and Children (WIC) is promoted and encouraged. The WIC programme has been funded by the US Department of Agriculture since 1972 and its aim is to provide food assistance (food packages containing cereals, eggs, juice, milk, cheese), nutrition education and health care/social service to low income women, infants and children. The purpose of the WIC programme is to improve pregnancy outcomes, fetal and infant mortality.

Findings from WIC evaluations have indicated that rates of LBW and very LBW (<1.5 Kg) among infants born to mothers participating in the programme have decreased significantly (25% and 44% respectively) and there has been a reduction in the anaemia rates in toddlers and preschool children. The prevalence of anaemia prior to participation was 13% for infants 6-23 months old and 29% of 24-47 months old (Owen and Owen 1997). After participation the prevalence rates dropped 5% and 14% respectively.

2.3 Non-nutritional factors

2.3.1 Cigarette smoking

Smoking is a major modifiable risk factor contributing to LBW (Dewan *et al* 2003) and varies considerably by social class. Women in semi-skilled or unskilled manual occupations and jobs in the private service sector are twice as likely to smoke as professional women (33 % and 14 % respectively) (Office for National Statistics, 2002). In Sheffield there are geographical variations in smoking rates with smoking being prevalent in the least affluent neighbourhoods (Low Edges and Manor wards have rates of over 50% of mothers being smokers at the time of delivery) and in the least affluent PCTs (Sheffield South East PCT, 2004) .

Both smoking and food intake are highly correlated with social class. For example, smokers (men and women) are more likely to consume fewer servings of breakfast cereals, wholemeal bread, fruit, fruit juices and vegetables (with the exception of potatoes) and have higher intakes of fat, cholesterol and alcohol and lower intakes of vitamin C, beta carotene and vitamin A , calcium and fibre than non-smokers (Birkett 1999; Zondervan *et al* 1996; Cade and Margetts 1991; Hebert and Kabat 1990). In another large-scale study, analysis of 1,842 dietary food records showed differences in dietary, nutrient, and biochemical measures between smokers and non-smokers. Smokers were more likely to eat chips, processed meats, white bread, sugar, butter, and whole milk and have lower intakes of, protein, carbohydrate, fibre, iron, carotene, and ascorbic acid and have lower circulating serum beta carotene concentrations than non-smokers (Margetts and Jackson 1994).

Smoking is associated with unhealthy eating patterns and lower nutrient intakes during pregnancy; however the validity of maternal self-reported smoking status is still questionable (Jacobson *et al* 2002). Studies examined the nutrient and food intakes in smokers compared to non-smokers shown that smokers in all social classes have poorer quality diets (Haste *et al* 1990).

In the UK, a study of 774 pregnant nulliparous women the dietary intake was investigated in relation to smoking and age by Mathews *et al* (2000). The authors suggested that smokers had lower dietary intakes of most micronutrients and that pregnant smokers of younger age had the lowest antioxidant intakes compared to the other age groups. Likewise, results of another UK study suggested lower micronutrient and dietary fibre intakes in smokers compared to the non-smokers at both 28 and 36 weeks of pregnancy. Smokers were more likely to reduce their dietary intake in late pregnancy and smoking explained 14.3% of the variance observed in birth weight (Haste *et al* 1991).

Studies looking at the dietary intakes of smokers have shown that they were more likely to consume alcoholic beverages compared to non-smokers (Wichelow *et al* 1991). Smoking appears to be more prevalent in low-income households nationally and locally (Sheffield South East PCT, 2004; Office for National Statistics, 2002), however the evidence is conflicting as the results of the EFS and NDNS have shown that household and individuals in receipt of benefits were less likely to consume alcohol (National Statistics 2005; Henderson *et al* 2002).

In the UK studies on alcohol intakes during pregnancy and variation across SES groups are limited. In the USA, where alcohol consumption is major public health issue; especially within ethnic minorities, the results of a cross-sectional survey on 826 pregnant women participating in the WIC programme showed two thirds of the participants drank before conception and approximately one third continued drinking alcohol throughout pregnancy (Connor and Whaley 2003).

There is no current recommendation on alcohol consumption during pregnancy. The FSA (2005) however recommends no more than one or two units once or twice per week because evidence has shown that increased alcohol consumption is associated with high risk of spontaneous abortion and fetal alcohol syndrome (Burd *et al* 2003; Rasch, 2003). Further research is needed into the alcohol intakes of pregnant populations, and into to the development of reliable assessment methods of alcohol consumption (Kesmodel and Olsen 2001).

2.3.2 Other non-nutritional factors

Ethnicity

Ethnicity is associated with variations in adverse pregnancy outcomes and disparities in LBW rates exist between racial and ethnic groups. In Sheffield between 1998 and 1999, the next largest proportions of births (white mothers 78.2%) were to Pakistani mothers (6.8%). Yemeni mothers experienced the highest rates of LBW (16.7% of births), followed by Pakistani mothers (14.2%) and the white mothers had the lowest rates (6.0%) (Richardson and Stead 2001).

In a retrospective cohort study, birth records of babies born in Southampton, UK from 1957 to 1996 were examined in an attempt to identify differences in LBW rates between first and second generation of babies of South Asian origin (Margetts *et al* 2002). The results suggested that the average birth weight of the babies studied was significantly below the national average and no increase in the average birth weight was observed. On the other hand, in another study in the UK, a difference of 249g in the mean birth weight was observed between first and second generation Asian women (Dhawan, 1995). Dietary differences by race have been observed (Siega-Riz *et al* 2002), and for specific nutrients e.g. folic acid these differences persist even after food fortification (Lawrence *et al* 2006).

In the UK, evidence on nutrient intakes of pregnant women from different ethnic backgrounds is limited. A study conducted by Rees *et al* (2005b) on the nutrient intakes of mothers of LBW babies examined the nutrient intakes of mothers (*n*=165) of LBW babies of different ethnic groups in East London, UK using a 7-day diet diary at 8 and 12 weeks post-partum. The findings suggested variations in nutrient intakes by ethnicity. For example, African women had the lowest energy intakes and the highest vitamin D intakes compared to the Caucasian and Asian women. Calcium intakes were significantly different as well; with the Caucasian women having the highest calcium intakes most probably because of a wider inclusion in their diet of dairy products. Two-thirds of the African and Asian women did not meet the RNI for calcium. The authors however, suggested that prior to the interpretation of the results the study limitations in relation to recruitment, risk factors for LBW and timing of diet assessment, they reported low intakes of calcium, magnesium, iron, folate and riboflavin needed to be taken into consideration.

Teenage Pregnancy

England has the highest rate of teenage births in Western Europe. Sheffield has high rates of teenage pregnancy and recently available data indicated that conceptions under 18 have remained static overall since 1998 (Sheffield South East PCT, 2004). There is variation in rates of teenage pregnancy, with the most deprived electoral wards like Southey Green, Manor, and Darnall having the highest rates (Joint Annual Report of the Sheffield PCT Directors of Public Health, 2003).

A number of studies have suggested that teenage pregnancy is associated with social disadvantage. Demographic and socio-economic factors like residence in deprived areas and non-marital childbearing (McCulloch, 2001), unemployment, reliance on state benefits, low educational attainment are some of the associations with becoming pregnant during adolescence (Williams *et al* 1987).

There is evidence suggesting that gynaecological immaturity might have an influence on poor pregnancy outcome amongst pregnant adolescents (Wallace *et al* 2006) and that adolescent pregnancy is associated with adverse pregnancy outcome such as prematurity, neonatal and post-neonatal mortality (Olausson *et al* 1999; Fraser *et al* 1995). Lao and Ho (1998) however, suggested that teenage mothers living in a relatively affluent society and receiving appropriate prenatal care might have a good obstetric outcome and perform as well as older women.

Results from the NDNS of young people aged 4-18 (Gregory and Lowe 2000) have showed that 40%-50% of the girls aged 11-18 had iron intake below the LRNI and a significant number had inadequate intakes of magnesium, calcium, zinc, potassium, vitamin A and riboflavin. Two recent systematic reviews of available evidence relating to the dietary assessment and the use of biochemical markers of pregnant adolescents living in industrialized countries were conducted by Moran (2007a, 2007b). The results of the reviews suggested that the diet of adolescents pregnant women appeared to be low in energy, iron, folate, calcium, vitamin E and magnesium intakes. It was also suggested that indicators of anaemia and iron status were compromised in particular during the third trimester. The author called for further higher quality research however, and further consideration of the influence of the socioeconomic support on pregnant adolescents' nutritional status.

2.4 Summary of the findings

In this chapter, the etiological determinants, consequences and the prevalence of LBW as well as the mediating determinants of socioeconomic disparities in pregnancy outcome i.e. maternal anthropometry, micronutrient intakes and cigarette smoking were examined. Some of the epidemiological studies which unveiled the early life programming hypothesis and its long term effects on health of the infants were reviewed. Requirements during pregnancy for energy, vitamins and minerals and the recommended increments in the average daily requirements for energy and reference nutrients intakes for pregnant women aged 19-50 years were described.

Several studies examining the dietary intakes of pregnant women have identified nutrient inadequacies, and research findings suggested that mothers of LBW infants usually have low intakes of most of the nutrients studied compared to mothers who deliver babies weighing more than 2.5 Kg. Low intakes of folic acid, iron, calcium, magnesium, fibre, and zinc were reported and concerns over the proportion of pregnant women in the UK meeting the RNI for important nutrients during pregnancy have been raised. Nutritional variations between pregnant women who are smokers and non-smokers and also across different ethnic groups were also reviewed.

Several key issues should be considered when interpreting the findings of the studies appraised; comparability of the findings identified in the literature between studies i.e. large scale vs. small scale studies. Generalisability of the studies to other populations due to cultural, ethnical and lifestyle differences. Interpretability of findings identified in the literature related to nutrient intakes i.e. mothers of LBW infants, pregnant women, smokers and non-smokers etc may vary due to the various nutritional assessment instruments used. Finally, issues involved in assessing the diet of pregnant women such as within-person variation due to physiological changes that alter nutrient absorption, metabolism and requirements, plasma volume expansion and periods of exposure between measurements.

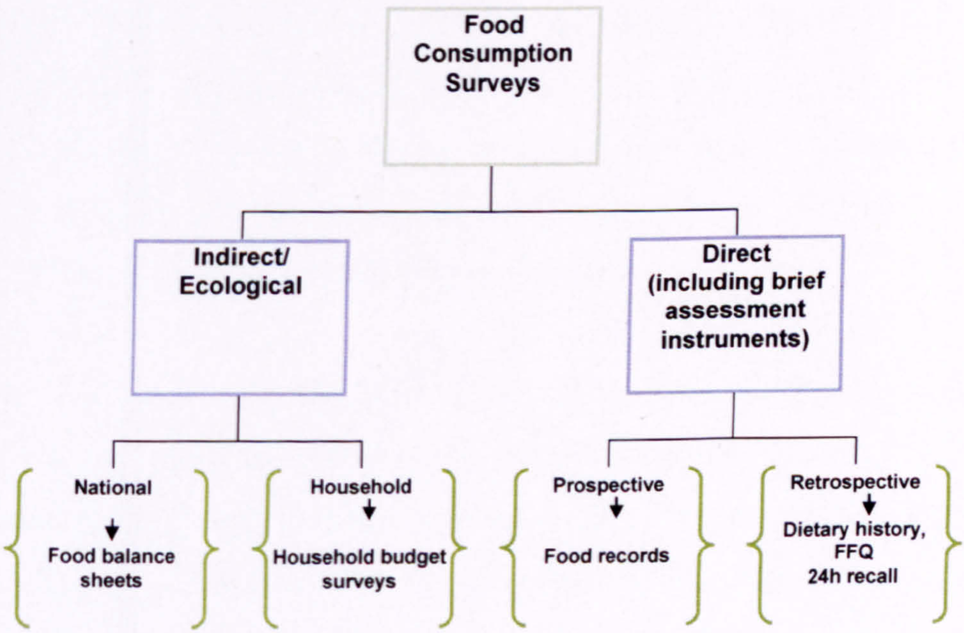
Chapter 3

3. Assessment of nutritional status in individuals and populations

3.1 Nutrition Assessment

Four major approaches are used in nutritional epidemiology to determine the nutritional status of individuals or populations. The first approach is anthropometry; dimensions and composition of the human body are measured. The second is biomarkers, which reflect and measure the impact of nutrient intakes. The third approach is examining the clinical consequences of unbalanced diet known as clinical assessment and finally the fourth and more widely used approach is the dietary assessment, which assesses the nutritional status by estimating food and/or nutrient intakes (Gibney *et al* 2004). The primary focus of this chapter will be on the dietary assessment approach; specifically the direct methods. An overview of the available methods for the measurement of food and/or nutrient intake can be seen in the figure 5 below.

Figure 5. Measurement methods of food and/or nutrient intake



Adapted by Margetts *et al* 1997

3.2 Direct assessments

3.2.1 Measurement on specified days

The 24-hour recall (24h recall) method was designed to quantitatively assess current nutrient intakes and is primarily based on individual's actual food consumption of one or more days. Prior to the implementation of the above methodology, consideration need to be given on the number of days and which days. That is because of the significant effect of day-to-day variation on the actual intake which can be affected by seasonal, cultural and ecological factors. Regarding gross characterisation of an individual's energy and macronutrient intakes, evidence has shown 3 to 10 days to be sufficient. However, for nutrients with increased day-to-day variation like vitamin C, the number of days increases dramatically and ranges between 20 to over 50 days (Willet, 1998; Nelson *et al* 1989).

It is a method based on an in-depth interview, which the interviewee is asked to recall food and drinks consumed over the past 24-hour period. A crucial component of obtaining accurate and complete dietary data and precise quantification of amounts is rigorous training of the interviewer. The ability of the respondent to recall the previous day's intake can be affected and regulated by the way the questions are asked (Willet, 1998).

A procedure to facilitate collection of representative results and avoid misclassification was recommended by Margetts *et al* (1997). In brief, no prior warning should be given to the subjects who will be interviewed, as they might choose to change their intake. The assessment can be conducted as face-to-face or telephone based interview with similar results (Willet, 1998), and should be evenly distributed over the days of the week in a quiet and relaxed atmosphere in preferable. The assessment should commerce with the first food or drink taken in the day and neutral questions should be asked. Finally, assistance with the description of portion sizes might be necessary for those respondents with lower level of understanding portion size.

3.2.2 Measurement of usual days (FFQ)

The food frequency method is one of primary methods used for measuring dietary intake in epidemiological studies due to their time- and cost-effectiveness. As stated in Willet (1998) "*the underlying principle of the food frequency approach is that average long-term diet, for example over weeks, months or years, is the conceptually important exposure rather than intake on a few specific days*". A food list (varies from 80 to 120 food items) and a frequency response section are the two basic components of a FFQ. Further questions on food preparation practices and nutrient content specific food items question are usually contained in a typical FFQ. Depending on the scope and requirements of the study the FFQ could be self-administered or interviewer administered (telephone-based interviews similar to face-to-face interviews could be equally practical) (Margetts *et al* 1997).

There are a number of issues related to the design of FFQs; the objective of the questionnaire ought to be clearly defined (assessment of frequency or amounts, group or individual mean intakes). The included food items should be representative of major sources of nutrients for the majority of participants, and be selected to capture between –person variability and specific objectives of any hypotheses being tested (Gibney *et al* 2004; Cade *et al* 2004; Cade *et al* 2002). In an attempt to increase accuracy and reduce coding time and transcription errors, the use of closed questions rather open-ended is encouraged. Portion sizes should reflect known consumption patterns and the use of models of portion sizes (e.g. cups, teaspoons, side plates) and photographs are advantageous (Margetts *et al* 1997)

Strengths and limitations of the 24h recall and FFQ

Both methods of dietary assessment have strengths and weaknesses (table 7). Blue boxes suggest possible strengths of the methodology and the green boxes suggest possible limitations.

Table 7. Strengths and limitations of the dietary assessment methods (Willet, 1998)

	24h recall	FFQ
Ease and uniformity of administration	Strength	Strength
Cost effective	Limitation	Strength
Use with subjects which are geographically widespread	Limitation	Strength
Interviewer administered or self-administered	Limitation	Strength
Face-to-face or telephone administered	Strength	Strength
Low literacy level acceptable	Strength	Limitation
High level of specificity	Strength	Limitation
Sensitive to cultural differences	Strength	Limitation
Less likely to alter eating behaviour	Strength	Strength
Minimal respondent burden	Strength	Strength
Development and validation might be time consuming	Strength	Limitation
High level of imprecision	Strength	Limitation
Requires motivated subjects	Strength	Strength
Reliance on memory	Limitation	Limitation
Effect of "flat-slope" syndrome*	Limitation	Limitation
High day-to-day variation	Limitation	Strength
Need for highly trained interviewer	Limitation	Strength

■ Strengths
■ Limitations
*"Flat slope syndrome": a tendency toward overestimation of portion size by those who eat smaller portions and underestimation, by those who eat larger portions

The 24h recall method is relatively brief and the subject's burden is less in comparison to other methods i.e. food records. The main advantage of this method is the appropriateness of use in low-income and poorly literate populations as it does not require the participants to be able to read or write in order to complete the recall. The main limitations of the 24h recall are reliance on the memory, the need for trained interviewer and finally the inability of a single day's intake to describe the usual intake.

Advantages of the use of FFQ are that they can be self-administered; thereby can be posted and can reach large numbers of people geographically spread and remove the need for an interviewer. When literacy levels of the study sample are low however, interview-administered FFQ might be more suitable. Disadvantages of the FFQ method relating to its use are that it can be time consuming, requires careful design and motivated subjects and concerns with accurate estimation of the usual frequency of consumption and portion sizes.

An on-going debate in relation to the use of FFQs is centred on its ability to support aetiological inference in diet-disease relations associated to its ability to provide reliable estimates of absolute intakes. It is argued that the FFQs are not an optimal method for assessing individual/group means intakes (Kipnis *et al* 2003; Schaefer *et al* 2000) and even though FFQs can be used for broad characterisation of dietary patterns they cannot accurately capture the diversity and variability of foods eaten or measure individuals' nutrient intakes (Kristal & Potter 2006). That is mainly attributed to the fact that FFQs are subject to substantial random and systematic error which can have an effect on the interpretation of findings and consequently attenuate the disease relative risks and decreases the statistical power (Kipnis *et al* 2003). Others argue that FFQs can be used however, because there is sufficient evidence suggesting the validity and usefulness in large epidemiological studies (Block, 2001; Byers, 2001; Willet, 2001).

3.3 Measurement error

3.3.1 Types of error

In any branch of science, all biological and physiological measurements have error. There are many types and sources of error; however the dietary assessment methods are associated with random error, group-specific and person-specific error. Random error occurs by chance i.e. coding errors, day-to-day variability, group-specific error may be the result of an instrument's overestimation or underestimation and finally person-specific error could occurs when an individual's characteristics bias their nutritional status measure (Gibney *et al* 2004).

Other sources of error likely to affect the measurement could arise from use of food composition tables, assessment of the frequency of consumption, changes in dietary habits whilst participating in the study, portion sizes quantification process and misreporting of food choice or amount (Bingham 2002; Willet, 1998).

3.3.2 Under reporting

Bias of reporting energy intake resulting in systematic error in recorded food consumption intake is a well-known problem in dietary surveys. Low-energy reporting occurs when people report estimated food intakes that are lower than their true intake. The prevalence of underreporting in large nutritional surveys of general population varies from 18% to 54% of the whole sample to as high as 70% in particular subgroups (MacDiarmid and Blundell 1998). The estimated number of pregnant women likely to under report their energy intake was 38% in the ALSPAC study, which assessed the diet of 11,923 pregnant women in the South-west of England using a self-completed FFQ (Rogers *et al* 1998b). Percentage under reporting assessed in a population of Indonesian pregnant women was 30%, 16 % and 18% for each pregnancy trimester respectively. (Winkvist *et al* 2002). The results of the multivariate logistic regression analysis suggested that high BMI and low education were significantly associated with under reporting at least in any of the three trimesters.

Underreporting can be detected using various techniques of direct measurements of energy expenditure such as the doubly-labelled water method and twenty-four hour urinary nitrogen and potassium method. A method often used in large-studies is the ratio of reported energy intake (EI) to Basal Metabolic Rate (BMR) EI: BMR (Goldberg *et al* 1991). Schoffield equations (please refer to section 4.8.3.1) can be used to estimate BMR based on age, gender and body weight (DoH, 1991). The ratio can then be compared with a specific cut-off value that represents the lowest value of EI: BMR that could reflect the habitual energy expenditure. Subsequently subjects reporting EI less than the specified by the study cut-off values can be termed as under reporters (Goldberg *et al* 1991). There are however, some concerns related to the appropriateness of the use of these equations for obese subjects as very few obese subjects were featured in the original data used for the development of the equations (Price *et al* 1997).

Reported food consumption can also be biased by factors like age, sex, social class and educational level. A study conducted by Pryer *et al* (1997) examined the characteristics of 2197 men and women termed as low energy reporters (reported energy intake below 1.2 times the estimated BMR) and non-low energy reporters participating in the Dietary and Nutritional Survey of British

Adults. The study findings suggested that low energy reporters were more likely to be of manual social class, smokers, self-reported non-alcohol drinkers and of higher BMI than the non-low energy reporters. The authors also suggested evidence of differential reporting of nutrients and foods by energy reporting levels.

Similarly, analysis of data collected for the MRC National Survey of Health and Development suggested that the characteristics of subjects that reported implausibly low or high energy intakes differed. Participants with increased BMI, overweight or weight instability were more likely to report low energy intake. Amongst women participants characteristics like smoking, low educational attainment, social class, and increased BMI differentiated between under reporters and non-under reporters (Price *et al* 1997).

Studies examining the proportion of under reporters and their characteristics in using the food frequency and the 24h recall methods have also suggested considerable under reporting resulted by the use of both methods. Factors strongly related to low energy reporting included increased body weight and BMI, age, smoking, low educational levels, social desirability and body image perception (Bedard *et al* 2004; Novotny *et al* 2003; Johansson *et al* 2001; Gnardellis *et al* 1998).

3.3.3. Energy adjustment

Adjustment for energy intake in dietary surveys is an approach often used for correction of the measurement error i.e. control for confounding, removal of extraneous variation. Gibney *et al* (2004) specified that energy adjustments should be considered amongst others in cases where systematic over reporting or under reporting exist or when caloric intakes might be potential confounding variable on the association examined. The authors also stated that adjusting for energy intake potentially offers several benefits including reduced extraneous variation, which allows a more precise estimate of the association investigated.

In case of corrections for under or over reporting on FFQ data, the authors suggest the use of the regression residual or the linear regression calibration method which can perform equally to the nutrient density method which does not fully remove the effect of caloric intakes. An approach widely used for correction of measurement error in nutritional epidemiology is the nutrient residual method described by Willet *et al* (1997). At this method the crude nutrient intakes of the individuals are regressed on their total energy intake. The differences between each individual's crude intakes and the intakes predicted by their total energy intake are represented by the residuals from the regression.

3.4 Validation process

An approach that can be used to identify and quantify errors occurring in methods of assessing nutritional status is the conduct of reproducibility and/or validity studies. FFQs have become the primary methods for measuring nutrient intakes in large epidemiological studies because they are easy to administer and cost-effective (table 6); however the major components of the FFQ (food list and response section) differ from FFQ to FFQ, making the use of a group specific questionnaire e.g. South Asian inappropriate for use in a group from a Caucasian population unless appropriately validated and adapted for the needs and habitual diet of the groups or populations investigated.

Means comparison, proportion of total intake accounted for by foods included on the questionnaire, reproducibility, comparison with an independent standard (validity) or with biochemical markers and correlation with a physiological response include the main approaches used to evaluate the performance of FFQs.

Reproducibility refers to consistency of questionnaire measurements on more than one administration to the same person at different times and validity refers to the degree to which the questionnaire actually measures the aspect of the diet that it was designed to measure, and it represents a higher standard and will be discussed in detail below (Willet 1998; Gibney *et al* 2004). Findings from validation studies conducted on general and pregnant populations are discussed in section 3.5.

Willet (1998) proposed the main objectives that should be applied in the design of validation studies of dietary instruments:

- Measurement of the true between-subject variation in the dietary factors of interest.
- Qualitative documentation that the dietary assessment method can detect the differences in diet which exist between subjects.
- Calibration of a dietary questionnaire against a true measure of absolute intake, which enhances the capacity to compare findings with other studies.
- Quantitative assessment of exposure to measurement error so that measures of association, such as relative risks, can be corrected for measurement error.

The choice of a population and an appropriate time frame, the sequence of measurements and the number of subjects and replicate measurements are critical elements of the study design having direct effects on the accuracy of the validation study (Willet, 1998). In addition, there are many factors, which could potentially undermine the validation process; Gender, age, socio-economic group, education, language, culture, length of food list and dietary supplements are examples of possible determinants (Margetts *et al* 1997).

3.5 Research evidence on validation studies

3.5.1 Validation studies (general population)

The validity of FFQs has been examined under a wide variety of conditions i.e. different design settings, populations, sample size, statistical techniques, and reference methods (Bhakta *et al* 2005; Cade *et al* 2004; Bacardi-Gascon *et al* 2003; Cade *et al* 2002; Kroke *et al* 1999; Katsouyanni *et al* 1997).

Amongst the early detailed studies conducted, was the validation assessment of a 61-item semi quantitative FFQ (Willet *et al* 1985). In that study, women participants in the Nurses' Health Study were randomly selected to participate in the validation of the FFQ. Over a period of one-year 2 FFQS and four 1-week food records were collected for each participant (n=173). Following energy adjustment, correlation coefficients values between the first FFQ and the mean of four 1 week food records ranged from 0.37 for protein to 0.61 for cholesterol and from 0.47 for protein to 0.75 for vitamin C between the second FFQ and the mean score of the four food records. Similar findings were observed in other validation studies including women participants, in which correlations ranged from 0.34 to 0.76 (Chen *et al* 2004; Xu *et al* 2004;Jain *et al* 1996).

In another study, evaluating the relative validity of a self-administered FFQ against a 4-day dietary records used in a prospective study of risk factors for cervical neoplasia in Danish women, the authors reported that mean correlation values following energy adjustment ranged from 0.40 to 0.70 and concluded that the FFQ acceptably ranked individuals according to their nutrient intakes in that group of women (Friis *et al* 1997).

FFQs perform well when compared to 24h recalls. Results of the Canadian Study of Diet, Lifestyle and Health cohort (Jain *et al* 2003) have suggested acceptable levels of food and nutrient estimates as assessed by a self-administered FFQ against three 24h recalls. Correlation observed in that study ranged from 0.29 (β-carotene) to 0.76 (caffeine) for female participants and 0.23 (vitamin A) to 0.81 (caffeine) for male participants.

Studies evaluating the validity of FFQs in culturally diverse populations have also reported similar findings. For example, a study examining the validity of a FFQ against a series of eight 24h recalls in a sample of African-American, non-Hispanic white, and Hispanics, reported total median correlation value for the total sample of 0.49 and reasonable validity of the FFQ in a diverse sample (Mayer-Davis *et al* 1999).

Similarly, a study conducted by Sevak *et al* (2004) on a UK South Asian women population (*n*=133) suggested reasonable validity of the FFQ. The energy-adjusted correlation coefficient for most of the nutrients examined were over 0.50 and the proportion of individuals assigned to the same or adjacent quartile by the FFQ and the multiple 24h recalls ranged from 74% (energy) to 96% (protein).

Results from the Health Professionals Follow-up Study and the National Health Interview Survey in the US, have also suggested reasonable reproducibility and validity of major dietary patterns assessed by FFQs compared to other dietary assessment methods (Newby *et al* 2003; Kant and Thompson 1997).

3.5.2 Validation studies (pregnant population)

Studies examining the performance of FFQs in assessing nutrient intakes of pregnant women are limited. Amongst the earliest, is the study conducted by Suitor *et al* (1989) on 295 Massachusetts, USA pregnant women aged 14 to 43 years of age. The study objectives were the development of a self-administered prenatal FFQ for use with low-income pregnant women and its evaluation in classifying women according to nutrient intakes. Nutrients examined were energy, protein, calcium, iron, zinc and vitamins A, B_6 and C. The mean intake of three 24h recalls provided by 95 participants was used as a reference method. Nutrient intakes estimated by the FFQ were consistently higher compared to the 24h recall. Following adjustments for measurement error and exclusion of participants with incredibly high energy intakes (>4500Kcal), the correlation value increased by 15% (r=0.50) and quintile agreement ranged from 5% to 61%.

Wei *et al* (1999) expanded the study conducted by Suitor *et al* (1989), by assessing the validity of the questionnaire for 17 further nutrients (e.g. fat, carbohydrate, folate). Complete dietary information was provided by 101 low-income pregnant women (at least one recall and energy intake less than 4500 Kcals). Similar mean nutrient values were reported by the authors and correlation coefficient values adjusted for energy ranged from 0.3 (B_{12}) to 0.46 (folate). Following correction of the correlation coefficient for day-today variability correlation values ranged from 0.07 (B_{12}) to 0.90 (zinc).

Robinson *et al* (1996) have conducted one of the few validation studies on UK pregnant population. The aim of the community-based study was to compare nutrient intakes assessed by FFQs and food diaries. A 100-item FFQ and a food diary were administered to women at 15 and 16 weeks of pregnancy respectively. The response rate was high (88%) and 569 Caucasian pregnant women provided complete dietary data. The FFQ gave higher intakes of all nutrients and the Spearman rank correlation values for energy adjusted intakes ranged form 0.27 (protein and starch) to 0.37 (fat) and quintile agreement from 30% (starch) to 41% (calcium). The authors argued that, over reporting (5%) and experience of nausea were potential attenuators of the correlation strength.

The results of validation study conducted on a Finnish pregnant population (n=113) suggested acceptable validity of a self-administered 181-item FFQ (Erkkola *et al* 2001). The purpose of the study was to assess the dietary intake of pregnant Finnish women using a self-administered 181-item food frequency and food records as the reference method. Nutrient intakes assessed by the FFQ were higher than the food record intakes and as in most other validation studies including a pregnant population, the FFQ overestimated food consumption and nutrient intakes. After energy adjustments mean nutrient correlation values ranged from 0.19 (vitamin E) to 0.70 (thiamin) and for foods 0.03 (high-fat milk) to 0.84 (low-fat milk). Quintile agreement in this study was the highest compared to the other pregnancy validation studies being on average 70% for foods and 69% for nutrients.

A recent study conducted by Baer *et al* (2005), examined the validity of the Harvard Service FFQ (100-item self-administered questionnaire) against six 24h recalls, on a sample of low-income American-Indian and Caucasian pregnant women at 12 and 28 weeks of gestation. Average deattenuated correlation coefficient values were 0.48 at 12 weeks and 0.47 at 28 weeks.

Finally the results of a nutrient-specific FFQ, designed to estimate fat consumption of pregnant Belgian women indicated acceptable agreement between the FFQ and the food records. Average energy adjusted Pearson correlation coefficient values ranged from 0.62 to 0.68 and approximately 47% of the study participants were assigned to the same quintile and less than 2% to the opposite extreme quintile (De Vriese *et al* 2001).

3.6 Methods of defining dietary patterns

Epidemiological studies have proposed the analysis of the dietary patterns as an alternative method of measuring dietary exposures in nutritional epidemiology because of the methodological limitations of the single nutrient or food approach i.e. nutrient interactions and colinearity. Several overall diet measures have been developed based on three major approaches resulting in an overall dietary score; indices derived from nutrients, indices based on food or food groups and indices based on combination of nutrients and foods (Kant, 1996).

There are concerns however, related to the use of dietary pattern analysis as an alternative approach to examining the relationship between diet and the risk of chronic disease because dietary patterns are likely to vary by culture, gender, socio-economic status and ethnic group. It is necessary therefore to replicate the results in diverse populations and also because this approach considers overall diet rather than individual nutrients or foods therefore it is not very informative about particular nutrient responsible for any association observed (Hu, 2002).

Examples of overall diet measures include the Healthy Eating Index (HEI) and the Diet Quality Index (DQI) which both evaluate the overall diet quality. The Healthy Eating Index was developed by Kennedy *et al* (1995) and was developed on a 10-component system of 5 food groups e.g. grains, fruits and vegetables, 4 nutrients e.g. fat, sodium and a measure of diet variety. In 1999

(Haines *et al* 1999) the DQI originally included measures of 8 food groups and nutrient-based recommendation was revised to incorporate improved methods of food portions quantification and to reflect current dietary recommendations.

The use of overall quality indices in pregnant populations is limited. Results from the validity of the HEI in pregnancy (Pick *et al* 2005) between 20 and 38 weeks of gestation suggested that the index was a useful and practical tool in providing a composite assessment of overall dietary quality.

Dietary data obtained by a 120-item modified Block FFQ from the Pregnancy, Infection and Nutrition Study were used to develop a Diet Quality Index for use in pregnancy (Bodnar and Siega-Riz 2002). The Diet Quality Index score was based on seven components; the first three components reflected intake adequacy of grains, fruits and vegetables. The next three components reflected folate, iron and calcium intakes and the third component was related to meal and snack patterning. Despite concerns of misreporting of grain servings and moderate correlation of energy intake between the index score and the FFQ, the authors suggested that the index was able to detect quantitatively different diets similarly to the FFQ and an ability to identify dietary variation according to socio-economic factors such as income and education.

An alternative method for dietary patterns identification is the use of factor, or cluster, analysis. Factor analysis, reduces data into patterns based upon inter-correlations between dietary items, whereas cluster analysis reduces data into patterns based upon individuals' differences in mean intakes (Kant, 1996; (Hair *et al* 2006).

Dietary data obtained for 6125 non-pregnant women as part of the Southampton Women's Survey, using a 100-item interview administered FFQ were analysed using factor and cluster analysis. The authors concluded that both analytical approaches suggested similar dietary patterns but highlighted that in the context of the study factor analysis was seen to be particularly valuable as a discriminatory tool (Crozier *et al* 2006).

A recent analysis of dietary data obtained by a FFQ as a part of a population-based cohort study conducted in the South-west of England by Northstone *et al* (2007) examined the use of factor or principal component analysis on identifying distinct dietary patterns of 12053 pregnant women and related its findings to the socio-demographic and lifestyle characteristics of the sample. The analysis revealed 5 distinct dietary patterns/components; the 'health conscious' component characterised by a diet based on fruit, salad, white meat, rice etc, the 'traditional' component which included vegetables, red meat and poultry, the 'processed' component characterised by high-fat proceed foods, the 'confectionary' component associated with high sugar content and finally the 'vegetarian' component which was associated with consumption of meat substitutes, pulses, nuts etc. Increased maternal age and education and ethnicity were strongly positive related to the 'health conscious' component. On the other hand increased parity, single status, unemployment, smoking and increased BMI prior to pregnancy were all negatively associated to the 'health conscious' component.

3.7 Brief dietary assessment instruments

The complexity and variability of diet among individuals, and by gender, age, ethnic group etc makes eating behaviour difficult to measure and determine. In a variety of settings, where precise estimation of individual's diet is impractical and not essential or in health behaviour studies diet is often measured by brief dietary instruments. In most cases such dietary assessment instruments are nutrient and/or food specific and may be most useful for characterisation of a population' median intakes, for discrimination among individuals or population with lower versus higher intakes and for tracking changes over time in individuals or populations.

Diet in these surveys frequently has been measured with short FFQ. Short FFQ are usually constructed for assessment of intake of specific nutrients or foods and different concepts of data-based procedures to construct food item lists have been establishes during the past years. The variance explaining approach is such an approach which the food list is constructed or reduced on the basis of identification of food items explaining most of the observed variance in nutrient intake. Byers *et al* (1985) applied stepwise regression analysis to data of a 128-item FFQ to shorten a comprehensive food list and identification of key foods. The results suggested that in order to explain 90 % of variance in intake, eight foods were required for vitamin C, five foods for vitamin A, 17 for fat, 18 for dietary fibre, and19 for protein and the authors concluded that a small number of foods could explain a large fraction of the variability of nutrient intake.

Research evidence has showed accepted validity of short FFQ in terms of correlation with full-length FFQs or other dietary assessment methods and good estimates of nutrient intakes (Warkene *et.al* 2001; Schaffer *et al* 1997; Eck *et al* 1996). For example, a validation study conducted by Olsen and Heitmann (1996) on a general Danish population reported mean correlation coefficient values of 0.50 for most foods. Similarly, Svilaas *et al* (2002) reported mean agreement of 0.73 between a 15-item FFQ and a 7-day food record.

PrimeScreen is an example of a brief FFQ, developed to target consumption of fruit, vegetables, full and low fat dairy products as well as wholegrain, fish and red meat (Rifas-Shiman *et al* 2001). The results suggested a mean correlation value of 0.61 for foods and food groups and 0.60 for nutrients compared to a 131-item semi quantitative FFQ. Another brief instrument similarly structured to FFQs developed and validated by Block *et al* (2000) is the one-page Food Screener. The study findings suggested that intakes of fat, fibre, fruit and vegetable assessed by the Food Screener were strongly correlated (0.6-0.7, *P*=0.0001) with the Block 100-item FFQ and could be an inexpensive, rapid and valid tool for assessing dietary intakes in busy settings.

Gibney *et al* (2004) pointed out that consideration should be given however, to the fact that these instruments have been developed to meet the requirements of study specific objectives and populations and applicability to other populations or study settings might not be appropriate.

3.8 Nutritional assessment and screening tools

Nutritional assessment and screening tools are practical for identifying individual's nutritional status and risk of malnutrition. Research findings have suggested that simple and quick dietary tools, designed to be administered by nurses could perform equally well and be comparable to more complicated assessment instruments (weighed intake records and biochemical markers) (Little *et al* 1999). In most cases such tools need to be reliable, valid practical and should be linked to specified protocols for action. For example, a tool needs to be piloted for identification of any problems with its formatting and content as well as to be evaluated in terms of its performance e.g. reliability and validity (Kondrup *et al* 2003).

Nutritional toolkits have been developed in UK, mainly for adult hospital and community patients, trauma and surgical patients administered by nurses, community nurses and community health professionals and usually incorporate anthropometric, biochemical, dietary and clinical criteria. Two recent systematic reviews however, conducted by Jones (2002) and Green and Watson (2005) on available tools emphasised methodological problems and concerns of some of the published tools. For example the authors stated that some of the tools have not been subject to rigorous testing i.e. assessment of reproducibility and validity but are still in clinical use and that often sensitivity, specificity and acceptability are not known.

3.9 Summary of the findings

In this chapter, the importance of accurate and detailed information on food and nutrient intakes and the main approaches has been examined. The four major approaches used in nutritional epidemiology for assessment of nutritional status in individuals and population were identified; anthropometry, biomarkers, clinical assessment and finally the most widely used approach which is the dietary assessment. From all the available dietary assessment methods, the focus was on the measurement of specified days by the use of 24h recall and on measurement of usual days by the use of FFQ. Each method has strengths and weaknesses and they are not immune from the effects of measurement error. Research findings on validation studies of FFQ using a variety of reference methods, sample sizes and populations have been reviewed. Finally, newer approaches used in nutritional epidemiology like brief dietary assessment instruments and nutritional assessment and screening tools have been examined.

Several issues should be considered when interpreting the findings of the validation studies which are related to the comparability of the findings identified in the literature between studies i.e. large scale vs. small scale studies. Also, because of study population differences, differences in the FFQs and reference methods used number of days obtained and period of pregnancy makes comparison of the results difficult.

Chapter 4

4. Research design and methodology

4.1 Aim and objectives

Aim:

To evaluate the performance of a modified version of an existing semi-quantified FFQ and apply it to a population of pregnant women in Sheffield. To identify if possible dietary intakes and/or eating patterns which might lead to nutrient deficiencies, particularly in low income groups.

Objectives:

- Evaluation of the performance of a pre-existing FFQ in terms of validity using the 24h recall method as reference method.
- Assessment of the diet of pregnant women living in Sheffield using a FFQ.
- Comparison of the dietary intakes of pregnant women living in economically deprived and non-economically deprived areas in Sheffield using a FFQ.
- Explore the background to the development of a brief dietary risk assessment tool, to apply to low income women in Sheffield.

4.2 The sample frame and size

The sampling frame included a general population of pregnant women living within the city of Sheffield. The number of women needed for the validation study was determined followed the suggestions of the literature *'Although no cut-off existed to define an optimal sample size, for realistic condition (correlation between 0.5 to 0.7) it was apparent that validation studies larger than 150 to 200 subjects provide little additional precision in corrected CI. On the other hand validation studies with as few as 30 subjects lead to a major increase in the width of corrected CI. A reasonable size for a validation study seems to be about 100 to 200 persons'* (Willet, 1998).

In determining the overall sample size for the main stage study (characterisation of population's diet and sub-group comparison), no calculation was conducted on the number necessary to meet the requirements of the research design. That was mainly because of the eligibility criteria and the nature of the population used in the study, as well as time limitations. Therefore, the number to be recruited was opportunistic and the final population consisted of a non-random sample of women.

4.2.1 Eligibility

Eligibility was defined as being between 14 and 18 weeks of pregnancy and of Caucasian ethnic origin. Women were also excluded if they did not speak English, or if they had any nutrition-related pre-existing medical conditions such as diabetes or coeliac disease. The choice of the specific gestational age period was opportunistic because between 14 to 18 weeks the women are usually attending their first antenatal appointments. In addition to that evidence from the literature has shown that pregnant women of this gestation are much less likely to be affected by nausea and vomiting which is common in the 1st trimester and is known to decrease at the beginning of the second trimester (Huxley, 2000). The decision to exclude Black and Minority Ethnic (BME) groups came from evidence suggesting possible difficulties related to the applicability within different ethnic groups of an identical FFQ, as a questionnaire appropriate for one group might not be appropriate for another (Gibney *et al* 2004).

4.3 The components of the study

4.3.1 Research Instruments

The participants were approached by the researchers at the waiting area of the antenatal clinic at Jessop Wing, Royal Hallamshire Hospital, Sheffield, UK and/or at local Sure Start midwifery clinics (pilot study). A face-to-face interview was conducted with each subject, with each interview lasting at least 30-45 minutes. The data collection was carried out from May 2003 to September 2004. Participants in both stages were asked to take part in the following components of the study:

- • A subject information questionnaire administered face-to-face collecting details about the anthropometrical (height, weight and gestational age), socio-demographic and behavioural data. Some of the variables used to obtain information on the socio-economic background of the participants included maternal highest educational qualification level, maternal occupation, partner's occupation and receipt of benefits. Behavioural data collected included smoking habit, preconceptional and periconceptional multi-mineral/multi-vitamin supplement usage. Other data included information on cooking skills, main household cook, the habitual eating and physical activity patterns.

- A semi-quantified FFQ determined the dietary intakes of all participants taking part in the validation and main studies.

- Participants in the validation study were asked to provide two 24h recalls. The first was obtained face-to-face following administration of the FFQ and the second 24h recall was obtained through a telephone based interview.

4.3.2 Project stages

This study forms a part of an on-going project for the development of a brief dietary risk assessment tool to be used for the identification of dietary patterns of low income pregnant women living in Sheffield. It is anticipated that the brief dietary assessment tool would be a shorter version of the validated FFQ. The PhD research project was the first step towards the development of the tool by providing information about the validity of a pre-existing FFQ and about the diet of a general population of pregnant women in Sheffield.

Even though, the optimal aim of the on-going research is to develop a dietary risk assessment tool for low income population, this study assessed and compared dietary intakes of low and high income population of pregnant women. The reason is because in order to develop a tool or a strategy concerning specifically a part of a local population, clear evidence confirming the existence of a problem and suggestions of possible strategies for tackling it are needed. Research evidence published in the UK and elsewhere has suggested a link between low socioeconomic status and inadequate dietary patterns. Clear evidence of this relation of the Sheffield pregnant population was needed however, in order to detect and appraise the problem, before planning an appropriate course of action.

Pilot study

The project started with the piloting of the pre-existing FFQ to a sample of general pregnant population (low and high income) living in Sheffield and the assessment of its practicality in applying it to the local population. The FFQ was applied to pregnant women recruited at the Jessop Wing Hospital and at local Sure Start midwifery clinics jointly by a MMedsci student and the PhD student. The total number of women recruited in the pilot study was 110 pregnant women. Data obtained at that stage were only used for modification and evaluation purposes.

Validation study

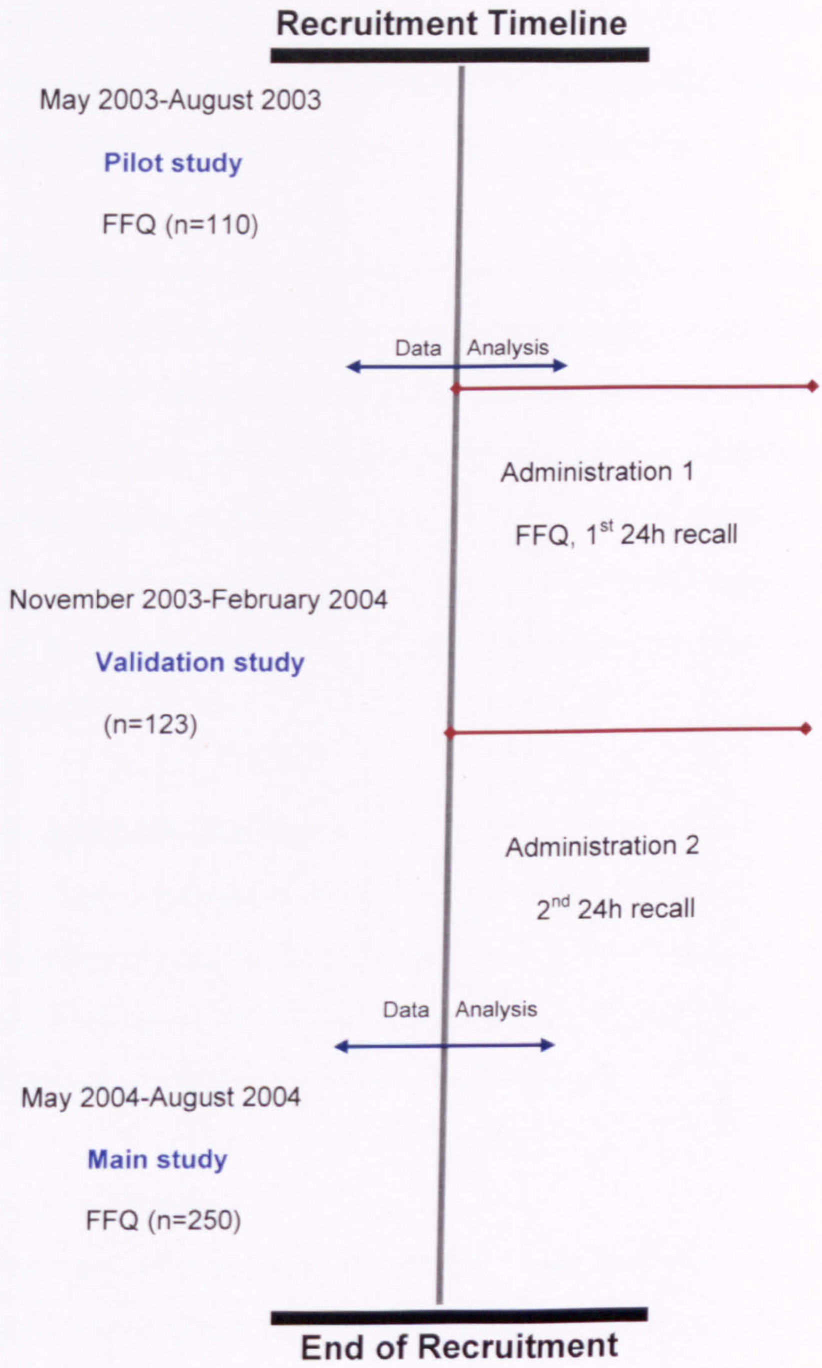
The validation study also included a sample of a general pregnant population (low and high income) living in Sheffield attending their antenatal clinic appointment at the Jessop Wing Hospital and included the administration of a FFQ and two 24h recalls (first 24h recall was conducted at the antenatal clinic following the administration of the FFQ and the second through a telephone-based interview after a 10-14 day period). The total number of women recruited at that stage was 123.

Main study

Similar to the other stages, the sample at this stage consisted of a general pregnant population (low and high income) living in Sheffield. One hundred and twenty-seven women attending their antenatal clinic appointment at the Jessop Wing Hospital were recruited by a MMedsci student under the guidance and support of the PhD student. The main stage study data analysis included in total 250 women (123 from the validation study plus and 127 recruited by the MMedSci student).

The following figure (6) provides a description of the project timeline in terms of recruitment of study participants, instruments used and total number of participants included at each stage of the study.

Figure 6. Recruitment timeline of the study participants, instruments used and total number of participants included at each stage of the study.



4.4 Ethical approval

Ethics Committee approval was gained for the study from both the South and North Ethics Committees in Sheffield. The participants were introduced to the study by the researcher at the waiting area of the antenatal clinic with a detailed information sheet explaining what would be required from them.

They were made aware that they had the option to participate or not, the right to withdraw from the study at any time without giving a reason, and that the care that they normally receive from doctors or midwives would not be affected in any way. They were also informed that the information collected would be treated confidentially and would be used for research purposes only. At the end of the interview, all agreeable participants read and signed an informed consent form. Copies of the informed consent form and the patient information sheet are given in Appendix III and IV.

4.5 Main classificatory variables

Questions used to describe and classify some of the socio-demographic and behavioural characteristics of the participants were similar to the questions used in NDNS respondents' classification (Henderson *et al* 2002). A copy of the subject information questionnaire is given in Appendix V.

Educational attainment

Information was collected during the interview about the years of education completed by the subject i.e. no formal educational qualification, not yet finished, 14 to 20, 21 or over. Information was also collected about the participants highest qualification attained e.g. no qualification, other qualification, GCSE's, A level.

Employment status

Respondents were asked whether they were in paid full or part time employment at the time of the interview. Those in non-paid employment were categorised into those being unemployed, or economically inactive at the time of the interview.

Social Class

During the interview, details of the participants and their partners' current or most recent job were collected in order to define social class. The highest occupation within the household was used as an indicator of social class. In cases which no partner was reported the participants' current or most recent job was used to define social class.

Household composition

Information on all the members of the participant's household was collected to classify participants according to household composition i.e. living alone, living alone with children, living with partner, living with partner and children, living with family/siblings,

Residency in the 40% most deprived electoral wards

The participants' postcodes were collected during the interview. Following participants' electoral ward identification, the sample was classified into those living in the 40% of most deprived wards (Group 1) or other wards within Sheffield (Group 2) using the Index of Multiple Deprivation (IMD). The IMD is derived from six separate domains; income, employment and health deprivation, education, skills and training, housing and geographical access to services (Gordon, 2001). This report identifies the 40% most deprived wards as Southey Green, Bunrgreave, Manor, Park, Firth Park, Castle, Nether Shire, Darnall, Owlerton, Brightside, Sharrow, Norton, Handsworth, Birley, Netherthorpe, Heeley, Intake, Walkley, Mosborough, Hillsborough and Stocksbridge. Non-deprived wards were Chapel Green, South Wortley, Nether Edge, Dore, Beauchief, Hallam, Broomhill and Ecclesall wards. A copy of the IMD is given in appendix VI.

Residency within Sure Start area

Sure Start is a Government program which aims to achieve better outcomes for children, parents and communities by:

- *increasing the availability of childcare for all children*
- *improving health and emotional development for young children*
- *supporting parents as parents and in their aspirations towards employment* (http://www.surestart.gov.uk/aboutsurestart/).

As mentioned above, participants' postcodes were collected during the interview. Participants' postcodes enabled us to identify whether they were residents within a Sure Start area of Sheffield or not. The identification was facilitated with the use of Microsoft excel databases containing the post codes aligned to the Sure Starts areas obtained from the local Sure Start centres. Within the Sheffield authority, Sure Start programs were available in the following district: Arbourthourne, Broomhall, Foxhill and Parson Cross, Gleadless Valley, Manor, Sharrow Shiregreen and Firth Park, Southey and Shirecliffe, Burngreave and Fir Vale and Woodthorpe and Wybourn.

Receipt of Benefits

Information was collected on whether the participants or their partners were receiving benefits at the time of the interview e.g. Income Support, Working Families Tax Credit or Job Seekers Allowance.

Smoking Status

Smoking behaviour of the participants was also considered during the interview. Participants were asked whether they were current or past smokers or non-smokers. Smokers were asked the number of cigarettes smoked per a day and whether their smoking behaviour had changed since becoming pregnant. Individuals were classified as non-smokers, light smokers (less those 20 cigarettes or heavy smokers (20 or more cigarettes per day).

Supplement usage

Participants were asked whether they took any vitamin or mineral supplements prior to and during pregnancy and if so the type of supplements and length of period taken. Information on folic acid supplement usage and timing of usage during pregnancy was also collected.

Body Mass Index

BMI was calculated as bodyweight (Kg) divided by height (m) ^{2}. Heights and weights were recorded routinely at the same antenatal visits.

Gestational Age

Gestational age at the time of the interview was recorded as length of pregnancy in weeks, calculated from the date of the first day of the last menstrual period and delivery date.

4.6 Dietary methodology

4.6.1 Choice of dietary methodology

For the purposes of the study, the food frequency method has been the chosen method for the collection of dietary data on nutrient and food intakes. In deciding to use the food frequency methodology, research evidence highlighting its potential to be tailored to cover the diet of the target population, its ability to detect pregnancy-related dietary changes (Brown *et al* 1996), the derivation of brief instruments and indices of overall diet from FFQs (Pick *et al* 2005; Bodnar and Siega-Riz 2002) and finally its reasonable agreement with other dietary instruments (Willet *et al* 1985) were taken into consideration. It was assumed that the food-frequency method was the most appropriate methodology in the context of the study however; the strengths and limitations of the method were taken into consideration by the authors during the PhD research in relation to the data analysis and interpretation.

The food frequency method is considered to be the most appropriate method for large scale epidemiological studies because of its cost and time effectiveness. In addition to that it is suggested that '*average long-term diet is the conceptually important exposure rather than intake on few specific days*' (Willet, 1998). For that reason it might be more beneficial to obtain crude dietary data over an extended period of time, rather than precise dietary intakes based on one, or a few, days. This method provides information on a respondent's usual diet, and can be used to rank individuals according to nutrient intake. Calculation of food groups is also provided as well as identification of major dietary patterns.

The food frequency method does have limitations however. A major limitation is that compared to other dietary assessments methods, such as weighed records, the FFQs provide a less accurate approximation of dietary intakes of individuals.

Comparisons of nutrient intakes obtained by the FFQ to nutrient intakes obtained from more accurate dietary assessment methodologies therefore need to be considered and the sources of errors need to be taken into consideration prior to the analysis and interpretation of the results.

4.6.2 Food Frequency Questionnaire

Dietary intakes of all women were determined using a semi-quantified FFQ. The Sheffield FFQ is an adaptation of the FFQ developed by Rogers *et al* (1998b) for the ALSPAC study. The ALSPAC study is a collaborative project of the European Longitudinal Study of Pregnancy and Childhood and it aims to identify pathways to optimal well-being for given environments or genotypes (Golding *et al* 2001).

The ALSPAC FFQ was used to describe the diet of a population of 11,923 pregnant women resident within the South Western Regional Health Authority at 32 weeks of gestation. The FFQ contains questions about the weekly frequency of consumption of 43 food groups and items, additional questions about daily consumption and amounts of bread, coffee, tea, sugar, alcohol, fat and milk and ways in which food is prepared and eaten. To increase the simplicity and the inclusion of a wider range of food eaten, no portion size quantification was asked, thus standard portion sizes were used throughout. (Rogers *et al* 1998b).

After being piloted in 110 women in Sheffield, the list of foods was then revised by eliminating some items found not to be consumed or to be consumed very rarely locally e.g. liver, liver pate, peanuts. The revised food list of the FFQ included 62 quantitative and qualitative questions: 40 of which were about the frequency of consumption of meat, poultry, fish, seafood, common vegetables and fruits, breakfast cereals and confectionery. There were also detailed questions about the type and amount of fat, bread, alcohol and milk consumed. Frequency options included: never or rarely, once a fortnight, 1 to 3 times a week, 4 to 7 times a week and more than once a day. Copies of the ALSPAC and Sheffield FFQs are given in appendices VII and VIII.

4.6.3 Twenty-four hour recalls

As discussed in chapter 3, a very important part of the validation process is the choice of the reference method against which the validity of the test measurement will be assessed. A systematic review on the development, validation and utilisation of FFQs conducted by Cade *et al* (2002) suggested that 75% of the reviewed studies have validated an FFQ against another dietary method, and 19% against biomarkers. The review pointed out that weighed records should be the choice for validating FFQ, but when co-operation or literacy of the study population is limited, 24h recalls might be more appropriate reference measurement. The authors concluded that there was no 'gold' standard for direct assessment of the validity of FFQs.

Two 24h dietary recalls were used as a reference method for validating the FFQ. The choice of the 24h recall was based on the assumption that the response rate was expected to be much higher that of other dietary assessment method such as food records (Margetts *et al* 1997). Findings from validation studies conducted on pregnant populations have suggested good agreement between FFQs and 24h recalls (Wei *et al* 1999; Suitor *et al* 1989).

The first 24h recall was collected at the initial face-to-face interview at the antenatal clinic following the administration of the FFQ. The second 24-hour recall was administered via the telephone after 10-14 days period. All the participants were asked to provide telephone numbers and it was emphasised to them that they would be contacted after an appropriate period of time. The date was not specified, as some of the participants might choose to change their eating habits. For a number of participants weekend dietary information was randomly collected. The foods were recalled chronologically from the previous day. Household measurements were used to estimate portion sizes. At the end of the interview the foods were summarized for the respondent. Mean daily intake was estimated from the two 24h recalls.

4.7 Nutrient calculations

FFQs

The daily intakes of energy, nutrients and food items obtained from the FFQ were calculated and analysed using the Q-Builder Questionnaire Design System (version 1). Q-builder (Tinuviel, 2002) is a questionnaire development programme which incorporates nutritional analysis and enables generation of any type of open or closed questions e.g. type of bread, frequency of consumption, amount consumed.

It includes an up to date food composition database with the nutrient contents of approximately 5000 foods, and a database of portion sizes for 3,800 foods. Analysis outputs include text, pie and bar charts. Nutrient intakes can be compared directly with the DRV. The nutritional analysis of Q-Builder is based on the UK food tables (HMSO, 5th Edition plus 9 supplements).

Information on food consumption collected by the FFQ is converted by the Q-Builder into a list of foods and weights, to generate mean daily food and nutrient intakes. Portions sizes reported by participants were quantified according to weights given by the database or as suggested by the Ministry of Agriculture, Fisheries and Food (MAFF) now Department for Environment, Food and Rural Affairs (DEFRA) (MAFF, 1993).

The approximate daily intake was calculated by multiplying the weekly frequency of consumption of a food by the nutrient content of a standard portion. Each one of the frequency options of the questionnaire allocated was mapped as follows: never or rarely=0, once a fortnight=0.5, 1-3 times a week=2, 4-7 times a week=5.5 and more than once a day=14. A complete set of values for 38 nutrients of interest were calculated. Q-Builder also enables analysis of the qualitative dietary behaviour questions included in the FFQ such as 'are you vegetarian?', or 'do you buy organic foods?'.

24h recalls

The daily intakes of energy and nutrients obtained by the two 24h recalls were analysed using WISP (Weighed Intake analysis Software Package) version 3.0 (Tinuviel, 2003). WISP is a nutritional analysis program that enables analysis of food intake records and 24h recalls, recipes, menu planning e.g. for school meals and performs statistical analyses. Data can be added for up to 8,000 of ingredients and up to 13 additional nutrients to the food composition database.

The nutritional analysis of WISP is based on the UK food tables (HMSO, 6th Edition plus supplements). Reported missing food items i.e. home-made dishes or manufactured products in the databank were not common; however, in cases for which no data were included, a similar food contained in the databank was included instead. Portions sizes reported by participants were quantified according to weights given by the database or as stated by MAFF (1993).

Nutrients measured and units

Nutrients, whose mean daily intakes, have been measured are given in the following tables (8, 9 and 10).

Table 8. Energy and macro-nutrients

Energy (kcal)	*Englyst* fibre* (g)
Protein (g)	Saturated fatty acids
Fat (g)	Monounsaturated fatty acids (g)
Carbohydrate (g)	Cholesterol (mg)
Sugars (g)	
Starch (g)	
Alcohol (g)	

**Englyst* Fibre: non-starch polysaccharides

Table 9. Vitamins

Retinol (µg)	Folate (µg)
Total carotene (µg)	Pantothenic acid (mg)
Thiamine (mg)	Biotin (µg)
Riboflavin (mg)	Vitamin C (mg)
Niacin equivalent (mg)	Vitamin D (µg)
Vitamin B6 (mg)	Vitamin E (mg)
Vitamin B12 (µg)	

Table 10. Minerals

Sodium (mg)	Copper (mg)
Potassium (mg)	Zinc (mg)
Calcium (mg)	Chloride (mg)
Magnesium (mg)	Iodine (µg)
Phosphorus (mg)	Manganese (mg)
Iron (mg)	

4.8 Statistical analysis

Statistical analyses have been conducted on data obtained from the validation and main study. The following sections present the statistical analysis which is related to the assessment of the validity of the FFQ and the statistical analysis which is related to the presentation and comparison of dietary data of participants recruited during the validation and main study.

In addition, participants of the main study defined as low income (residency in the 40% most deprived electoral wards) were used as a sample for further analysis; the preliminary exploration of approaches used for the identification of the food items which contribute most to between-subject variation in the low income sample, and for the identification of food items included in the FFQ which best discriminate opposite dietary patterns by tertile distribution of the nutrients of interest. We have selected calcium, folate, iron and vitamin C as nutrients of interest because between them are markers of a good general diet and by and large derive from different food groups. The results of these analyses were only used for exploration of possible application of these methodologies in the on-going project of the development of the dietary risk assessment tool and if possible to provide additional information which might lead to a greater understanding of the dietary habits of the studied population and the observed differences.

4.8.1 Validation study

The Statistical Package for Social Sciences (SPSS) version 12.1 (SPSS Inc. Chicago IL, USA) was used to analyse quantitative and qualitative data obtained from the FFQs and the 24h recalls for the validation part of the study. The descriptive procedure was used to display summary statistics for the numeric variables i.e. height, weight and the frequency procedure was used to provide summary statistics for the categorical variables.

Means and standard deviations of intakes for energy, macro- and micronutrients were calculated for the FFQ and the 24h recalls as well as the contribution from the main food groups. The relationship between the two dietary assessment methods was assessed by the use of two statistical approaches.

Firstly the Pearson's correlation coefficient (r) was used to determine agreement for nutrient and food intakes obtained from FFQ and 24h recalls. The correlation coefficient is a number between -1 and 1. In general the correlation expresses the degree that, on average two variables change correspondingly. If one variable increases when the second one increases, there is a positive correlation and the r value will be closer to 1, if one variable increases and the other decreases, then there is a negative correlation and the r value will be closer to -1. The agreement between the two methods was further examined by classification of nutrient intakes divided into quintiles.

Secondly an alternative statistical approach based on a graphical technique and simple calculation was used to assess the agreement between the FFQ and the 24h recall (Bland and Altman 1999; Bland and Altman 1986). This is accomplished by plotting the differences between the two measurements against the mean of the two measurements. The plot of difference against the mean allows investigation of the potential relationship between the measurement error and the true value. The analysis assesses agreement in individuals, defined as the limits of agreements (LOA) and provides an interval within which 95% of differences between the measurements by the two methods are expected to lie.

The first step undertaken in the process of calculating the LOA was to conduct a paired T-test analysis between the FFQ and the 24h recall. Afterwards, the mean differences and the SD of the differences in nutrient intakes between the two methods were used for the following calculations (lower and upper limit):

- **Lower: mean (difference) – (2 ×SD (difference))**
- **Upper: mean (difference) + (2 ×SD (difference))**

Finally, a Paired T-test was used to estimate the performance of the telephone-based 24h recall in adequately described energy, macro-, and micronutrient intakes compared to the in-person administered 24h recalls. In order to improve data normality and screen out inaccurate reports of energy intakes, participants with intakes below and above 2 SD were excluded from the comparison analysis following consultation with the university statistician.

4.8.2 Main stage study

The SPSS software was used to analyse quantitative and qualitative variables and data analysis has been conducted at individual and group level. The descriptive procedure was used to display summary statistics for the numeric variables i.e. means of the anthropometrical characteristics of the sample.

The frequencies procedure was used to provide statistics and graphical displays for the categorical variables. Standard cross-tabulated tables were conducted in order to compare two-way and multi way tables and to identify relations between cross tabulated variables e.g. pregnancy planned to preconceptional vitamin and/ or mineral supplementation. Chi-square was used to test the significance of the relationship.

The statistical analysis included means, SD and CI for energy, macro- and micronutrients, obtained from the FFQs. One sample T-test was used to obtain the nutrient means of the whole sample. The sample medians, 25^{th} and 75^{th} percentiles were computed for nutrient intakes. The frequencies procedure was applied to provide statistics for the frequencies of consumption of the food items included in the FFQ.

Principal component analysis (PCA) was used for identification of dietary patterns. Factor analysis is a technique which examines underlying patterns or factors, in a number of observed variables and it is often used in data reduction to identify a small number of factors that explain most of the variance observed in a much larger number of variables. Hence, factor analysis provides the tools for analysis of the structure of the correlations among a large set of variables by defining sets of variables that are highly interrelated.

Factors were rotated with varimax rotation in order to achieve a simpler structure, to improve interpretability and minimise correlation between factors. A factor is usually extracted by default if its eigenvalue value is >1. Eigenvalues are the variances of the factors. Additionally, the point at which the scree plot (plot of the eigenvalues against the number of factors) levels off was used for determination of the number of factors to retain.

Differences in nutrient intakes between the two groups as identified by the IMD were assessed using an Independent sample T-test and a Pearson's Chi-square was used to compare the maternal characteristics and identify the significance of the relationship. The frequencies procedure was performed to provide statistics for the frequencies of consumption of the food items included in the FFQ for group 1 and group 2.

4.8.3 Preliminary exploration of approaches used for the identification of foods items which contribute most to between-subject variation and to distinct dietary patterns of the low income group

4.8.3.1 Under reporting and energy-adjustment

Because of potential under reporting of energy intake, the proportion of under reporters in each tertile (according to energy ranking) was calculated. Underreporting of energy intake was determined by the use of the energy intake to basal metabolic ratio (EI/BMR) with physiological plausible ratios of total energy expenditure to BMR (TEE/BMR) also referred to as the physical activity level (PAL) (Goldberg *et al* 1991). The BMR (MJ/day) was calculated using the Schofield equations for age, gender and body weight (Schofield, 1985):

- BMR=0.056* weight+2.298

  10 to 18 years
- BMR=0.062* weight+2. 036

  18 to 30 years
- BMR=0.034* weight+3.538

  30 to 60 years

The cut-off limits for physiologically plausible energy intakes at weight maintenance were calculated as described by Goldberg *et al* (1991):

$$EI: BMR > PAL^{*}$$

$$\frac{BMR*EI}{BMR} > PAL*BMR$$

$$EI > PAL*\{BMR-2SD\}$$

*PAL=1.55 (Winkvist *et al* 2002), SD was set -2 to obtain the lower limit of a 95% CI.

Consequently participants reporting energy intake less than the study specific cut-off values were termed as under reporters. Valid reporters were defined as the number of individuals whose reported energy intake to BMR rate ratio was within the determined 95% CI.

In case of significant under reporting, the proposed model for adjustment for total energy intake in order to control for confounding effect was the nutrient residual method suggested and described by Willet *et al* (1997).

4.8.3.2 Stepwise multiple regression analysis

We have used stepwise regression analysis for the identification of the food items included in the questionnaire, which contribute most to the between-subject variation in the low income sample. The general purpose of regression analysis is to find out more about the relationship between several independent or predictor variables and a dependent variable. Multiple regression can establish that a set of independent variables which explain a proportion of the variance in a dependent variable at a significant level (Hair *et al* 2006). Stepwise multiple regression analysis has often been used for the selection of food items which contribute most to absolute intake and between-subject variation of data obtained from 24hr recalls or FFQs. The selected food items were often used for the development or condensing of pre-existing FFQs (Shai et *al* 2004; Mosdol *et al* 2000; Stryker *et al* 1991). For instance Willett *et al* (1985) calculated the contribution of each food item to between-subject variation in the targeted nutrient intake as a basis for the selection of the most informative foods by applying stepwise regression analysis on dietary data in order to identify foods explaining most of the variance in nutrient intake.

This procedure starts by selecting the independent variable which best correlates with the dependent. In the second stage, the remaining independent with the highest partial correlation with the dependent, controlling for the first independent, is entered. This process is repeated, at each stage partialling for previously-entered independents, until the addition of a remaining independent does not increase the R^2 by a significant amount. The earlier the stage of entry into the regression the higher the contribution to the variance in consumption (R^2) of the food item to the nutrient of interest (Hair *et al* 2006). R^2 is the multiple correlation or the coefficient of multiple determination, and is the percent of the variance in the dependent explained uniquely or jointly by the independents.

In our analysis, firstly the contribution of each food item of the FFQ to the one of the four nutrients of interest for the whole sample of low income women was calculated by the syntaxes designed by the University statistician. Secondly, the food items of the four nutrients were ranked according to their percent contribution to the average nutrient consumption. And finally, the twenty foods contributing most to the mean intakes of the selected nutrients were entered into the stepwise regression analysis as independent variables and nutrient intakes i.e. calcium, iron, folate and ascorbic acid as the dependent variables (Willet *et al*).

4.8.3.3 Tertiles of the distribution for calcium, iron, folate and vitamin C intakes

Tertile distribution (three groups of equal size) was used to examine the mean intakes and major food sources of participants with lower and higher intakes of the key nutrients considered to be of special interest for pregnancy; calcium, iron, folate and vitamin C. The 174 low income women (group 1) identified by the IMD were allocated into tertiles on the basis of the above nutrients. Such classification is based on the subject's intake compared to the intake levels of the rest of the population.

This is one of the procedures that have been used in the publications of Food-based Dietary Guidelines- A staged Approach (Williams *et al* 1999)) and it was suggested that can be used for the determination of dietary patterns of those with desirable and undesirable levels of intake. In this study however, tertiles were only used to look at and illustrate mean intakes, major food sources and identification of foods discriminating opposite patterns of nutrient intakes.

Independent sample T-test was used to obtain mean nutrient intakes by calcium, iron, folate and vitamin C ranking. Also, frequencies of consumption of the food items of the FFQ by tertile nutrient ranking were also calculated. Chi-square was used to test the significance of the relationship. The contribution of each food item of the FFQ to the one of the four nutrients of interest was calculated by syntaxes designed by the University statistician using the SPSS software. The food items of the four nutrients were ranked according to their percentage contribution to the average nutrient consumption.

4.8.3.4 Discriminant analysis

The discriminant analysis was used as the method for the identification of food items included in the FFQ, which best discriminated opposite patterns of nutrient intakes or else for the identification of the food items that were the most predictive for differences in calcium, iron, folate and vitamin C intake among women in the lower and the upper tertiles. Discriminant analysis is a sophisticated method used to study intake differences and can be used to statistically distinguish between two or more pre-defined groups to define how one or more independent variable discriminate. To distinguish between groups, discriminant variables are selected that measure characteristics on which the groups are expected to differ. The mathematical objective of the discriminant analysis is to weight and linearly combine the variables in such way that groups are forced to be as statistically distinct as possible (Hair *et al* 2006).

In our study the two pre-defined groups were the upper and lower tertiles by nutrient of interest distribution ranking. The stepwise discriminant function analysis was used as an estimation method to obtain the discriminant function. The independent variables were entered in the function one at a time depending on their discriminating power. The procedure started by choosing the single best discriminating variable. Next, the variable was paired with each of the independent variables one at a time, and the variable which improved the discriminating power of the function in combination with the first variable was chosen in the model. In a similar manner, the third and any other variable were selected. At each step the variable that maximised the smallest F ratio between pairs of groups was entered in the model. Maximum significance of F to enter was .05 and minimum significance of F to remove was .10 in our analysis. Variables that were not useful in discriminating between groups were eliminated and at the end a reduced set of independent variables was identified (Hair *et al* 2006).

The ranking of the independent variables in terms of their discriminating power was assessed by the use of the standardised canonical function coefficient. The standardised canonical function coefficient examines the sign and the magnitude of the discriminant coefficients assigned to each of the variables which entered the model. The signs do not affect ranking; they denote whether the variables made either a positive or a negative contribution. The canonical standardised coefficient function used did not explain between of which groups the respective functions discriminate but it described that the larger the discrminant coefficient, the larger was the respective variable's contribution to the discrimination. Variables with coefficient function value of greater than 0.30 (or less than -0.30) were considered significant (Hair *et al* 2006).

The Univariate F ratio is also presented which is the ratio of between-groups variability to the within-groups variability. The F value for a variable indicates the extend to which a variable makes a unique contribution to the prediction of group membership; large F values indicate greater discriminating power. The square of the canonical correlation and its significance were also used to identify the percentage of variance in the dependent variable explained by the model (Hair *et al* 2006).

Chapter 5

5. Validation study

5.1 Anthropometrical characteristics

Of the 130 women invited to participate 123 (95%) agreed to complete the study, 4 (3%) refused to participate but reported no reason and 3 (2%) were excluded from the analysis because of incomplete dietary data. Table 11 presents the anthropometrical characteristics of the validation study population. The mean age of the women was 29 years (SD±6.4), mean BMI was 25 (SD±4.64) and mean gestational age was 15 (±0.08) weeks.

Table 11. Anthropometrical characteristics of the subjects enrolled at the validation part of the study (*n*=123)

	Mean	SD
Height† (m)	1.65	.36
Weight˙ (Kg)	68.3	12.97
BMI *	25.0	4.64
Age (years) **	29.3	6.49
Gestational age*** (weeks)	15.16	.08

†n=117
˙ n=109
*n=108
**n=119
*** n=122

5.2 Socio-demographic and behavioural characteristics

Table 12 shows some of the socio-demographic and behavioural characteristics of subjects took place at the validation study. Seventy-one percent of participants reported being in paid employment and of those reported having a partner, 87% of their partners were in paid employment. During their pregnancy 14.6% of the women were self-reported smokers. Overall, 47% reported periconceptional vitamin and or mineral supplementation of whom 96 % reported postconceptional folic acid supplement usage.

Table 12. Socio-demographic and behavioural characteristics of the participants (*n*=123)

		%
Maternal employment		
	Working×	70.7
	Unemployed	9.8
	Economically inactive*	19.5
Employment status of partner		
	Working×	87.0
	Unemployed	9.8
	Economically inactive*	0.8
	N/A†	2.4
Self-reported smoking status		
	Non-smoker	85.4
	Current smoker	14.6
Preconceptional supplement usage		
	Yes**	47.2
	No	52.8
Postconceptional folic acid supplements		
	Yes	95.9
	No	4.1

×Full time or part time
*includes: students, looking after the house or disabled
†no partner reported
**percentage of participants taken supplements of folic acid alone is unknown.

5.3 Mean energy, macro- and micronutrient intakes

Nutrient intakes of energy, macronutrients and micronutrients assessed by the FFQs and the 24h-recalls are presented in tables 13-15. Mean, SD and range of the nutrients are provided. The FFQs provided higher estimates of energy and macronutrients intakes than the 24h recalls (table 13). For example, mean energy difference was 377Kcals, mean protein difference was 15g and mean total fat difference was 20g.

Table 13. Mean±SD daily energy and macronutrient intakes based on FFQs and 24h-recall (n=123)

	FFQ		24h-recall	
	Mean ± SD	Range	Mean ± SD	Range
Energy (Kcal)	1923±516	(958-3804)	1546 ±370	(657-2391)
Protein (g)	70 ± 20	(32-132)	54 ± 15	(21.9-101)
Total Fat (g)	85±28	(31 -164)	65 ± 19	(25-110)
Carbohydrate (g)	228±61	(112 -499)	195± 56	(51 -400)
Saturated Fat (g)	32 ±12.6	(11.4-73)	22 ± 9.1	(5.8-47)
Monounsaturated fatty acids (g)	29±9.8	(10.7-57)	18.5 ± 6.7	(5.1-35)
Polyunsaturated fatty acids (g)	13.9±4.9	(4.7-30)	9.2 ± 5.1	(2.9-28)
Cholesterol (mg)	223±83	(74-461)	152 ± 95	(20-718)
Sugars (g)	83±35	(25 -226)	76 ±37	(10.4-271.6)
Starch (g)	145±40	(64 -272)	116 ± 33	(17.1-200)
Englyst fibre (g)	14.1±4.5	(4.2-25)	10.8 ± 4.5	(1.9-39)
Alcohol (g)	0.1±0.1	(0-0.7)	0.4 ± 2.1	(0.0-17)

Likewise for energy and macronutrient, the FFQ method gave higher estimates of minerals compared to the 24h-recall method as seen in table 14, with the exception of iodine, where higher intakes were reported by the 24h recalls. For example, mean calcium and mean iron differences were 61mg and 3mg respectively.

Table 14. Mean±SD and range of daily mineral intakes based on FFQs and 24h-recalls (n=123)

	FFQ		24h-recall	
	Mean ± SD	Range	Mean ± SD	Range
Sodium (mg)	2417±679	(1291-4962)	2311±789	(407-6160)
Potassium (mg)	2532±646	(874-5088)	2179±741	(947-5208)
Calcium (mg)	715 ±226	(275-1346)	654 ±246	(164-1264)
Magnesium (mg)	235 ±68.2	(88-402)	188±66	(75-547)
Phosphorus (mg)	1153±318	(439-2065)	916±258	(390-1707)
Iron (mg)	11.2±3.9	(4.7-21)	8.0±2.8	(2.6-17.8)
Copper (mg)	1.1±0.3	(0.5-2.3)	0.9±0.6	(0.2-4.6)
Zinc (mg)	7.8±2.3	(3.1-14.6)	6.2±2.1	(2.3-11.3)
Manganese (mg)	1.8±0.6	(0.7-3.8)	2.1±1.0	(0.6-6.9)
Selenium (µg)	39 ±15.2	(8.0-92)	36 ±15.9	(8.0-86)
Iodine (µg)	79 ±27	(15-143)	82 ±65	(20-567)

Twenty-four hour recalls gave lower estimates for most of the vitamins examined (table 15). Exceptions were for carotene, vitamin E, biotin and vitamin C intakes. The size of the difference for folate was 50μg and for vitamin C was 0.7mg.

Table 15. Mean±SD daily vitamin intakes based on FFQs and 24h-recalls (n=123)

	FFQ		24h-recall	
	Mean ± SD	Range	Mean ± SD	Range
Retinol (μg)	369±152	(44-876)	276 ±141	(11-795)
Carotene (μg)	1228±570	(154-3162)	1287 ±1364	(33- 9095)
Vitamin D (μg)	2.7±1.4	(0.5-9.5)	1.6±1.4	(0.1-9.4)
Vitamin E (mg)	4.3±1.7	(1.3-10.1)	5.0±2.4	(0.6-12.4)
Thiamine (mg)	1.5±0.4	(0.7-2.8)	1.2±0.4	(0.5-2.4)
Riboflavin (mg)	1.3±0.5	(0.4-2.7)	1.1±0.4	(0.4-2.4)
Niacin (mg)	18.5±6.2	(5.0-40)	13.3±5.3	(4.4-28)
Potential niacin (mg)	14.3±4.1	(6.6-26)	11.2±3.3	(4.7-19.2)
Vitamin B6 (mg)	2.0±0.6	(0.8-4.4)	1.4±0.5	(0.4-2.8)
Vitamin B12 (μg)	3.5±1.5	(0.7-9.0)	2.4 ± 1.3	(0.1-6.4)
Folate (μg)	229±67.7	(94-412)	179±62.6	(62-350)
Pantothenic acid (mg)	3.5±1.0	(1.1-6.2)	3.0±1.1	(1.3-7.9)
Biotin (μg)	18.2±7.2	(4.5-36)	18.7±9.9	(4.5-79)
Vitamin C (mg)	74±29.1	(10.0-154)	75±52.5	(3.0-294)

5.3.1 Results of the correlation coefficient analysis for nutrients

Pearson's correlation coefficients for nutrients assessed by the FFQ and the 24h-recalls are presented at tables 16-18. For macronutrients non-significant correlation coefficient values obtained for protein, alcohol, polyunsaturated fatty acids, cholesterol and starch. For minerals and vitamins only potassium, calcium, retinol and vitamin B_{12} correlation coefficient values were non-significant. Positive correlations observed at P=0.005 and P=0.001 level. Overall, positive correlation values for nutrients ranged from 0.18 for phosphorus to 0.47 for *Englyst* fibre. The mean r value for nutrients assessed and present at the following sections was 0.27.

Table 16. Pearson's correlation coefficients between macronutrient and micronutrient intakes based on the FFQs and the 24h-recalls

Nutrient	Pearson's Correlation Coefficient
Energy	0.26**
Protein	-0.14
Total Fat	0.28**
Carbohydrate	0.25**
Alcohol	-0.11
Saturated fatty acids	0.23**
Monounsaturated fatty acids	-0.22*
Polyunsaturated fatty acids	-0.14
Cholesterol	-0.11
Sugars	0.19*
Starch	-0.14
Englyst fibre	0.47**

*Correlation is significant at level P=0.05
** Correlation is significant at level P=0.01

Table 17. Pearson's correlation coefficients between mineral intakes based on the FFQ and the 24h-recall

Nutrient	Pearson's Correlation Coefficient
Potassium	-0.15
Phosphorus	0.18*
Manganese	0.40**
Calcium	-0.12
Magnesium	0.37**
Iron	0.32**
Zinc	0.19*

* Correlation is significant at level P=0.05
** Correlation is significant at level P=0.01

Table 18. Pearson's correlation coefficients between vitamin intakes based on the FFQ and the 24h-recall

Nutrient	Pearson's Correlation Coefficient
Vitamin D	0.20*
Carotene	0.26**
Retinol	-0.09
Vitamin E	0.20*
Thiamine	0.22*
Riboflavin	0.33**
Niacin	0.20*
Vitamin B6	0.27**
Vitamin B12	-0.09
Folate	0.29**
Pantothenic acid	0.24**
Vitamin C	0.42**

* Correlation is significant at level P=0.05
** Correlation is significant at level P=0.01

5.4 Results of the correlation coefficient analysis for food groups

Pearson's correlation coefficients for food groups, assessed by the FFQ and the 24h-recalls are presented in table 19. The correlation values for food groups were stronger than those for individual nutrients. All were strongly statistically significant at *P*=0.001 level except for the biscuits, cakes and puddings food group, the cheese group and finally the alcoholic drinks group, where correlations were non-significant. In the case of alcoholic drinks the correlation value was negative. Overall, positive correlation values ranged for the food groups ranged from 0.32 for other cereals to 0.99 for breads. Mean *r* value for food groups was 0.77.

Table 19. Mean contribution made by selected food groups to energy according to the food frequency and the dietary recall method

Food Groups	FFQ (%)	24h-recall (%)	Correlation coefficient
Breads	10	10	0.99 *
Breakfast Cereals	6	21	0.73*
Meats	11	5	0.86*
Fish	4	14	0.94*
Vegetables	17	4	0.64*
Biscuits, cakes, puddings	6	7	0.21
Fruit	2	1	0.66*
Eggs	2	4	0.91*
Milk/Cream	4	1	0.85*
Cheese	5	4	0.33
Fats	9	4	0.85*
Alcoholic drinks	1	2	-0.85
Other drinks	5	8	0.62*
Added Sugar	6	2	0.91*
Rice, pasta	6	1	0.74*
Other Cereals	3	3	0.32*
Other Foods	4	9	0.80*

*Correlation significant at level *P*=0.001

5.4.1 Classification by quintiles

Nutrient intakes were divided into quintiles in order to evaluate the ability of the FFQ to rank individuals into the same or opposite extreme quintile of intake. Table 20-22 shows the overall proportion of participants categorised to the same extreme opposite quintile of the distribution of the total nutrient intakes. An average of 59.2% of intakes by the two methods were assigned to the same quintile and an average of 4.7% to the extreme opposite quintile. The percentage of participants classified in the same quintile ranged from 48% for alcohol to 70.7% for *Englyst* fibre and misclassification ranged from 0.8% for alcohol and vitamin C to 9.8% for iodine.

Table 20. Percentage of women categorised in the same quintile of the distribution for macronutrient and micronutrient intakes according to the FFQ

Nutrient	Overall proportion categorised in the same quintile %	Proportion classified in the extreme quintile%
Energy	64.2	8.1
Protein	54.5	4.9
Total Fat	67.5	4.9
Carbohydrate	56.1	3.3
Saturated Fat	64.2	3.3
Monounsaturated fatty acids	61.0	4.1
Polyunsaturated fatty acids	59.3	5.7
Cholesterol	61.0	4.1
Sugars	60.2	4.1
Starch	57.7	4.9
Englyst fibre	70.7	3.3
Alcohol	48.0	0.8

Table 21. Percentage of women categorised in the same quintile of the distribution for micronutrient intakes according to the FFQ

Nutrient	Overall proportion categorised in the same quintile %	Proportion classified in the extreme quintile%
Sodium	58.5	6.5
Potassium	58.5	4.9
Calcium	59.3	5.7
Magnesium	63.4	4.9
Phosphorus	58.5	3.3
Iron	61.0	4.1
Copper	58.5	6.5
Zinc	55.3	6.5
Manganese	66.7	4.1
Selenium	49.6	7.3
Iodine	52.8	9.8

Table 22. Percentage of women categorised in the same quintile of the distribution for vitamin intakes according to the FFQ

Nutrient	Overall proportion categorised in the same quintile %	Proportion classified in the extreme quintile%
Retinol	55.3	4.9
Carotene	52.8	2.4
Vitamin D	61.0	4.9
Vitamin E	61.0	5.7
Thiamine	57.7	3.3
Riboflavin	61.8	2.4
Niacin	49.6	4.1
Vitamin B6	62.6	4.9
Vitamin B12	56.9	7.3
Folate	59.3	5.7
Pantothenic acid	61.0	4.1
Biotin	59.3	4.1
Vitamin C	62.6	0.8

5.5 Bland-Altman Analysis

A paired T-test analysis initially has been conducted in order to obtain mean differences and SD of the mean differences of nutrient intakes between the FFQ and the 24h recall. The mean difference reflects the estimated bias and the SD of the difference measures random fluctuations around the mean difference. It is expected that 95% of the differences will lie between these limits. These differences are referred to as LOA and are presented in the following table (23) for specified nutrients.

Table 23. Means±SD of the mean differences and lower and upper limits of agreement for selected nutrients between the FFQ and the 24h recall

Nutrient	Means±SD of differences	Lower LOA	Upper LOA
Energy (Kcal)	-377±552	-1481	727
Calcium (mg)	-61±309	-679	557
Iron (mg)	-3.2±3.9	-11	4.6
Folate (μg)	-49±78	-205	107
Vitamin C (mg)	0.66±47	-93	95

The sign of the assessed mean differences is important as there is a possibility that one method may give higher values than the other and that may be related to the true value intended to be assessed. For instance observed differences were negative for energy, calcium, iron and folate intakes and positive for vitamin C meaning that participants both underreported vitamin C intakes and over reported intakes for the rest of the nutrients with the FFQ compared with the 24h recall. Mean difference for vitamin C which was close to zero suggested little evidence of overall bias.

The size of the mean difference among energy intakes assessed by the FFQ and the 24h recall was higher than the mean differences assessed for the rest of the nutrients, which is possibly related to an overestimation of energy intake by the FFQ method. Relatively smaller differences were observed for calcium and vitamin C intakes. Wide LOA indicated the potential for very large differences between methods and agreement considered poor. For instance, it is estimated that for 95% of participants, energy intakes assessed by the FFQ will be between 1481kcals below and 727Kcals above the 24h recall and for calcium will be between 697mg below and 557mg above the 24h recall. Folate intakes assessed by the FFQ may be 207µg below to 107µg above the 24h recall.

The following figures (7-11) describe the average of the FFQ and the 24h recall plotted on the *x*-axis against the difference between the two methods plotted on the *y*-axis or differences between measurements on the same individual by the two methods. Increase in variability was shown by an increase in the scatter of differences, as the magnitude of the measurement increased.

Wide scattering of the differences were observed for energy and calcium intakes (figures 7 and 8). Also, a trend in bias reflected by a tendency for the mean difference to rise (figures 8 and 11) or fall (figures 7 and 9) with increasing magnitude was observed. It also appeared that participants reported low iron, vitamin C and energy intakes tended to report more accurately than those who consumed higher amounts.

Figure 7. Agreement between FFQ and 24h recall, energy (Kcal)

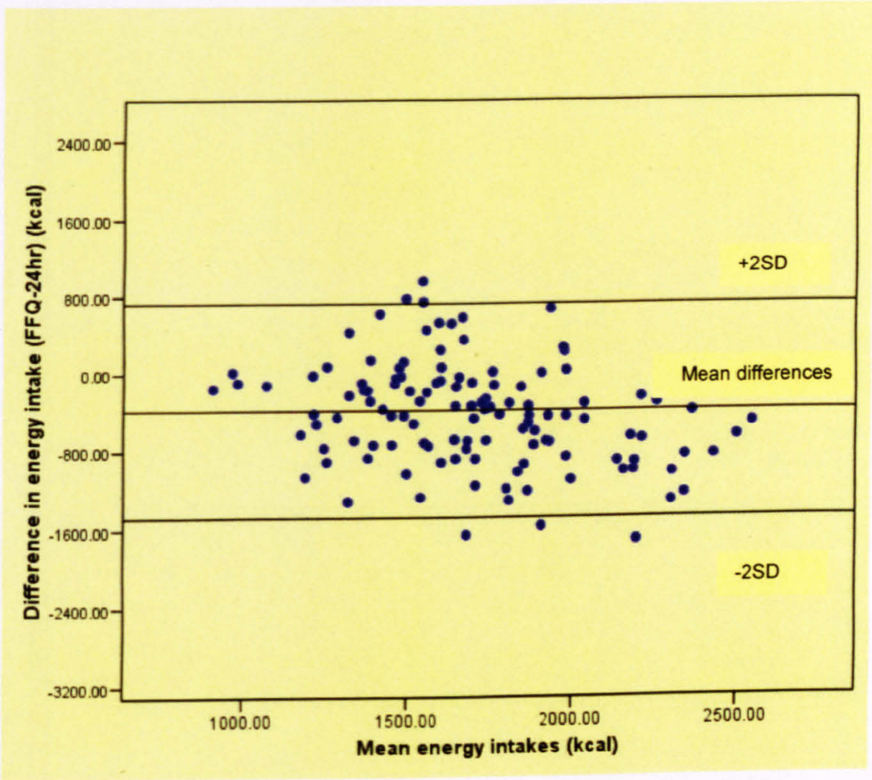


Figure 8. Agreement between FFQ and 24h recall, calcium (mg)

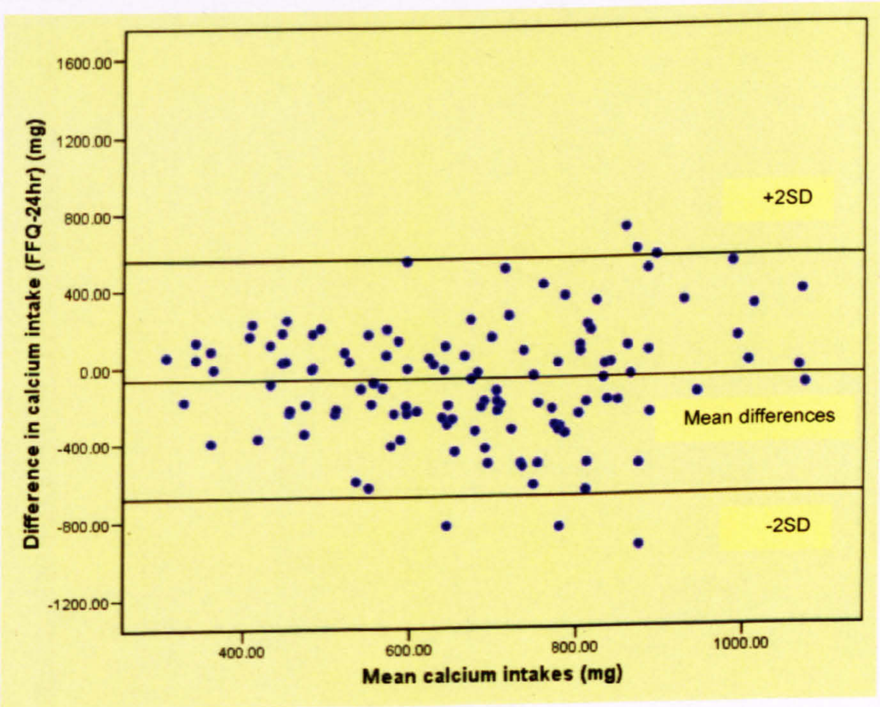


Figure 9. Agreement between FFQ and 24h-recall, iron (mg)

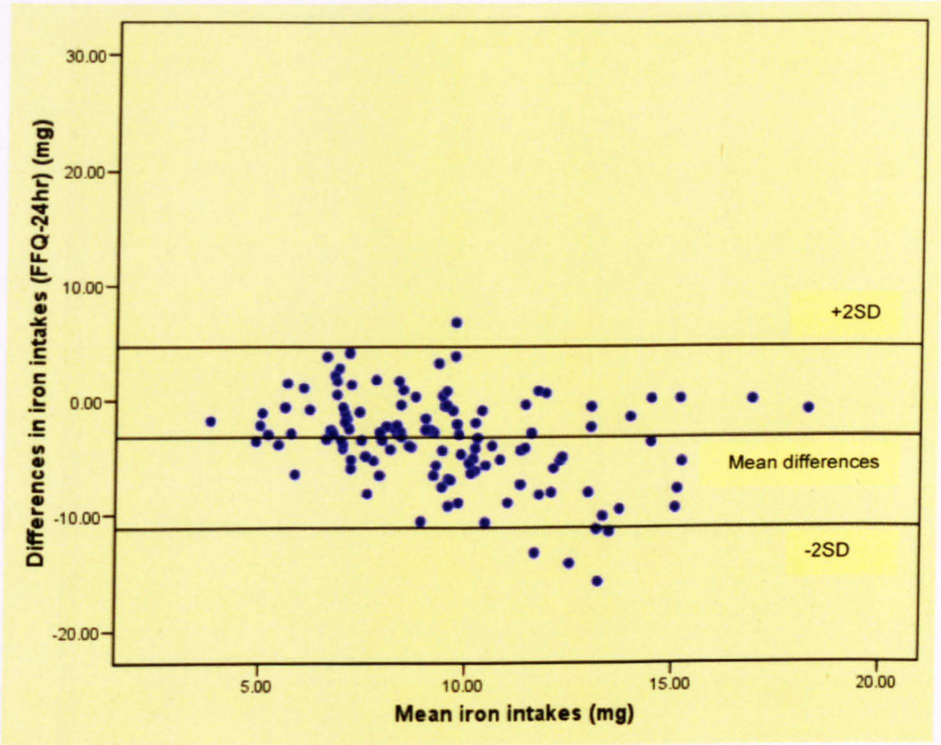


Figure 10. Agreement between FFQ and 24h-recall, dietary folate (μg)

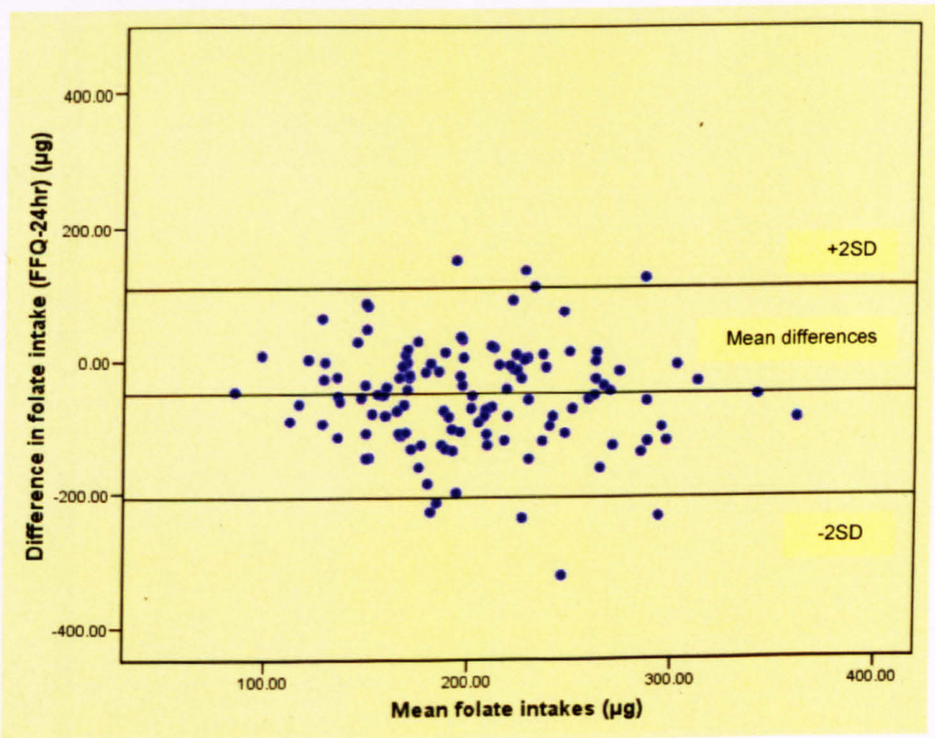
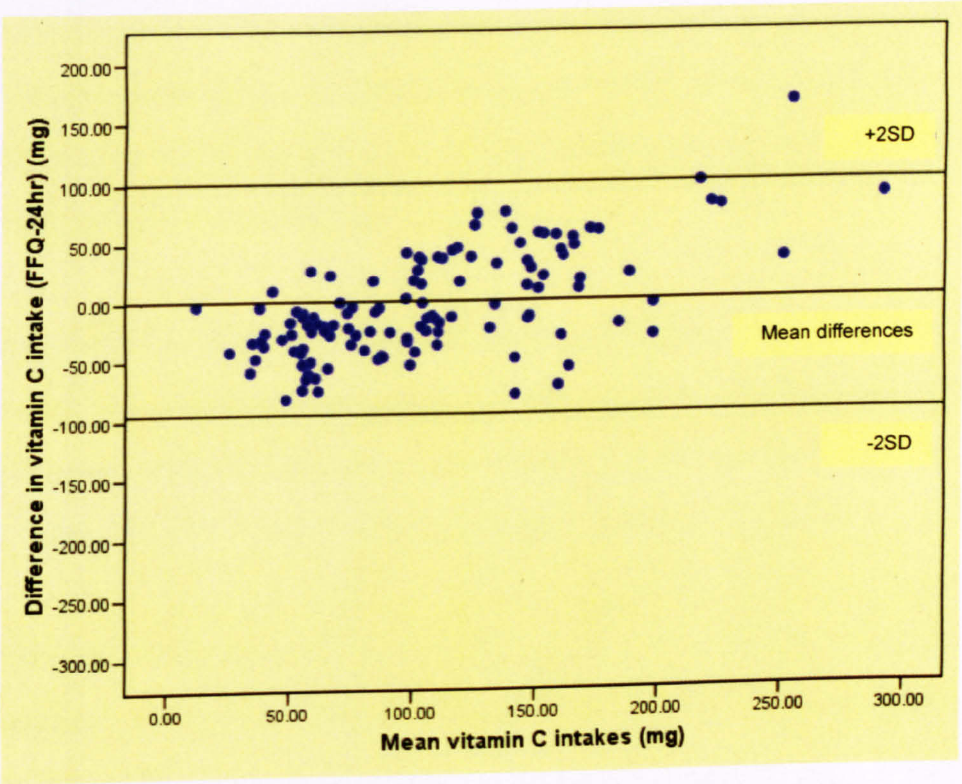


Figure 11. Agreement between FFQ and 24h-recall, vitamin C (mg)



5.6 Twenty-four hour recalls

Mean nutrient intakes obtained by the face-to-face 24h recall and by the telephone administered 24h recall were compared. The following tables (24 and 25) present the results of the paired t-test; means and SD, mean difference between the two approaches and the p value.

There were no statistically significant differences between the telephone and face-to-face 24h recalls for energy and macronutrients. For example mean difference between face-to-face and telephone interviews for energy was 47Kcals (*P*=0.33), for protein 0.14mg (*P*=0.94) and for total fat 3.10mg (*P*=0.28).

Table 24. Comparison of energy and mean macronutrient intakes as assessed the by face-to-face (1st recall) and telephone (2nd recall) dietary recalls (*n*=93)

Nutrient	1st Recall Mean±SD	2nd Recall Mean±SD	Mean difference	*P* value
Energy (Kcal)	1595±405	1642±312	46	0.334*
Protein (g)	57±17	57±17	0.14	0.949*
TotalFat (g)	67±25	70±17	3.10	0.287*
Carbohydrate (g)	200±55	206±53	6.12	0.430*
Saturated fat (g)	22±11	23±10.1	0.95	0.453*
Sugars (g)	77±33	78±39	0.58	0.912*
Starch(g)	120±37	124±29	4.18	0.340*

**P* value significant at level 0.05

The analysis revealed that there were no statistically significant differences between the telephone and in-person 24h-recall for all minerals and vitamins assessed except for selenium (*P*=0.01). For example mean difference between the two methods for calcium was 11mg (*P*=0.76), for iron 0.02mg (*P*=0.97), for folate 8 μg (*P*=0.41) and for vitamin C 2 mg (*P*=0.79).

Table 25. Comparison of mean mineral and vitamin intakes as assessed the by face-to-face (1st recall) and telephone (2nd recall) dietary recalls (*n*=93)

Nutrient	1st Recall Mean±SD	2nd Recall Mean±SD	Mean difference	*P* value
Na (mg)	2354 ±860	2552 ±1173	197	0.194*
Calcium (mg)	674 ±263	685 ±320	10.6	0.765*
Iron (mg)	8.2 ±3.60	8.2 ±3.28	0.02	0.972*
Selenium (µg)	40±21	34.2 ±19	6.72	0.018
Retinol (µg)	282 ±176	287 ±187	5.27	0.818*
Vitamin D (µg)	1.83±2.14	1.45±1.24	0.38	0.101*
Vitamin E (mg)	5.33±2.86	5.18±2.94	0.15	0.678*
Thiamine (mg)	1.13±0.41	1.24±0.50	0.12	0.060*
Riboflavin (mg)	1.16±0.56	1.13±0.48	0.03	0.681*
Vitamin B6 (mg)	1.46±0.62	1.48±0.58	0.02	0.837*
Vitamin B12 (mg)	2.57±1.75	2.48±1.65	0.09	0.690*
Folate (µg)	188 ±74	180 ±78	8.12	0.413*
Vitamin C (mg)	77 ±66	74 ±63	2.18	0.799*

**P* value significant at level 0.05

Chapter 6

6. Main study

6.1 Anthropometrical, socio-demographic and behavioural characteristics of the participants

Two-hundred and fifty pregnant women participated in the main study. Tables 26-28 present a series of characteristics of the main study population included in the analysis. Differences in periconceptional vitamin and or mineral and postconceptional folic acid supplementation were tested according to educational attainment, pregnancy planning and residency within the Sure Start areas of Sheffield. Significance was assessed using likelihood ratio statistics at 95% level (when stated likelihood ratio statistics at 99% level is used).

Table 26 presents the anthropometric characteristics of the study participants. The mean BMI of the participants was 26 (SD 6.7). Mean age of the women was 27 (SD 7.4) years and mean gestational age 14.4 (SD 2.6) weeks. The highest proportion of participants was at the 25-34 years (42.4%) age category and the lowest at the less of 19 years (12.4%) maternal age category.

Table 26. Anthropometrical characteristics of main study participants (*n*=250)

	Mean	SD
Height† (m)	1.63	7.2
Weight* (Kg)	69.8	17.4
BMI ∞	26.0	6.7
Age (years)	27.0	7.4
Gestational age‡ (weeks)	14.4	2.6

†n=243
*n=235
∞n=234
‡n=249

Socio-demographic characteristics

Table 27 presents the socio-demographic characteristics of the study participants. Fourteen percent of the participants had a higher degree or equivalent and 60% completed their education between 14-20 years of age. A high percentage of the women (60%) at the time of the interview, were in full or part-time employment. Nearly 23% of the women were classified as economically inactive compared to 17% being unemployed. Almost 7% of the participants did not report having a partner and 5% reported living alone. A high proportion of women's partners were in full or part-time employment (70%), mainly in manual occupations. Overall, 42% of the participants were living in households where they or a member of the household was in receipt of state benefits.

Table 27. Socio-demographic characteristics of main study participants (*n*=250)

		%
Educational attainment		
	21 or over years	14.4
	14-20 years	60.8
	Other∞	24.8
Maternal employment		
	Working ×	60.0
	Unemployed	16.8
	Economically inactive*	23.2
Employment status of partner		
	Working	78.0
	Unemployed	13.2
	Economically inactive*	1.6
	N/A†	7.2
Receipt of benefits		
	Working Families Tax Credit	20.4
	Income Support	14.8
	Job-Seekers Allowance	7.2
	None	57.6

∞No formal educational qualification or not yet finished
×Full time or part time
*includes: students, looking after the house or disabled
†no partner reported

Behavioural Characteristics

Table 28 shows some of the behavioural characteristics of the participants. Overall, 28% of the participants were self-reported smokers. Smokers were significantly younger (P=0.0001), less educated (P=0.0001) and less likely to be in paid employment (P=0.001). Of the 250 participants 60% reported pregnancy planning but of those 40% reported periconceptional supplement usage. Folic acid supplements were reported to be taken by 90% of the sample following pregnancy confirmation (postconceptionally).

Table 28. Behavioural characteristics of main study participants (*n*=250)

		%
Self-reported smoking status		
	Non-smoker	71.6
	Current smoker	28.4
Pregnancy Planning		
	Yes	61.2
	No	38.8
Preconceptional supplement usage		
	Yes*	26.4
	No	73.6
Postconceptional folic acid supplements		
	Yes	92.0
	No	8.0
Cooking skills		
	Yes	92.0
	No	8.0
Main household cook		
	Participants	53.2
	Partner	15.2
	Sharing (participant/partner)	21.6
	Member of the family	10.0

*Percentage of participants taken supplements of folic acid alone is unknown.

Women living in the Sure Start areas of Sheffield were less likely to take preconceptional vitamin and/or mineral supplements (*P*=0.001) and postconceptional folic acid supplements (*P*=0.02) (Figures 12 and 13).

Figure 12. Preconceptional vitamin and or mineral supplementation and residency within Sure Start areas of Sheffield

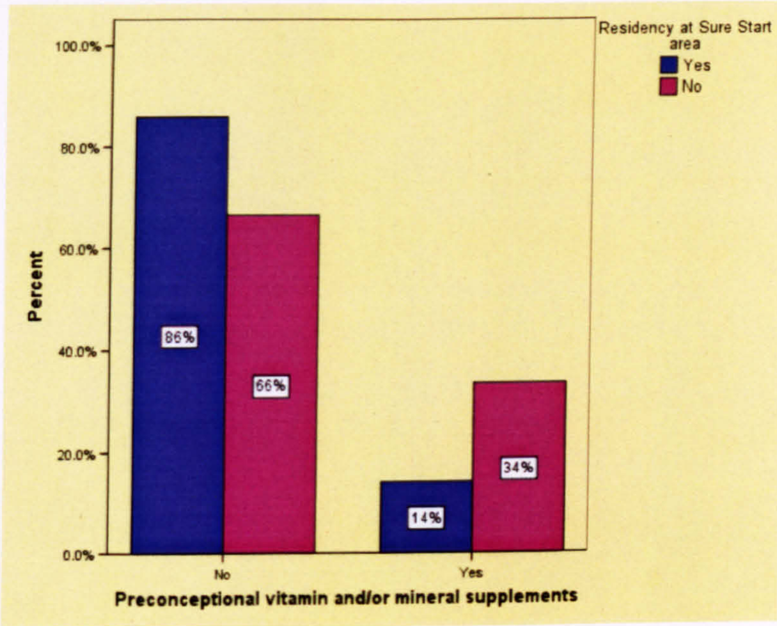
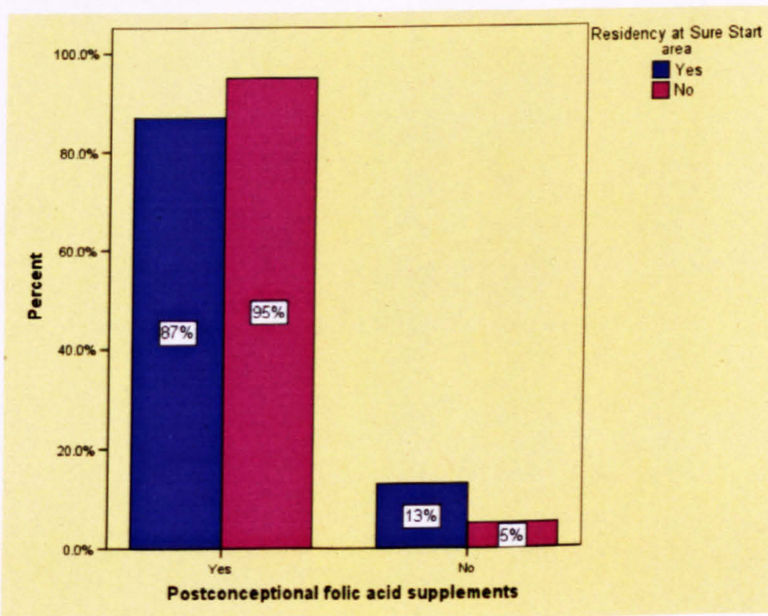


Figure 13. Postconceptional folic acid supplementation and residency within Sure Start areas of Sheffield



Young participants (P=0.004) and those with no formal educational qualification (P=0.01) were less likely to take postconceptional folic acid (figures 14 and 15). Differences were however, relatively small.

Figure 14. Maternal age and postconceptional folic acid supplementation

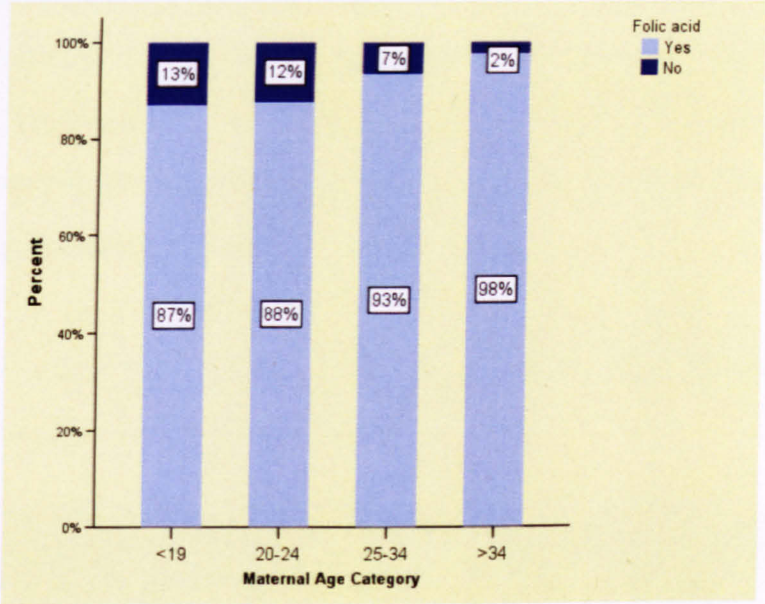
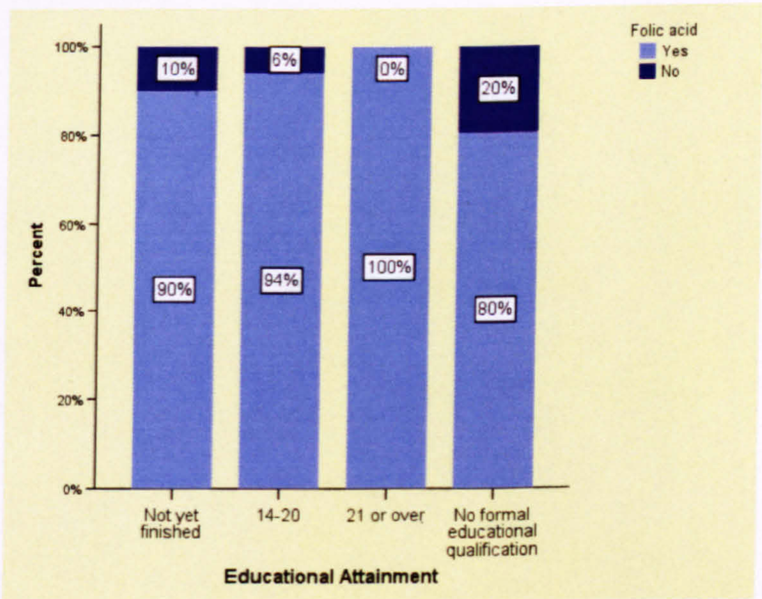


Figure 15. Maternal highest educational attainment and postconceptional folic acid supplementation



6.2 Mean energy, macro- and micronutrient intakes of the participants

In tables 29-33, data are presented on the intakes of energy, macronutrients and micronutrients. Mean and SD of the nutrients are provided as well as the proportion of energy derived from protein, fat and carbohydrate.

Intakes of energy, protein, total fat and alcohol

Table 29 shows average daily energy, protein, fat and alcohol intakes for the sample. The mean daily energy intake was 7.8MJ (1880Kcals). Mean protein intake was 74g and mean fat intake was 83g. Total carbohydrate daily amount was 217g and alcohol intake was 1.7g.

Table 29. Mean ±SD of total energy, protein, fat and alcohol intakes of respondents based on the FFQ (*n*=250)

	Mean	SD	95% CI	
			Lower	Upper
Energy (MJ)	7.8	2.1	7.5	8.0
(Kcal)	1880	521	1815	1945
Protein (g)	74	23.9	71	77
Total fat (g)	83	27.9	79	86
Carbohydrate (g)	217	62.1	210	225
Alcohol (g)	1.7	5.6	1.0	2.4

Intakes of saturated, mono- and polyunsaturated fatty acids and cholesterol

Table 30 shows average daily saturated, mono- and polyunsaturated fatty acids and cholesterol intakes for the sample. The mean daily saturated and mono-saturated fatty acid intakes were 29g and 28mg respectively. Mean polyunsaturated fatty acid intake was 16mg and mean daily cholesterol intake was 195mg.

Table 30. Mean ±SD of saturated, mono- and polyunsaturated fatty acids and cholesterol based on the FFQ (*n*=250)

	Mean	SD	95% CI	
			Lower	Upper
Saturated fatty acids (g)	29	11	28	31
Monounsaturated (g) fatty acids	28	9.3	26	29
Polyunsaturated (g) fatty acids	16	7.3	15	17
Cholesterol (mg)	195	80	185	204

Intakes of sugar, starch, *Englyst* fibre

The mean daily intake for total sugar was 78g and 139g for starch. Mean *Englyst* fibre intake was 12g.

Table 31. Mean ±SD of sugars, starch and *Englyst* fibre based on the FFQ (*n*=250)

		Mean	SD	95% CI	
				Lower	Upper
Sugars	(g)	78	34	74	82
Starch	(g)	139	40	134	144
Englyst fibre	(g)	12	4.7	12	13

Intakes of minerals

Mean daily intakes for sodium were 2509mg and 692mg for calcium. Mean magnesium intake was 221mg, mean iron 10mg and mean zinc intake was 7.4mg. Variation of mean calcium and iron intakes by maternal educational attainment is shown at figures 16 and 17 (pages 127,128).

Table 32. Mean ±SD sodium, calcium, magnesium, iron, zinc and iodine based on the FFQ (*n*=250)

		Mean	SD	95% CI	
				Lower	Upper
Na	(mg)	2509	762	2414	2604
Calcium	(mg)	692	223	665	720
Magnesium	(mg)	221	68	212	229
Iron	(mg)	10.2	3.7	9.7	10
Zinc	(mg)	7.4	2.3	7.1	7.7
Iodine	(µg)	92.5	40	87	97

Intakes of vitamins

Table 33 shows mean intakes of certain vitamins. Mean daily folate intake was 204μg per day and mean vitamin C intake was 67mg.

Table 33. Mean ±SD of certain vitamins based on the FFQ (*n*=250)

		Mean	SD	95% CI	
				Lower	Upper
Retinol	(μg)	271	159	251	291
Carotene	(μg)	1447	841	1342	1552
Vitamin D	(μg)	2.6	1.6	2.4	2.8
Vitamin E	(mg)	4.1	1.9	3.8	4.3
Thiamine	(mg)	1.2	.44	1.2	1.3
Riboflavin	(mg)	1.0	.45	1.0	1.1
Niacin	(mg)	18	6.2	17	19
Vitamin B_6	(mg)	1.8	.61	1.7	1.8
Vitamin B_{12}	(μg)	4.5	2.5	4.2	4.8
Folate	(μg)	204	71	196	214
Pantothenic acid	(mg)	3.4	1.2	3.2	3.5
Vitamin C	(mg)	67	34	63	72

Table 34 presents mean nutrient intakes of specified nutrients at selected points of the distribution; the 25th, 50th and 75th percentile.

Table 34. Mean nutrient intakes of specific nutrients at the 25th, 50th and 75th percentile

Nutrient		25th	50th	75th
Energy	(Kcal)	1493	1856	2181
Protein	(g)	58	70	87
Total fat	(g)	63	80	100
Carbohydrate	(g)	177	212	260
Saturated fatty acids	(g)	21	28	35
Sugars	(g)	54	73	93
Starch	(g)	110	137	165
Englyst fibre	(g)	9.3	12	16
Calcium	(mg)	543	660	833
Magnesium	(mg)	167	216	265
Iron	(mg)	7.7	10	12
Vitamin D	(μg)	1.6	2.4	3.4
Thiamine	(mg)	1.0	1.2	1.5
Riboflavin	(mg)	0.7	1.0	1.3
Vitamin B_6	(mg)	1.3	1.7	2.1
Vitamin B_{12}	(μg)	2.9	4.0	5.5
Folate	(μg)	160	193	243
Vitamin C	(mg)	45	63	86

Figures 16-18 present mean calcium, iron and folate intakes by educational attainment. In particular, mean calcium, iron and folate intakes were lower for those with no formal educational qualifications when compared to those who had a degree or equivalent (education >21 years). Women who had a degree or equivalent had significantly higher mean iron intakes (11mg) than those with no formal educational qualification (9.2mg) (P=0.04).

In addition, mean calcium intake was 623mg per day for the women with no formal educational qualification compared with 753mg per a day for the women with a degree or equivalent (P=0.05). Participants with no formal educational qualifications also had significantly lower mean folate intakes 179μg, compared to those who had a degree or equivalent, 229μg (P=0.007).

Figure 16. Mean iron intakes of participants by educational attainment

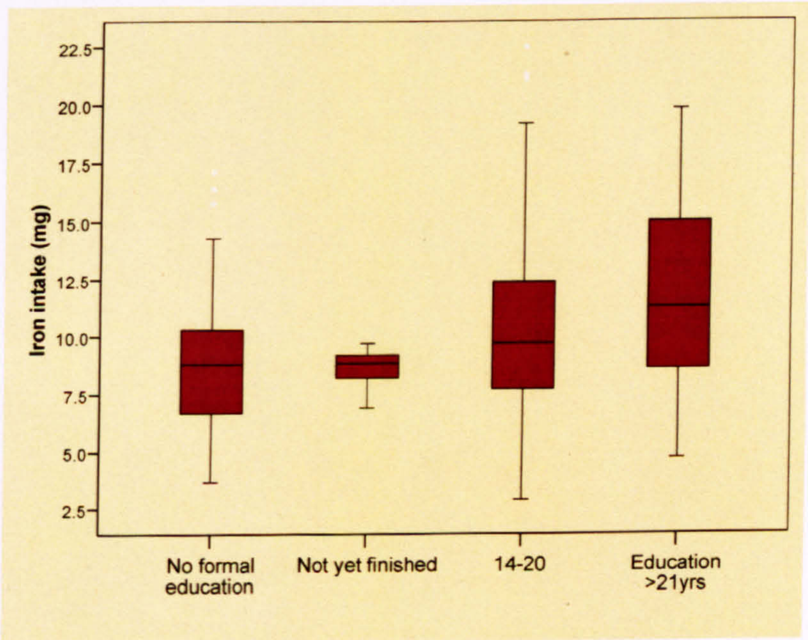


Figure 17. Mean calcium intakes of participants by educational attainment

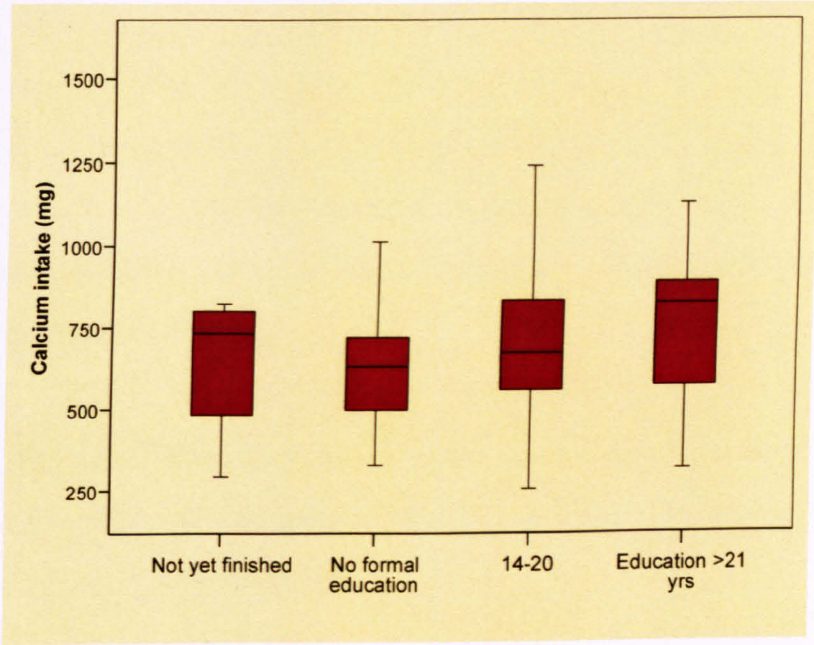
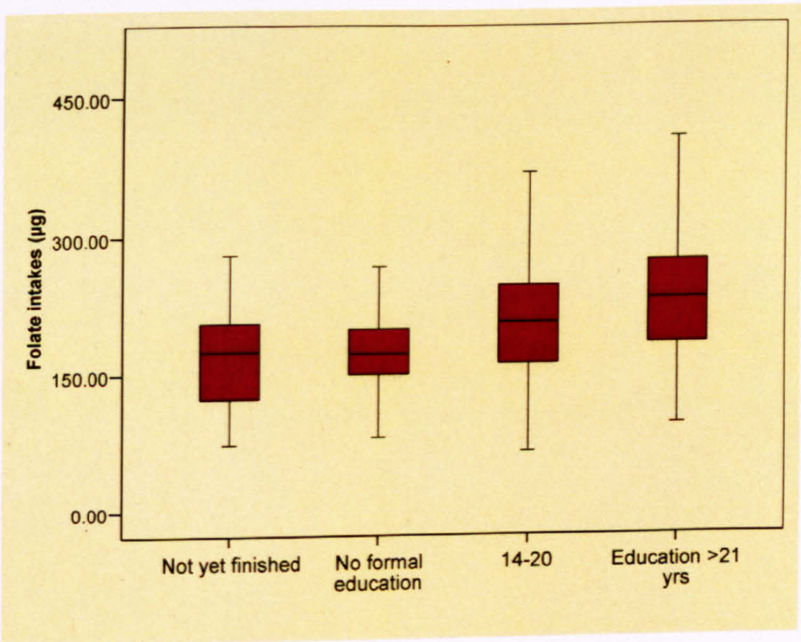


Figure 18. Mean folate intakes of participants by educational attainment



Frequencies of consumption by educational attainment suggested that participants with no formal educational qualification or had not yet finished their education consumed less often white fish, green leafy vegetables, salad, fruits, wholegrain and oat cereals and more often crisps and other cereals in relation to those with a degree or equivalent. Statically significant differences however, were observed for the other green vegetables (*P*=0.012), fruits (*P*=0.016) and oat cereals (*P*=0.001) categories but no statistically significant differences were observed in the consumption of the white fish (*P*=0.949), salad (*P*=0.245), wholegrain (*P*=0.063) and other cereals (*P*=0.132), crisps (*P*=0.440) and green leafy vegetables (*P*=0.130).

Table 35 shows that the participants derived a mean of 16% of their energy intake from protein and a mean of 39% from total fat. The mean of energy derived from carbohydrate was 44%

Table 35. Percentage of energy intakes from protein, fat and carbohydrate based on the FFQ (*n*=250)

			95% CI	
	Mean	SD	Lower	Upper
% energy from protein	16	4	15	16
% energy from fat	39	5	39	40
% energy from carbohydrate	44	6	43	44

6.3 Types of foods and drinks consumed

In the following section the types and the frequencies of consumption of the food items included in the FFQ are given. Some of the characteristics of the low and high consumers of specified food items e.g. fruits are discussed. Red meat was consumed more frequently and by the largest number of participants followed by chicken and turkey dishes, sausages and burgers and meat pies. For example 21% of the women consumed red meat between 4-7 times a week followed by chicken and turkey dishes (18%). White fish from the fish dishes was preferred by the largest proportion of participants, 22% having had it 4-7 times a week. The group of vegetables consumed by the greatest proportion was boiled, mashed or jacket potatoes eaten by 95% of the participants, followed by salad vegetables (84%).

The following table (36) presents the frequency of the food items of the FFQ eaten by the participants. The foods consumed more than once a day by some participants included crisps 10%, diluted drinks 19%, fruit 11%, and biscuits 7%. Foods consumed never or rarely by the participants included soya 92%, quorn 92% and shellfish 86%. Butter was the most commonly consumed fat for spreading (42%). This was followed by soft margarine (26%) and polyunsaturated fat spreads (10%).

Table 36. Frequencies of consumption of specific food items of the FFQ consumed by the respondents (*n*=250)

Food Items	Never or Rarely %	1-3 times a week %	4-7 times a week %	More that once a day %
Meat	10.8	63.2	21.2	0.4
White Fish	40	34.4	5.2	0.0
Soya	92.4	4.4	0.8	0.0
Chips i.e. oven, homemade, fries	15.2	55.6	15.6	1.2
Crisps	13.6	36	34	10
Salad Vegetables	16.4	48.8	24.4	1.6
Fresh fruits	12	29.6	42	10.8
Other green vegetables i.e. leeks	27.2	56.4	6.4	0.0
Oat Cereals i.e. muesli	69.6	16.4	9.2	0.4
Other cereals i.e. cornflakes	36.8	34	21.6	0.8
Biscuits	24	37.6	22.4	6.8
Chocolate bars	30.4	36.8	19.6	2.8

Figures 19 and 20 show the preferred types of bread and milk by the participants. For example 77% of the women usually consumed white bread compared with just 16% for brown and 7% for wholemeal bread. Nearly half of the participants took skimmed milk (46%), compared to approximately 25% who took full fat or semi-skimmed.

Figure 19. Type of bread participants usually consumed (*n*=250)

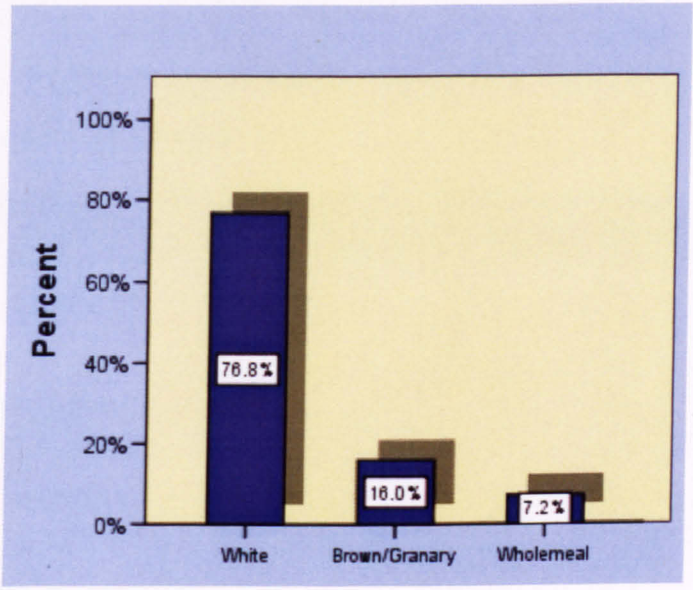
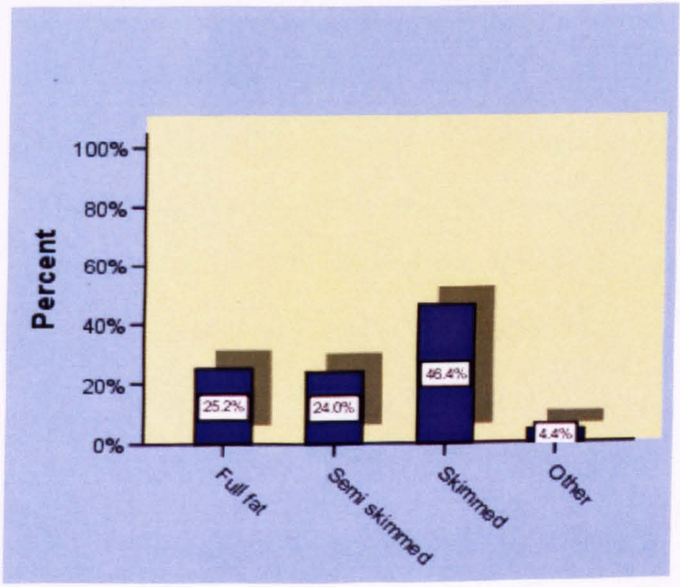


Figure 20. Type of milk participants usually consumed (*n*=250)



6.3.1 Portions of fruits and vegetables

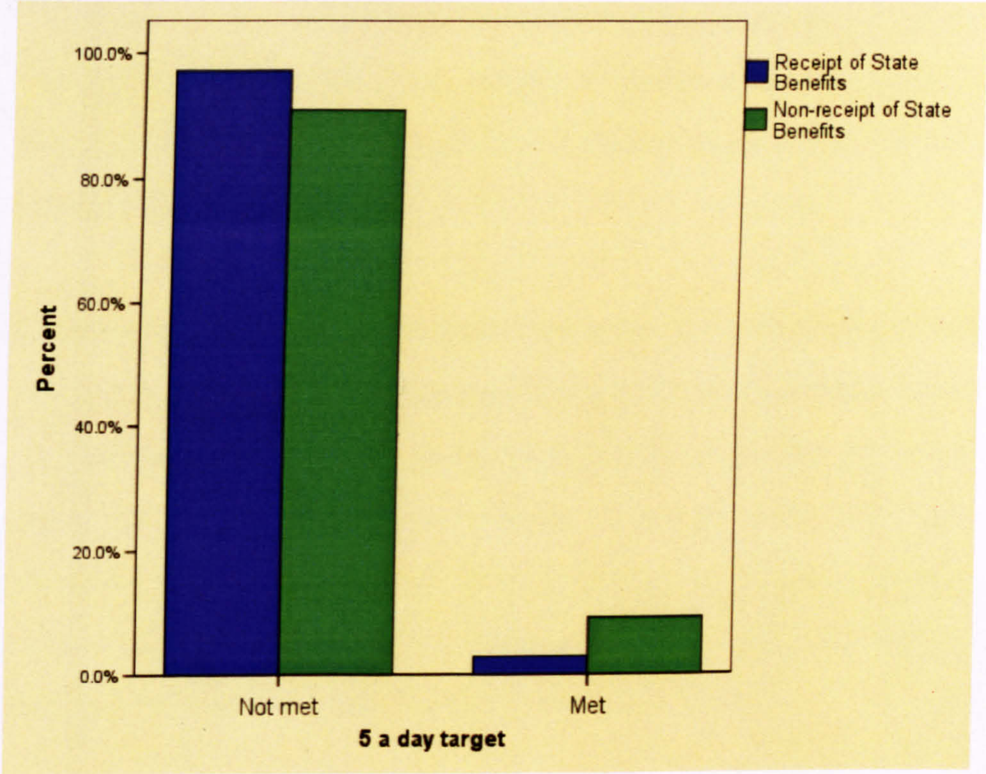
In this section the number of portions of fruits and vegetables consumed daily by the participants is described. Variation in number of portions of fruit and vegetables by households in receipt, or not, of state benefits is also presented. Table 37 shows the proportion of participants and number of portions consumed daily.

Table 37. Proportion of participants consuming portions of fruits and vegetables per a day (*n*=250)

Number of portions		%
More than one portion		22.0
More than two portions		35.2
More than three portions		22.8
More than four portions		13.6
More than five portions		6.4
Mean number of portions consumed	*1.6*	
SD	*1.5*	

As described by the following figure (21) the proportion of women living in households in receipt of benefits who met the 5 a day target was statistically significantly different to those women living in households not in receipt of state benefits (*P*=0.048). Differences however, were comparatively low. Specifically, 3% of women receiving any form of state benefits met the five a day target as opposed to nearly 10% of those reported not receiving any benefits.

Figure 21. Proportion of participants meeting or not meeting the five a day target by households on receipt of benefits



6.4 Relationship to the RNI, the LRNI, the NDNS and mean nutrient intakes of studies performed during pregnancy

Where appropriate, mean intakes of the participants were related to the RNI and LRNI (COMA, 1991) (tables 38-40), NDNS (Henderson *et al* 2002) (table 41) and finally with the ALSPAC (Rogers *et al* 1998b) and Mathews study (Mathews and Neil 1998) (table 42).

Table 38 shows mean intakes and percentage of the participants below the RNI for specified nutrients. Mean daily energy intakes were below the RNI for 60% of the participants. Similarly, 54% of the participants failed to meet the RNI for calcium and 87% for iron. In addition, more than 75% of the women had a mean daily intake of riboflavin below the RNI and 40% for vitamin C. The proportion of women that meet the RNI for dietary folate was small, as only 8.5% meet the recommended intake of 300μg from dietary sources per day.

Table 38. Mean intakes and percentage of women with intakes below the RNI[a]

	Mean intakes of sample	RNI	% below RNI
Energy (Kcal) [b]	1880	1940[*]	60
Calcium (mg)	692	700	54
Iron (mg)	10.2	14.8	87
Riboflavin (mg)	1	1.1[†]	75
Folate (μg)	204	200[‡]	92
Vitamin C (mg)	67	40[§]	31

[a]The RNI shown in the table is the figure for women aged 19-50 with the addition where appropriate of an increment for pregnancy
[b] for last trimester only
[*]+200 Kcals/day (last trimester only)
[†]+0.3mg/d
‡100μg/d
[§]+10μg/d

Furthermore, the results of the analysis have shown that a high proportion of women who met the RNI for folate and iron, also met the RNI for calcium and vitamin C. On the other hand, only a small proportion of women who met the RNI for calcium and vitamin C did meet the RNI for folate and iron. For example of those participants who met the RNI for folate, over 56% did meet the RNI for the rest of the key nutrients compared to those who met the RNI for vitamin C (6%). The proportion of participants meeting the RNI for all four target nutrients according to each individual nutrient is shown in table 39.

Table 39. Proportion of participants meeting the RNI for all four target nutrient according to individual nutrient

Met RNI for all four targets			
		Yes	No
Folate RNI met	Yes	**56%**	**44%**
Iron RNI met	Yes	**30%**	**70%**
Calcium RNI met	Yes	**13%**	**87%**
Vitamin C RNI met	Yes	**6%**	**94%**

Table 40 presents the intakes and percentage of the participants below the LRNI for specified nutrients. Mean daily calcium intakes were below LRNI for 10% of the participants and a high proportion of the women had a mean daily intake of iron (30%) below the LRNI. The percentage of women that fell below the LRNI for folate (4%) and vitamin C (1%) was relatively insignificant.

Table 40. Mean intakes and percentage of women with intakes below the Lower RNI for selected nutrients

	Mean intakes of sample	LRNI	% below LRNI
Calcium (mg)	692	400	10
Iron (mg)	10.2	8	30
Folate (µg)	204	100	4
Vitamin C (mg)	67	10	1

Table 41 relates the nutrient intakes of the Sheffield sample with data from the NDNS of women aged 16-64 years. Overall Sheffield women had relatively higher mean energy intakes, and relatively similar intakes of daily protein, carbohydrate, and total fat. For all minerals (except for sodium and iron) and all vitamins presented, mean daily intakes were moderately lower in the Sheffield sample. Mean folate intake for instance was 204μg compared to 292μg for the NDNS population.

Table 41. Estimated daily energy, macronutrient and micronutrient mean intakes based on the FFQ, in relation to the results of the DNDS

	Sheffield Sample	NDNS
Energy (MJ)	7.8	6.8
Protein (g)	74	64
Total Fat (g)	83	86
Carbohydrate (g)	217	203
Sodium (mg)	2509	2303
Calcium (mg)	692	777
Magnesium (mg)	221	229
Iron (mg)	10.2	10
Zinc (mg)	7.4	7.4
Vitamin D (µg)	2.6	3.7
Vitamin E (mg)	4.1	15
Thiamine (mg)	1.2	1.5
Riboflavin (mg)	1.0	1.6
Niacin (mg)	18	31
Vitamin B_6 (mg)	1.8	2.0
Vitamin B_{12} (μg)	4.5	4.8
Folate (μg)	204	251
Vitamin C (mg)	67	81
Survey method	*FFQ*	*dietary record*

Table 42 relates the Sheffield study results to data of the ALSPAC and Mathews pregnancy studies. The Sheffield sample had similar energy and macro-nutrient intake levels to the ALSPAC study and relatively lower energy intakes to the Mathews study. Mean daily intakes for calcium were notably lower for the Sheffield sample when related to the other studies. Iron intakes were similar however. Similarly to the association with the national survey, the Sheffield sample had lower vitamin daily intakes. For instance, mean daily vitamin C intake for the Sheffield sample was 67mg compared to 80mg for the ALSPAC and 83mg for the Mathews sample. Mean Vitamin E intakes of the Sheffield sample were lower compared to the NDNS and the two pregnancy studies. This is probably reflected by lower intakes of polyunsaturated fatty acids and by higher intakes of saturated fatty acids (table 30) as well as low consumption of polyunsaturated fat spreads which are considered to be a major source of Vitamin E (10% reported regular consumption of polyunsaturated fat spreads compared to 42% for butter).

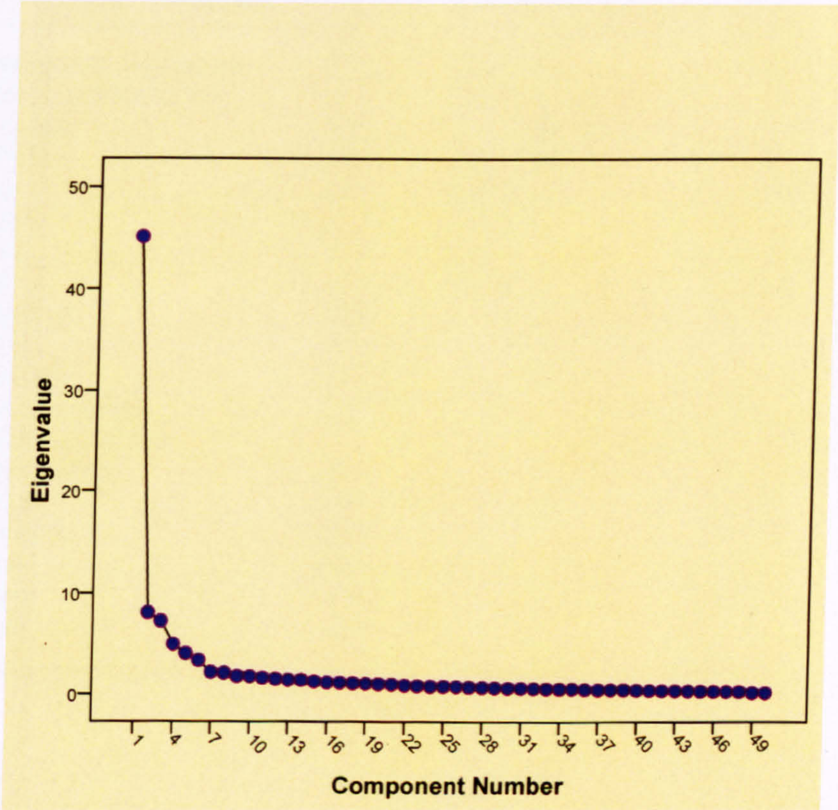
Table 42. Estimated daily energy, macronutrient and micronutrient mean intakes based on the FFQ, in comparison to the results from the ALSPAC and Mathews study (Mathews and Neil 1998; Rogers *et al* 1998b)

	Sheffield sample	ALSPAC	Mathews
Energy (MJ)	7.8	7.7	8.5
Protein (g)	74	66	73
Total Fat (g)	83	70	86
Carbohydrate (g)	218	-	256
Calcium (mg)	692	953	922
Iron (mg)	10.2	10	10
Zinc (mg)	7.4	8.3	8.2
Vitamin E (mg)	4.1	8.4	9.0
Thiamine (mg)	1.2	1.4	1.5
Riboflavin (mg)	1.0	1.7	1.7
Folate (µg)	204	250	242
Vitamin C (mg)	67	80	83
Acohol (g)	1.7	-	1.5
n	250	11,923	774
Survey method	FFQ	FFQ	dietary record

6.4.1 Principal Components Analysis

The PCA identified two main components that accounted for 53% of the variance (figure 22). In order to emphasize the food items with stronger association (the larger the factor loading, the greater association) with the identified dietary pattern, food items with factor loadings <0.25 were not considered in the interpretation (table 43).

Figure 22. Scree plot of the factors identified by the PCA



Two main types of dietary behaviour were identified; the first characterised by food items often reported being part of a healthy diet and the second strongly related to food items reported being part of an unhealthy diet. The first component 'Health conscious' had strong positive loadings with green leafy and root vegetables, salad, rice, pasta, fruits and fish and was strongly related with increased vitamin and iron intakes. Foods with negative loadings were chips, crisps and sugar. The second component was characterised by positive loadings with biscuits, chocolate bars, crisps, pizza etc. This component was related to increased energy, sugar and fat intake.

Table 43. Factor loadings of food items for each component

Components			
'Health Conscious'		'Processed and confectionary'	
Other green vegetables	.726	Biscuits	.734
Other root vegetables	.640	Cakes or buns	.656
Cabbage	.636	Chocolate bars	.649
Carrots	.576	Chocolate	.534
Rice	.535	Pudding	.530
Peas	.502	Crisps	.510
Pasta	.422	Eggs	.274
Fruit	.422	Bread	.259
Other fish	.395		
Salad	.372		
Whitefish	.344		
Boiled, mashed or jacket potatoes	.312		
Baked beans	.302		
Cheese	.264		
Pure juice	.254		
Chips	***-.299***		
Crisps	***-.248***		
Sugar	***-.295***		

6.5 Group comparisons

6.5.1 Anthropometrical, socio-demographic and behavioural characteristics of women living in the 40% most deprived wards and other wards within Sheffield

Following subjects' electoral ward identification, the sample was classified into those living in the 40% of most deprived wards (group 1=174) or other wards within Sheffield (group 2=76) using the IMD. Tables 44-46 present a series of characteristics of the two groups and their differences (likelihood ratio statistics at 95% level was used). Table 44 presents the anthropometric characteristics of the two groups. Women living in the 40% of most deprived wards of Sheffield were significantly younger, heavier, and shorter and had higher BMI compared to women living in the rest of electoral wards within Sheffield. For example, mean age was 26 years for group 1 and 30 years for group 2. Mean BMI was 26.5 for group 1 compared to 24.0 for group 2.

Anthropometrical characteristics

Table 44. Anthropometrical characteristics of group 1 (*n*=174) and group 2 (*n*=76)

	Group 1 Mean±SD	Group 2 Mean±SD	*P* value
Height (m)	1.63±7.6†	1.65±6.1††	0.014*
Weight (Kg)	70.6±19.6˙	67.9±10.6˙˙	0.180
BMI	26.5±7.6∞	24.0±3.5∞∞	0.011*
Age (years)	25.9±6.7	29.7±8.3	0.001*
Gestational age (weeks)	14.1±2.6‡	15.1±0.8	0.001*

†n=169 ††n=74
˙n=165 ˙˙n=70
‾n=164 ‾‾n=70
‡n=173
[a] Independent sample *t*-test for equality of means
*Difference is significant

Socio-demographic characteristics

Table 45 presents the socio-demographic characteristics of the two groups. Women living in the 40% of most deprived wards of Sheffield were significantly younger than women living in the rest of electoral wards within Sheffield. Nearly 50% of them were in the age categories <19 and 20-24 years of age unlike group 2 in which 20% of them were in these categories. Women in group 2 were significantly more likely to hold a degree or equivalent, they and their partner to be in paid employment and not in receipt of state benefits. For example, over 35% of them had a degree or equivalent compared to 5%. Similarly 80% of them were in paid employment compared to 54% of group 1 and 82% of them did not receive any state benefits compared to 47% for group 1.

Table 45. Socio-demographic characteristics of group 1 (*n*=174) and group 2 (*n*=76)

	Group 1 %	Group 2 %	*P* value
Maternal age category			*0.0001*
<19	16.8	2.7	
20-24	32.4	12.3	
25-34	35.8	60.3	
>34	15.0	24.7	
Educational attainment			*0.0001*
21 or over years	5.2	35.5	
14-20 years	59.2	64.5	
Other∞	35.6	0.0	
Maternal employment			*0.0001*
Working	53.8	80.2	
Unemployed	21.8	5.3	
Economically inactive*	27.0	14.5	
Receipt of benefits			*0.0001*
Working Families Tax Credit	22.4	23.5	
Income Support	20.7	1.3	
Job-Seekers Allowance	9.8	1.3	
None	47.1	73.9	

[a] Chi-square test
∞No formal educational qualification or not yet finished
*includes: students, looking after the house or disable

Behavioural Characteristics

Table 46 shows some of the behavioural characteristics of group 1 and group 2. Participants in group 1 were significantly less likely to be non-smokers, to have planned their pregnancies or to have taken preconceptional vitamin and or mineral supplements and postconceptional folic acid. For example, 37% of the participants in group 1 were smokers compared with 9% in group 2.

Table 46. Behavioural characteristics of group 1 (*n*=174) and group 2 (*n*=76)

		Group 1 %	Group 2 %	*P* value
Self-reported smoking status				*0.0001*
	Non-smoker	63.2	90.8	
	Current smoker	36.8	9.2	
Pregnancy Planning				*0.0001*
	Yes	51.7	82.9	
	No	48.3	17.1	
Preconceptional supplement usage				*0.0001*
	Yes*	14.4	53.9	
	No	85.6	46.1	
Postconceptional folic acid supplements				*0.010*
	Yes	89.1	98.7	
	No	10.9	1.3	

[a] Chi-square test
*Percentage of participants taken supplements of folic acid alone is unknown.

6.5.2 Mean energy, macro- and micronutrient intakes of women living in the 40% of most deprived wards and other wards within Sheffield

In tables 47 and 48 data are presented on the estimated intakes of energy, macronutrients and micronutrients. Mean, SD and CI of the nutrients are provided. Significance was assessed using likelihood ratio statistics at the 95% level.

A comparison of the mean nutrient intakes of those participants living in the most deprived wards to those living in the rest of the city suggested significant differences for some of the nutrients. The diet of pregnant women living in the most deprived electoral wards was characterised by lower intakes of total fat, saturated fat, *Englyst* fibre, calcium, iron, and 11 of the 14 vitamins examined including folate and vitamin C. Group 2 had higher intakes of carbohydrate, magnesium, and thiamine and most of the minerals and vitamins assessed (not all data are shown).

For example, mean iron daily intakes were statistically significant different. Women in group 1 it was 9.7mg compared to 11.2mg for women in group 2 (P=0.004). In addition, women in deprived electoral wards had significantly lower mean daily intakes of folate (P=0.0001) and vitamin C (P=0.04) than those in non deprived wards. Finally, mean daily intake of calcium for those living in the 40% most deprived electoral was 676mg compared to 729mg for women in the rest of electoral wards but this difference was not statistically significant different (P=0.08).

Table 47. Mean (SD) nutrient intakes and mean differences and 95% CI of the difference in daily macronutrient intakes of women living in the 40% most deprived groups (n=174) and other wards (n=76) within Sheffield based on the FFQs

		40% most deprived wards ±SD	Other wards ± SD	Mean Difference	95% CI	*P*-value
Energy	(Kcal)	1872 ±546	1898±461	-26	-167, 115	0.717
Protein	(g)	76±25	70±19	6.0	-0.46, 12	0.069
Total Fat	(g)	82±28	86±27	-3.6	-11, 3.9	0.344
Carbohydrate	(g)	212±66	222±51	-7.3	-24, 9.5	0.395
Saturated fat	(g)	27±10	33±12	-5.4	-8.6, -2.1	0.001*
Englyst fibre	(g)	12±4.58	14 ±4.5	-2.5	-3.7, -1.2	0.0001*
Alcohol	(g)	2.4±6.6	0.14±0.13	2.3	0.8, 3.8	0.0001*

a Independent sample *t*-test for equality of means
*Difference is significant

Table 48. Mean (SD) nutrient intakes and mean differences and 95% CI of the difference in daily mineral and vitamin intakes of women living in the 40% most deprived groups (n=174) and other wards (n=76) within Sheffield based on the FFQs

		40% most deprived wards ±SD	Other wards ± SD	Mean Difference	95% CI	*P*-value
Calcium	(mg)	676±222	729±221	-54	-113, 6.5	0.080
Magnesium	(mg)	213±69	236±63	-23	-41, -4.59	0.014*
Iron	(mg)	9.7±3.8	11±3.5	-1.5	-2.4, -0.48	0.004*
Vitamin D	(μg)	2.6±1.7	2.6±1.4	-0.09	-0.53, 0.35	0.698
Thiamine	(mg)	1.1±0.44	1.4±0.39	-0.32	-0.43, -0.20	0.0001*
Riboflavin	(mg)	0.96±0.41	1.3±0.43	-0.40	-0.51, -0.28	0.0001*
Vitamin B_6	(mg)	1.7±0.62	2.0±0.55	-0.29	-0.04, -0.12	0.001*
Vitamin B_{12}	(μg)	4.9±2.7	3.5±1.5	1.48	0.94, 2.01	0.0001*
Folate	(μg)	193±71	230±64	-37	-56, -18	0.000*
Vitamin C	(mg)	65±36	73±28.4	-8.6	-17, -0.18	0.045*

[a] Independent sample *t*-test for equality of means
*Difference is significant

6.5.3 Types of foods and drinks consumed by the two groups

In the following section the types and the frequencies of consumption of the food items included in the FFQ are provided for the two groups. Variations in the number of portions of fruit and vegetables per a day consumed by the participants in the two groups and the proportion that met the 5 a day target existed. For example, women living in the 40% most deprived electoral wards consumed an average of 1.5 portions of fruit and vegetables a day compared with 2 by women in the rest of the city wards, but the difference was not statistically different (P=0.149). About 25% of women in group 1 had eaten 1 portion per a day compared with 15% during the recall period. In contrast, nearly 10% of the women in group 2 consumed five or more portions of fruits and vegetables per a day compared to 5% during the recall period.

Participants in group 1 were more frequent consumers of sausages and burgers, meat pies, pizza, crisps, chips, take-away chips, baked beans, diluted drinks and fruit juices and chocolate bars. On the other hand, they were less frequent consumers of chicken and turkey dishes, rice, boiled, roast potatoes, cabbage and other green leafy vegetables, other green vegetables, carrots and other root vegetables, salad and fruits. For some of the above food items statistically significant differences in frequencies of consumption were observed e.g. chips and for some were not e.g. salad, fruits.

Table 49 presents the main statistical differences in the eating behaviour of the participants in group 1 and group 2. White bread was consumed by a higher proportion of women in group 1. It was consumed by 83% of the participants in group 1 compared to 62% of the participants in group 2. In addition, women in deprived wards were more likely than women in non deprived wards to have consumed full fat milk, 40% and 5%.

Table 49. Main statistical significant differences in the eating behaviour of respondents in women living in the 40% most deprived groups (n=174) and other wards (n=76) within Sheffield

Food items	40% most deprived wards	Other wards	*P*
Sausages	∞		0.021
White Fish		∞	0.002
Other fish i.e. tuna		∞	0.002
Soya meat		∞	0.030
Quorn		∞	0.036
Chips i.e. oven, homemade, fries	∞		0.003
Baked beans		∞	0.011
Peas, sweet corn, broad beans		∞	0.001
Other green vegetables i.e. leeks		∞	0.000
Carrots		∞	0.046
Other root vegetables i.e. parsnip		∞	0.000
Cakes or buns		∞	0.026
Chocolate i.e. milk chocolate		∞	0.026
White bread	∞		0.001
Full fat milk	∞		0.000
Soft drinks	∞		0.001
Beer or lager	∞		0.033

∞Food items statistically more likely to be consumed by indicated group

6.5.4 Relationship to the RNI and to mean nutrient intakes of studies performed during pregnancy

Where appropriate, mean intakes of the participants were related to the RNI (COMA 1991) and to the ALSPAC (Rogers *et al* 1998b) and Mathews study (Mathews and Neil 1998). Table 50 shows the estimated mean intakes and percentage of the participants below RNI. No differences observed in the proportion of women in both groups who had mean daily energy intakes below RNI. A lower proportion of women from deprived wards met the RNI for calcium and iron, 42% and 11%, respectively than women in non-deprived wards, 54% and 17%. Additionally, 64% of women in group 1 met the RNI for vitamin C compared to 80% of women in group 2.

Table 50. Mean intakes and percentage of women meeting the RNI [a] amongst the two groups

	40% most deprived wards	Other wards	RNI
Energy (Kcal) [b]	1872	1898	1940 [*]
% met the RNI	*40*	*41*	
Calcium (mg)	676	729	700
% met the RNI	*42*	*54*	
Iron (mg)	9.7	11	14.8
% met the RNI	*11*	*17*	
Vitamin C (mg)	65	73	40 [§]
% met the RNI	*64*	*80*	

[a] The RNI shown in the table is the figure for women aged 19-50 with the addition where appropriate of an increment for pregnancy
[b] for last trimester only
[*] +200 Kcal/day (last trimester only)
[†] +0.3mg/d
[§] +10μg/d

Table 51 presents data for the Sheffield sample and average daily intakes of energy, macro- and micronutrients from the ALSPAC and the Mathews studies. Overall, Sheffield groups had similar mean daily intakes of energy and macro-nutrient intakes to the comparison studies. Mean daily intakes of calcium for group 1 and group 2 were lower than the other studies. Group 1 have had the lowest intakes in contrast to the other samples. Women in the non-deprived electoral wards of Sheffield had the highest daily iron intakes compared to group 1, the ALSPAC and the Mathews population. For all vitamins presented, mean daily intakes were lower for the Sheffield samples, 194μg and 231μg compared to 250μg and 242μg for the ALSPAC and Mathews population correspondingly.

Table 51. Approximate daily energy, macronutrient and micronutrient mean intakes based on the FFQ of women living in the 40% most deprived wards (n=174) and other wards (n=76) within Sheffield to the results from the ALSPAC and the Mathews study

		40% most deprived wards	Other wards	ALSPAC	Mathews
Energy	(MJ)	7.7	7.8	7.7	8.5
Protein	(g)	76	70	66	73
Total Fat	(g)	82	85	70	85.7
Carbohydrate	(g)	216	223	-	256
Alcohol	(g)	2.4	0.1	-	1.5
Calcium	(mg)	676	730	953	922
Iron	(mg)	9.7	11.2	10	10
Thiamine	(mg)	1.1	1.4	1.4	1.5
Riboflavin	(mg)	0.9	1.3	1.7	1.7
Folate	(μg)	194	231	250	242
Vitamin C	(mg)	65	73	80	83

Chapter 7

7. Preliminary exploration of approaches used for the identification of foods items which contribute most to between-subject variation and to distinct dietary patterns of the low income group

7.1 General Overview

The aim of this chapter is to explore possible applications of data obtained from FFQs for the low income group (n=174). Stepwise multiple regression analysis was used for identification of the items included in the FFQ which contributed most to between-subject variation in the whole sample of low income pregnant women. Therefore, in the first section of the chapter the results of the regression analysis for the sample are described.

The second section of the chapter, presents the estimated mean nutrient intakes for each selected key nutrient i.e. calcium, iron, folate and vitamin C by their tertile distribution (lower and upper). Also, the major food sources of the nutrients of interest by tertile distribution (lower and upper) are presented. Finally, the results of the discriminant analysis used for the identification of food items, which best discriminate opposite dietary patterns by tertile of nutrients of interest distribution (lower and upper) are also presented.

7.2 Under reporting and energy-adjustment

Estimation of the number of under reporters was undertaken using the methodology described in section 4.8.3.1. At table 52, the percentage of under reporters in each tertile (lower and upper) by energy distribution is shown. The percentage of participants who reported mean energy intakes significantly lower than the estimated total energy expenditure at the lower tertile was 82%. In the upper tertile percentage under reporting was 7%, significantly lower than the percentage of under reporting in the lower tertile (P=0.0001).

Table 52. Percentage of under reporting and valid reporting

Tertile	Under reporting %	Valid reporting %
Lower	82.0	18.0
Upper	6.9	93.1

Because of the high proportion of under reporters, nutrient intakes of the individuals were adjusted for energy intake using the nutrient residual method described at section 4.8.3.1. Therefore, results of the analysis presented at this chapter are based on data which were firstly energy-adjusted and then statistically analysed.

7.3 Stepwise multiple regression analysis

Stepwise regression analysis was used for the identification of the food items included in the questionnaire, which contribute most to the between-subject variation. As already explained at section 4.8.3.2, firstly the contribution of each food item of the FFQ to one of the four nutrients of interest for the whole sample of low income women was calculated. Secondly, the food items of the four nutrients were ranked according to their percent contribution to the average nutrient consumption and finally, the first 20 food sources contributing most to the mean intakes of the selected nutrients were entered into the stepwise regression analysis.

7.3.1 Major food sources

The following tables (53 and 54) present the first twenty sources contributing most to the total calcium, iron, folate and vitamin C intakes for the whole sample. The major food sources for calcium intake included; milk (total) followed by white fish, pasta, pizza and cheese (table 53). For iron intakes the major food sources included bread, wholegrain cereals, other breakfast cereals, oat cereals and poultry (table 53).

Table 53. Top 20 sources contributing to calcium and iron mean intakes for the low income sample (n=174)

Nutrient-Calcium	%	Nutrient-Iron	%
Milk (total)	**23.25**	**Bread (total)**	**13.42**
Cheese	**21.74**	**Wholegrain cereals**	**11.59**
Pizza	**8.36**	**Other breakfast cereals**	**9.82**
Pasta	**4.39**	**Oat cereals**	**7.57**
White fish	**4.28**	**Poultry**	**6.87**
Puddings	3.87	Crisps	3.95
Eggs	3.14	Chips (homemade, fries, oven)	3.40
Oat cereals	2.25	Pizza	3.11
Quiche	1.90	Boiled, mashed or jacket pots	2.84
Fruits	1.83	Pasta	2.82
Pies	1.66	Baked beans	2.81
Choclate	1.52	Roast pots	2.42
Crisps	1.50	Pudding	2.20
Chips (homemade, fries, oven)	1.48	Chips from fish&chip shop	2.17
Other fish	1.37	Pies	1.98
Boiled, mashed or jacket pots	1.36	Peas, sweet corn and broad beans	1.98
Cakes	1.32	Eggs	1.96
Carrots	1.28	Meat	1.89
Cabbage and other green leafy vegs	1.13	Biscuits	1.66
Fruit juice	1.10	White fish	1.53

Other breakfast cereals, bread, boiled, mashed or jacket potatoes, wholegrain cereals, and cabbage and other green vegetables were the highest contributors to mean folate intakes (table 54). Fruit juice was the most important contributor to vitamin C intake, followed by fruits, cabbage and other green vegetables, crisps and boiled, mashed or jacket potatoes (table 54).

Table 54. Top 20 food sources contributing to folate and vitamin C mean intakes for the low income sample (n=174)

Nutrient-Folate	%	Nutrient-Vitamin C	%
Other breakfast cereals	**15.20**	**Fruit juice**	**23.98**
Bread (total)	**13.08**	**Fruits**	**11.00**
Boiled, mashed or jacket pots	**8.90**	**Cabbage and other green leafy vegs**	**10.83**
Wholegrain cereals	**8.22**	**Crisps**	**7.78**
Cabbage and other green leafy vegs	**7.79**	**Boiled , mashed or jacket pots**	**7.24**
Roast pots	6.05	Chips (homemade, fries, oven)	7.24
Crisps	4.72	Coffee	6.88
Other green vegs	3.29	Sugar	6.37
Fruit	2.98	Carbonated drinks	6.23
Cheese	2.94	Roast pots	3.62
Pizza	2.85	Chips from fish&chip shop	3.02
Chips (homemade, fries, oven)	2.40	Other green vegs	2.93
Carrots	2.14	Carrots	2.53
Peas, sweet corn and broad beans	2.10	Oat cereals	1.83
Meat	1.95	Peas, sweet corn and broad beans	1.80
Salad	1.74	Salad	1.31
Eggs	1.63	Wholegrain cereals	1.13
Pasta	1.61	Pasta	0.22
Oat cereals	1.45	Puddings	0.16
White fish	1.33	Other root vegs	0.12

7.3.2 Between-subject variation

The following tables (55-58) show those food items selected by the stepwise regression analysis contributing most to the between-subject variation of calcium, iron, folate and vitamin C intakes and their percentage contribution to the average nutrient consumption of the sample.

The analysis detected three food items that explained 8% of the variance in calcium intake (table 55). Four percent of the variance in calcium intake in the population was explained by wholegrain cereals, followed by other root vegetables and biscuits. These three food items included in the final model identified as important classifiers of calcium intake explaining 8% of variance were however, minor contributors to total calcium intake (rank 21, 26 and 37 respectively).

Table 55. Food items contributing most to between-person variation of calcium intake and to the total calcium intake

	Contribution to between-subject variation	
Food item	Adj.R^{2} [a]	% [b] (rank [c])
Wholegrain cereals	.041	1 (21)
Other root vegetables	.060	0.3 (37)
Biscuits	.077	0.7 (26)

[a] Adjusted R^2 for the linear regression model
[b] Average percentage contribution to total calcium intake from each food category
[c] the order of contributors to total calcium intake from higher to lower

A total of 9 items explain 33% of the between-person variation in iron intake (table 56). Most variance in iron intake of the sample was explained from the consumption of bread and oat cereals, which explained 20% of the variance. The rest of food items explained between 1% to 3% of the variance. Bread which was good classifier and entered in the first stage to the regression (1) was the most important contributor of total iron intake as well (rank 1). However, peas, sweet corn and broad beans and puddings which were entered at later stages of the regression (3 and 9 respectively) were minor contributors to iron intake (rank 13 and 15, respectively) but still within the top twenty major sources. Except for them, the rest of the food items included in the final model were major contributors to iron intake i.e. wholegrain cereals, entered at fifth stage of the regression and is ranked the second most important contributor to iron intake, other breakfast cereals entered in the 7th stage of the model and was ranked as the third most important contributor to total iron intake.

Table 56. Food items contributing most to between-person variation of iron intake and to the total iron intake

	Contribution to between-subject variation	
Food item	Cum. $R^{2\,a}$	%[b] (rank [c])
Bread	.118	13 (1)
Oat cereals	.195	7.5 (4)
Peas, sweet corn, broad beans	.236	2 (15)
Crisps	.257	4 (6)
Wholegrain cereals	.276	12 (2)
Boiled, mashed, or jacket	.296	3 (9)
Other breakfast cereals	.309	10 (3)
Chips (homemade, fries, oven)	.322	3.4 (7)
Puddings	.335	2 (13)

[a] Cumulative R^2 for the linear regression model
[b] Average percentage contribution to total iron intake from each food category
[c] the order of contributors to total iron intake from higher to lower

A total of six food items explained 36% of the between-person variation in folate intake (table 57). Most variance in folate intake (26%) in the population resulted from the consumption of oat cereals, and crisps. These items were entered at the earlier stages in the regression (1 and 2, respectively). Oat cereals were minor contributors to folate intake, ranked as the 20th contributor and crisps were ranked 7th. For the rest of the nutrients the explained variance ranged from 1% to 4%. In general, except for crisps, the rest of the food items were minor contributor to total folate intake.

Table 57. Food items contributing most to between-person variation of folate intake and to the total folate intake

	Contribution to between-subject variation	
Food item	Cum. $R^{2\,a}$	%[b] (rank [c])
Oat cereals	.143	1.4 (20)
Crisps	.260	5 (7)
Chips (homemade, fries, oven)	.289	2.4 (12)
Meat	.324	2 (15)
Pasta	.354	1.6 (18)
Cheese	.367	3 (10)

[a] Cumulative R^2 for the linear regression model
[b] Average percentage contribution to total folate intake from each food category
[c] the order of contributors to total folate intake from higher to lower

Finally, a total of three food items explained 64% of the between-subject variation in vitamin C intake. Most variance in vitamin C intake (51%) resulted from the consumption of fruit juice. Fruit juice was entered first in the regression model. As can be seen at table 54, fruit juice was the most important contributor to total vitamin C intake (23%, rank 1). Oat cereals were entered second in the regression model, explaining 12% of the variance in the vitamin C intake; however they were not major contributors to total vitamin C intake (rank 14). The last food item which entered the model was fruits which explained 1% of the between-subject variation in vitamin C intake. As seen at table 54 fruits were the second most important contributor to total vitamin C intake.

Table 58. Food items contributing most to between-person variation of vitamin C intake and to the total vitamin C intake

	Contribution to between-subject variation	
Food item	Cum.$R^{2\,a}$	%[b] (rank [c])
Fruit juice	.511	23 (1)
Oat cereals	.631	1.8 (14)
Fruits	.641	11 (2)

[a] Cumulative R^2 for the linear regression model
[b] Average percentage contribution to total vitamin C intake from each food category
[c] the order of contributors to total vitamin C intake from higher to lower

7.4 Tertiles of the distribution for calcium, iron, folate and vitamin C intakes

7.4.1 Estimated energy-adjusted intakes

The 174 low income women identified as living in the 40% most deprived electoral wards within Sheffield using the IMD were allocated into tertiles (thirds) of the distribution for each selected key nutrient i.e. calcium, iron, folate and vitamin C following energy-adjustment. Also, the contribution of each food item of the FFQ for the lower and upper tertile was calculated.

The following tables (59 and 60) present mean±SD energy-adjusted nutrient intakes in the lowest and highest tertiles of calcium, iron, folate and vitamin C. Also, the frequency of consumption of food items identified to be statistically significant different between the lower and upper tertile is presented. In addition, the first 20 food sources contributing most to calcium, iron, folate and vitamin C intakes for the lower and upper tertiles is also described (tables 61 and 62).

Estimated energy-adjusted mean macronutrient intakes between women in the lower tertile to those in the upper tertile were similar as ranked by the nutrient of interest. As expected, by calcium ranking, subjects in the lower tertile had lower intakes for iron, folate and vitamin C and the same trend was observed across the rest of the nutrient ranking.

Table 59. Energy-adjusted mean daily intakes of the low income women classified in the lower (n=58) and upper (n=58) tertile according to calcium and iron intakes

Nutrient	Calcium intakes		Iron intakes	
	Lower	Upper	Lower	Upper
Energy (Kcal)	1805±495	1919±589	1951±474	1874±606
Protein (g)	66±13	84±15	66±13	83±16
Total fat (g)	83±11	82±9.8	81±12	81±9.2
Carbohydrate (g)	221±30	208±29	223±33	211±28
Englyst fibre (g)	11±2.6	12±3.2	10±2.2	13±3.2
Calcium (mg)	510±83	837±100	634±174	706±131
Iron (mg)	9.0±2.3	10±2.6	7.3±1.0	12±1.9
Thiamine (mg)	1.1±.29	1.2±.29	1.0±.16	1.4±.32
Riboflavin (mg)	.83±.31	1.0±.29	.80±.20	1.1±.46
Vitamin B6 (mg)	1.6±.37	1.7±.35	1.5±.24	1.9±.43
Vitamin B12 (µg)	3.7±1.6	5.9±2.7	3.9±1.8	6.2±2.6
Folate (µg)	182±48	206±51	166±34	218±50
Vitamin C (mg)	57±23	71±40	60±29	70±34

Table 60. Energy-adjusted mean daily intakes of the low income women classified in the lower (n=58) and upper (n=58) tertile according to folate and vitamin C intakes

Nutrient	Folate intakes		Vitamin C intakes	
	Lower	Upper	Lower	Upper
Energy (Kcal)	1934±500	1913±625	1849±590	1899±573
Protein (g)	69±13	78±18	73±16	76±17
Total fat (g)	83±11	79±9.7	82±11	80±10
Carbohydrate (g)	223±31	214±32	216±31	220±32
Englyst fibre (g)	10±1.9	13±3.4	10±2.5	13±3.1
Calcium (mg)	623±133	710±164	655±160	698±163
Iron (mg)	8.3±1.8	10±2.6	9.2±2.3	10±2.7
Thiamine (mg)	1.0±.14	1.3±.30	1.1±.27	1.2±.27
Riboflavin (mg)	.84±.21	1.2±.32	.93±.30	1.0±.34
Vitamin B6 (mg)	1.5±.23	2.0±.33	1.6±.34	1.8±.36
Vitamin B12 (µg)	4.2±2.0	5.2±2.6	4.9±2.1	4.9±2.73
Folate (µg)	146±17	249±37	169±36	221±58
Vitamin C (mg)	53±28	80±38	33±9.1	101±27

7.4.2 Frequencies of consumption

Differences in energy-adjusted estimated macronutrient and micronutrient intakes might be explained by the proportion of subjects in the lowest and highest tertiles consuming selected food items. Comparison of the frequencies of consumption of the food items according to calcium distribution indicated that the proportion of women in the lower tertile consumed significantly less frequently chocolate bars (P=0.012), chocolate (P=0.024), milk in tea (P=0.027), and beer (P=0.028) compared to women in the higher tertile.

When frequencies of consumption of the food items according to iron distribution were examined, the results showed that women in the lower tertile consumed significantly less frequently rice (P=0.042), baked beans (P=0.044), sweet corn and broad beans (P=0.0001), cabbage and other green leafy vegetables (P=0.0001), other green vegetables (P=0.0001), other root vegetables (P=0.0001), carrots (P=0.015), oat cereals (P=0.002), soya (P=0.042), brown and wholegrain bread (P=0.0001), low fat or polyunsaturated fat spreads (P=0.041) and milk in tea (P=0.033). Women in the higher tertile consume significantly less frequently chips from fish&chip shop (P=0.033), and carbonated drinks (P=0.045).

Women with low folate intakes by folate distribution consumed significantly less frequently roast potatoes (P=0.023), boiled, mashed or jacket potatoes (P=0.047), crisps (P=0.015), peas, sweet corn and broad beans (P=0.015), cabbage and other green leafy vegetables (P=0.020), other green leafy vegetables (P=0.003), other root vegetables (P=0.006), carrots (P=0.022), oat cereals (P=0.0001), wholegrain cereals (P=0.032), other breakfast cereals (P=0.017) and milk in tea (P=0.033) and significantly more frequently white bread (P=0.0001), chips from fish&chip shop (P=0.027), carbonated drinks (P=0.023) and chips (homemade, fries, oven) (P=0.048).

Finally, women with low vitamin C intakes according to vitamin C ranking were statistically significantly less likely to frequently consume cabbage and other green leafy vegetables (*P*=0.026), other green vegetables (*P*=0.001), carrots (*P*=0.017), fruits (*P*=0.004), fruit juice (*P*=0.0001), and oat cereals (*P*=0.0001) and more likely to consume more frequently white bread (*P*=0.004) and boiled mashed or jacket potatoes (*P*=0.048).

7.4.3 Food sources

The following tables 61-64 present the 20 highest ranked sources of calcium, iron, folate and vitamin C for the lower and upper tertiles by nutrient of interest ranking. Cheese was the highest calcium contributor followed by milk (total), pizza, white fish and pasta in the lower tertile (table 61). The major sources were similar in the upper tertile with very small differences in the position ranking of the food items and the percentage contribution. For example, cheese was the major source of calcium intake for the lower tertile compared to milk (total) for the upper tertile. As shown in the table 62, bread (total) followed by other breakfast cereals, wholegrain cereals, poultry and crisps were the major iron sources in the lower tertile. In the upper tertile bread (total) was followed by wholegrain cereals, oat cereals, other cereals and poultry.

Differences observed in the rank of the major food sources as well as the percentage contribution made from them, were most probably due to differences in frequencies of consumption of these sources. Some of these differences were statistically significant and some not. For example, no statistically significant differences were observed in the consumption of the 6 first major sources of calcium between the women in the lower and upper tertiles. In the case of iron however, differences in the ranking and percentage contribution of some of the food sources e.g. oat cereals and crisps were due to differences in frequencies in consumption. For example, oat cereals were the third most important food source to iron intake for the upper tertile and seventh for the lower tertile. The frequencies of consumption analysis suggested that oat cereals were statistically significantly more often consumed by women in the upper tertile and crisps statistically significantly more often consumed by women in the lower.

Table 61. Major sources and % contribution of the food items to calcium intake by calcium intake distribution

Lower Tertile		Upper Tertile	
Food item	%	Food item	%
Cheese	**22.67**	**Milk (total)**	**21.98**
Milk (total)	**22.27**	**Cheese**	**21.83**
Pizza	**8.73**	**Pizza**	**8.26**
White fish	**4.70**	**Puddings**	**4.15**
Pasta	**4.61**	**Pasta**	**4.06**
Puddings	**4.20**	**White fish**	**3.92**
Eggs	**2.69**	**Eggs**	**3.53**
Quiche	**2.09**	**Oat cereals**	**2.62**
Fruits	**2.00**	**Quiche**	**2.05**
Oat cereals	**1.83**	**Other fish**	**2.01**
Pie	**1.56**	**Pies**	**1.96**
Carrots	**1.46**	**Chocolate**	**1.91**
Wholegrain cereals	**1.42**	**Cakes**	**1.77**
Cabbage, other green leafy vegs	**1.39**	**Crisps**	**1.55**
Crisps	**1.38**	**Fruit**	**1.44**
Chips (homemade, fries, oven)	**1.36**	**Chips (homemade, fries, oven)**	**1.40**
Boiled, mashed or jacket pots	**1.32**	**Boiled, mashed or jacket pots**	**1.29**
Other fish	**1.30**	**Fruit juice**	**1.18**
Cakes	**1.15**	**Mushy pea**	**1.07**

Table 62. Major sources and % contribution of the food items to iron intake by iron intake distribution

Lower Tertile		Upper Tertile	
Food item	%	Food item	%
Bread (total)	14.54	Bread (total)	13.55
Other breakfast cereals	9.37	Wholegrain cereals	12.91
Wholegrain cereals	8.60	Oat cereals	11.92
Poultry	6.53	Other breakfast cereals	9.76
Crisps	6.02	Poultry	6.11
Chips (homemade, fries, oven)	4.47	Baked beans	3.03
Oat cereals	4.43	Chips (homemade, fries, oven)	2.92
Pizza	3.90	Crisps	2.71
Chips from fish&chip shop	3.34	Pizza	2.60
Boiled, mashed or jacket pots	3.07	Pasta	2.45
Roast pots	2.90	Boiled, mashed or jacket pots	2.31
Pasta	2.72	Puddings	2.23
Baked beans	2.40	Meat	1.96
Pies	2.40	Peas, sweet corn, broad beans	2.19
Biscuits	2.24	Eggs	1.91
Puddings	2.06	Pies	1.91
Mushy peas	1.87	Roast pots	1.62
Meat	1.84	White fish	1.43
Eggs	1.82	Mushy peas	1.38
Peas, sweet corn, broad beans	1.75	Biscuits	1.33

Other breakfast cereals were the major sources of folate in the diet of the low tertile by folate ranking followed by bread (total), boiled, mashed or jacket potatoes, crisps and cabbage and other green leafy vegetables (table 63). The only food item which differed for the upper tertile was wholegrain cereals positioned as the third major source of folate. Once again the differences in the ranking positioned were very small with a small variation in the percentage contribution.

The trend observed at the above nutrients i.e. similar ranking position of the food items and small differences in the percentage contribution to total calcium, folate and iron intake differed for vitamin C at least for the food items high in the ranking (table 64). For example fruit juice was the highest vitamin C contributor followed by fruits, cabbage and other green leafy vegetables, coffee and boiled, mashed or jacket potatoes for the upper tertile. For the lower tertile, carbonated drinks were the major source of vitamin C, followed by cabbage and other green leafy vegetables, crisps and chips (homemade, fries, oven).

Similarly to differences observed in the rank of the major food sources as well as the percentage contribution made from them to the calcium and iron intakes, differences were also observed in the rank and the percentage contribution of the major food sources to folate and vitamin C intakes. Consumption variations and statistically significant differences in the frequency of consumption may partly explain these differences. For example, the proportion of women consuming other breakfast cereals was significantly higher for the upper tertile (P=0.017). Other examples include, statistically significant differences in the consumption of wholegrain cereals (P=0.032), crisps (P=0.015) and roast potatoes (P=0.023).

Table 63. Major sources and % contribution of the food items to folate intake by folate intake distribution

Lower Tertile		Upper Tertile	
Food item	%	Food item	%
Other breakfast cereals	13.80	Other breakfast cereals	16.57
Bread (total)	13.54	Bread (total)	13.25
Boiled, mashed or jacket pots	9.68	Wholegrain cereals	9.06
Crisps	7.45	Boiled, mashed or jacket pots	8.76
Cabbage and other green leafy vegs	6.97	Cabbage and other green leafy vegs	8.12
Roast pots	5.76	Roast pots	7.14
Wholegrain cereals	5.17	Other green vegs	3.59
Pizza	3.21	Crisps	2.84
Chips (homemade, fries, oven)	3.18	Fruits	2.74
Cheese	3.15	Oat cereals	2.54
Fruits	3.00	Cheese	2.51
Other green vegs	2.52	Carrots	2.27
Peas, sweet corn, broad beans	2.28	Pizza	2.21
Carrots	2.13	Peas, sweet corn, broad beans	2.06
Meat	2.09	Meat	1.64
Pasta	1.80	Chips (homemade, fries, oven)	1.64
Eggs	1.71	Eggs	1.56
Salad	1.62	Salad	1.55
White fish	1.58	Pasta	1.53
Poultry	1.55	White fish	1.44

And finally, differences in the rank of the food sources and percentage contribution are to a large extent explained by the differences in frequencies of consumption of the major food sources. For example, 60% of the women in the lower tertile did not consume fruit juice at all during the recall period compared to 3% in the upper tertile. On the other hand, carbonated drinks were consumed by 75% of the women on the lower tertile and 15% by the women on the upper tertile of vitamin C intake.

Table 64. Major sources and % contribution of the food items to vitamin C intake by Vitamin C intake distribution

Lower Tertile		Upper Tertile	
Food item	%	Food item	%
Carbonated drinks	**11.21**	**Fruit juice**	**38.14**
Fruit	**10.78**	**Fruits**	**11.05**
Cabbage and other green leafy vegs	**10.73**	**Cabbage and other green leafy vegs**	**9.87**
Chips (homemade, fries, oven)	**10.02**	**Boiled, mashed or jacket pots**	**5.58**
Crisps	**10.02**	**Coffee**	**5.87**
Boiled, mashed or jacket pots	**9.45**	**Sugar**	**5.37**
Coffee	**8.91**	**Chips (homemade, fries, oven)**	**5.04**
Fruit juice	**7.89**	**Crisps**	**4.97**
Sugar	**6.89**	**Oat cereals**	**3.21**
Chips from fish&chip shop	**4.85**	**Other green vegs**	**2.97**
Roast pots	**4.18**	**Roast pots**	**2.70**
Carrots	**2.86**	**Carbonated drinks**	**2.59**
Other green vegs	**2.33**	**Carrots**	**2.24**
Peas, sweet corn, broad beans	**2.18**	**Chips from fish&chip shop**	**1.65**
Salad	**1.75**	**Peas, sweet corn, broad beans**	**1.57**
Wholegrain cereals	**1.35**	**Salad**	**1.00**
Oat cereals	**0.81**	**Wholegrain cereals**	**0.99**
Pasta	**0.24**	**Pasta**	**0.20**
Pies	**0.15**	**Puddings**	**0.15**

7.5 Discriminant analysis

To identify the variables which best predicted differences in calcium, iron, folate and vitamin C intakes between women in the lower and the upper tertile of the distribution for the specified nutrients, discriminant analysis was performed. As already explained (please refer to section 4.8.3.4) statistics are presented as standardised canonical function coefficient and Univariate F ratio. The following tables 65-68 present the results of the discriminant analysis between the two defined tertiles for the nutrient of interest.

The summary table (65) indicates that seven variables entered the final model related to calcium intake. The model explained 38% of the variance in calcium intake between the two tertlies. Variables that were positively associated with calcium intake included; other root vegetables, beer, frequency of wine consumption and biscuits. Variables which entered the model and were negatively associated with calcium intake included; wholegrain cereals, sausage and burgers and cabbage and other green leafy vegetables. However, the variables considered substantive (standardised discriminant function coefficients greater than .30 or less than -.30) were, in order of importance; other root vegetables, beer, frequency of wine consumption and finally consumption of biscuits. As a result the above food items were found to be the items that best distinguish lower mean calcium intakes from higher mean calcium intakes and were the most predictive food items in the FFQ for differences in calcium intake.

Table 65. Summary of interpretative measures for stepwise discriminant function analysis of low income women allocated at the upper (n=58) and lower tertile (n=58) of the distribution according to calcium intake

Food item	Standardised canonical discriminant function coefficient	Univariate F ratio (Sig.)
Other root vegs	.754	1.6 (.195)
Beer	.655	74 (.007*)
Biscuits	.426	4.6 (.033)
Wine frequency of consumption	.412	4.3 (.04)
Carbonated drinks	.352	2.0 (.153)
Wholegrain cereals	-.574	7.6 (.007*)
Sausages, burgers	-.587	0.5 (.441)
Cabbage and other green vegs	-.690	3.8 (.052)

The summary table (66) indicates that nine variables entered the final model. The model explained 63% of the variance in iron intake. The food items positively associated with iron intakes included; cabbage and other green leafy vegetables, bread, other breakfast cereals, peas, sweet corn and broad beans and wholegrain cereals. Variables entered in the model which were negatively associated with iron intakes included; carbonated drinks and sugar, chips from fish&chip shop and roast potatoes. However, taking into account only the variables with discriminant coefficients of .30 or less than -.30, it was suggested that cabbage and other green leafy vegetables, bread, other breakfast cereals, peas, sweet corn and broad beans, carbonated drinks and sugar in order of importance were the most significant. As a result the above food items were found to be the items that best distinguish lower mean iron intakes from higher mean iron intakes and were the most predictive food items in the FFQ for differences in calcium intake.

Table 66. Summary of interpretative measures for stepwise discriminant function analysis of low income women allocated at the upper (n=58) and lower tertile (n=58) of the distribution according to iron intake

Food item	Standardised canonical discriminant function coefficient	Univariate F ratio (Sig.)
Cabbage and other green vegs	.839	87 (0.001*)
Bread	.369	16 (0.001*)
Other breakfast cereals	.324	1.8 (0.175)
Peas, sweet corn, broad beans	.262	15 (0.001*)
Wholegrain cereals	.289	4.1 (0.044)
Chips FC	-.393	7.7 (0.006)
Roast potatoes	-.313	0.2 (0.628)
Carbonated drinks	-.273	13 (0.001*)
Sugar	-.294	3.5 (0.064)

The following summary table (67) describes the eleven variables entered the final model related to folate intake. The model explained 57% of the variance in folate intake. The food items that were positively associated with folate intakes included; oat cereals, bread, milk in cereals, beer, other breakfast cereals, other green leafy vegetables, roast potatoes and boiled, mashed or jacket potatoes. Variables entered the model which were negatively associated with folate intakes were sugar, diluted drinks and chips from fish&chip shop. Only the positively related food items had discriminant coefficients of .30 or less than -.30, and were considered substantive. That is suggesting oat cereals, bread, milk in cereals, beer, other breakfast cereals, other green leafy vegetables, roast potatoes and boiled, mashed or jacket potatoes were the most predictive food items included in the FFQ for differences in folate intakes were found to be the items that best distinguish lower mean folate intakes from higher mean folate intakes.

Table 67. Summary of interpretative measures for stepwise discriminant function analysis of low income women allocated at the upper (n=58) and lower tertile (n=58) of the distribution according to folate intake

Food item	Standardised canonical discriminant function coefficient	Univariate F ratio(Sig.)
Oat cereals	.518	18 (0.001*)
Bread	.428	12 (0.001*)
Milk in cereals	.426	5.2 (0.024*)
Beer	.410	1.4 (0.229)
Other breakfast cereals	.399	6.2 (0.014*)
Other green vegs	.384	15 (0.001*)
Roast potatoes	.383	9.0 (0.003*)
Boiled, mashed or jacket pots	.362	9.3 (0.003*)
Sugar	-.335	5.0 (0.027*)
Dilluted drinks	-.401	0.59 (0.443)
ChipsFC	-.456	9.2 (0.003*)

* Difference statistically significant

Finally, the results of the discriminant analysis suggested that 5 variables were included in the final model related to vitamin C intakes (table 68). This model explained 84% of variance in vitamin C intakes. Food items positively associated to nutrient intakes were fruit juice, oat cereals, and other green leafy vegetables. Food items negatively associated were milk in milky drinks and grams of fat used. These five variables were considered substantive as they all had discriminant coefficients greater than .30 or less than -.30 and were found to be the most predictive food items included in the FFQ for differences in vitamin C intakes the items that best distinguish lower mean vitamin C intakes from higher mean F vitamin C intakes. The food item with the highest discriminant coefficient was fruit juice and with the lowest were grams of fat.

Table 68. Summary of interpretative measures for stepwise discriminant function analysis of low income women allocated at the upper (n=58) and lower tertile (n=58) of the distribution according to vitamin C intake

Food item	Standardised canonical discriminant function coefficient	Univariate F ratio (Sig.)
Fruit juice	.990	176 (0.001*)
Oat cereals	.681	23 (0.001*)
Other green leafy vegetables	.300	17 (0.001*)
Milk in milky drinks	-.252	2.4 (0.316)
Grams of fat on bread	-.275	1.0 (0.121)

* Difference statistically significant

Chapter 8

8. Discussion

This study is the fundamental research for subsequent development of a brief dietary risk assessment tool to be used on low income pregnant women living in Sheffield. The PhD project provided information on the validity of a pre-existing FFQ and the diet of a general population of pregnant women in Sheffield. It is anticipated that the brief dietary assessment tool would be a shorter version of the validated FFQ. Therefore, two multivariate techniques-stepwise regression and discriminant analysis- were used on energy-adjusted data obtained by the FFQ from participants recruited during the validation and the main study defined as low income, in an attempt to provide an insight of the utility of these approaches for future use in the on-going development of the dietary risk assessment tool and possible further understanding of the dietary habits of the studied population.

8.1 Design and methodological issues

In the following section a number of factors that might have had an effect on the data collection and analysis are critically appraised. In relation to the participants' recruitment, the opportunistic design needs to be considered due to the effects of the eligibility criteria and the random sample selection. The findings of the study provide important data on the usual intakes of pregnant women and are based on an appropriate numbers of pregnant women as although the final numbers are smaller than the ALSPAC and Mathews studies (Mathews and Neil 1998; Rogers *et al* 1998b) but they are equal to or relatively higher than those in other studies conducted in pregnant populations in the UK i.e. Rees *et al* (2005).

Self-reporting of eating behaviour is vulnerable to social desirability bias and in particular at some members of sections of the population to whom the dietary guidelines are aimed to e.g. pregnant women. The dietary reporting of our participants might therefore have been exposed to bias due to the setting where the interviews took place as well as by their physiological state. Factors likely to have had an impact on the emotional and psychological status of the pregnant women included the place of interview, the presence of the partner, other family members or friends and their relation to the social desirability factor -a tendency to report foods which are considered socially acceptable or considered to be nutritionally healthier (Willet, 1998). Hebert *et al* (1995) suggested a large bias in reporting of food intakes from data obtained from FFQs due to social desirability bias which was also related to gender i.e. bias was twice as large for women and Johansson *et al* (2001) pointed out that socially desirable foods were not under reported to the same extent as socially undesirable food items data obtained by 10 consecutive 24h recalls.

It is likely that a more comprehensive picture of the accuracy of the FFQ in terms of validity and in general of the diet of the participants might have been achieved either by the use of a more precise dietary method of assessment in terms of absolute intakes, or as reference method, or by obtaining measurements of maternal nutritional status using biochemical markers in relation to dietary intake or as an indicator of intake. Nevertheless, the use of biochemical methods is also associated with considerable problems related to their usability, practicality etc. For instance, food records are considered to be the gold standard of dietary assessment because they provide a more precise estimation of an individual's actual nutrient intake. Large respondent burden, low response rates and the impact on usual food consumption associated with record keeping however, limits their usability in epidemiological studies.

Similarly, biomarkers are usually employed in cases where an objective unbiased measure of nutritional status is needed. The use of biomarkers though is limited in large epidemiological studies due to cost and practicality issues i.e. they require biological specimens, resources and technology for laboratory analysis (Gibney *et al* 2004).

The FFQ is best used to assess the ranking of subjects within a population by their long-term dietary intake rather than providing absolute intakes. Despite its limitations the food frequency method was used in our study and there were several reasons for this decision. To begin with, in chapters 1, 2 and 3, the relative paucity of pregnancy studies in the UK is evident. The ALSPAC (Rogers *et al* 1998b) study however, whose questionnaire was used initially, is the largest scale study conducted in pregnant women (nearly 12,000) in the UK, it provides clear evidence to support the administration and effectiveness of a food frequency method on pregnant population. Secondly, this method is increasingly used in epidemiological studies even though there are concerns related to its use e.g. assessment of mixed dishes and food groupings (Gibney *et al* 2004). The simplicity of the technique, its cost-effectiveness and the low respondent burden however, made it a more sensible and suitable method to use in our study.

When interpreting the findings of this study, especially when relating the findings to the RNIs and other studies using more precise measurements of intakes, concerns related to the suitability of the FFQ in assessing absolute measurements of intakes needs to be considered. As described in earlier chapter (3.2.2), the evidence of the ability of the FFQ to provide reliable estimates of nutrient intakes is debatable with some authors questioning and calling for re-evaluation of the interpretation of the findings from FFQ-based epidemiological studies (Kristal and Potter 2006; Kipnis *et al* 2003; Schaefer *et al* 2000) whilst others argue that the FFQ is a valid method of dietary assessment (Block, 2001; Byers, 2001; Willet, 2001). The concerns of those questioning the ability of the FFQs to provide reliable intakes are mainly related to the fact that FFQ reported values are subject to substantial error which has an impact on the analysis and interpretation nutritional epidemiological studies.

The choice of the 24h recall as a reference method was mainly based on the assumption that the response rate was expected to be much higher compared to other dietary assessment methods (Margetts *et al* 1997) and from research findings suggesting its suitability as a reference method (Cade *et al* 2002) and the relatively good agreement between FFQs and 24h recalls on pregnant population (Wei *et al* 1999; Suitor *et al* 1989). The effects of some of the limitations of this method e.g. reliance on memory, high day-to-day variation might have been decreased by the collection of more than two dietary recalls (Willet, 1998), but time limitation of the research project and possible effects of the progression of the pregnancy on subsequent diet prevented the collection of additional 24h recalls.

When interpreting the results of this study the use of standard portion sizes for the first part of the questionnaire has to be considered. Portion size information was not included which might have led to under- or over-representation of intakes for those women who consumed relatively smaller or larger portions of foods because of the difficulty to accurately judge the frequency of consumption of specific food items. For the second part of the questionnaire (including foods that come with typical units such as slices of bread, cups of tea) specification of portion size as part of the frequency consumption provided further information and clarity.

The nutrient calculation of the FFQ presumes that the participants consume a selection of the foods described by each question but in fact they might only eat one of the items described by each question resulting in a wider range of estimated nutrient intakes. In addition, it is possible that some of the food items likely to be consumed by the participants more than twice a day i.e. fruits, crisps, drinks, were under mapped by the maximum frequency options included in the FFQ "more than once a day" which in terms of nutrient calculation meant: weekly frequency of consumption of a food by the nutrient content of a standard portion multiplied by 14 times (twice a day). It is possible that this inaccuracy has led to an underestimation of the contribution of these items to the estimated daily intake and needs to be taken into consideration especially when referring to consumption of the food items included in the FFQ. Cade *et al* (2002) however, suggested that frequency options of more than once a day tends to lead to gross overestimation for some people.

Finally, the high proportion of under reporters identified following calculation for the purposes of chapter 7 need to be taken into consideration when interpreting the study findings related to the validation of the FFQ and the main study where no control for under reporting was undertaken. Evidence suggests that under reporting could disturb the search for associations especially in cases when systematic under- or over reporting is related to consumption of selected foods and when the degree of biased reporting is unevenly distributed within the population (Johansson *et al* 1998).

8.2 Validation study

8.2.1 Correlation coefficient and quintile agreement

Overestimation of nutrient intakes in FFQ in comparison to 24hr recalls was apparent for most of the nutrients examined. In our study, under reporting of energy intake, over reporting of the frequency of consumption of the food items in the FFQ or under reporting of quantity and frequency of use of foods in the 24h recalls might have resulted in this overestimation.

Published data of validation studies conducted in pregnant populations have reported acceptable agreement for energy and many nutrients between the food frequency and the comparison methods. The correlation coefficient values observed in this study at least for the nutrients of interest i.e. folate (0.29), iron (0.32), vitamin C (0.42) -with the exception of calcium- were similar to those observed in other validation studies evaluating the performance of FFQ in pregnant women; the overall value however, was lower. For instance, Robinson *et al* (1996) reported mean crude correlation coefficient values of 0.36 for folate, 0.26 for iron, and 0.37 for vitamin C. Similarly Erkkola *et al* (2001) reported mean crude correlation coefficient values of 0.32 for folate, 0.30 for iron, and 0.47 for vitamin C. In both cases however, energy-adjustments, significantly improved the correlation values and subsequently the overall mean agreement. On the other hand energy-adjustment on the results reported by Wei *et al* (1999) led to a decrease of the correlation values for the above nutrients from 0.61 to 0.46 for folate, 0.37 to 0.36 for iron and 0.41 to 0.36 for vitamin C intakes, but corrections for random within-person variation in the 24hr recall resulted in increase of the *r* values.

Quintile agreement was also calculated. Quintile agreement provided information on the capacity of the assessment method to rank individuals according to their intakes. The results of the analysis suggested that an average of 59.2% of intakes by the two methods was assigned to the same quintile and 4.7% to the extreme opposite quintile. Classification in the same quintile ranged from 48% for alcohol to 70.7% for *Englyst* fibre and misclassification ranged from 0.8% for alcohol and vitamin C to 9.8% for iodine. Quintile agreement and misclassification assessed in our study was more closely related to the findings of the Finnish study (Erkkola *et al* 2001) which reported quintile agreement of an on average 69% and misclassification of 5%. Results reported by Robinson *et al* (1996) showed lower same quintile agreement in relation to our findings but a similar misclassification range from 4% for riboflavin to 8% for protein and vitamin E intakes. Masson *et al* (2003) suggested percentages of acceptable correct classification and gross misclassification of more than 50% and less than 10% respectively.

The dietary patterns were similar between the two dietary assessment methods but there were some differences between the two methods in the mean contribution made by selected food groups to energy. The Pearson's correlation coefficients showed strong agreement between the two methods and mean *r* value was 0.77. The correlation for foods was stronger than the correlation for nutrients, and that is in line with the results reported by Erkkola *et al* (2001), which reported stronger correlation for foods than nutrients. The strong agreement for foods between the FFQ and the 24h recalls in our study, might suggest that the differences observed in the nutrient intakes is not the result of differences in reporting different foods but differences in consumption of foods recorded by the FFQ. Exceedingly high correlations observed for the food group however, might potentially also reflect issues related to the nutritional software used i.e. different nutritional software based on different versions of UK food tables. Similarly, weak association observed between the two methods for calcium intakes might reflect concerns discussed related to intake under mapping by the maximum frequency options included in the FFQ, which possibly led to an underestimation of calcium intake.

The findings of our study might not necessarily be directly comparable or related to results of other pregnant groups however, as the result of differences in the FFQ length, sample size, population characteristics, stage of pregnancy, use of reference method and days of recording. For example, Erkkola *et al* (2001) used a 181-item FFQ questionnaire and a 5-day food record as reference method for measuring the diet of the mothers in the third trimester of pregnancy. Robinson *et al* (1996) used a 100-item FFQ administered at 15 weeks of pregnancy and used 4-day food diaries as a reference method. Suitor *et al* (1988) used 3 consecutive 24h recalls as a reference method and Wei *et al* (1999) extended the study conducted by Suitor by assessing the validity of the FFQ for 17 additional nutrients using participants who provided at least one 24h recall.

Even in studies where a FFQ was applied in the same population but its validity examined in a wider range of nutrients for a random sub sample of the original population, differences in correlation values were reported (Wei *et al* 1999). We have also, examined and reported intakes and correlation values for a wide range of nutrients which inevitably might have affected the overall mean value and lead to reduced mean agreement. Some of the other validation studies conducted on pregnant women reported agreement for a smaller number of nutrients. For instance Suitor *et al* (1988) reported agreement for 8 nutrients and Wei *et al* (1999) for 25.

It is likely that the agreement between the two methods was affected by under reporting and if adjustments for energy intake were undertaken the observed relationship might have been different. At least this is the case for the majority of the validation studies conducted on pregnant populations where the impact of measurement error seemed less severe after energy-adjustment and resulted in substantial increases of the correlation values (Baer *et al* 2005; Erkkola *et al* 2001; Wei *et al* 1999; Robinson *et al* 1996; Suitor *et al* 1989). Also, there is evidence suggesting that the agreement between the FFQ and the reference method might increase when increasing the number of recording days (Cade *et al* 2002).

Willet *et al* (1997) suggested that validation studies should assess the validity of energy-adjusted nutrients as well as absolute nutrient intakes. Block *et al* (2001) on the other hand, questioned the appropriateness of energy-adjustments in cases where "absolute, unadjusted intakes are important and energy–adjustments is clearly inappropriate, difficult to interpret or too cumbersome for routine use". For micronutrients in particular she stated " I really want to know whether a person's vitamin C intake is 45mg or 95 mg per day. I want to be able to infer to that 45mg/day is low and I do not want to infer that this level is normal or even high, simply because it is high in relation to a very low reported energy intake".

8.2.2 Bland-Altman analysis

We have used the Bland-Altman analysis to assess agreement between the FFQ and the 24-hour recall and to obtain further information that the correlation coefficient itself cannot provide. Agreement assessed by the degree of relative bias (mean difference), the random error (width of LOA) and the dependence of differences on the magnitude of the estimates.

Observed differences were negative for energy, calcium, iron and folate intakes and positive for vitamin C suggesting that participants both underreported vitamin C intakes and over reported intakes for the rest of the nutrients with the FFQ compared to the 24h recall. The size of the mean difference among energy intakes assessed by the FFQ and the 24h recall was relatively higher than the mean differences assessed for the rest of the nutrients, which is also related to an overestimation of energy intake by the FFQ method. Relatively smaller differences were observed for calcium and vitamin C intakes. A study conducted by Matthys *et al* (2004) also suggested relatively large SD of the mean differences for iron and vitamin C intakes assessed by a computerised tool and 11-day estimated dietary intakes.

Differences between the two methods might reflected either consumption of different food groups recorded by the two methods, which is unlikely because the correlation value for food groups was relatively high or differences in the amount of foods consumed which is likely as FFQ tends to over estimate intakes. Also, differences observed in the variance of the two methods might be due to one method having greater within-subject variation that the other, a common concern related to the use of 24h recalls. Not controlling for the effect of misreporting might have had an effect on the results of the Bland-Altman analysis. The methods each come with their own sets of concerns regarding accuracy of measurement and therefore nutrient–specific biases are also due to inherent biases within the method.

Increase in variability was shown by an increase in the scatter of differences as the magnitude of the measurement increased and also, a trend in bias reflected by a tendency for the mean difference to rise or fall with increasing magnitude. We are not aware of any other published study comparing FFQs with 24h recalls in pregnancy. It is difficult to compare the results of the Bland-Altman analysis found in this study with others as the LOA are only estimates of the values which apply to the whole population and a second sample would have given different limits.

Similar trends in the bias though, were observed in other studies which applied the Bland-Altman analysis in their results. For instance Andersen *et al* (2004) and Robinson *et al* (1999) used weighted records as reference method for evaluating the performance of a FFQ. Both studies suggested wide scatter of differences between intakes estimated by the FFQ and the weighed intake record as a result of misreporting and a tendency for under- and/or over reporting to increase with intake.

8.3 Main study

8.3.1 Periconceptional Supplement usage

The DoH (1992) recommends that all women who could become pregnant should continue to be advised to take 400μg folic acid per a day in the form of food supplement prior to conception and up to 12 weeks post-conceptionally. Data from the Health Survey of England (Blake *et al* 2003) provides the most up date information on the use of folic acid supplements prior to and during pregnancy by women of childbearing age. Information on folic acid supplement intake was collected prior to pregnancy from mothers who had planned their pregnancy, who comprised two thirds of the interview sample. Of those mothers who planned a pregnancy over half (55%) reported taking supplements or modifying their diet to increase folate intake.

Examination of the maternal characteristics of the total sample has shown that 61% of the participants reported planning their pregnancy and 26% reported taking periconceptional folic acid supplements. A similar proportion (nearly 70%) of the pregnant women in the ALSPAC study reported planning their pregnancies but periconceptional supplementation was not reported (advice on periconceptional supplementation was not widely followed at that time). The authors pointed out however, that women with unplanned pregnancies were unlikely to be taking supplementation of any kind (Rogers *et al* 1998b). This is in line with the results of our study where periconceptional supplement usage by women with unplanned pregnancies was equally unlikely (5%).

8.3.2 Smoking status

Examination of the behavioural characteristics suggested that around a third of the study participants reported smoking during pregnancy. Women reporting smoking were significantly younger, less educated, unemployed or economically inactive and in receipt of benefits compare to non-smokers. A higher percentage of smokers amongst groups of other pregnant populations were similarly of younger age, less educated (Mathews and Neil 1999), claiming more difficulty in affording food (Rogers *et al* 1998b) and of lower social class (Haste *et al* 1991). These UK studies also suggested that smokers had lower dietary intakes of most micronutrients examined and of dietary fibre (Mathews *et al* 2000; Haste *et al* 1991) in addition to increased consumption of processed type of foods including burgers, pies and pasties, crisps etc (Rogers *et al* 1998a) and less frequent consumption of poultry, fish and fruits and vegetables than non-smokers. Our study did not assess differences in dietary intakes between smokers and non-smokers however, given the fact that a fair proportion of our sample has similar characteristics may be of importance.

8.3.3. Maternal age

Twelve percent of the whole sample was less than 19 years of age. The NDNS of young people aged 4-18years (Gregory and Lowe 2000) suggested that a considerable number of adolescent girls have had low intakes of nutrients including iron, calcium, and a similar trend is suggested by our results. For instance, pregnant adolescents had lower mean intakes of energy and significantly lower mean intakes of protein, calcium, iron, folate and most of the vitamins assessed, but relatively higher sugar and carbohydrate intakes compared to the non-teenage pregnant women. These results are of concern even though based on small number of adolescents, because teenagers already have high nutrient requirements for growth and development and therefore competition for nutrients exists with the developing fetus (COMA, 1991). The observation can be partly explained by differences in food choice by age group i.e. younger age groups appear to have lower nutritional awareness and less positive feelings towards healthier eating behaviour (Conner, 1994).

8.3.4 Nutrient variations by educational attainment and receipt of benefits

Younger participants with no formal educational qualification were less likely to report intake of post-conceptional folic acid supplements. The results also suggested an increase of mean calcium, iron and folate intake by years of education. This trend confirms results of other studies conducted on non-pregnant and pregnant populations. A UK based study conducted by Robinson *et al* (2004) suggested a relation between poor achievement at school and poor dietary quality. In that study, the diet of 6125 non-pregnant women aged 20-34 years was assessed using a FFQ and a single diet score was calculated for each woman using PCA. Educational attainment was the most important factor related to the dietary score. The diet of the women with no formal educational qualification was characterised by low consumption of fruit and vegetables, wholemeal bread, breakfast cereals and yogurt and high consumption of chips, sugar and white bread. Another American study of 2063 pregnant women suggested that better educated women had higher iron intakes and consumed higher percentages of recommended vegetable servings compared to the less educated women (Bodnar and Siega-Riz 2002).

Finally, a very small but statistically significant variation was noted between consumption of fruit and vegetables and households in receipt or not in receipt of state benefits; women living in households in receipt of benefits were less likely to meet the five a day target. The findings of the NDNS, have also suggested differences in portions of fruit and vegetables consumed by participants living in households in receipt of benefits, an average of 1.9 compared to 3.1 portions per day for participants in non-benefit houses (1.5 and 2 in our study respectively) (Henderson *et al* 2002).

When interpreting the above results the ability of the FFQ to provide reliable estimates of nutrient intakes, the small number of participants in subgroup comparisons and the generalisability and comparability of findings due to differences in sample characteristics and size need to be taken into consideration.

8.3.5 Relation of nutrient intakes to other findings

Taking into account methodological and design issues discussed in section 8.1, the following section discusses the findings of our study in terms of nutrient intakes in relation to the NDNS (Henderson *et al* 2002), the ALSPAC and Matthew pregnancy studies (Mathews and Neil 1999; Rogers *et al* 1998b) and the RNIs (COMA, 1991).

In an attempt to draw a relation between the nutrient intakes of our sample to the national average nutrient intakes for non-pregnant women, data were related to the NDNS findings (Henderson *et al* 2002). Sheffield women had relatively higher mean energy intakes, and similar macronutrient intakes. For all minerals (except for sodium and iron) and all vitamins presented however, mean daily intakes were moderately lower in the Sheffield sample. Mathews and Neil (1999) also suggested higher energy and similar macronutrient intakes of their sample to the earlier Dietary and Nutritional Survey of British Adults (Gregory *et al* 1990). More likely differences in the dietary assessment methods used and in the sample sizes reflect these differences between our sample and the NDNS. Both surveys used the dietary record method to assess the diet of the population, which research has shown to be susceptible to common under reporting as nutrient intakes and recorded amount of food reduces with as few as 4 days of recording dietary intake (Gibney *et al* 2004).

In relation to the ALSPAC and Mathews studies, energy and macronutrient intakes were relatively similar between studies- with the exception of energy levels which were comparatively higher for the Sheffield women than those of the ALSPAC pregnancy study. Nutrient intakes for calcium, iron, zinc and all vitamins presented including folate, were lower in the Sheffield women.

The observed differences could possibly suggest that these nutrients are likely to be inadequately supplied in the diet of Sheffield pregnant women compared to other pregnant populations in the UK although factors like differential pregnancy stages which diet was assessed, a large year gap between the studies, different dietary assessment methodology used in the Mathews study, and vastly differing sample sizes and population characteristics should be considered when interpreting the results. For instance, the ability of the FFQ to assess absolute intakes should be considered when relating the findings to those reported by Mathews and Neil (1999) which used a more precise measurement. Also, the ALSPAC study reported that nearly 40% of the participants under recorded their energy intakes and it is likely that under reporting has occurred in our study and possibly disrupt the findings and any associations. Differences also might be reflected by differential frequency or consumption of different food types by the study populations.

The low nutrient values for iron and folate fall within the ranges of previously reported studies. Mean iron and folate intakes were 10.2mg and 204µg respectively, with 13% achieving the RNI of 14.8mg for iron and 8% the RNI of 300µg for folate. Furthermore, 30% of the respondents had iron intakes below the LRNI. The ALSPAC and Mathews studies have reported also daily intakes below the RNI and LRNI for iron and folate. For example, Mathews and Neil (1998) suggested that 83% of the study population did not meet the RNI for iron and 16% the LRNI. Similarly, 83% of the women had mean folate intakes below the RNI.

The low iron and folate intakes should be taken into consideration due to their significant effects on the health of the mother and the infant. For instance, low iron stores are associated with increased risk of maternal anaemia and having a LBW baby. Anaemia during pregnancy could lead to symptoms like breathing difficulties, fatigue, palpitations etc. It also reduces the resistance to infections and is a risk factor of preterm delivery and consequently LBW. Maternal anaemia is also associated with folate deficiency. Extra folate is needed in early pregnancy for the prevention NTDs and in late pregnancy for the prevention of megaloblastic anaemia, which is most likely to occur in late pregnancy or the first weeks after birth and might lead to maternal fatigue, nausea and vomiting (British Nutrition Foundation, 2006).

Studies assessing the nutritional status of pregnant women in the UK using biochemical measurements suggested biochemical deficiencies. For instance, a small scale study of women attending an inner-city antenatal department in the UK, suggested that 9% of the participants had low haemoglobin, 10% low serum ferritin and 34% low thiamine status as assessed by erythrocyte transkelotase activation coefficient (Rees *et al* 2005). These results suggested a lower number of women with biochemical deficiencies than that previously suggested by Doyle *et al* (2001) in women three months after delivering a LBW weight baby; 16% of the participants had low haemoglobin, 50% low serum feritin and 56% had low erythrocyte folate concentration indicating severe deficiency.

The above results emphasize the importance of timely supplementation and nutritional advice. It is estimated that half of all pregnancies in the UK are unplanned which limits the usefulness of folic acid supplements around the time of conception or in early pregnancy in reducing the risk of NTD (Botting, 2001). Folic acid supplements were reported to be taken by 90% of the Sheffield sample following pregnancy confirmation. Seventy-three percent of the mothers participating in the 2000 Infant Feeding Survey reported modification in their diet or folic acid supplement usage in order to increase their folate intake around the time of conception or in early pregnancy (Hamlyn *et al* 2002). Finally, it is worth noting that none of the participants reported taking vitamin D supplements even though their use is recommended for all pregnant women in the UK (Food Standards Agency, 2005). On the other hand, a report of the National Collaborating Centre for Women's and Children's Health recommends that in the absence of evidence of benefit, vitamin D supplementation should not be offered routinely to pregnant women (National Institute for Health and Clinical Excellence, 2003).

Research into the effects of micronutrient supplementation of women who planned a pregnancy and participated in a nutritional intervention program and the influence of nutritional advice in women's nutrient intakes suggested some impact on nutrition knowledge (Anderson *et al* 1995) and little effect on nutrient intakes (Doyle *et al* 2001; Anderson *et al* 1995). The results of a cross-sectional survey of 300 antenatal Irish women suggested that the women may associate folic acid with pregnancy and less with pre-pregnancy as 76% of the participants have heard about folic acid, 16% had taken it before and 51% during pregnancy (McDonnell *et al* 2004). A recent report on folate and disease prevention produced by the UK Scientific Advisory Committee on Nutrition (2006) recommended that mandatory fortification of flour with folic acid in the UK might lead to a reduction of the incidence of NTDs but levels of fortification and form of folate to be used must be considered.

8.3.6 Food types

Evidence suggesting that PCA is a useful discriminatory tool especially when related to lifestyle and socio-demographic characteristics (Crozier *et al* 2006; Balder *et al* 2003). A recent analysis used PCA on dietary data of 12,053 pregnant women in the South-west of England obtained by a FFQ and related its findings to the socio-demographic and lifestyle characteristics of the sample. The analysis revealed 5 district dietary patterns/components including the 'health conscious', the 'processed' and the 'confectionary'. Increased maternal age and education and ethnicity were strongly positive related to the 'health conscious' component and increased parity, single status, unemployment, smoking and increased BMI prior to pregnancy were all negatively associated

(Northstone *et al* 2007). The number of components is largely affected by the sample size; despite that we also have identified two factors often emerging in other studies; the 'processed and confectionary' and 'healthier' which we did unfortunately did not relate to the population characteristics. Should we have done so, we might possibly have gained further understanding of the dietary patterns and food choices of our population.

Crisps, diluted drinks, fruit and biscuits were consumed by the participants more than once and items least consumed included soya, quorn and shellfish. Butter, white bread and skimmed milk were the most commonly consumed fat spread and types of bread and milk. Butter and white bread were also the most commonly consumed fat spreading and type of bread by the participants in the NDNS (Henderson *et al* 2002).

Mean portions of fruit and vegetables consumed by the participants per day was 1.6 compared to 2.9 portions per day for participants in the NDNS (Henderson *et al* 2002). Low rates of fruit and vegetable consumption are associated with increased incidences of cardio-vascular disease and some forms of cancer. The government initiative 'Five a Day' recommends eating at least 5 portions of fruits and vegetables per day and aims to increase fruit and vegetable consumption by raising awareness of the health benefits and by improving access to fruit and vegetables (Food Standards Agency, 2005b).

Fifty percent of the participants in our study reported no consumption of white or oily fish during the recall period and only 30% consumed at least one portion per a week. The DoH (1994), recommended consumption of at least two portions of fish per week, one of which should be oil-rich, for both the general population and for pregnant women or those who are planning to become pregnant. This recommendation is based on the assumption that essential fatty acids and their long-chain derivatives are important structural components of cell membranes and are required for the development of the central nervous system in the fetus.

The possible effects of factors such as social, or emotional influencing food choices needs to be taken into consideration when referring to the dietary patterns and types of food consumed by our participants. A study conducted in the UK by Tuffery and Scriven (2005) investigated self-reported perceived factors affecting the diets of 39 antenatal women participating in a cross-sectional study in the South-west of England in their first and third trimester of pregnancy and 6 months post partum. The authors suggested that key influences on dietary choices changed over the three assessed periods (1st and 2nd trimester and 6 months post partum). For instance, during the first trimester all influences were of physical nature i.e. nausea and food cravings. Social, emotional, environmental and physical influences affected dietary behaviour during the third trimester of pregnancy i.e. restricted income, anxiety, new cooker, heartburn. By six months post partum the dominant factors were of social and environmental nature i.e. changed of lifestyle brought on and demands of parenting a new baby.

An American study suggested that at 28 weeks of gestation psychosocial factors like stress, anxiety influenced the dietary behaviour 134 women taking part in a cross-sectional study. Taste and flavour, time scarcity and convenience food consumption are also related to food choice and acceptance (Carrigan *et al* 2006; Jabs and Devine 2006; Clark, 1998).

8.3.7 Group comparisons

8.3.7.1 Group characteristics

Examination of the socio-demographic and behavioural characteristics of the study participants suggested that women living in deprived electoral wards appeared more likely to have unplanned pregnancies, low education, to be smokers and of younger age, high BMI, and be less frequent users of supplements than those living in the rest of the electoral wards in Sheffield. While interpreting the results of the group comparison, the possible effect of under reporting should be considered given the high proportion of under reporters identified in group 1 (those living in the 40% most deprived electoral wards) following calculation for the purposes of chapter 7.

Research evidence suggests that misreporting of energy is positively associated with increased BMI, employment, low education and social class and smoking (Mattisson *et al* 2005; Stallone *et al* 1997). Also, factors related to current and past dieting and body image appear to have an influence on intentional misreporting (Lara *et al* 2004). The prevalence of underreporting in large nutritional surveys of the general population varies from 18 to 54% of the whole sample to as high as 70% in particular subgroups (MacDiarmid and Blundell 1998). The study conducted by Rogers *et al* (1998*a*) suggested a range of 37 to 44% of under reporting by level of difficulty in affording food.

Women living in deprived electoral wards had significantly higher BMI compared to women living in the rest of electoral wards within Sheffield. BMI in this study was in line with findings suggesting an inverse relationship between increased BMI and socio economic status. Inappropriate maternal weight gain and increased BMI prior to conception are of significant importance due to their adverse association to maternal and infant health. Pregnancy and delivery complications such as hypertensive disorders, gestational diabetes, caesarean sections and prolonged delivery, increased risk of obesity in the long term and increased infant macrosomia and perinatal mortality (Krishnamoorthy *et al* 2006; Yu *et al* 2006; Linné, 2004) are some of the associated risks. Currently in the UK, no national guidelines exist related to the antenatal care of obese women despite the increasing prevalence of obesity in the general and the pregnant population.

A systematic review of available evidence on rates of pre- and periconceptional folic acid supplement usage suggested rates in the range of 0.9 to 50% preconceptionally and 0.5 to 52% periconceptionally (Ray *et al* 2004). Reduced rates were related to low education, young maternal age, unplanned pregnancy, and lack of partner and immigrant status. The Health Survey of England (2002) also suggested differences by maternal age and socioeconomic status in the proportion of women taking action to address folate intakes. In our study, nearly half of the low income women reported planning their pregnancy compared to 83% in the higher income group. Differences were observed in the rates of periconceptional vitamin or mineral supplementation varying from 14 to 54% for the low and the high income group respectively. Smaller differences however, were observed in the rates of the post-conceptional folic acid supplementation. No significant association between financial difficulty and supplement usage was reported by Rogers *et al* (1998a) in a population of pregnant women in the UK.

8.3.7.2 Variation in nutrient intakes

No statistically significant differences were observed for macronutrient intakes between the two groups. On the other hand, statistically significant differences were observed for some minerals and vitamins. Women living in the 40% most deprived electoral wards had significantly lower intakes of fibre, magnesium, iron, thiamine, riboflavin, vitamin B6, vitamin B12, vitamin C and folate than the women living in the rest of Sheffield. The subgroup comparisons reflect the results of a previous pregnancy study (Rogers *et al* 1998a), which identified a relationship between financial difficulties and nutrient intakes. The diet of the pregnant women facing financial hardships was characterised by low protein, vitamin C, iron, magnesium and potassium intakes and by relatively higher calcium and folate intakes.

Although the whole group of Sheffield women showed similar trends in nutrient intakes in comparison with the results from other pregnancy studies, a very different trend emerged for the low-income group. Those living in the 40% most deprived electoral wards had relatively lower intakes of calcium, iron, thiamine, riboflavin, folate and vitamin C than those reported in the ALSPAC and Mathews and Neil, studies. The interpretation of the above findings however, need to take into consideration differences in study methodologies, differential pregnancy stages which diet was assessed, and differing sample sizes and population characteristics.

Employment of stepwise regression analysis on our data suggested that observed differences in nutrient intakes between the two Sheffield groups could be explained by demographic, anthropometric and behavioural characteristics. Results indicated that although the differences in nutrient intakes could partly be explained by whether or not the pregnancy was planned, lower socio-economic status was still a predictor of low maternal dietary intakes. Despite these findings there is a probability that the results of the comparison were confounded by the high proportion of under reporters identified in the low income group. Therefore, any conclusions drawn of the relationship of income to diet need to take into account the above issues.

Analysis on the types of food eaten and their frequency of consumption suggested variations which possibly reflect differences observed in nutrient intakes. Women in deprived electoral wards were more frequent consumers of full-fat milk, white bread, convenience, processed and high sugar and fat content food items and less frequent consumers of poultry, fish , fruit juice and fruits and vegetables. Rogers *et al* (1998b) also suggested unhealthy eating patterns of pregnant women facing financial hardships. Their diet was characterised by increased consumption of sausages, pies, cheese, soft drinks and white bread and less frequent consumption of fish, wholemeal bread, fruit and vegetables.

Variations in eating habits amongst social groups could possibly be explained by evidence reporting key influences on food choices (Beydoum and Wang 2007; Shepherd *et al* 1996). For instance, the results of logistic regression analysis adjusted for age and socioeconomic indicators suggested reporting of unhealthy food habits among those in lower socio-economic positions and in economic difficulties (Lalluka *et al* 2006). Finally, the results of a qualitative exploration of 56 Australian women of different SES conducted by Inglis *et al* (2005) reported the reasons behind the poor dietary behaviours of women of low SES. The authors suggested that a population level variation observed by SES can be affected by a combination individual level, social and environmental factors. At individual level stronger traditional and family dietary practices were associated with low SES. On the other hand, women of higher SES appeared to place greater value on health beliefs and body image when making food choices. At the social level perceived high cost of healthy eating and time constraints due to work commitments, explained poorer dietary behaviour in women of lower SES.

8.4 Identification of food items explaining most of the variance in nutrient intakes of the low income sample and of food items discriminating opposite patterns of nutrient intakes of the targeted nutrients

8.4.1 Under reporting and energy-adjustment

Misreporting of energy has been examined by a number of studies using FFQ (Bedard *et al* 2004; Gnardellis *et al* 1998) and other methods of dietary assessment (Mattisson *et al* 2005; Stallone *et al* 1997) and an influence of bias in self-reported dietary intakes by socioeconomic status has been documented i.e. individuals from lower socioeconomic background tended to under estimate their intake. As discussed earlier, the concerns of those questioning the ability of the FFQs in providing reliable nutrient intakes are mainly related to the fact that FFQ reported values are subject to substantial error which has an impact on the analysis and interpretation of nutritional epidemiological studies, therefore estimation of the number of under reporters for the purposes of the analysis presented in the following sections was undertaken.

Because of the high proportion of under reporters, nutrient intakes of the individuals were adjusted for energy intake using the nutrient residual method. Therefore, findings discussed at sections 8.4.2 and 8.4.3 are based on data which were energy-adjusted and then statistically analysed.

8.4.2 Regression analysis

Within the low income sample, the number of food items necessary to explain variance in calcium, iron, folate and vitamin C intakes was estimated through stepwise regression analysis. No published research findings using regression analysis to assess the food items of the FFQ which contribute most to the between-subject variation on pregnant population were identified by the authors. Therefore interpretation and association of the study results is mainly based on study findings of general adult populations using similar techniques for different purposes i.e. development or shortening of FFQs.

The contribution of food items to the between-subject variation of the nutritional component examined differed in terms of the percentage of variance explained by each model and the number of food items included in the final model. In our study, 3 food items explained 8% of variance in calcium intake, 9 items explain 33% of the between-person variation in iron intakes, 6 food items explained 36% of variation in folate intake and 3 items explained 64% of the variation in vitamin C intake. The results indicated that possibly the number of important food items for the explanation of variance in intake depends on the nutrient under investigation. There are nutrients, whose relatively high variance in intake can be explained by few key food items e.g. vitamin C, whereas others need a more comprehensive list of foods e.g calcium most probably because some nutrients have few major sources in contrast to other nutrients that are provided by a lot of foods.

The number of food items needed to explain variation in nutrition intakes differed in reported data. Byers *et al* (1985) suggested that in order to explain 90 % of variance in intake, 21 items were required for energy, 8 foods were required for vitamin C, 5 foods for vitamin A, 17 for fat, 18 for dietary fibre, and19 for protein. Shai *et al* (2004) suggested that a total of 37 items explained 80% of the variance in energy intake, one item for vitamin A, 30 items for fibre, 20 items for calcium and 11 items explained 80% of the variance in folic acid intake. Mosdol *et al* (2000) reported 31 predictors of energy intake, 7 of vitamin C, 28 for fat and 14 for fibre explaining at least 90 % of variance in nutrient intakes.

Some of the reasons that possibly explain these differences across studies include; different number of food categories and different cut-off points for inclusion of the independent variables in the regression analysis. While in our study we included only the 20 most important contributors and 46 food categories, others included 149 food categories which were included in the model if they contributed at least 0.5% to the energy intake (Mosdol *et al* 2000). The study conducted by Byers *et al* (1985) included 128 and the cut-off point was 1% and the study conducted by Shai *et al* (2004) included 170 food groups and based the inclusion of the food items in the model on the nutrient content and the frequency of intake.

Differences were also observed in the number of major contributors included in the final regression models of the targeted nutrient i.e. minor contributors explained variance in calcium intake but two out of the three food items included in the final vitamin C regression model were also the top two contributors of total vitamin C intake.

These results possibly suggest that for some nutrients high quantitative contributors to a specific nutrient might not necessarily be important determinants of its intake and that R^2 values build up much more rapidly for those nutrients that are highly concentrated in a few foods than those that are dispersed through many foods. Therefore, the selection of the 20 high contributors to the key nutrients might not have been the most appropriate cut-off point for some of the nutrients; these high contributors might have been highly related with each other and the independent variable and failed to provide a model which explains a high proportion of the variation.

The results of the regression analysis on the 20 food items contributing most to total intakes of calcium, iron, folate, and vitamin C provided useful information of the identification of foods that best discriminate amongst a sample however,. A general point from the results is that a number of factors related to the nature of target nutrients to be included needed to be taken into consideration when attempting to identify foods that contribute most to between-subject variation including more careful investigation of identified dietary behaviour and food items as well as the nutrient content of the foods.

8.4.3 Discriminant analysis

Identification of food items discriminating opposite nutrient intakes by tertile distribution of the nutrient of interest i.e. calcium, folate, iron and vitamin C were assessed by the use of the discriminant analysis. To our knowledge, no published research reported findings of the use of the discriminant analysis for the identification of food items, which best discriminate opposite dietary patterns by intake distribution for pregnant women. Therefore findings are related to findings of studies using similar techniques in different populations.

Mean intakes of subjects and percentage contribution of different food items to the intakes of the nutrients of interest for the upper and lower tertile were calculated. While the high contributors for the key nutrient were comparatively similar between the tertiles, a number of differences in the proportion of contribution made by specific food items were observed. In most case these differences in calcium, folate, iron and vitamin C intakes were explained by variation in the frequency of consumption of the major sources.

Analysis of the diet of adult women in six European countries indicated that women in lower quartile of iron intake had also lower consumption of most of the food groups, and that they consumed significantly less breakfast cereals, red meat, poultry, offal, eggs, fruit and vegetables and significantly more white bread, cheese, savoury snacks and sweets compared to those in the highest quartile (Hulshof *et al* 2001). Similarly, the Sheffield women in the lower tertile distribution for iron intake consumed less frequently oat cereals and vegetables and more frequently white bread and carbonated drinks.

An example of the use of discriminant analysis was provided for on data of adult women participated in the second Dutch National Food Consumption Survey (Hulshof *et al* 2001; Hair *et al* 1998). The sample was allocated into the lowest and highest quartiles of iron intake and the findings indicated the food items that were found to be the best predictors for differences in iron intakes among the women.

Potatoes, red meat, sausages, offal, savoury snacks, eggs and total vegetables (discriminant coefficients of greater than .30 or less than -.30) were strong predictors of differences in iron intake among Dutch women. In our study, the results of the discriminant analysis suggested also potatoes and vegetables as strong predictors of low and high iron intakes. Bread, breakfast cereals, milk, cheese, butter, poultry and sweets were also included in the Dutch model, but they were not considered to be important because they did not reach the recommended cut-off point for discriminant coefficient. Similarly in our study, predictors not considered substantive but included in the final model included bread, other breakfast and oat cereals.

8.5 Conclusions

The study assessed the habitual nutrient intakes of a general population of pregnant women living in Sheffield. Firstly a validation study was conducted.

Similarly to findings of other validation studies conducted on pregnant or general adult populations the FFQ tended to overestimate nutrient intakes compared to the 24h recall. The findings also suggested acceptable agreement between the two methods but that was not observed across the whole range of nutrients examined. Correlation coefficient values where similar to non energy-adjusted values reported by other validation studies, the overall mean value was lower and likely to be related to energy misreporting and the wide range of nutrient assessed. Cross classification according to quintiles of intake showed good agreement between the two methods; an average of 59% of intakes by the two methods was assigned to the same quintile and less 5% to the extreme opposite quintile. The agreement for energy intake was poor as suggested by the wide LOA. For the rest of the nutrients of interest the LOA were relatively narrow and in most cases lack of agreement was related to the tendency of the mean difference to rise or fall suggested dietary misreporting.

The results of the dietary assessment of the group and subgroup comparisons suggested similar trends to those from previous studies in the UK that have commonly reported low intakes of iron, calcium, vitamin C and folate lower than recommended in pregnancy. Low nutrient intakes were related to educational attainment as well being in receipt of state benefits and our findings therefore reflect results of other studies suggesting similar possible links. Reported consumption of food items suggested relatively low consumption of fruit and vegetable amongst the general population.

Finally, we explored the applications of two statistical approaches for future use in the development of the dietary risk assessment tool on energy-adjusted data obtained by the low income group. The results of both the regression and the discriminant analyses suggested that for some of the nutrients of interest e.g.

vitamin C, high contributors were also predictors of the variation. In contrast some common food items which were not substantial contributors to the nutrient of interest were nonetheless good predictors of variation e.g. oat cereals and iron intake. Both methods indicated common food items which might be of significant importance in the habitual diet of the low income pregnant women in Sheffield. Application of these methods to consumers only might have provided a clearer picture of the foods contributing more to between-subject variation and of the best predictors of low and high intakes. This however might have resulted in a smaller sample.

8.6 Further research

This study makes an important contribution to the continuing development of a dietary risk assessment tool by providing valuable information of the diet of pregnant women in Sheffield, which will need to be taken into account before planning any dietary or nutritional interventions. The findings of the regression and discriminant analysis provided valuable information about the different aspects related to the nutrients of interest that need to be taken into consideration prior to the development of the dietary risk assessment tool. For instance the results of both analyses for vitamin C have clearly indicated similar food items with increased discriminant power. In other cases i.e. calcium, both analyses failed to provide robust results. In order to evaluate the findings further, several steps will be considered. For instance, it might be necessary to change the number of independent variables to be entered in the regression model or to apply the same techniques to a larger sample. Either way, the findings of both analyses enable us to explore and understand better, some of the issues related to the nutrients of interest and the diet of the sample. Funding has already been secured for further application of the PhD results.

Bibliography

Abrams B, Altman SL and Pickett KE. (2000) Pregnancy weight gain: still controversial. *American Journal of Clinical Nutrition* **71**, 1233S-1241S.

Abrams BF and Laros KR. (1986) Pre-pregnancy weight, weight gain and birth weight. *American Journal of Obstetrics and Gynaecology* **154**, 503-509.

Allen LH. (2000) Anaemia and iron deficiency: effects on pregnancy outcome. *American Journal of Clinical Nutrition* **71**, 1280S-1284S.

Andersen IF, Lande B, Trygg K and Hay G. (2004) Validation of a semi-quantitative food frequency questionnaire used among 2-year-old Norwegian children. *Public Health Nutrition* **7** *(6)*, 754-764.

Anderson AS, Campell DM and Shepherd R. (1995) The influence of dietary advice on nutrient intake during pregnancy. *British Journal of Nutrition* **73**, 163-177.

Bacardi-Gascon M, Gongora SL, Castro-Vzquez BY and Jimenez-Cruz. (2003) Validation of a semi-quantitative food frequency questionnaire to assess folate status. Results discriminate a high-risk group of women residing on the Mexico-US border. *Archives of Medical Research* **34**, 325-330.

Baer HJ, Blum RE, Rockett HRH, Leppert J, Gardner JD, Suitor CW et al. (2005) Use of a food frequency questionnaire in American-Indian and Caucasian pregnant women: a validation study. *BMC Public Health* **5**, 135-144.

Baker AH and Wardle J. (2003) Sex differences in fruit and vegetable intake in older adults. *Appetite* **40**(*3*), 269-275.

Baker D, Taylor H, Henderson J and the ALSPAC study team. (1998) Inequality in infant morbidity: causes and consequences in England in the 1990s. *Journal of Epidemiology and Community Health* **52**, 451-458.

Balder HF, Virtanen M, Brants HAM, Krogh V, Bixon LB, Tan F *et al.* (2003) Common country-specific dietary patterns in four European cohort studies. *Journal of Nutrition* **133**, 4246-4251.

Balke M, Herrick K and Kelly Y. (2003) *Health Survey for England 2002: Maternal and Infant Health*. London. TSO.

Ball L and Kirkham M. (2002) Low birth weight in Sheffield: A review of interventions and their effectiveness. University of Sheffield, School of Nursing and Midwifery.

Bambang S, Spencer NJ, Logan S and Gill L. (2000) Cause-specific perinatal death rates, birth weight and deprivation in the West Midlands, 1991-93. *Child: Care, Health and Development* **26**(*1*), 73-82.

Barker DJP, Osmond C, Simmonds SJ and Wield GA. (1993) The relation of small head circumference and thinness at birth to death from cardiovascular disease in adult life. *British Medical Journal* **306**, 422-426.

Barker DJP, Osmond C, Winter PD and Margetts B. (1989) Weight in infancy and death from ischaemic heart disease. *Lancet* (ii), 577-580.

Bates CJ, Prentice A, and Finch S. (1999) Gender differences in food and nutrient intakes and status indices from the National Diet and Nutrition Survey of people aged 65 years and over. *European Journal of Clinical Nutrition* **53**(*9*), 694-699

Bates CJ, Prentice A, Finch S. Gender differences in food and nutrient intakes and status indices from the National Diet and Nutrition Survey of people aged 65 years and over. *European Journal of Clinical Nutrition* **53**(*9*), 694-9.

Bedard D, Shatenstein B and Nadon S. (2004) Underreporting of energy intake from a self-administered food frequency questionnaire completed by adults in Montreal. *Public Health Nutrition* **7** (*5*), 675-681.

Beydoum MA and Wang Y. (2007) How do socioeconomic status, perceived economic barriers and nutritional benefits affect quality of dietary intake among US adults?. *Eurpoean Journal of Clinical Nutrition* **7** (Epub ahead of print).

Bhakta D, Silva IS, Higgins C, Sevak L, Kassam-Khamis T, Mangtani P et al. (2005) A semi-quantitative food frequency questionnaire is a valid indicator of the usual intake of phytoestrogens by South Asian women in the UK relative to multiple 24-hour recalls and multiple plasma samples. *Journal of Nutrition* **135**, 116-123.

Bingham SA. (2002) Biomarkers in nutritional epidemiology. *Public Health Nutrition* **5** (*6A*), 821-827.

Birkett NJ. (1999) intakes of fruits and vegetables in smoker. *Public Health Nutrition* **2**(*2*), 217-222.

Black RE. (2001) Micronutrients in pregnancy. *British Journal of Nutrition* **85**, (*Suppl* 2), 193-197.

Blake M, Herrick K and Kelly Y. (2003) *Health Survey for England 2002: Maternal and Infant Health*. London: TSO.

Bland JM and Altman DG. (1986) Statistical methods for assessing agreement between two methods of clinical measurements. *Lancet* **1**, 307-10.

Bland JM and Altman DG. (1999) Measuring agreement in method comparison studies. *Statistical Methods in Medical Research* **8**, 135-160.

Block G, Gillespie C, Rosenbaum EH and Jenson C. (2000) A rapid food screener to assess fat and fruit and vegetable intake. *Preventive Medicine* **18** (*4*) 284-288.

Block G. (2001) Invited commentary: another prospective on the food frequency questionnaire. *American Journal of Epidemiology* **154** (*12*), 1103-1104.

Bodnar LM and Siega-Riz AM. (2002) A Diet Quality Index for Pregnancy detects variation in diet and differences by socio-demographic factors. *Public Health Nutrition* **5** (*6*):801-9.

Bongle M, Stuff J, Davis L, Forester I, Strickland E, Casey P et al.(2001) Validity of a telephone-administered 24-hour dietary recall in telephone and non-telephone households in the rural Lower Mississippi Delta Region. *Journal of the American Dietetic Association* **101**(*2*), 216-222.

Botting B. (2001) Trends in neural tube defects. *Health Statistics Quarterly* **10**, 5-12.

British Nutrition Foundation. (2004) *NO9017/A critical review of the psychosocial basis of food choice and identification of tools to effect positive food choice-a summary.* Summary of the main findings of the review commissioned by the Food Standards Agency.

Brown JE, Buzzard M, Jacobs DR, Hannan PJ, Kushi LH, Barosso GM et al. (1996) A food frequency questionnaire can detect pregnancy-related changes in diet. *Journal of the American Dietetic Association* **96**, 262-266.

Brown JE, Murtaugh MA, Jacobs DR and Margellos HC. (2002) Variation in newborn size according to pregnancy weight change by trimester. American Journal of Clinical Nutrition **76**, (*1*)205-209.

Bull J, Mulvihil C and Quigley R. *Prevention of low birth weight: assessing the effectiveness of smoking cessation and nutritional interventions.* Evidence briefing: Health Development Agency July 2003. Available at: www.hda-online.org.uk

Burd Left, Costonas-Hassler TM, Martsolf JT and Kerbeshian J. (2003) Recognition and management of fetal alcohol syndrome. *Neurotoxicology and Teratology* **25**, 681-688.

Byers T. (2001) Food frequency assessment: how bad is good enough?. *American Journal of Epidemiology* **154** (*12*), 1087-1088.

Cade J, Burley V, Warm D, Thompson R and Margetts BM. (2004) Food frequency questionnaires: review of their design, validation and utilisation. *Nutrition Research Reviews* **17**, 5-22.

Cade J, Thompson R, Burley V and Warm D. (2002) Development , validation and utilisation of food frequency questionnaires-a review. *Public Health Nutrition* **5** (*4*), 567-587.

Cade J, Upmeier H, Calvert C, and Greenwood D. (1999) Costs of a healthy diet: analysis from the UK Women's Cohort Study. *Public Health Nutrition* **2**(*4*), 505-512.

Cade JE and Margetts BM. (1991) Relationship between diet and smoking--is the diet of smokers different? *Journal of Epidemiology and Community Health* **45**(*4*), 270-272.

Carrigan M, Szmigin I and Leek S. (2006) Managing routine food choice in UK families: the role of convenience consumption. *Appetite* **27**, 372-383.

Casey PH, Goolsby SLP, Lensing SY, Perloff BP and Bongle ML. (1999) The use of telephone interview methodology to obtain 24-hour recalls. *Journal of the American Dietetic Association* **99**, 1406-1411.

Chen Y, Ahsan H, Parvez F and Howe GR. (2004) Validity of a food frequency questionnaire for a large prospective study in Bangladesh. *British Journal of Nutrition* **92**, 851-859.

Clark JE. (1998) Taste and flavour: their importance in food choice and acceptance. *Proceedings of the Nutrition Society* 157(*4*), 639-643.

COMA. (1991) *Dietary Reference Values for Food Energy and Nutrients for the United Kingdom.* Report of the Panel on Dietary Reference Values, Committee on Medical Aspects of Food and Nutrition Policy. HMSO, London.

Conner M. (1994) Accounting for gender, age and socioeconomic differences in food choice. *Appetite* **23**, 195.

Connor MJ and Whaley SE. (2003) Alcohol use in pregnancy. *Journal of Studies in Alcohol* **64**, 773-783.

Crawley H. (1993) Food Portion Sizes. Ministry of Agriculture, Fisheries and Food. 2nd Edition. London. HMSO.

Crozier SR, Robinson SM, Borland SE, Inskip HM and the SWS Study Group. (2006) Dietary patterns in the Southampton Wome's Survey. *European Journal of Clinical Nutrition* **60**, 1391-1399.

Cummins S, Macintyre S. (2002) "Food deserts"—evidence and assumption in health policy making. *British Medical Journal* **325**, 436-438.

Cummins S, Petticrew M, Sparks L and Findlay A. (2005) Large scale food retail interventions and diet. *British Medical Journal* **330**, 683-684

Curhan GC, Chertow GM, Willet W, Spiegelman D, Colditz GA, Manson JE *et al.* (1996a) Birth weight and adult hypertension and obesity in women. *Circulation* **94**, 1310-1315.

Curhan GC, Willet W, Rimm EB, Spiegelman D, Ascherio A and Stamfer MJ. (1996b) Birth weight and adult hypertension, diabetes mellitus and obesity in US men. *Circulation* **94**, 1310-1315.

Czeizel AE. (2004) The primary prevention of birth defects: Multivitamins or folic acid?. *International Journal of Medical Sciences* **1** (*1*), 50-61.

Darmon N, Ferguson EL. and Briend A. (2002) A cost constraint alone has adverse effects on food selection and nutrient density: an analysis of human diets by linear programming. *Journal of Nutrition* **132**, 3764-3771.

De Viese SR, De Henauw S, De Backer G, Dhont M and Cristophe AB. (2001) Estimation of dietary fat intake of Belgian pregnant women. *Annals of Nutrient and Metabolism* **45**, 273-278.

Department of Health. (1991) *Dietary reference values for food energy and nutrients for the UK: Report of the panel on dietary reference values of the Committee of Medical Aspects on Food Policy.* London HMSO, (Report on health and social subjects; 41).

Department of Health. (1994) Nutritional aspects of cardiovascular disease: Report on Health and Social Subjects 48. Report of the Committee of Medical Aspects on Food Policy. London HMSO.

Department of Health. (2000). Folic Acid and the Prevention of Disease: Report on Health and Social Subjects 50; Report of the Committee of Medical Aspects on Food Policy. The Stationery Office. London.

Department of Health. (2003) *Tackling health inequalities: a programme for action.* London: Department of Health Publications. Available at: www.doh.gov.uk

Dewan N, Brabin B, Wood Left, Dramond S and Cooper C. (2003) The effects of smoking on birth weight for gestational age curves in teenage and adult primigravidae. *Public Health* **117**, 31-35.

Dhawan S. (1995) Birth weight of infants of first generation Asian women in Britain compared with second generation Asian women. *British Medical Journal* **311**, 86-88.

Dibsdall LA, Lambert N, Robbin RF and Frewer LJ. (2003) Low income consumers' attitudes and behaviour towards access, availability and motivation to eat fruit and vegetables. *Public Health Nutrition* **6**(*2*), 159-168.

Donkin AJM, Dowler EA, Stevenson SJ and Turner SA. (2000) Mapping access to food in a deprived area: the development of price and availability indices. *Public Health Nutrition* **3**(*1*), 31–38.

Doran T, Drever F and Whitehead M. (2004) Is there a north-south divide in social class inequalities in health in Great Britain? Cross sectional study using data from the 2001 census. *British Medical Journal* **328** 1043-1045.

Dowler E. (2001) Inequalities in diet and physical activity in Europe. *Public Health Nutrition* **4**(*2B*), 701-709.

Doyle W, Crawford MA, Laurance BM and Drury P. (1982) Dietary survey during pregnancy in a low socioeconomic group. *Human Nutrition: Applied Nutrition* **36A**, 95-106.

Doyle W, Crawford MA, Srivastana A and Costeloe KL. (1999) Interpregnancy nutrition intervention with mothers of low birth weight babies living in an inner-city area: a feasibility stud. *Journal of Human Nutrition and Dietetics* **12**, 517-527.

Doyle W, Crawford MA, Wynn AHA and Wynn SW. (1989) Maternal nutrient intake and birth weight. *Journal of Human Nutrition and Dietetics* **2**, 415-422.

Doyle W, Srivastana A, Crawford MA, Bhatti Right, Brooke Z and Costeloe KL. (2001) Inter-pregnancy folate and iron status of women in an inner-city population. *British Journal of Nutrition* **86**, 81-87.

Eck LH, Klesges LM and klesges RC. (1996) Precision and estimated accuracy of two short-term food frequency questionnaires compared with recalls and records. *Journal of Clinical Epidemiology* **49** (*10*), 1195-1200.

Ehrenberg HM, Dierker L, Milluzi C and Mercer BM. (2003) Low maternal weight, failure to thrive in pregnancy and adverse pregnancy outcomes. *American Journal of Obstetrics and Gynaecology* **189**, 1726-1730.

Erikson JG, Forsen T, Tuomilehto J, Osmond C and Barker DJP. (2001) Early growth and coronary heart disease in later life: longitudinal study. *British Medical Journal* **322**, 949-953.

Errkola M, Karppinen M, Javanainen J, Rasanen L, Knip M and Virtanen SM. (2001) Validity and reproducibility of a food frequency questionnaire for pregnant Finnish women. *American Journal of Epidemiology* **154** (*5*), 466-76.

Expert Group on Vitamins and Minerals. (2003) Safe Upper Levels for Vitamins and Minerals. London, Food Standards Agency.

Fairley L. (2005) Changing patterns of inequality in birth weight and its determinants: a population-based study, Scotland 1980-2000. Paediatric and Perinatal Epidemiology **19**, 342-351.

Food Standards Agency. (2005) When you are pregnant (nutritional advice for pregnant women). Available at
http://www.eatwell.gov.uk

Forsen T, Erikson JG, Tuomilehto J, Teramo K, Osmond C and Barker DJP. (1997) Mother's weight in pregnancy and coronary heart disease in a cohort of Finish women. *British Medical Journal* **315**, 837-840.

Fowles ER. (2002) Comparing pregnant women's nutritional knowledge to their actual dietary intake. *American Journal of Maternal/Child Nursing* **27**(*3*), 171-177.

Frankel S, Elwood P, Sweetnam P, Yanell J, Davey Smith G. (1996) Birth weight, adult risk factors and incidence coronary heart disease: the Caerphilly study. *Public Health* **110**, 139-143.

Fraser AM, Brockert JE and Ward RH. (1995) Association of young maternal age with adverse reproductive outcome. *The New England Journal of Medicine* **332** (*17*), 1113-1117.

Friis S, Kjaer SK, Stripp C and Overvad K. (1997) Reproducibility and relative validity of a self-administered semi quantitative food frequency questionnaire applied to younger women. *Journal of Clinical Epidemiology* **50** (*3*), 303-11.

Food Standards Agency (2007). Low Income Diet and Nutrition Survey. Available at: (http://www.food.gov.uk/science/101717/lidnsbranch/).

Gallobardes B, Davey-Smith G and Lynch J. (2006) Systematic review of the influence of childhood socio-economic circumstances on risk for cardiovascular disease in adulthood. *Annals of Epidemiology* **16**, 91-104.

Gibney MJ, Margetts BM, Kearney JM and Arab L. (2004) *Public Health Nutrition*. 1st edition. London, Blackwell Publishing.

Giddens JB, Krug SK, Tsang RC, Guo S, Miodovnik M and Prada JA. (2000) Pregnant adolescent and adult women have similarly low intakes of selected nutrients. *Journal of the American Dietetic Association* **110**, 1334-1340.

Glynn L, Emmett P, Rogers I, and the ALSPAC Study Team. (2005) Food and nutrient intakes of a population sample of 7-year-old children in the south-west of England in 1999/2000 - what difference does gender make? *Journal of Human Nutrition and Dietetics* **18**(*1*), 7-19.

Gnardelis C, Boulou C and Trichopoulou A. (1998) Magnitude, determinants and impact of under-reporting of energy intake in a cohort study in Greece. *Public Health Nutrition* **1**(*2*), 131-137.

Godfrey K, Robinson S, Barker DJP, Osmond C and Cox V. (1996) Maternal nutrition in early and late pregnancy in relation to placental and fetal growth. *British Medical Journal* **312**, 410-414.

Godfrey KM and Barker DJP. (2001) Fetal programming and health. *Public Health Nutrition* **4** (*2B*), 611-624.

Godfrey KM, Redman CWG, Barker DJP and Osmond C. (1991) The effect of maternal anaemia and iron deficiency on the ratio of fetal weight to placental weight. *British Journal of Obstetrics and Gynaecology* **98**, 886-891.

Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA et al. (1991) Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify underreporting. *European Journal of Clinical Nutrition* **45**, 569-581.

Golding J, Pembry M, Jones R and the ALSPAC Study Team. (2001) ALSPAC- The Avon Longitudinal Study of Parents and Children I. Study methodology. *Paediatric and Perinatal Epidemiology* **15**, 74-78.

Gordon R. (2001) Sheffield and its Electoral Wards- a review of the Index of Multiple Deprivation 2000. Sheffield Health Authority.

Green SM and Watson R. (2005) Nutritional screening and assessment tools for use by nurses: literature review. *Journal of Advanced Nursing* **50** (*1*) 69-83.

Gregory J, Foster K, Tyler H and Wiseman M. (1990) *The Dietary and Nutritional Survey of British Adults.* Office of Population Censuses and Surveys, London: HSMO.

Gregory, J and Lowe S. (2000) *National Diet and Nutrition Survey: young people aged 4 to 18 years. Volume 1: Report of the diet and nutrition survey.* The Stationery Office, London.

Haines PS, Siega-Riz AM and Popkin BM. (1999) The Diet Quality Index revised: a measurement instrument for population. *Journal of the American Dietetic Association* **99**, 697-704.

Hair FJ, Anderson RE, Tatham RL, Black WC. (1998) *Multivariate Data Analysis.* 5th edition. New Jersey: Pearson Prentice Hall.

Hair FJ, Black WC, Babin BJ, Anderson RE and Tatham RL. (2006) *Multivariate Data Analysis.* 6th edition. New Jersey: Pearson Prentice Hall.

Hales CN and Barker DJP. (2001) The thrifty phenotype hypothesis. *British Medical Bulletin* **60**, 5-20.

Hamlyn B, Brooker S, Oleinikova K and Wands S. (2002) *Infant Feeding Survey 2000. A survey conducted on behalf of DH, the Scottish Executive, the National Welsh Assembly for Wales and DHth, Social Services and Public Health Safety in Northern Ireland.* London: TSO, 2002.

Haste FM, Brooke OG, Anderson HR and Bland JM. (1991) The effect of nutritional intake on outcome of pregnancy in smokers and non-smokers. *British Journal of Nutrition* **65**, 347-354.

Haste FM, Brooke OG, Anderson HR, Bland JM, Shaw A, Griffin J and Peacock. (1990) Nutrient intakes during pregnancy: observation on the influence of smoking and social class. *American Journal of Clinical Nutrition* **51**, 29-36.

Hebert JR, Clemow L, Pbert L, Ockene IR and Ockene JK. (1995) *Social desirability bias in dietary self-report may compromise the validity of dietary intake measures.* *International Journal of Epidemiology* **24** (2), 389-398.

Hebert JR and Kabat GC. (1990) Differences in dietary intake associated with smoking status. *European Journal of Clinical Nutrition* **44**(3), 185-193.

Henderson L, Gregory J and Swan G. (2002) *The National Diet and Nutrition Survey: adults aged 19 to 64 years.* National Statistics - Social Survey Division, Medical Research Council, Human Nutrition Research. London HMSO.

Hu FB. (2002) Dietary patterns analysis: a new direction in nutritional epidemiology (Nutrition and metabolism). *Current Opinion in Lipidology 13* (**1**), 3-9.

Hulshof KFAM, Valsta LM, Welten DC and Lowik MRH. (2001) Ananlytical approaches to food-based dietary guidelines in the European setting. *Public Health Nutrition* **4** (*2B*), 667-672.

Hurley KM, Caulfield LE, Sacco LM, Costigan KA and Dipietro JA. (2005) Psychosocial influences in dietary patterns during pregnancy. *Journal of the American Dietetic Association* **105**, 963-966.

Huxley R and Neil A. (2004) Does maternal nutrition in pregnancy and birth weight influence levels of CHD risk factors in adult life?. *British Journal of Nutrition* **91**, 459-468.

Huxley R, Neil A and Collins R. (2002) Unravelling the fetal origin hypothesis: is there really an inverse association between birth weight and subsequent blood pressure? *Lancet* **380**, 659-665.

Huxley RR. (2000) Nausea and vomiting in early pregnancy: its role in placental development. *Obstetrics and Gynaecology* **95**, 779–782.

Inglis V, Ball K and Crawford D. (2005) Why do women of low socioeconomic status have poorer dietary behaviours than women of higher socioeconomic status? A qualitative approach. *Appetite* **45**, 334-343.

Institute of Medicine. (1990) *Nutrition during pregnancy: weight gain and nutritional supplements.* Washington DC: National Academy Press.

Jabs J and Devine CM. (2006) Time scarcity and food choices: and overview. *Appetite* **47**, 196-204.

Jackson AA and Robinson SM. (2001) Dietary guidelines for pregnancy: a review of current evidence. *Public Health Nutrition* **4**(*2B*), 625-630.

Jacobson SW, Chiodo LM, Sokol RJ and Jacobson JL. (2002) Validity of maternal report on alcohol, cocaine and smoking in relation to neurobehavioral outcome. *Paediatrics* **109**, 815-825.

Jain M, Howe GR and Rohan T. (1996) Dietary assessment in epidemiology: comparison of a food frequency and diet history questionnaire with a 7-day food record. *American Journal of Epidemiology* **143** (*9*), 953-960.

Jain M, Rohan TE, Soskolne CL and Kreiger N. (2003) Calibration of the dietary questionnaires for the Canadian Study of Diet, Lifestyle and Health cohort. *Public Health Nutrition* **6** (*1*), 79-86.

Johansson G, Solvoll K, Bjorneboe GE and Drevon C. (1998) Under- and over reporting of energy intake related to weight status and lifestyle in a nationwide sample. *American Journal of Clinical Nutrition* **68**, 266-274.

Johansson G, Wikman A, Ahren AM, Hallmans G and Johansson I. (2001) Underreporting of energy intake in repeated 24-hour recalls related to gender, age, day of interview, educational level, reported food intake, smoking habits and area of living. *Public Health Nutrition* **4** (*4*), 919-927.

Joint Annual Report of the Sheffield PCT Directors of Public Health. *Tackling Health Inequalities in Sheffield* 2003. Available at:
www.sheffield.nhs.uk

Jones M. (2002) The methodology of nutritional screening and assessment tools. *Journal of Human Nutrition and Dietetics* **15** (*1*), 59-71.

Joshipura KJ, Hu FB, Manson OE, Stampfer MJ, Rimm EB, Speizer FE *et al.* (2001) The effect of fruit and vegetable intake on risk for coronary heart disease. *Annals of Internal Medicine* **134**, 1106-1114.

Kant A. (2004) Dietary patterns and health outcomes. *Journal of the American Dietetic Association* **104**, 615-635.

Kant AK and Thompson FE. (1997) Measures of overall diet quality from a food frequency questionnaire: National Health Interview Survey, 1992. *Nutrition Research* **17** (9), 1443-1456.

Kant AK. (1996) indexes of overall diet quality: a review. *Journal of the American Dietetic Association* **96**, 785-791.

Katsouyanni K, Rimm EB, Gnardellis C, Trichopoulos D, Polychronopoulos E and Trichopoulou A. (1997) Reproducibility and relative validity of an extensive semi-quantitative food frequency questionnaire using dietary records and biochemical markers among Greek schoolteachers. *International Journal of Epidemiology* **2**(*1*), S118-S127.

Kennedy ET, Ohls J, Carlson S and Fleming K. (1995) the Healthy Eating Index: design and application. *Journal of the American Dietetic Association* **95**, 1103-1108.

Kesmodel U and Olsen SF. (2001) Self reported intake in pregnancy: comparison between four methods. *Journal of Epidemiology and Community Health* **55**, 738-745.

Kimm SYS. (2004) Fetal origins of adult disease: The Barker hypothesis revisited-2004. *Current Opinion in Endocrinology and Diabetes* **11**, 192-196.

King J C. (2000) Physiology of pregnancy and nutrient metabolism. *American Journal of Clinical Nutrition* **71**(*5*), 1218S-1222S.

Kipnis V, Subar AF, Midthune D, Freedamn LS, Ballard-Barbash R, Troiano RP *et al.* (2003) Structure of dietary measurement error: results of the OPEN biomarker study. *American Journal of Epidemiology* **158**, 14-21.

Kondrup J, Allison SP, Elia M, Vellas B and Plauth M. (2003) ESPEN guidelines for nutrition screening 2002. *Clinical Nutrition* **22** (*4*), 415-421.

Kramer SM, Sequin Left, Lydon J and Goulet L. (2000) Socioeconomic disparities in pregnancy outcome: why do the poor fare so poorly? *Paediatric and Perinatal Epidemiology* **14**, 194-210.

Kramer SM. (1987) Determinants of low birth weight: methodological assessment and meta-analysis. *Bulletin of the World Health Organisation* **65**(*5*), 663-737.

Krishnamoorthy U, Schram CMH and Hill SR. (2006) Maternal obesity in pregnancy: is it time for meaningful research to inform preventive and management strategies? *British Journal of Obstetrics and Gynaecology* **113**, 1134–1140.

Kristal AR and Potter JD. (2006) Not the time to abandon the food frequency questionnaire: counterpoint. *Cancer Epidemiology Biomarkers & Prevention* **15** (*10*), 1759-1760.

Kroke A, Klipstein-Grobusch K, Voss S, Moseneder J, Thielecke F, Noack R and Boeing H. (1999) Validation of a self-administered food frequency questionnaire administered in the European Prospective Investigation into Cancer and Nutrition (EPIC) study: comparison of energy, protein and macronutrient estimated with the doubly labelled water, urinary nitrogen and repeated 24-h recall methods. *American Journal of Clinical Nutrition* **70** (*4*), 439-447.

Lagiou P, Mucci Left, Tamimi R, Kupper H, Lagiou A, Hsieh CC *et al.* (2004) Micronutrient intake during pregnancy in relation to birth size. *European Journal of Nutrition* **491**, 1-8.

Lalluka T, Laaksonen M, Rahkonen O, Roos E and Lahelma E. (2006) Multiple socio-economic circumastnes and healthy food habits. *European Journal of Clinical Nutrition* [Epub ahead of print].

Lang R, Thane CW, Bolton-Smith C and Jebb S. (2003) Consumption of whole-grain foods by British adults: findings from further analysis of two national dietary surveys. *Public Health Nutrition* **6**(*5*), 479-484.

Langley-Evans AJ and Langley-Evans SC. (2003) Relationship between maternal nutrient intakes in early and late pregnancy and infants weight and proportion at birth: prospective cohort study. *The Royal Society for the Promotion of Health* **123** (*4*), 210-216.

Lao TT and Ho LF. (1998) Obstetric outcome of teenage pregnancies. Human Reproduction **13**(*11*), 3228-3232.

Lao TT, Tam KF and Chan LY. (2000) Third trimester iron status and pregnancy outcome in non-anaemic women: pregnancy unfavourably affected by iron excess. *Human Reproduction* **15**(*8*), 1843-1848.

Lapido OA. (2000) Nutrition in pregnancy: mineral and vitamin supplements. *American Journal of Clinical Nutrition* **72**, 280S-290S.

Lara JJ, Scott JA and Lean MEJ. (2004) Intentional mis-reporting of food consumption and its relationship with body mass index and psychological scores in women. *Journal of Human Nutrition and Dietetics* **17**, 209-218.

Laraia BA, Siega-Riz AM, Kaufman JS and Jones SJ. (2004) Proximity of supermarkets is positively associated with diet quality index for pregnancy. *Preventive Medicine* **39**, 869-875.

Lauren L, Jarvellin MR, Elliot P *et al.* (2003) Relationship between birth weight and blood lipid concentrations in life: evidence from the existing literature. *International Journal of Epidemiology* **12**, 862-876.

Law CM and Shiel AW. (1996) Is blood pressure related to birth weight? The strength of evidence from a systematic review of the literature. *Journal of Hypertension* **14**, 935-941.

Lawrence JM, Watkins ML, Chiu V, Erickson D and Petitti DB. (2006) Do racial and ethnic differences in serum folate values exist after food fortification with folic acid? *American Journal of Obstetrics and Gynaecology* **194**, 520-526.

Lennernas M, Fjellstrom C, Becker W, Giachetti I, Schmitt A, Remaut de Winter A, Kearney M. (1997) Influences on food choice perceived to be important by nationally-representative samples of adults in the European Union. *European Journal of Clinical Nutrition* **51** (2), S8-15.

Leon DA, Lithell HO, Vagero D, Koupilova I, Mohsen R, Berglund L *et al.* (1998) Reduced fetal growth rate and increased risk of death from ischaemin heart disease: cohort study of 15000 Swedish men and women born 1915-29. *British Medical Journal* **317**, 241-245.

Little P, Barnett J, Margetts B, Kinmonth AL, Gabbay J, Thompson R et al. (1999) The validity of dietary assessment in general practice. *Journal of Epidemiology and Community Health* **53**, 165-172.

Linné Y. (2004) Effects of obesity on women's reproduction and complications during pregnancy. *Obesity Reviews* **5**, 137–143

Liu S, Stampfer HJ, Hu FB, Giovahnucci E, Rimm E, Manson JE et al. (1999) Whole-grain consumption and risk of coronary heart disease: results from the Nurse's Health Study. *American Journal of Clinical Nutrition* **70**, 412-419.

Lumley, J., Watson, L., Watson, M. & Bower, C. (2001) 'Periconceptional supplementation with folate and/or multivitamins for preventing neural tube defects. Cochrane Database Systemic Review, 3: CDOO1056.

MacDiarmid J and Blundell. (1998) Assessing dietary intake: who, what and why of underreporting. *Nutrition Research Reviews* **11**, 231-253.

Mackenbach JP, Bos V, Andersen O, Cardano M, Costa G, Harding S *et al.* (2003) Widening socioeconomic inequalities in mortality in six Western European countries. *International Journal of Epidemiology* **32**, 830–837.

Mahomed K. Iron and folate supplementation in pregnancy. *The Cochrane Database of Systematic Reviews* 1998, Issue 3. Art. No.: CD001135. DOI: 10.1002/14651858.CD001135.

Mahomed K. Iron supplementation in pregnancy. *The Cochrane Database of Systematic Reviews* 2000, Issue 1. Art. No.: CD000117. DOI: 10.1002/14651858.CD000117.

Margetts B and Michael N. (1997) Design Concepts in Nutritional Epidemiology. 2nd edition. Oxford, Oxford University Press.

Margetts BM and Jackson AA. (1994) Interactions between people's diet and their smoking habits: the dietary and nutritional survey of British adults. *British Medical Journal* **308**(*6935*), 1042-10423.

Margetts BM, Yusof SM, Dallal ZA and Jackson AA. (2002) Persistence of lower birth weight in second generation South Asian babies born in the United Kingdom. *Journal of Epidemiology and Community Health* **56**, 684-687.

Masson LF, McNeill G, Tomany JO, Simpson JA, Peace HS, Wei L, *et al* . (2003) Statistical approaches for assessing the relative validity of a food-frequency questionnaire: use of correlation coefficients and the kappa statistic. *Public Health Nutrition* **6**, 313-321.

Mathews F & Neil HAW. (1998) Nutrient intakes during pregnancy in a cohort of nulliparous women. *Journal of Human Nutrition and Dietetics.* **11**, 151-161.

Mathews F, Yudkin P and Neil A. (1999) Influence of maternal nutrition on outcome of pregnancy: prospective cohort study. *British Medical Journal* **319**, 339-343.

Mathews F, Yudkin P, Smith RF and Neil A. (2000) Nutrient intakes during pregnancy: the influence of smoking status and age. *Journal of Epidemiology and Community Health* **54**, 17-23.

Mattisson I, Wirfalt E, Aronsson CA, Wallstrom P, Sonestedt E et al. (2005) Misreporting of energy: prevalence, characteristics of misreporters and influence on observed risk estimates in the Malmo Diet and Cancer Cohort. *British Journal of Nutrition* **94**, 832-842.

Matthys C, Pynaert I, Roe M, Fairweather-Tait SJ, Heath AL, De Henauw S. (2004) Validity and reproducibility of a computerised tool for assessing the iron, calcium and vitamin C intake of Belgian women. *European Jounral of Clinical Nutrition* **58** (*9*), 1297-305.

Mayer-Davis EJ, Vitolins MZ, Carmichael SL, Hemphil S, Tsaroucha G, Rushing J *et al*. (1999) Validity and reproducibility of a food frequency interview in a multi-cultural epidemiological study. *Annals of Epidemiology* **9**, 314-324.

McCulloch A. (2001) Teenage childbearing in Great Britain and the spatial concentration of poverty households. *Journal of Epidemiology and Community Health* **55**, 16-23.

McDonnell R, Johnson Z, Doyle A, Sayers G. (1999) Determinants of folic acid knowledge and use among antenatal women. *Journal of Public Health Medicine* **21**(*2*), 145-9.

McIntyre L, Glanville NT, Raine KD, Dayle JB, Anderson B and Battaglia N. (2003) Do low income lone mothers compromise their nutrition to feed their children? Canadian Medical Association Journal **168** (*6*), 686-669.

Medical Research Council Vitamin Study Research Group. (1991) Prevention of neural tube defects: results of the Medical Research Council Vitamin Study. *Lancet* **338**, 131-137.

Moore VM, Davies MJ, Wilson KJ, Worsley A and Robinson J. (2004) Dietary composition of pregnant women is related to size of the baby at birth. *Journal of Nutrition* **134**, 1820-1826.

Moran VH. (2007a) A systematic review of dietary assessments of pregnant adolescents in industrialised countries. *British Journal of Nutrition* **97**(*3*), 411-25.

Moran VH. (2007b) Nutritional status in pregnant adolescents: a systematic review of biochemical markers. *Maternal and Child Health Nutrition* **3**(2), 74-93.

Mosdol A, Holmboe-Ottesen G, Bjorge-Loken E, Solvoll K, Johansson L and Thelle DS. (2000) Contribution of food categories to absolute nutrient intake and between-person variation within a representative sample of 2677 Norwegian men and women. *Norsk Epidemiologi* **10** (*1*), 25-30.

Moser K, Li L and Power C. (2003) Social inequalities in low birth weight in England and Wales: trends and implications for future population health. *Journal of Epidemiology and Community Health* **57**, 687-691.

Murcott A. (1998) Food choice, the social sciences and 'The Nation's Diet' Research Programme. *The Nation's Diet. The Social Science of Food Choice.* A. Murcott. Harlow, Addison Wesley Longman: 1-22.

National Children's Home. Going hungry: the struggle to eat healthily on a low income. London; NCH 2004. Available at:
www.nch.org.uk/goinghungry

National Institute for Health and Clinical Excellence, Antenatal Care: Routine Care for the Healthy Pregnant Woman. 2003, RCOG: London.

National Statistics Publication by Defra. (2005) *A report on the 2003-04 Expenditure and Food Survey.* London: The Stationery Office.

Neggers YH, Goldenberg RL, Tamura T. Cliver SP and Hoffman HJ. (1997) The relationship between maternal dietary intake and infant birth weight. *Acta Obstetricia et Gynaecologica Scandinavica* **165** (*76*), 71-75.

Nelson M, Black AE, Morris JA and Cole TJ. (1989) Between- and within-subject variation in nutrient intake from infancy to old age: estimating the number of days required to rank dietary intakes with desired precision. *American Journal of Clinical Nutrition* **50**, 155-167.

Nelson M, Dick and Holmes B (2002) Food budget standards and dietary adequacy in low-income families. *Proceedings of the Nutrition Society* **61**, F569-577.

Newby PK, Hu FB, Rimm EB, Smith-Warner SA, Feskanich D, Sampson Left et al. Reproducibility and validity of the diet quality index revised as assessed by the use of a food frequency questionnaire. *American Journal of Clinical Nutrition* 78, 941-949.

Northstone K, Emmet P and Rogers I. (2007) Dietary patterns in pregnancy in association with socio-demographic and lifestyle factors. *European Journal of Clinical Nutrition* (Epub ahead of print).

Novotny JA, Rumpler WV, Riddick H, Hebert JR, Rhodes DA, Judd JT *et al.* (2003) Personality characteristics as predictors of energy intake on 24-hour dietary recall interviews. *Journal of the American Dietetic Association* **103**, 1146-1151.

Office for National Statistics. *Health Statistics Quarterly and Population Trends.* National Statistics Publication HSMO; London 2002.

Olafsdottir AS, Magnusardottir AR, Thorgeirsdottir, Hauksonn A, Skuladottir GV and Steingrimsdottir L. (2005) Relationship between dietary intake of cod liver oil in early pregnancy and birth weight. *International Journal of Obstetrics and Gynaecology* **122**, 424-429.

Olausson PO, Cnattingius S and Haglund B. (1999) Teenage pregnancies and risk of late fetal death and infant mortality. British *Journal of Obstetrics and Gynaecology* **106**, 116-121.

Oliver G, Wardle J (1999) Perceived effects of stress on food choice. *Physiology and Behaviour* **66**, 511-515.

Olsen SF, Hansen HS, Sorensen JD, Secher MH, Jensen B, Sommer S and Knudsen LB. (1986) Intake of marine fat, rich in (n-3) polyunsaturated fatty acids may increase birth weight by prolonging gestation. *Lancet* **ii**, 367-369.

Olsen SF, Sorensen JD, Secher MH, Henrinsen TB, Hansen HS and Grant A. (1992) Randomised controlled trial of effect of fish oil supplementation on pregnancy duration. *Lancet* **339**, 1003-1007.

Oslen M and hietmann BL. (1996) The validity of a short food frequency questionnaire and its ability to measure changes in food intake: a longitudinal study. *International Joumal of Epidemiology* **25** (*5*) 1023-1029.

Osmond C, Barker DJ, Winter PD, Fall CH and Simmonds SJ. (1993) Early growth and death from cardiovascular disease in women. *British Medical Journal* **307**, (*6918*), 1519-1524.

Owen AL and Owen GM. (1997) Twenty years of WIC: a review of some effects of the programme. *Joumal of the American Dietetic Association* **97**, 777-782.

Painter RC, Roseboom TJ and Bleker OP. (2005) Prenatal exposure to the Dutch famine and disease in later life: an overview. *Reproductive Toxicology* **20**, 345-352.

Pattenden S, Dolk H and Vrijheid M. (1999) Inequalities in low birth weigh: parental social class, area deprivation and "lone mother" status. *Joumal of Epidemiology and Community Health* **53**, 355-358.

Pearson T, Russell J, Campbell MJ and Barker ME. (2005) Do 'food deserts' influence fruit and vegetable consumption?--A cross-sectional study. *Appetite* **45**(*2*), 195-197.

Petrakos G, Panagopoulos P, Koutras I, Kazis A, Panagiotakos D, Economou A *et al.* (2006) A comparison of the dietary and total intake of micronutrients in a group of pregnant Greek women with the Dietary Reference Intakes. *European Joumal of Obstetrics, Gynaecology* and *Reproductive Biology* **127**(2):166-71

Petrou S, Kupek E, Hockley C and Goldacre M. (2006) Social class inequalities in childhood mortality and morbidity in an English population. *Paediatric and Perinatal* Epidemiology **20**, 14-23.

Phillipmore P, Beattie A and Townsend P. (1994) Widening inequality of health in northern England, 1981-91. *British Medical Journal* **308**, 1125-1128.

Picciano MF. (2003) Pregnancy and lactation: physiological adjustments, nutritional requirements and the role of dietary supplements. *Journal of Nutrition* **133**, 1997S-2002S.

Pick ME, Edwards M, Moreau D and Ryan ED. (2005) Assessment of diet quality in pregnant women using the Healthy Eating Index. *Journal of the American Dietetic Association* **105**, 240-246.

Price GM, Paul AA, Cole TJ and Wadsworth MEJ. (1997) Characteristics of the low-energy reporters in a longitudinal national dietary survey. *British Journal of Nutrition* **77**, 833-851.

Pryer JA, Vrijhreid M, Nichols R, Kiggins M and Elliot P. (1997) Who are the low energy reporters in the Dietary and Nutritional Survey of British Adults? *International Journal of Epidemiology* **26** (*1*) 146-154.

Rasch V. (2003) Cigarrette, alcohol and caffeine consumption: risk for spontaneous abortion. *Acta Obstetricia et Gynaecologica Scandinavica* **82**, 182-188.

Ray JG, Singh G and Burrows RF. (2004) Evidence for suboptimal use of periconceptional folic acid supplements globally. *British Journal of Obstetrics and Gynaecology* **111**, 399-408.

Rees G, Brooke Z, Doyle W and Costeloe K. (2005a) The nutritional status of women in the first trimester of pregnancy attending an inner-city antenatal department in the UK. *The Journal of the Royal Society for the Promotion of Health* **125** (*5*), 232-238.

Rees GA, Doyle W, Srivastava A Brooke ZM, Crawford MA and Costeloe K. (2005) The nutrient intakes of mothers of low birth weight babies-a comparison of ethnic groups in East London, UK. *Maternal and Child Nutrition* **1**, 91-99.

Reime B, Ratner PA, Tomaselli-Reime SN, Kelly A, Schuecking BA and Wenzlaff P. (2006) The role of mediating factors in the association between social deprivation and low birth weight in Germany. *Social Science and Medicine* **62** (*7*), 1731-1744.

Richardson A and Stead M. *Births, 1998-99, Sheffield by PCT and ward. Health Informatics Service*. Sheffield 2001.

Rifas-Shiman SL, Willet WC, Lobb R, Kotch J, Dart C and Gillman MW. (2001) PrimeScreen, a brief dietary assessment tool: reproducibility and comparability with both a longer food frequency questionnaire and biomarker. *Public Health Nutrition* **4** (*2*), 249-254.

Robinson SM, Crozier SR, Borland SE, Hammond J, Barker DJ, Inskip HM. (2004) Impact of educational attainment on the quality of young women' diet. *European Journal of Clinical Nutrition* **58** (*8*), 1174-80.

Robinson SM, Godfrey K, Osmond C, Cox V, Barker D. (1996) Evaluation of a food frequency questionnaire used to assess nutrient intakes in pregnant women. *European Journal of Clinical Nutrition* **50**(*5*), 302-8.

Robinson S, Skelton R, Barker M, Wilman C. (1999) Assessing the diet of adolescent girls in the UK. *Public Health Nutrition* **2**(*4*), 571-7.

Rogers I, Emmett P & the ALSPAC Study Team. (1998b) Diet during pregnancy in a population of pregnant women in the South West England. *European Journal of Clinical Nutrition* **52**, 246-250.

Rogers I, Emmett P, Baker D, Golding J & the ALSPAC Study Team. (1998a) Financial difficulties, smoking habits, composition of the diet and birth weight in a population of pregnant women in the South West England. *European Journal of Clinical Nutrition* **52**, 251-260.

Schaefer EJ, Augustin JL, Schaefer MM *et al.* (2000) Lack of efficacy of a food-frequency questionnaire in assessing dietary macronutrient intakes in subjects consuming diets of known composition. *American Journal of Clinical Nutrition* **71**, 746-751.

Schaeffer DM, Coates AO, Caan BJ, Slattery ML and Potter JD. (1997) Performance of a shorterns telephone-administered version of a quantitative food frequency questionnaire. *Annals of Epidemiology* **7**, 463-471.

Scientific Advisory Committee on Nutrition. (2006) *Folate and Disease Prevention*. London: TSO
Available at:
http://www.sacn.gov.uk/reports/#

Schofield C, Steward J and Wheeler E. (1989) The diets of pregnant and post-pregnant women in different social groups in London and Edinburgh: calcium, iron, retinol, ascorbic acid and folic acid. *British Journal of Nutrition* **62**, 363-377.

Schofield WN. (1985) Predicting Basal Metabolic Rate, new standards and review of previous work. *Human Nutrition: Clinical Nutrition* **39C** (1) 5-41.

Scholl TO and Reily T. (2000) Anaemia, iron and pregnancy outcome. *Journal of Nutrition* **130**, 443S-447S.

Sevak L, Mangtani P, McCormack V, Bhakta D, Kasssam-Khamis T and Silva I. (2004) Validation of a food frequency questionnaire to assess macro- and micro-nutrient intake among South Asians in the United Kingdom. *European Journal of Clinical Nutrition* **43**, 160-168.

Shai I, Shahar DR, Vardi H and Fraser D. (2004) Selection of food items for inclusion in a newly developed food frequency questionnaire. *Public Health Nutrition* **7**(6), 745-749.

Shaw M, Gordon D, Dorling D, Mitchell Right and Smith GD. (2000) Increasing mortality differentials by residential area level of poverty: Britain 1981-1997. *Social Science and Medicine* **51**, 151-153.

Sheffield South East Primary Care Trust December. *Strategy for Maternal Health in Sheffield, 2004 – 2010*, 2004.

Shepherd R. (1999) Social determinants of food choice. *Proceedings of the Nutrition Society* **58**(*4*), 807-812.

Shepherd RS, Paisley CM, Sparks P, Aderson AS, Eley S and Lean MEJ. (1996) Constraints on dietary choice: the role of income. *Nutrition and Food Science* **5**, 19-21.

Shohaimi S, Welch A, Bingham S, Luben R, Day N, *et al.* (2004) Residential area deprivation predicts fruit and vegetable consumption independently of individual educational level and occupational social class: a cross sectional population study in the Norfolk cohort of the European Prospective Investigation into Cancer (EPIC-Norfolk). *Journal of Epidemiology and Community Health* **58**, 686-691.

Siega-Riz AM, Bodnar LM and Savitz DA. (2002) What are pregnant women eating? Nutrient and food differences by race. *American Journal of Obstetrics and Gynaecology* **186**, 480-486.

Slavin JL, Jacobs D, Marquet L and Wiemer K. (2001) The role of whole grains in disease prevention. *Journal of the American Dietetic Association* **101**(*7*), 780-785.

Sloggett A and Joshi H. (1994) Higher mortality in deprived areas: community or personal disadvantage? *British Medical Journal* **309**, 1470-1474.

Spencer N, Bambang S, Logan S and Gill L. (1999) Socio-economic status and birth weight: comparison of an area-based measure with Registrar General's social class. *Journal of Epidemiology and Community Health* **53**, 495-498.

Stallone DD, Brunner EJ, Bingham SA and Marmot MG. (1997) Dietary assessment in Whitehall II: The influence of reporting bias on apparent socioeconomic variation in nutrient intakes. *European Journal of Clinical Nutrition* **51**, 815-825.

Stryker WS, Salvini S, Stamfer MJ, Samson L, Colditz GA and Willet W. (1991) Contribution of specific foods to absolute intake and between-person variation of nutrient consumption. *Journal of the American Dietetic Association* **91** *(2)*, 172-178.

Suitor CJ, Gardner J and Willett W. (1989) A comparison of food frequency and diet recall methods in studies of nutrient intake of low-income pregnant women. *Journal of the American Dietetic Association* **89** (*12*), 1786-94.

Susser M. (1991) Maternal weight gain, infant birth weight, and diet: causal sequences. *American Journal of Clinical Nutrition* **53**, 1384-1396.

Svilaas A, Strom EC, Svilaas T, Borgejordet A, Thoresen M and Ose L. (2002) Reproducibility and validity of a short food questionnaire for the assessment of dietary habits. *Nutrition Metabolism and Cardiovascular Disease* **12** (*2*), 60-70.

Swensen AR, Harnack LJ and Ross JA. (2001) Nutritional assessment of pregnant women enrolled in the Special Supplemental Programme for Women, Infants and Children (WIC). *Journal of the American Dietetic Association* **101**, 903-908.

Symonds ME, Budge H and Stephenson T. (2006) Current topic: limitations of models used to examine the influence of nutrition during pregnancy and adult disease. *Archives of Disease in Childhood* **83**, 215-219.

Theobald H. (2003) Oily fish and pregnancy. *Nutrition Bulletin* **28**, 247-251.

Thompson RL, Margetts BM, Speller VM and McVey D. (1999) The Health Education Authority's Health and Lifestyle Survey 1993: who are the low fruit and vegetable consumers? *Journal of Epidemiology and Community Health* **53**, 294-299.

Tinuviel software. *Version 1.0, Q-Builder users' manual*: questionnaire *design and intake analysis system*, 2002.

Tinuviel software. *Version 3.0, WISP users' manual; intake and recipe analysis system,* 2003.

Tuffery O and Scriven A. (2005) Factors influencing antenatal and postnatal diets of primigravid women. *The Journal of the Royal Society for the Promotion of Health* **125** (*5*), 227-231.

Turrel Graft, Blakely T, Patterson C and Oldenburg B. (2004) A multilevel analysis of socioeconomic (small area) differences in household food purchasing behaviour. *Journal of Epidemiology and Community Health* **58**, 208-215.

United Nations Children's Fund and World Health Organization. *Low Birth weight: Country, regional and global estimates.* UNICEF, New York, 2004.

Vyas A, Greenhalgh A, Cade J, Sanghera B, Riste L, Sharma S *et al.* (2003) Nutrient intakes of an adult Pakistani, European and African-Caribbean community in inner city Britain. *Journal of Human Nutrition and Dietetics* **16**, 327-337.

Wallace JM, Luther JS, Milne JS, Aitken RP, Redmer DA, Reynolds LP et al. (2006) Nutritional modulation of adolescent pregnancy outcome-a review. *Placenta* **27**, 61S-68S.

Wallstrom P, Wirfalt E, Janzon L, Mattison I, Elmstahl S, Johanson U *et al.* (2000) Fruit and vegetable consumption in relation to risk factors for cancer: a report from the Malmo Diet and Cancer Study. *Public Health Nutrition* **3**(*3*), 263-271.

Wardle J, Haase AM, Steptoe A, Nillapun M, Jonwutiwes K, and Bellisle F. (2004) Gender differences in food choice, the contribution of health beliefs and dieting. *Annals of Behavioural Medicine* **27**(*2*), 107-116.

Warneke CL, Davis M, De Moor C and Baranoswi T. (2001) A 7-item versus 31-item food frequency questionnaire for measuring fruit, juice and vegetable intake among a predominantly African-American population. *Journal of the American Dietetic Association* **101**, 774-779.

Weerd S, Steegers EAP, Heinen MM, Van de Eertwegh, Vehof RMEJ, Steegeres-Teunissen RPM. (2003) Preconception nutritional intake and lifestyle factors: first results of an exploratory stud. *European Journal of Obstetrics and Gynaecology and Reproductive Biology* **11**, 167-172.

Wei EK, Gardner J, Field AE, Rosner BA, Colditz GA and Suitor CW. (1999) Validity of a food frequency questionnaire in assessing nutrient intakes of low-income pregnant women. *Maternal and Child Health Journal* **3** (*4*), 241-6.

Westenhoefer J. (2005) Age and gender dependent profile of food choice. *Forum of Nutriton* 57, 44-51.

Whichelow MJ, Erzinclioglu SW, and Cox BD. (1991) A comparison of the diets of non-smokers and smokers. *British Journal of Addiction* **86** (*1*), 71-81.

WHO collaborative study. (1995) Maternal anthropometry and pregnancy outcomes. *Bulletin of the World Health Organisation* volume **73**.

Willet W, Sampson L, Stampfer MJ, Rosner B, Bain C, Witschi J *et al.* (1985) Reproducibility and validity of a semi quantitative food frequency questionnaire. *American Journal of Epidemiology* **122** *(1),* 51-65.

Willet W, Howe GR and Kushi LH. (1997) Adjustment for total energy intake in epidemiological studies. *American Journal of Clinical Nutrition* **65**, 1220S-1228S.

Willet W. (1998) *Nutritional Epidemiology.* 2nd edition. New York, Oxford University Press.

Willet W. (2001) Invited commentary: a further look at dietary questionnaire validation. *American Journal of Epidemiology* **154** (*12*), 1100-1102.

Williams S, Forbes J, McIlwaine G and Rosenberg K. (1987) Poverty and teenage pregnancy. *British Medical Journal* **294**, 78-79.

Williamson CS. (2006) Nutrition in pregnancy: Briefing paper. British Nutrition Foundation *Nutrition Bulletin* **31**, 28-59.

Winkvist A, Persson V and Hartini TNS. (2002) Underreporting of energy intake is less common among pregnant women in Indonesia. *Public Health Nutrition* **5** (*4*), 523-529.

Wrieden WL and Symon A. (2003) The development and pilot evaluation of a nutrition education intervention programme for pregnant teenage (food for life). *Journal of Human Nutrition and Dietetics* **16**, 67-71.

Wynn S, Wynn A, Doyle W and Crawfor M. (1994) The association of maternal social class with maternal diet and the dimensions of babies in a population of London women. *Nutrition and Health* **9**, 303-315.

Xu Left, Dibley MJ and D'Este C. (2004) Reliability and validity of a food frequency questionnaire for Chinese post-menopausal women. *Public Health Nutrition* **7** (*1*), 91-98.

Yanek L R, Mou F T, Raqueno J V, and Becker D. (2000) Comparison of the effectiveness of a telephone 24-hour dietary recall method vs an in person method among urban African-American women. *Journal of the American Dietetic Association* **100**(*10*), 1172-1177.

Yu CKH, Teoh TG, Robinson S (2006) Obesity in pregnancy. *British Journal of Obstetrics and Gynaecology* **113**, 1117–1125.

Zondervan KT, Ocke MC, Smit HA and Seidell JC.(1996) Do dietary and supplementary intakes of antioxidants differ with smoking status? *International Journal of Epidemiology* **25**(*1*), 70-79.

Appendices

Appendix I: Publication 1

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Validation of a food-frequency questionnaire for use in pregnancy

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Abstract

Objectives: As a part of an ongoing project to develop a nutritional screening tool, we evaluated the performance of a semi-quantitative food-frequency questionnaire (FFQ) in terms of validity in a Sheffield Caucasian pregnant population using two different statistical approaches – the correlation coefficient and the limits of agreement (LOA). The FFQ was designed specifically for pregnant women and previously used in a large-scale study.

Design: A validation study.

Setting: A community-based field study of a general population of pregnant women booked for their first antenatal appointment at the Jessop Wing, Royal Hallamshire Hospital, Sheffield, UK.

Subjects: One hundred and twenty-three women of different socio-economic status, aged between 17 and 43 years, provided complete dietary data.

Results: The validity of the FFQ was tested against a series of two 24-hour recalls. As expected, the intakes of all examined nutrients, except for iodine, carotene, vitamin E, biotin, vitamin C and alcohol, were higher when determined by the FFQ than when determined by 24-hour recall. Pearson's correlation coefficient between the two methods ranged from 0.19 (added sugar, zinc) to 0.47 (Englyst fibre). The LOA were broader for some of the nutrients, e.g. protein, Southgate fibre and alcohol, and an increasing lack of agreement between the two methods was identified with higher dietary intakes.

Conclusions: The FFQ gave useful estimates of the nutrient intakes of Caucasian pregnant women and appears to be a valid tool for categorising pregnant women according to dietary intake. The FFQ performed well for most nutrients and had acceptable agreement with the 24-hour recall.

Keywords
Food frequency method
Pregnancy
Validation
Diet
Nutritional screening

Pregnancy is a critical period during which good maternal nutrition is a key factor influencing the health of both mother and child. Maternal nutrition prior to and during pregnancy is of known aetiological importance for the risk of low birth weight (LBW) (birth weight less than 2.5 kg). LBW is a major cause of mortality and morbidity; LBW babies are at risk of neurocognitive and motor development problems[1] and may have an increased susceptibility to cardiovascular disease in later life[2,3]. An increased risk of having an LBW baby exists amongst mothers who smoke[4], are of low socio-economic status[5,6], have low pre-pregnancy body mass index (BMI) and/or low gestational weight gain[7]. Poor dietary quality is common among groups of low socio-economic status and several studies have investigated its effect on pregnancy outcome. Various dietary studies of pregnant women have reported dietary differences between different social groups. The results of a study investigating the relationship between financial difficulties and diet showed that difficulty in affording food is associated particularly with lower intakes of protein, fibre, vitamin C, niacin, pyridoxine, iron, zinc, magnesium and potassium[8].

The Dietary and Nutritional Survey of British Adults[9] demonstrated a range of socio-economic differences in dietary intakes. A study conducted by Darmon *et al.*[10] investigated the impact of food budget on food selection patterns and dietary quality. The findings suggested that unhealthy eating patterns and nutritional inadequacy observed in persons of low socio-economic status are the result of economic constraint.

Assessment of nutritional risk is complex because there are very few well-validated nutritional screening instruments available in UK and those available are targeted at, for instance, the elderly, athletes or surgical patients[11–13]. To our knowledge no instruments have been developed and validated for nutritional screening risk in pregnancy. Screening with an appropriate a tool could identify a group of women at nutritional risk in whom interventions may be applied.

The food-frequency questionnaire (FFQ) is a tool commonly used in large epidemiological studies in different contexts, groups and populations[14–17]. FFQs are designed to assess eating habits and can be used for ranking individuals appropriately, according to their

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nutrient intakes. An optimal comparison method to assess the validity of the FFQ is the 24-hour recall method. 24-Hour recalls are commonly employed in nutritional epidemiology to evaluate the performance of FFQs, primarily because they do not require subject literacy and produce high levels of specificity. On the other hand, one day is unlikely to be representative of an individual's habitual intake owing to day-to-day variation; therefore two 24-hour recalls could reduce the chance variation between the methods.

In the present paper, as a part of an ongoing project to develop a nutritional screening tool, we evaluate the validity of nutrient and food intakes as estimated by an FFQ compared with dietary information obtained from two 24-hour recalls among a Sheffield Caucasian pregnant population.

Materials and methods

Subjects

The study population consisted of Caucasian pregnant women attending their first antenatal booking visit at the Jessop Wing, Royal Hallamshire Hospital, Sheffield, UK. Women with a gestational age of less than 14 weeks or more than 18 weeks were excluded. Women were also excluded if they did not speak English, or if they had any nutrition-related pre-existing medical conditions such as diabetes or coeliac disease.

Study design

The data collection was carried out from October 2003 to February 2004. The subjects were approached about the study by the researcher in the antenatal clinic and informed consent was obtained. Sociodemographic and anthropometric data were collected using a questionnaire with closed questions. Data collected included height, weight, education level, occupation, partner's occupation, smoking status and any supplement usage. The employment status of the head of the household was used to categorise women into social-class groups in a way similar to that used in the Dietary and Nutritional Survey of British Adults[9]. The FFQ was administered prior to the 24-hour recalls. The same trained nutritionist (T.M.) conducted all the interviews.

Ethical approval

All subjects gave informed consent to participate in the study. The North and South Sheffield Local Research Ethics Committees approved the study protocol.

Dietary assessment methods

Semi-quantitative FFQ

The Sheffield FFQ is an adaptation of the FFQ developed and evaluated by Rogers *et al.*[18] for the Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC), where the dietary intakes of 11 923 pregnant women were assessed. The ALSPAC FFQ contains 84 quantitative and qualitative questions and was piloted in 110 women in Sheffield, then adapted and revised by eliminating some items found not to be consumed or to be consumed very rarely by Sheffield women, e.g. liver, liver pâté, peanuts and tahini. The revised food list of the FFQ included 62 quantitative and qualitative questions, 40 of which queried about the frequency of consumption of meat, poultry, fish and seafood, common vegetables and fruits, cereals and confectionery. There were also detailed questions about the type and amount of fat, bread, alcohol and milk consumed. Participants were asked to report the frequency of consumption of the food items contained in the FFQ over the 4 weeks prior to administration. The frequency options included: never or rarely, once a fortnight, 1–3 times a week, 4–7 times a week and more than once a day. To increase the simplicity and the inclusion of a wide range of food eaten, no portion size quantification was asked; thus standard portion sizes were assumed throughout.

24-Hour dietary recalls

The reference method was a series of two 24-hour dietary recalls. The first 24-hour recall was collected at the initial interview with the subjects and after administration of the FFQ. The choice of the 24-hour recall was based on the assumption that the response rate would be much higher than that of other dietary assessment methods such as food records[19]. The second 24-hour recall was administered via telephone after a period of 10–14 days. Statistically significant differences were found between the two recall methods. All subjects were asked to provide telephone numbers and it was emphasised to them that they would be contacted after an appropriate period of time. The date was not specified, as some of the subjects might choose to change their eating habits. For a number of participants weekend dietary information was randomly collected. The foods were recalled chronologically from the previous day. Household measurements were used to estimate portion sizes. At the end of the interview the foods were summarised for the respondent. Mean daily intake was estimated from the two 24-hour recalls.

Analysis of food consumption data

The daily intakes of energy, nutrients and food items obtained from the FFQ were analysed using the Q-Builder[20] Questionnaire Design System (version 1). Q-Builder is a questionnaire design program which incorporates nutritional analysis. It enables generation of any type of open or closed questions; e.g. for the type of food, the type of bread, frequency of consumption, amount consumed. It includes an up-to-date food composition database with the nutrient contents of approximately 5000 foods and a database of portion sizes for 3800 foods. The nutritional analysis of Q-Builder is based on the UK food tables (*McCance & Widdowson's The Composition of Foods*, 5th edition, plus nine supplements; HMSO, London). Information on food consumption collected by the FFQ is converted by Q-Builder into a list of foods and weights, to generate mean daily food and nutrient intakes. The approximate daily intake was calculated by multiplying the weekly frequency of consumption of a food by the nutrient content of a standard portion. Each one of the frequency options the questionnaire allocated was mapped as follows: never or rarely = 0, once a fortnight = 0.5, 1–3 times a week = 2, 4–7 times a week = 5.5 and more than once a day = 14. A complete set of values for 38 nutrients of interest were calculated. Q-Builder also enables analysis of the qualitative dietary behaviour questions included in the FFQ, such as 'Are you vegetarian?' or 'Do you buy organic foods?'

The daily intakes of energy and nutrients obtained from the mean of the two 24-hour recalls were analysed using the WISP[21] Food Intake Nutritional Analysis System (version 3). WISP is a nutritional analysis program that enables the user to conduct a broad nutritional analysis. The nutritional analysis of WISP is based on the UK food tables (see above).

Statistical analysis

All statistical analyses were performed using SPSS version 12.0 (SPSS Inc., Chicago, IL, USA). Means and standard deviations (SD) of absolute intakes for energy, macro- and micronutrients were calculated from the FFQ and the 24-hour recalls, as well as the contribution from the main food groups. The relationship between the two dietary assessment methods was assessed by the use of two statistical approaches. First, the Pearson correlation coefficient was used to determine agreement for nutrient and food intakes obtained from the FFQ and 24-hour recalls. The agreement between the two methods was further examined by classification of absolute nutrient intakes divided into quintiles.

Second, an alternative statistical approach based on a graphical technique and simple calculation to assess the agreement between two methods of measurement – the Bland–Altman analysis[22] – was used to assess agreement between the FFQ and 24-hour recall in terms of absolute energy, macro- and micronutrient intakes. This is accomplished by plotting the differences between the two measurements against the mean of the two measurements. The plot of the difference against the mean allows investigation of the potential relationship between the measurement error and the true value. The analysis assessed agreement in individuals, defined as the limit of agreement (LOA; ± 2SD of the bias).

Results

Of the 130 women invited to participate, 123 (95%) agreed to complete the study; four (3%) refused to participate but reported no reason and three (2%) were excluded from the analysis because of incomplete data. Table 1 presents the anthropometric characteristics of the study population. The mean (± SD) age of the women was 29 ± 6.6 years. The mean (± SD) BMI was 23.1 ± 8.0 kg m^{-2} and the mean (± SD) gestational age was 15 ± 0.9 weeks. During their pregnancy 14.6% of the women were self-reported smokers. The social class distribution was non-manual 45.5% and manual 39.0% (Table 2).

Of the 123 women, 49.6% were nulliparous. Folic acid supplement intake during pregnancy was reported by 95.9%. Some 76.4% of the women reported planning their pregnancies, but only 47.2% reported periconceptional vitamin or mineral usage (Table 2).

Nutrient intakes

The mean daily intakes of energy, macro- and micronutrients as assessed by the FFQ and the 24-hour recall are given in Tables 3, 4 and 5. The FFQ reported higher energy and macronutrients intakes except for alcohol. The Pearson correlation coefficients for nutrients estimated by the test and the reference method are also shown in Tables 3–5. Highly significant correlations were demonstrated for most nutrients, from 0.19 for

Table 1 Age and anthropometric characteristics of participants

	Mean ± SD	*n*
Age (years)	29 ± 6.4	119
Weight (kg)	60.6 ± 24.9	109
Height (m)	1.65 ± 0.60	117
Gestational age (weeks)	15 ± 0.9	122
Body mass index (kg m^{-2})	23.1 ± 8.06	117

SD – standard deviation.

Table 2 Social and behavioural characteristics of participants ($n = 123$)

	%
Self-reported smoking status	
Non-smoker	85.4
Current smoker	14.6
Social class	
Non-manual	45.5
Manual	39.0
Unclassified	15.4
Periconceptional supplement usage	
Yes*	47.2
No	52.8
Folic acid supplements during pregnancy	
Yes	95.9
No	4.1
Education	
No qualifications	0.8
GCSE A Level	40.6
Higher education below degree	21.1
Degree	23.6
Other qualification	13.8

* Percentage of participants taking supplements of folic acid alone is unknown.

added sugar and zinc to 0.47 for Englyst fibre (mean correlation value for all nutrients: 0.20). For most nutrients positive correlations between the two methods were observed; however, not for alcohol, protein, starch, retinol and biotin.

Nutrient intakes were divided into quintiles in order to evaluate the ability of the FFQ to rank individuals into the same quintile of intake as the 24-hour recall. Table 6 shows the overall proportion of participants categorised into the same quintile of the distribution of total nutrient intake. An average of 59.2% of intakes by the two methods was assigned to the same quintile. The percentage of participants classified into the same quintile ranged from 48.0% for alcohol to 70.7% for Englyst fibre.

Figures 1 and 2 demonstrate the findings of the Bland–Altman analysis for energy and folate, where the average intake from the FFQ and 24-hour recall was plotted on the *x*-axis and the difference in intake between the two methods was plotted on the *y*-axis. For most of the nutrients, the plots resulting from the analysis were similar to Figs 1 and 2.

Dietary patterns

The Pearson correlation coefficients for 17 food groups as assessed by the two methods are shown in Table 7. Positive correlation coefficients ranged from 0.62 (other drinks) to 0.99 (breads). For all food groups except for alcoholic drinks, cheese and biscuits, cakes & puddings, the correlations were significant at the 0.001 level.

Discussion

This validation study was undertaken because of a lack of available instruments to assess the dietary intakes of pregnant women in Sheffield. The study population was a non-random sample, as only women between 14 and 18 weeks of pregnancy were selected for inclusion. The choice of the specific gestational age period was opportunistic because between 14 and 18 weeks the women are attending their first antenatal appointments. The women were much less likely to be affected by nausea and vomiting, which is known to occur in the first trimester and to decrease at the beginning of the second trimester[23].

As shown in published data of other validation studies conducted in populations of pregnant women[24,25], there was good agreement for energy and many nutrients. Robinson *et al.*[26] compared nutrient intakes assessed in a population of pregnant women by an FFQ and a food diary. They suggested that higher intakes estimated by the FFQ might have been due to the portion sizes used in the FFQ being too large or overreporting of the frequency of consumption of foods, or the result of underreporting of consumption of food in the diaries. In a population of low-income adult women, Goldy *et al.*[17] reported that nutrients which were significantly overestimated included fibre, calcium, potassium, saturated fat, vitamin C, vitamin D and vitamin E.

The correlation coefficient values observed in the present study were similar and comparable for most of the nutrients to those observed in other validation studies evaluating FFQ performance among pregnant women. However, the findings of our study are not directly comparable with the results of other validation studies in pregnant groups as the result of differences in sample size, ethnic origin, stages of pregnancy and reference method between the studies. Erkkola *et al.*[27] used a 181-item FFQ and food records as the reference method, and provided mean daily intakes of nutrients and mean daily intakes of foods. Robinson *et al.*[26] used food diaries and provided data of the contribution of selected food groups to energy, fat, protein and carbohydrate. Suitor *et al.*[24] used the 24-hour recall as reference method and evaluated the performance of the questionnaire for eight index nutrients. Wei *et al.*[25] extended the study conducted by Suitor *et al.* by assessing the validity of the FFQ for 17 additional

Table 3 Mean daily energy and macronutrient intakes based on the food-frequency questionnaire (FFQ) and 24-hour recall ($n = 123$)

	FFQ		24-Hour recall		Pearson's correlation coefficient (r)
	Mean ± SD	Range	Mean ± SD	Range	
Energy (kcal)	1923 ± 516	958–3804	1546 ± 370	657–2391	0.26**
Protein (g)	70.0 ± 20.5	32.2–132.6	54.8 ± 15.2	21.9–101	−0.14
Total fat (g)	85.7 ± 28.4	31.0–164.0	65.4 ± 19.6	25.0–110.9	0.28**
Carbohydrate (g)	228.3 ± 61.6	112.2–499.9	195.9 ± 55.8	51.1–400.9	0.25**
Saturated fat (mg)	32.9 ± 12.6	11.4–73.8	22.3 ± 9.1	5.8–47.8	0.23**
Monounsaturated fatty acids (g)	28.9 ± 9.8	10.7–57.1	18.5 ± 6.7	5.1–35.0	0.22*
Polyunsaturated fatty acids (g)	13.9 ± 4.9	4.7–30.5	9.2 ± 5.1	2.9–28.2	−0.14
Cholesterol (mg)	223.8 ± 83.1	74.0–461.0	152.6 ± 95.2	20.0–718.0	−0.11
Sugars (g)	82.8 ± 35.2	25.4–226.8	76.5 ± 37.6	10.4–271.6	0.19*
Starch (g)	145.0 ± 35.9	64.3–272.6	116.3 ± 32.9	17.1–200.2	−0.14
Southgate fibre (g)	19.6 ± 5.4	7.9–34.5	14.0 ± 5.6	3.1–39.7	0.36**
Englyst fibre (g)	14.1 ± 4.5	4.2–25.1	10.8 ± 4.5	1.9–39.0	0.47**
Alcohol (g)	0.1 ± 0.1	0–0.7	0.4 ± 2.1	0–17.0	−0.11

SD – standard deviation.
*Correlation significant at $P < 0.05$ level; **correlation significant at $P < 0.01$ level.

Table 4 Mean daily mineral intakes based on the food-frequency questionnaire (FFQ) and 24-hour recall ($n = 123$)

	FFQ		24-Hour recall		Pearson correlation coefficient (r)
	Mean ± SD	Range	Mean ± SD	Range	
Sodium (mg)	2417 ± 679.6	1291–4962	2311 ± 789.5	407–6160	−0.07
Potassium (mg)	2532 ± 646.2	874–5088	2179 ± 741.4	947–5208	−0.15
Calcium (mg)	715.2 ± 226.2	275–1346	654.1 ± 246.2	164–1264	−0.12
Magnesium (mg)	235.2 ± 68.2	88–402	188.4 ± 66.8	75–547	0.37**
Phosphorus (mg)	1153 ± 318.3	439–2065	916.2 ± 258.2	390–1707	0.18**
Iron (mg)	11.2 ± 3.9	4.7–21.1	8.0 ± 2.8	2.6–17.8	0.32**
Copper (mg)	1.1 ± 0.3	0.5–2.3	0.9 ± 0.6	0.2–4.6	0.008
Zinc (mg)	7.8 ± 2.3	3.1–14.6	6.2 ± 2.1	2.3–11.3	0.19*
Manganese (mg)	1.8 ± 0.6	0.7–3.8	2.1 ± 1.0	0.6–6.9	0.40**
Selenium (μg)	39.9 ± 15.2	8.0–92	36.4 ± 15.9	8.0–86	−0.03
Iodine (μg)	79.2 ± 27.8	15–43	82.8 ± 65.8	20–567	−0.03

SD – standard deviation.
*Correlation significant at $P < 0.05$ level; **correlation significant at $P < 0.01$ level.

nutrients. Most of the studies concluded that the FFQ had reasonable validity across a wide range of nutrients and was a useful tool for categorisation of pregnant women according to energy intake.

In the present study we used Bland–Altman analysis to assess agreement between the FFQ and the 24-hour recall and to obtain further information that the correlation coefficient itself cannot provide. A systematic increase in lack of agreement between the two methods was observed with an increase in dietary intake. The scatter plots provided evidence of both under- and overreporting with the FFQ compared with the 24-hour recall. For some macronutrients such as protein, Southgate fibre, alcohol and mono- and polyunsaturated fatty acids, the LOA – defined as the bias (±2SD) of the difference – were wide, unlike for most of the minerals and vitamins analysed. The reason for this is unclear.

The dietary patterns shown in Table 7 were similar between the two dietary assessment methods, but there were some differences between them in the mean contribution made by selected food groups to energy. The Pearson correlation coefficients showed strong agreement between the two methods.

As expected, variation between actual and self-reported dietary intake has been demonstrated. The effects of some limitations of the 24-hour recall method, e.g. reliance on memory and high day-to-day variation, might have been decreased by the collection of more than two dietary recalls[28], but time limitations on the research project and the progression of the women's pregnancy and subsequent diet alterations prevented the collection of additional 24-hour recalls. Some other sources of error in this study included portion size estimation and nutritional analysis errors.

An additional issue that might have had an effect on the results was the emotional and psychological status of the mother, e.g. the location where the interview took place, the presence of the partner or other family members. Social acceptability might have affected a number of the participants as they might have overreported fruit and vegetable intake and underreported sweets or alcohol intake.

Table 5 Mean daily vitamin intakes based on the food-frequency questionnaire (FFQ) and 24-hour recall ($n = 123$)

	FFQ		24-Hour recall		Pearson correlation coefficient (r)
	Mean ± SD	Range	Mean ± SD	Range	
Retinol (μg)	369.2 ± 152.0	44–876	276.8 ± 141.5	11–795	−0.09
Carotene (μg)	1228 ± 570.9	154–3162	1287.6 ± 1364	33–9095	0.26**
Vitamin D (μg)	2.7 ± 1.4	0.5–9.5	1.6 ± 1.4	0.1–9.4	0.20*
Vitamin E (mg)	4.3 ± 1.7	1.3–10.1	5.0 ± 2.4	0.6–12.4	0.20*
Thiamine (mg)	1.5 ± 0.4	0.7–2.8	1.2 ± 0.4	0.5–2.4	0.22*
Riboflavin (mg)	1.3 ± 0.5	0.4–2.7	1.1 ± 0.4	0.4–2.4	0.33**
Niacin (mg)	18.5 ± 6.2	5.0–40.3	13.3 ± 5.3	4.4–28.5	0.20*
Potential niacin (mg)	14.3 ± 4.1	6.6–26.6	11.2 ± 3.3	4.7–19.2	−0.16
Vitamin B_6 (mg)	2.0 ± 0.6	0.8–4.4	1.4 ± 0.5	0.4–2.8	0.27**
Vitamin B_{12} (μg)	3.5 ± 1.5	0.7–9.0	2.4 ± 1.3	0.1–6.4	−0.09
Folate (μg)	229.2 ± 67.7	94–412	179.7 ± 62.6	62–350	0.29**
Pantothenic acid (mg)	3.5 ± 1.0	1.1–6.2	3.0 ± 1.1	1.3–7.9	0.24**
Biotin (μg)	18.2 ± 7.2	4.5–36.6	18.7 ± 9.9	4.5–79.0	−0.09
Vitamin C (mg)	73.9 ± 29.1	10.0–154	74.6 ± 52.5	3.0–294	0.42**

SD – standard deviation.
*Correlation significant at $P < 0.05$ level; **correlation significant at $P < 0.01$ level.

Table 6 Percentage of women categorised into the same quintile of the distribution according to the food-frequency questionnaire and the 24-hour recall

Nutrient	Overall proportion categorised into the same quintile (%)
Energy	64.2
Protein	54.5
Total fat	67.5
Carbohydrate	56.1
Saturated fat	64.2
Monounsaturated fatty acids	61.0
Polyunsaturated fatty acids	59.3
Cholesterol	61.0
Sugars	60.2
Starch	57.7
Southgate fibre	65.0
Englyst fibre	70.7
Alcohol	48.0
Sodium	58.5
Potassium	58.5
Calcium	59.3
Magnesium	63.4
Phosphorus	58.5
Iron	61.0
Copper	58.5
Zinc	55.3
Manganese	66.7
Selenium	49.6
Iodine	52.8
Retinol	55.3
Carotene	52.8
Vitamin D	61.0
Vitamin E	61.0
Thiamine	57.7
Riboflavin	61.8
Niacin	49.6
Potential niacin	58.5
Vitamin B_6	62.6
Vitamin B_{12}	56.9
Folate	59.3
Pantothenic acid	61.0
Biotin	59.3
Vitamin C	62.6

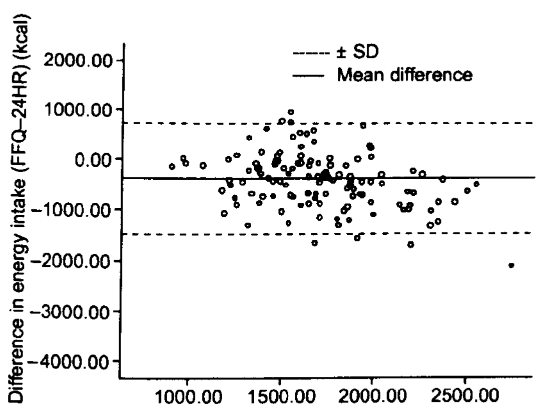

Fig. 1 Bland–Altman plot showing agreement between the food-frequency questionnaire (FFQ) and the 24-hour recall (24HR) for energy (kcal) (SD – standard deviation)

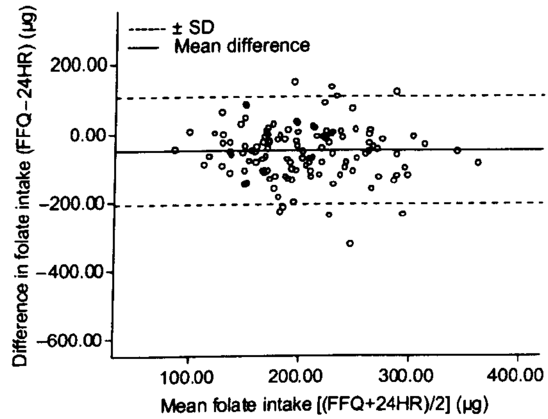

Fig. 2 Bland–Altman plot showing agreement between the food-frequency questionnaire (FFQ) and the 24-hour recall (24HR) for dietary folate (μg) (SD – standard deviation)

In conclusion, the FFQ showed correlations similar to those obtained in validation studies conducted in other similar groups. Positive correlations between the measurements were observed that ranged from 0.19 to 0.47 for most nutrients and from 0.62 to 0.99 for food groups. No significant correlations were observed for 13 out of 38 examined nutrients, which might be the result of not applying log-transformation on the data, not doing correction for measurement error and finally not doing adjustments for energy intake.

In several validation studies conducted on pregnant women, log-transformation of nutrients has been applied to correct for skewness[26,27] and others have used non-parametric tests to deal with the problem[29]. In our data,

Table 7 Mean contribution made by selected food groups to energy according to the food-frequency questionnaire (FFQ) and the 24-hour recall

Food group	FFQ (%)	24-Hour recall (%)	Pearson's correlation coefficient (r)
Breads	10	10	0.99**
Breakfast cereals	6	21	0.73**
Meats	11	5	0.86**
Fish	4	14	0.94**
Vegetables	17	4	0.64**
Biscuits, cakes & puddings	6	7	0.21
Fruit	2	1	0.66**
Eggs	2	4	0.91**
Milk/cream	4	1	0.85**
Cheese	5	4	0.33
Fats	9	4	0.85**
Alcoholic drinks	1	2	−0.85
Other drinks	5	8	0.62**
Added sugar	6	2	0.91**
Rice & pasta	6	1	0.74**
Other cereals	3	3	0.32**
Other foods	4	9	0.80**

** Correlation significant at $P < 0.01$ level.

tests for normal distribution were without skewness in the majority of cases and no corrections were applied. Even though the FFQ suggested greater nutrient intakes compared with the reference method, the validity observed in this study suggests a reasonable ability of the FFQ to rank individuals by levels of intake and that the FFQ is a useful tool in the collection of dietary data.

Future research

Data will be obtained from a larger sample of low-income women and divided into tertiles, in order to address the question of which food items (discriminant foods) of the FFQ make women from a homogeneous social and lifestyle environment have different intakes of key nutrients. Calculation of the mean contribution of each food item from the FFQ to key nutrients, e.g. folate, calcium, etc., will follow and the major sources of each nutrient of interest will be identified. The screening tool will consist of a simple list of discriminant food items and a scoring system similar to those used in the Healthy Eating Index and the Dietary Quality Index will be developed[30,31]. This will enable health professionals and community staff, such as those working in Sure Start projects with little nutrition assessment training, to administer the screening tool to the majority of low-income pregnant women and identify those at nutritional risk.

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References

1 Chaudhari S, Otiv M, Chitale A, Pandit A, Hoge M. Pune low birth weight study – cognitive abilities and educational performance at twelve years. *Indian Pediatrics* 2004; **41**(2): 121–8.

2 Barker DJ, Gluckman PD, Godfrey KM, Harding JE, Owens JA, Robinson JS. Fetal nutrition and cardiovascular disease in adult life. *Lancet* 1993; **341**(8850): 938–41.

3 Barker DJ, Osmond C, Golding J, Kuh D, Wadsworth ME. Growth *in utero*, blood pressure in childhood and adult life, and mortality from cardiovascular disease. *British Medical Journal* 1989; **298**(6673): 564–7.

4 Dewan N, Brabin B, Wood L, Dramond S, Cooper C. The effects of smoking on birth weight-for-gestational-age curves in teenage and adult primigravidae. *Public Health* 2003; **117**(1): 31–5.

5 Spencer N, Logan S. Social influences on birth weight. *Journal of Epidemiology and Community Health* 2002; **56**(5): 326–7.

6 Moser K, Li L, Power C. Social inequalities in low birth weight in England and Wales: trends and implications for population health. *Journal of Epidemiology and Community Health* 2003; **57**(9): 687–91.

7 Bull J, Mulvihille C, Quigley R. *Prevention of Low Birth Weight: Assessing the Effectiveness of Smoking Cessation and Nutritional Intervention – Evidence Briefing*. London: Health Development Agency, July 2003.

8 Rogers I, Emmett P, Baker D, Golding J. Financial difficulties, smoking habits, composition of the diet and birth weight in a population of pregnant women in the South West of England. ALSPAC Study Team. Avon Longitudinal Study of Pregnancy and Childhood. *European Journal of Clinical Nutrition* 1998; **52**(4): 251–60.

9 Gregory J, Foster K, Tyler H, Wiseman M. *The Dietary and Nutritional Survey of British Adults*. London: HMSO, 1990.

10 Darmon N, Ferguson EL, Briend A. A cost constraint alone has adverse effects on food selection and nutrient density: an analysis of human diets by linear programming. *Journal of Nutrition* 2002; **132**(12): 3764–71.

11 Ward J, Close J, Little J, Boorman J, Perkins A, Close SJ, *et al.* Development of a screening tool for assessing risk of under nutrition in patients in community. *Journal of Human Nutrition and Dietetics* 1998; **11**: 323–30.

12 Wright L. A nutritional screening tool for use by nurses in residential and nursing homes for elderly people: development and pilot study results. *Journal of Human Nutrition and Dietetics* 1999; **12**: 437–43.

13 McNulty KY, Adams CH, Anderson JM, Affenito SG. Development and validation of a screening tool to identify eating disorders in female athletes. *Journal of the American Dietetic Association* 2001; **101**(8): 886–92.

14 Shu X, Yang G, Jin F, Liu D, Kushi L, Wen W, *et al.* Validity and reproducibility of the food frequency questionnaire used in the Shanghai Women's Health Study. *European Journal of Clinical Nutrition* 2004; **58**(1): 17–23.

15 Katsouyanni K, Rimm EB, Gnardellis C, Trichopoulos D, Polychronopoulos E, Trichopoulou A. Reproducibility and relative validity of an extensive semi-quantitative food frequency questionnaire using dietary records and biochemical markers among Greek schoolteachers. *International Journal of Epidemiology* 1997; **26**(Suppl. 1): S118–27.

16 Friis S, Kruger Kjaer S, Stripp C, Overvad K. Reproducibility and relative validity of a self-administered semi quantitative food frequency questionnaire applied to younger women. *Journal of Clinical Epidemiology* 1997; **50**(3): 303–11.

17 Chacko-George G, Milani T, Hans-Nuss H, Kim M-S, Freeland-Graves JH. Development and validation of a semi-quantitative food frequency questionnaire for young adult women in the southwestern United States. *Nutrition Research* 2004; **24**: 29–43.

18 Rogers I, Emmett P. Diet during pregnancy in a population of pregnant women in South West England. ALSPAC Study Team. Avon Longitudinal Study of Pregnancy and Childhood. *European Journal of Clinical Nutrition* 1998; **52**(4): 246–50.

19 Margetts B, Nelson M. *Design Concepts in Nutritional Epidemiology*, 2nd ed. Oxford: Oxford University Press, 1997.

20 Tinuviel Software. *Q-Builder Users Manual. Version 1.0; Questionnaire Design and Intake Analysis System*. Warrington, UK: Tinuviel Software, 2002.

21 Tinuviel Software. *WISP Users Manual. Version 3.0; Intake and Recipe Analysis System*. Warrington, UK: Tinuviel Software, 2003.

22 Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurements. *Lancet* 1986; **1**(8476): 307–10.

23 Huxley RR. Nausea and vomiting in early pregnancy: its role in placental development. *Obstetrics and Gynecology* 2000; **95**(5): 779–82.

24 Suitor CJ, Gardner J, Willett WC. A comparison of food frequency and diet recall methods in studies of nutrient

intake of low-income pregnant women. *Journal of the American Dietetic Association* 1989; **89**(12): 1786–94.
25 Wei EK, Gardner J, Field AE, Rosner BA, Colditz GA, Suitor CW. Validity of a food frequency questionnaire in assessing nutrient intakes of low-income pregnant women. *Maternal and Child Health Journal* 1999; **3**(4): 241–6.
26 Robinson S, Godfrey K, Osmond C, Cox V, Barker D. Evaluation of a food frequency questionnaire used to assess nutrient intakes in pregnant women. *European Journal of Clinical Nutrition* 1996; **50**(5): 302–8.
27 Erkkola M, Karppinen M, Javanainen J, Rasanen L, Knip M, Virtanen SM. Validity and reproducibility of a food frequency questionnaire for pregnant Finnish women. *American Journal of Epidemiology* 2001; **154**(5): 466–76.
28 Willet WC. *Nutritional Epidemiology*, 2nd ed. New York: Oxford University Press, 1998.
29 Andersen LF, Lande B, Trygg K, Hay G. Validation of a semi-quantitative food-frequency questionnaire used among 2-year-old Norwegian children. *Public Health Nutrition* 2004; **7**(6): 757–64.
30 Kennedy ET, Ohls J, Carlson S, Fleming K. The Healthy Eating Index: design and applications. *Journal of the American Dietetic Association* 1995; **95**(10): 1103–8.
31 Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index revised: a measurement instrument for populations. *Journal of the American Dietetic Association* 1999; **99**(6): 697–704.

Appendix II: Publication 2

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Dietary assessment of a population of pregnant women in Sheffield, UK

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The present study examined the dietary intakes of a population of pregnant women living in the North of England. The objectives of the paper were to assess and describe the dietary intakes of the population and relate the findings to existing data on the diet of pregnant and non-pregnant women in the UK. A total of 250 pregnant women attending their first antenatal appointment at the Jessop Wing Hospital, Sheffield, UK were recruited. Information on their diet was assessed by an interviewer-administered semi-quantified food frequency questionnaire (FFQ). The mean intakes as assessed by the FFQ were similar to other studies of UK pregnant population; however Sheffield pregnant women had lower intakes of calcium and folate. Study findings were also related to the National Diet and Nutrition Survey and to the Estimated Nutrient Intakes (EAR). Of the study participants, 40 % did not meet the EAR for calcium, 67 % for iron and 69 % for folate. Subgroup comparisons suggested lower nutrient intakes of participants living in the 40 % most deprived electoral wards. The study findings suggest that the diet of pregnant women in Sheffield is characterised by low intakes of important nutrients for pregnancy such as folate and nutrient variations by electoral wards.

Diet: Pregnancy: Food frequency questionnaire: Nutrient intakes

The quality of the maternal diet during the pre- and periconceptional period is of significant importance because of its association with pregnancy outcome, e.g. low folate status is associated with an increased risk of neural tube defects (NTD; Medical Research Council Vitamin Study Research Group, 1991; Scholl & Johnson, 2000). Increasing evidence indicates that maternal nutrition might not only affect the immediate pregnancy outcome, but also the well-being of the infant later in life (Godfrey *et al.* 1996; Godfrey & Barker, 2001). Barker (1992) suggested that 'fetal under-nutrition at critical periods of development in *utero* and during infancy might lead to permanent changes in body structure and function'. These changes may result in increased adult susceptibility to CHD and non-insulin-dependent diabetes mellitus.

In the UK, the quality of a woman's diet during pregnancy tends to fall with income (Bull *et al.* 2003) and mothers from low-income households are nutritionally vulnerable and may go short of food in order to feed their children (Dobson *et al.* 1994; Dowler & Calvert, 1995). A small number of studies, which describe the diet of pregnant women in the UK, have been published (Mathews & Neil, 1998; Rogers *et al.* 1998*a*) and few have investigated the association between maternal diet quality and income (Rogers *et al.* 1998*b*). Up-to-date information on the diet, eating habits and dietary patterns of this potentially vulnerable group is necessary for future planning of nutrition-related interventions locally and nationally such as the Healthy Start initiative to reform the Welfare Food Scheme (Department of Health 2004).

The objective of the study was to assess the diet of pregnant women living in Sheffield, as the key to the development of a nutritional screening tool for low-income pregnant women. Sheffield, the fourth largest city outside London, is a city of stark contrasts. Since the decline of the steel industry in the 1970s, Sheffield's 0·531 million population have continued to face considerable economic difficulty, with rising unemployment causing a widening division between the richest and poorest areas. Deprivation is one of the most powerful determinants of health and almost all health indicators are adversely affected by poverty.

Deprivation indicators bring together a range of social and material deprivation factors to produce an overall summary score. By using these scores, areas can be ranked by their degree of relative disadvantage or affluence. These rankings are used in resource allocation calculations for health and local authority services. Sheffield's score is 26·1, which ranks it the twenty-fifth most deprived out of 354 local authorities in England. Within Sheffield, thirteen electoral wards are among the 10 % most deprived wards in the UK (Gordon, 2001).

In this paper we report the dietary intakes of a population of pregnant women and relate them to similar studies which included a pregnant population; the Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) conducted in the county of Avon describing the diet of 11 923 pregnant women at 32 weeks of gestation using a self-administered semi-quantified food frequency questionnaire (FFQ; Rogers *et al.* 1998*a*) and the Mathews' study (Mathews & Neil, 1998) conducted in Portsmouth, which reported information on the nutrient intakes

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Abbreviations: ALSPAC, Avon Longitudinal Study of Pregnancy and Childhood; EAR, Estimated Nutrient Intakes; FFQ, food frequency questionnaire; LNRI, Lower Recommended Nutrient Intakes; NDNS, National Diet and Nutrition Survey; NTD, neural tube defects.

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of 774 pregnant women between 9 and 20 weeks of gestation using a self-completed 7 d food diary. The present study findings are also related to the latest National Diet and Nutrition Survey (NDNS) of British adults aged 19–64, using a 7 d weighed-intake dietary record (Henderson et al. 2002) and to the Estimated Nutrient Intakes (EAR) and the Lower Recommended Nutrient Intakes (LRNI) relevant for individual nutrients (Department of Health, 1991).

Materials and methods

Subjects and study design

Study participants were women attending their first appointment at the antenatal booking clinic at the Jessop Wing Hospital, Sheffield, UK. Eligibility was defined as being between 14 and 18 weeks of pregnancy and of Caucasian ethnic origin. Women were also excluded if they did not speak English, or if they had any nutrition-related pre-existing medical conditions such as diabetes or coeliac disease.

The choice of the specific gestational age was opportunistic because attendance of the first antenatal appointment usually takes place between 14 and 18 weeks of gestation. Additionally, we have considered evidence from the literature indicating that the diet of pregnant women is affected less by nausea and vomiting which is known in the first trimester and decreases at the beginning of the second trimester (Huxley, 2000).

A number of different ethnic groups lives in the low-income areas of Sheffield, i.e. Pakistani, Indian, Somali and Afro-Caribbean, however, their eating habits are not similar to the Caucasian population. An attempt to document their diet using an identical FFQ most likely would have been unsuccessful due to large geographical and religious variations in the diet of these groups by region of origin (Kassam-Khamis et al. 1999; Vyas et al. 2003) as well as because of the questionable suitability of an identical FFQ to assess the diet of different ethnic groups (Gibney et al. 2004).

The pregnant women were approached by the researchers at the waiting area of the antenatal clinic. A face-to-face interview was conducted with each subject, with each interview lasting at least 30 min. A closed-question questionnaire was used to obtain socio-demographic and anthropometrical data (gestational age, self-reported height and pregnancy weight). Some of the variables used to obtain information on the socio-economic background of the participants included maternal highest educational qualification level, maternal occupation, partner's occupation and receipt of benefits. Behavioural data collected included smoking habit and periconceptional and during pregnancy multi-mineral/multivitamin supplement usage. Other data included information on cooking skills and main household cook. All the interviews were conducting by the same trained nutritionists (T. M. and F. P.).

Subgroup comparisons were facilitated by the use of the Index of Multiple Deprivation. Each subject's postcode was used to indicate whether they lived in the 40 % most deprived wards, or elsewhere within the Sheffield district, and information from the Index of Multiple Deprivation was used to identify them. The Index of Multiple Deprivation combines six separate domains: income, employment and health deprivation, education, skills and training, housing, and finally geographical access to services (Gordon, 2001).

Ethical approval

All subjects gave informed consent to participate in the study. The North and South Sheffield Local Research Ethics Committees approved the study protocol.

Dietary assessment

Dietary intakes of all women were determined using a validated interview-administered semi-quantified FFQ (Mouratidou et al. 2006). The Sheffield FFQ is an adaptation of the FFQ developed and evaluated by (Rogers et al. 1998a) for the ALSPAC study. The ALSPAC FFQ contains questions about the weekly frequency of consumption of forty-three foods and additional questions about bread, types of fat and milk, and consumption of coffee, tea and sugar.

After being piloted with 110 women in Sheffield, the list of foods was then revised by eliminating some items found not to be consumed or to be consumed very rarely locally, e.g. liver, liver pate and peanuts. The revised food list of the FFQ included sixty-two quantitative and qualitative questions, forty of which were about the frequency of consumption of meat, poultry, fish and seafood, common vegetables and fruits, cereals and confectionery. There were also detailed questions about the type and amount of spreading fat, bread, alcohol and milk consumed. Frequency options included: never or rarely, once a fortnight, one to three times a week, four to seven times a week and more than once a day. To increase the simplicity and the inclusion of a wide range of foods eaten, no portion size quantification was asked, thus standard portion sizes were used throughout.

Nutrient calculations

Mean nutrient intakes were calculated from foods only. Q-Builder (Questionnaire Design System version 1.0; Tinuviel Software, Anglesey, UK) was used to analyse daily intakes of energy, nutrients and food items obtained from the FFQ. Q-Builder is a questionnaire design program which incorporates nutritional analysis. It enables generation of any type of open or closed questions, e.g. the type of food, frequency of consumption and the amount consumed. It includes an up-to-date food composition database with the nutrient contents of approximately 5000 foods, and a database of portion sizes for 3800 foods.

The nutritional analysis of Q-Builder is based on the UK food tables (Holland et al. 1988, 1989, 1991 a,b, 1992 a,b, 1993; Chan et al. 1994, 1995, 1996; Food Standards Agency, 2002). Information on food consumption collected by the FFQ is converted by the Q-Builder into a list of foods and weights, to generate mean daily food and nutrient intakes. The approximate daily intake was calculated by multiplying the weekly frequency of consumption of a food by the nutrient content of a standard portion. Each one of the frequency options of the questionnaire allocated was mapped as follows: never or rarely = 0, once a fortnight = 0·5, one to three times a week = 2, four to seven times a week = 5·5 and more than once a day = 14.

Statistical analysis

The Statistical Package for Social Sciences version 12.1 (SPSS Inc., Chicago, IL, USA) was used to analyse the data.

The statistical analysis included means and standard deviations of absolute intakes for energy, macro- and micronutrients, obtained from the FFQ. Regression analysis was also used to model the value of a dependent scale variable, e.g. energy based on its linear relationship, to one or more predictors, e.g. employment, and provide the variable or variables that best predict the value of the dependent variable.

An Independent Sample *t* test was used to compare mean nutrient intakes of those participants living in the 40 % most deprived wards (Group 1) to those living in the rest of the electoral wards (Group 2) within Sheffield and a χ^2 test was used to compare the maternal characteristics.

Results

Population characteristics

Mean gestational age was 14·4 weeks. Table 1 presents the anthropometric characteristics of the study participants. The mean age of the women was 27·0 (SD 7·4) years and mean height and weight were 163·9 (SD 7·2) cm and 69·8 (SD 17·4) kg, respectively. Table 1 also presents some of the behavioural characteristics of the population. Of the 250 participants, 61 % had planned their pregnancies, but only 26 % reported periconceptional vitamin or mineral supplementation; 92 % claimed that they could cook, however, only half of them were regularly cooking at home.

Table 1. Anthropometric, demographic and behavioural characteristics of study participants (*n* 250)

	Mean	SD	Range
Age (years)	27·0	7·4	15–43
Weight (kg)	69·8*	17·4	40–33
Height (cm)	163·9†	7·2	142·1–182·1
Maternal highest educational qualification level (%)			
Degree	14·4		
Higher Education below degree	13·6		
'A' Levels	6·8		
GCSEs	36·8		
No or other qualifications	28·4		
Maternal employment (%)			
Full-time	30·8		
Part-time	29·2		
Unemployed	16·8		
Economically inactive‡	23·2		
Self-reported smoking status (%)			
Non-smoker	71·6		
Current smoker	28·4		
Pregnancy planning (%)			
Yes	61·2		
No	38·8		
Periconceptional supplement usage (%)			
Yes§	26·4		
No	73·6		
Folic acid supplements during pregnancy (%)			
Yes	92·0		
No	8·0		
Cooking skills (%)			
Yes	92·0		
No	8·0		

* *n* 235.
† *n* 243.
‡ Includes students, housewives and disabled.
§ Percentage of participants taking supplements of folic acid alone is unknown.

The comparison of the characteristics of the low-income and the rest of the Sheffield women suggested some differences although many of these differences were not statistically significant. However, the low-income women were significantly younger (P=0·001), more likely to smoke (P=0·001), less well educated (P=0·001), less likely to eat takeaway food (P=0·006) and less likely to have planned their pregnancy (P=0·001) and taken periconceptional folic acid supplements (P=0·001). Forward regression analysis was used to test if the highly significant differences in nutrient intakes between the two Sheffield groups could be explained by these characteristics. The results indicated that although the differences in nutrient intakes could partly be explained by whether or not the pregnancy was planned, lower socio-economic status was still a major contributor to lower maternal dietary intakes.

Daily intakes

Of the 257 women invited to participate, 250 (97 %) agreed to complete the study, four (2 %) refused to participate but reported no reason and three (1 %) were excluded from the analysis because of incomplete data. Complete dietary information was provided by 250 pregnant women. The data for the majority of the nutrients were normally distributed. Mean daily intakes and standard deviations of energy, macronutrients and micronutrients assessed by the FFQ are given in Table 2.

Table 3 reports approximate mean intakes related to the ALSPAC study (Rogers *et al.* 1998*a*), the Mathews' study

Table 2. Mean daily macronutrient and micronutrient intakes based on the food frequency questionnaire (*n* 250)

	Mean	SD	95 % CI
Energy (kJ)	7800	2·16	7530, 8070
Protein (g)	74·2	23·9	71·2, 77·1
Total fat (g)	83·5	27·9	79·5, 86·5
Carbohydrate (g)	217	62·1	210, 225
Saturated fat (mg)	29·2	11·2	27·8, 30·6
Sugars (g)	78·1	34·2	73·8, 82·3
Starch (g)	139	39·8	134, 144
Englyst fibre (g)	12·4	4·70	11·8, 13·0
Sodium (mg)	2508	762	2413, 2603
Calcium (mg)	692	222	664, 720
Magnesium (mg)	220	68·4	212, 229
Phosphorus (mg)	1187	351	1143, 1231
Iron (mg)	10·2	3·77	9·76, 10·7
Zinc (mg)	7·4	2·35	7·16, 7·74
Iodine (μg)	92·5	39·9	87·5, 97·5
Retinol (μg)	271	159	251·1, 290
Carotene (μg)	1446	841	1342, 1551
Vitamin D (μg)	2·6	1·66	2·43, 2·84
Vitamin E (mg)	4·1	1·98	3·87, 4·37
Thiamine (mg)	1·2	0·44	1·21, 1·32
Riboflavin (mg)	1·0	0·45	1·02, 1·14
Niacin (mg)	18·0	6·20	17·2, 18·8
Vitamin B_6 (mg)	1·8	0·61	1·73, 1·88
Vitamin B_{12} (μg)	4·5	2·50	4·22, 4·85
Folate (μg)	204	71·2	196, 213·8
Pantothenic acid (mg)	3·4	1·20	3·28, 3·58
Biotin (μg)	15·1	6·69	14·29, 15·9
Vitamin C (mg)	67·4	34·2	63·1, 71·6
Alcohol (g)	1·74	5·61	1·04, 2·45

Table 3. Approximate daily energy, macronutrient and micronutrient mean intakes based on the food frequency questionnaire, in comparison to the results from the Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC; Rogers *et al.* 1998*a*), Mathews study (Mathews & Neil, 1998) and the National Diet and Nutrition Survey (NDNS; Henderson *et al.* 2002)

	Whole group	ALSPAC	Mathews	NDNS
Energy (kJ)	7800	7700	8500	6870
Protein (g)	74·2	66·3	73·5	63·7
Total fat (g)	83·5	70·4	85·7	86·5
Carbohydrate (g)	217	–	255	203
Sodium (mg)	2508	–	–	2302
Calcium (mg)	692	953	921	777
Magnesium (mg)	220	253	–	229
Iron (mg)	10·2	10·4	10·5	10·0
Zinc (mg)	7·4	8·3	8·2	7·4
Vitamin D (μg)	2·6	–	2·6	3·7
Vitamin E (mg)	4·1	8·4	9·0	15
Thiamine (mg)	1·2	1·4	1·5	1·5
Riboflavin (mg)	1·0	1·7	1·7	1·6
Niacin (mg)	18·0	15·8	–	30·9
Vitamin B_6 (mg)	1·8	1·8	–	2·0
Vitamin B_{12} (μg)	4·5	–	3·9	4·8
Folate (μg)	204	250	242	251
Vitamin C (mg)	67·4	80·3	83·3	81·0
Alcohol (g)	1·74	–	1·5	9·3

(Mathews & Neil, 1998) and the NDNS (Henderson *et al.* 2002). In the ALSPAC study nutrient intakes were calculated from food sources; however, in the Mathews and the NDNS surveys estimated nutrient intakes were calculated from both food and all sources. The findings of the present study are related to the nutrient intakes resulted from calculation from food sources only. As seen in Table 5, mean macronutrient intakes were similar. Micronutrient intakes, however, were slightly lower for calcium, vitamin C, folate and for the majority of the vitamins examined.

The dietary intakes were matched up to the EAR (Department of Health, 1991) for women aged 19–50 with the addition, where appropriate, of an increment for pregnancy. Table 4 reports the mean intakes of selected nutrients chosen because of their importance in pregnancy related to the EAR and LRNI, and the percentage of the women below the EAR and LRNI.

A comparison of the mean nutrient intakes (*P* value) of those participants living in the most deprived wards (Group 1) to those living in the rest of the city (Group 2) suggested significantly statistical differences for some of the nutrients examined (Table 5). Pregnant women living in the most deprived electoral wards had lower intakes of Englyst fibre ($P=0·001$), iron ($P=0·004$) and most of the vitamins examined including folate ($P=0·001$) and vitamin C ($P=0·045$). Women assigned at Group 1 had lower but non-significantly lower intakes of energy, total fat, carbohydrate and calcium, and higher intakes of protein and vitamin B_{12}.

Discussion

This paper describes the diet of a population of Caucasian pregnant women living in the North of England and relates their diets to those reported from recent, relevant studies from the UK. The decision to exclude Black and minority ethnic groups came from evidence suggesting possible difficulties related to the applicability within different ethnic groups of an identical FFQ. A questionnaire with appropriate foods and portion sizes for one group might not be appropriate for another as a significant number of foods consumed in ethnic diets might not be covered by the questionnaire (Gibney *et al.* 2004). Vyas *et al.* (2003) attempted to evaluate the dietary intakes of different ethnic groups with specifically developed FFQ and pointed out potential limitations such as missing data from the food composition tables and underreporting related to portion sizes and grouping of mixed dishes.

The FFQ method was used to assess the habitual nutrient intakes of the study population. There were several reasons for this decision. The ALSPAC study (Rogers *et al.* 1998*a*), in which the questionnaire was used initially, is the largest study conducted in pregnant women (nearly 12 000) in the UK, therefore clear evidence existed to support the administration and effectiveness of a food frequency method on pregnant population. Secondly, this method is increasingly used in epidemiological studies even though there are concerns related to its use, i.e. assessment of absolute intakes, intakes of mixed dishes and food grouping (Gibney *et al.* 2004). The simplicity of the technique, its cost-effectiveness and the low respondent burden, however, made it a more sensible and suitable method to use in the present study. Unlike food records which are more precise in terms of assessing absolute intakes, the high level of motivation and high respondent burden required might have had an effect on the response rate (Willet, 1998).

When interpreting the results of the present study, the use of standard portion sizes for the first part of the questionnaire has to be considered. Portion size information was not included which might have led to under- or over-representation of

Table 4. Mean group intakes, Estimated Nutrient Intakes (EAR; Department of Health, 1991) for non-pregnant women aged 19–50 years, suggested increments during pregnancy, percentage of women below the EAR and Lower Recommended Nutrient Intakes (LRNI; Department of Health, 1991) and percentage of women below the LRNI for selected nutrients

	Group intakes	EAR	Increments for pregnancy	% Below EAR	LRNI	% Below LRNI
Energy (kcal)	1880	1940	200†	60	–	–
Calcium (mg)	692	525	0·0	40	400	10
Iron (mg)	10·2	11·4	0·0	67	8·0	30
Riboflavin (mg)	1·0	0·9	0·3	61	0·8	38
Folate (μg)	204	150	100	69	100	4
Vitamin C (mg)	67·4	25	10*	19	10	1

*Third trimester only.

Table 5. Comparison of the mean daily macronutrient and micronutrient intakes based on the food frequency questionnaire for Group 1 (*n* 174) and Group 2 (*n* 76)

	Group 1		Group 2			
	Mean	SD	Mean	SD	95 % CI	*P* value*
Energy (kJ)	7700	2260	7800	1910	−80, −200	0·717
Protein (g)	76·0	25·5	70·0	19·4	−0·46, 12·4	0·069
Total fat (g)	81·9	28·2	85·5	27·3	−11·2, 3·9	0·344
Carbohydrate (g)	215	66·1	222	51·8	−24·1, 9·5	0·395
Saturated fat (mg)	27·6	10·2	33·0	12·5	−8·66, −2·19	0·001
Englyst fibre (g)	11·7	4·58	14·2	4·56	−3·71, −1·26	0·0001†
Sodium (mg)	2559	817	2391	607	−37·5, 374	0·109
Calcium (mg)	676	222	729	221	−113, 6·56	0·080
Magnesium (mg)	213	69·3	236	63·7	−41·2, −4·59	0·014†
Iron (mg)	9·78	3·81	11·2	3·50	−2·49, −0·48	0·004†
Vitamin D (μg)	2·61	1·74	2·69	1·48	−0·53, 0·35	0·698
Thiamine (mg)	1·17	0·44	1·49	0·39	−0·43, −0·20	0·0001†
Riboflavin (mg)	0·96	0·41	1·36	0·43	−0·51, −0·28	0·0001†
Vitamin B_6 (mg)	1·72	0·62	2·01	0·55	−0·04, −0·12	0·001†
Vitamin B_{12} (μg)	4·99	2·71	3·50	1·56	0·94, 2·01	0·0001†
Folate (μg)	193	71·1	230	64·9	−56, −18·5	0·0001†
Vitamin C (mg)	64·8	36·3	73·4	28·4	−17·0, −0·18	0·045†
Alcohol (g)	2·45	6·65	0·14	0·13	0·80, 3·81	0·0001†

* Independent sample *t* test for equality of means.
† Difference is significant.

intakes for those women who consume relatively smaller or larger portions of foods. For the second part of the questionnaire (including foods that come with typical units such as slices of bread, cups of tea) specification of portion size as part of the frequency consumption provided further information and clarity. The nutrient calculation of the FFQ presumes that the participants consume a selection of the foods described by each question but in fact they might only eat one of the items described by each question, resulting in a wider range of estimated nutrient intakes. We are confident, however, that the questionnaire provided useful estimates of nutrient intakes as demonstrated by results of the validation study where the FFQ performed well for most of the nutrients and had acceptable agreement compared to the mean intakes of two consecutive 24 h recalls (Mouratidou *et al.* 2006).

Examination of the maternal characteristics for the total sample has shown that 61 % of the participants reported planning their pregnancy but this varied from 83 % in the higher-income group down to only 53 % of the low-income Sheffield women; 26 % of the total group of Sheffield women reported taking periconceptional folic acid supplements but again there was a statistically significant difference according to income, i.e. only 14 % of the low-income group took them compared to 54 % of the higher-income women.

It is estimated that half of all pregnancies in the UK are unplanned which limits the usefulness of periconceptional supplements in reducing the risk of NTD (Botting, 2001). A small percentage of the total participants, i.e. 8 %, reported not having taken folic acid supplements at all during pregnancy. We know that these folic acid supplements were not started periconceptionally but when the pregnancy was confirmed and then up until 12 weeks gestation, which would have been too late to reduce the risk of NTD but would have made a significant contribution to maternal folate status. The present results suggested that both the low-income and higher-income Sheffield women have low folate intakes, as can be seen in Table 4. Low folate status in pregnancy has been related to other poor pregnancy outcomes as well as NTD (Vollset *et al.* 2000).

Recent data from the Health Survey of England (Blake *et al.* 2003) provides the most up-to-date information on the use of folic acid supplements prior to and during pregnancy by women of childbearing age. Information on folic acid supplement intake was collected prior to pregnancy from mothers who had planned their pregnancy, who comprised two-thirds of the interview sample. Over half (55 %) reported taking supplements or modifying their diet to increase folate intake. However, only 43 % of mothers in the most socially deprived areas were likely to increase folate intakes compared to 70 % of mothers from the least socio-economically deprived areas.

Small differences in macronutrient intakes were observed between the Sheffield women and the other studies. Intakes of energy, protein and total fat were relatively higher for the Sheffield women than those from the ALSPAC pregnancy nutrition study and the NDNS. However, when the Sheffield women were compared to the Mathews study (Mathews & Neil, 1998), mean daily intakes of energy and macronutrients for the Sheffield women were lower with the exception of protein. Nutrient intakes for calcium, riboflavin, vitamin C and for most of the vitamins including folate were comparatively lower in the Sheffield women than those reported in the ALSPAC and Mathews studies.

Similar trends were also found in comparison with the NDNS. Differences observed may be partly explained by differences in the stage of pregnancy when the questionnaires were administered, a 10-year gap between the two studies, different dietary assessment methodologies, and vastly differing sample sizes and population characteristics. As seen in Table 4, 60 % of the Sheffield women failed to reach the EAR for energy; 40 % failed to meet the EAR for calcium, 69 % did not meet the folate recommendations, 61 % the riboflavin suggested intakes and 67 % failed to meet those for iron.

Although the whole group of Sheffield women showed similar trends in nutrient intakes in comparison with the results from other studies, when the Sheffield women were divided into two groups according to socio-economic status, a very different trend emerged for the low-income group, i.e. those living in the 40% most deprived electoral wards had significantly lower intakes of saturated fat, fibre, magnesium, iron, thiamine, riboflavin, vitamin B_6, vitamin B_{12}, vitamin C and folate than the women living in the rest of Sheffield. The subgroup comparisons reflect the results of a previous pregnancy study (Rogers et al. 1998b), which identified a relationship between financial hardship and nutrient intakes.

In the present study we have attempted to assess the habitual nutrient intakes of pregnant women living in Sheffield, using a semi-quantified FFQ. The present findings show similar trends to those from previous studies in the UK that have reported low iron, calcium, vitamin C and folate intakes in pregnancy. However, the low-income sample had worryingly low intakes of the majority of micronutrients in a similar fashion to the results of Rodgers *et al.* (1998*b*) which showed that out of twenty nutrients studied only three were unaffected by financial difficulty.

In late 2005 the National Institute for Health & Clinical Excellence (2005) was asked by the Department of Health to develop public health programme guidance on maternal and child nutrition. The guidance will provide recommendations for good practice and be based on the best research evidence available from a range of methodological traditions including quantitative, qualitative and economic analyses. It is designed for implementation by those working in the National Health Service but will also be relevant to local authorities and the wider public, private and voluntary sectors.

The guidance clearly states that 'there is a recognised need to optimise nutritional status before pregnancy, during pregnancy, the post partum period and breastfeeding, and in the early years of life ... Folic acid supplementation, both before pregnancy and in the first 12 weeks of pregnancy, is particularly important as it significantly reduces the risk of NTD. Optimising nutritional status before, during and after pregnancy is important to the mother herself, both in the short term and the long term. She needs to have sufficient energy and nutrient supply from diet and reserves to maintain her own health as well as to provide for the fetus and the breastfed infant (National Institute for Health & Clinical Excellence, 2005, p. 2).

From a date to be notified in late 2006, the long-standing UK Government Welfare Food Scheme for low-income pregnant women and children, which provides liquid and formula cow's milk, is to be replaced by an initiative called 'Healthy Start' (Belton, 2005) which will include fresh fruit and vegetables as well as liquid cow's milk and infant formula. The findings of the present study provide valuable information about the eating habits and nutritional status of a pregnant population in Sheffield, which will need to be taken into account before planning any dietary or nutrition education intervention such as the introduction of Healthy Start in Sheffield.

The present study will make a valuable contribution to our aim of developing a validated nutrition-screening tool, which will incorporate discriminant foods, i.e. foods for which intakes have been shown to make a significant contribution to the dietary intakes of low-income Sheffield women. Practitioners with little nutrition training such as midwives or Sure Start workers do not currently have any instruments available that have been developed and validated for nutritional screening in pregnancy to identify those at nutritional risk. Those women identified as being at nutritional risk can then be referred as appropriate for advice to improve their dietary intake, cooking skills and food shopping behaviour.

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References

Barker DJP, (editor) (1992) *Fetal and Infant Origins of Adult Diseases*. London: BMJ Publishing Group.

Belton NR (2005) Healthy Start – will it provide optimal infant and child nutrition? *Nutr Food Sci* **35**(2), 74–80.

Blake M, Herrick K & Kelly Y (2003) *Health Survey for England 2002: Maternal and Infant Health*. London: Health Development Agency. http://www.archive2.officialdocuments.co.uk/document/deps/doh/survey02/hse02.htm

Botting B (2001) Trends in neural tube defects. *Health Stat Q* **10**, 5–12.

Bull J, Mulvihill C & Quigley R (2003) *Prevention of Low Birth weight: Assessing the Effectiveness of smoking cessation and Nutritional Interventions. Evidence Briefing*. London: Health Development Agency, July. http://www.hda-online.org.uk

Chan W, Brown J, Buss DH (1994) *Miscellaneous Foods. Fourth Supplement to McCance & Widdowson's The Composition of Foods*, 5th ed. Cambridge: Royal Society of Chemistry.

Chan W, Brown J, Church SM, Buss DH (1996) *Meat Products and Dishes. Sixth Supplement to McCance & Widdowson's The Composition of Foods*, 5th ed. Cambridge: Royal Society of Chemistry.

Chan W, Brown J, Lee SM, Buss DH (1995) *Meat, Poultry and Game. Fifth Supplement to McCance & Widdowson's The Composition of Foods*, 5th ed. Cambridge: Royal society of Chemistry.

Department of Health (1991) *Report on Health and Social Subjects* no. 41. *Dietary Reference Values for Food, Energy and Nutrients for the United Kingdom. Report of the Committee on Medical Aspects of Food Policy*. London: HMSO.

Department of Health (2004) *34534/Healthy Start: Government Response to Consultation Exercise*. http://www.dh.gov.uk/assetRoot/04/07/25/52/04072552.pdf

Dobson B, Beardworth A, Keil T & Walker R (1994) *Diet, Choice and Poverty: Social, Cultural and Nutritional Aspects of Food Consumption Among Low Income Families*. Loughborough: Loughborough University of Technology, Centre for Research in Social Policy.

Dowler E & Calvert C (1995) *Nutrition and Diet in Lone-parent Families in London*. London: Family Policy Studies Centre.

Food Standards Agency (2002) *McCance & Widdowson's The Composition of Foods. Sixth summary edition*. Cambridge: Royal Society of Chemistry.

Gibney BM, Margetts BM, Kearney JM & Arab L (2004) *Public Health Nutrition*. London: Blackwell Publishing.

Godfrey KM & Barker DJP (2001) Fetal programming and adult health. *Public Health Nutr* **4**(2B), 611–624.

Godfrey K, Robinson S, Barker DJP, Osmond C & Cox V (1996) Maternal nutrition in early and late pregnancy in relation to placental and fetal growth. *Br Med J* **312**, 410–414.

Gordon R (2001) *Sheffield and its Electoral Wards – A Review of the Index of Multiple Deprivation 2000*. Sheffield: Sheffield Health Authority.

Henderson L, Gregory J & Swan G (2002) *The National Diet and Nutrition Survey: adults Aged 19 to 64 Years*. National Statistics – Social Survey Division, Medical Research Council, Human Nutrition Research. London: HMSO.

Holland B, Brown J, Buss DH (1993) *Fish and Fish Products. Third Supplement to McCance & Widdowson's The Composition of Foods*, 5th ed. Cambridge: Royal Society of Chemistry.

Holland B, Unwin ID, Buss DH (1988) *Cereals and Cereal Products. Third Supplement to McCance & Widdowson's The Composition of Foods*, 4th ed. Cambridge: Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.

Holland B, Unwin ID, Buss DH (1989) *Milk products and Eggs. Fourth Supplement to McCance & Widdowson's The Composition of Foods*, 4th ed. Cambridge: Royal Society of Chemistry.

Holland B, Unwin ID, Buss DH (1991*a*) *Vegetables, Herbs and Spices. Fifth Supplement to McCance & Widdowson's The Composition of Foods*, 4th ed. Cambridge: Royal Society of Chemistry.

Holland B, Unwin ID, Buss DH (1992*a*) *Fruit and Nuts. First Supplement to McCance & Widdowson's The Composition of Foods*, 5th ed. Cambridge: Royal Society of Chemistry.

Holland B. Welch AA, Unwin ID, Buss DH, Paul AA, Southgate DAT (1991*b*) *McCance & Widdowson's The Composition of Foods*, 5th ed. Cambridge: Royal Society of Chemistry.

Holland B, Welch AA, Buss DH (1992*b*) *Vegetable Dishes. Second Supplement to McCance & Widdowson's The Composition of Foods*. 5th ed. Cambridge: Royal Society of Chemistry.

Huxley RR (2000) Nausea and vomiting in early pregnancy: its role in placental development. *Obstet Gynecol* **95**, 779–782.

Kassam-Khamis T, Nanchahal K, Mangtani P, dos Santos Silva I, McMichael A & Anderson A (1999) Development of an interview administered food-frequency questionnaire for use amongst women of South Asian ethnic origin in Britain. *J Hum Nutr Diet* **12**, 7–19.

Mathews F & Neil HAW (1998) Nutrient intakes during pregnancy in a cohort of nulliparous women. *J Hum Nutr Diet* **11**, 151–161.

Medical Research Council Vitamin Study Research Group (1991) Prevention of neural tube defects: results of the Medical Research Council Vitamin Study. *Lancet* **338**, 131–137.

Mouratidou T, Ford F & Fraser RB (2006) Validation of a food-frequency questionnaire for use in pregnancy. *Public Health Nutr* 9(4), 515–522.

National Institute for Health and Clinical Excellence (2005) *Public Health Programme Guidance on Maternal and Child Health Nutrition* (draft). http://www.nice.org.uk/page.aspx?o = Maternaland Child-NutritionMain

Rogers I Emmett P & the ALSPAC Study Team (1998*a*) Diet during pregnancy in a population of pregnant women in South West England. *Eur J Clin Nutr* **52**, 246–250.

Rogers I, Emmett P, Baker D, Golding J & the ALSPAC Study Team (1998*b*) Financial difficulties, smoking habits, composition of the diet and birth weight in population of pregnant women in South West England. *Eur J Clin Nutr* **52**, 251–260.

Scholl TO & Johnson WG (2000) Folic acid: influence on the outcome of pregnancy. *Am J Clin Nutr* **71**, 1295S–1303S.

Vollset SE, Refsum H, Irgens LM, Emblem BM, Tverdal A, Gjessing HK, Monsen AL, Ueland PM (2000) Plasma total homocysteine, pregnancy complications, and adverse pregnancy outcomes: the Hordaland Homocysteine study. *Am J Clin Nutr* **71**, 962–968.

Vyas A, Greenhalgh A, Cade J, Sanghera B, Riste L, Sharma S, Cruickshank K (2003) Nutrient intakes of an adult Pakistani, European and African-Caribbean community in inner city Britain. *J Hum Nutr Diet* **16**, 327–337.

Willet W (1998) *Nutritional Epidemiology*, 2nd ed. New York: Oxford University Press.

Appendix III: CONSENT FORM

University of Sheffield

Centre for Pregnancy Nutrition

Patient Identification Number for this study:

Name of Researcher: **Mouratidou Theodora**

Please tick relevant box

1. I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions. ☐

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

3. I understand that all information that is collected will be treated confidentially and used for research purposes only. ☐

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

....

Name of Patient Date Signature

....

Researcher Date Signature

Appendix IV: PATIENT INFORMATION SHEET

University of Sheffield

Centre for Pregnancy Nutrition

You are being invited to take part in a research study. Before you decide to take part it is important for you to understand why the study will be done and what it will involve. Please take time to read the following information carefully. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

1. What is the purpose of the study?

You have been asked to take part in a study because we want to find out what pregnant women in Sheffield usually eat. Your help will be of great benefit to us in our studies of diet during pregnancy. The survey will be carried out by the Centre for Pregnancy Nutrition, Jessop Wing Hospital, Sheffield by PhD student, Theodora Mouratidou under the supervision of a Senior Research Dietician Fiona Ford.

2. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

3. What if I do not wish to take part?

This will not affect the care that you would normally receive from your midwife or doctor in any way.

4. What will happen to me if I take part?

Your part of the study will last approximately 30 minutes but the whole study will last approximately 3 years. Throughout this time we will approach nearly 500 pregnant women in Sheffield. We are trying to find out about your diet, by recording the food and drink that you usually eat using a food frequency questionnaire. We will also be using a subject information questionnaire to find out some of your characteristics e.g. age, weight. This will take place at the waiting area of the antenatal clinic or GP surgeries. A number of randomly selected women will be asked to take part for a second time in the study, but their participation will be voluntary. At the second visit they will be asked to to complete a weighted food diary at home. All the subjects will be provided with an electronic scale to weigh all food and drink consumed over a four-day period.

5. Will my taking part in this study be kept confidential?

All information, which is collected, about you during the research study will be kept strictly confidential and will be used for academic purposes only and will be destroyed by the end of the study.

6. What are the possible benefits of taking part?
There are no direct benefits of taking part in the study. However, this research will enable a validated food frequency questionnaire to be administered to large numbers of pregnant women across the city and identify those at nutritional risk

7. What if something goes wrong?
If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone's negligence, then you may have grounds for a legal action but you may have to pay for it. Regardless of this, if you wish to complain, or have any concerns about any aspect of the way you have been approached or treated during the course of this study, the normal National Health Service complaints mechanisms should be available to you.

8. What will happen to the results of the research study?
All data collected during the study will be destroyed but the results of the research study will be used to develop a nutritional screening tool.

9. Who is organising and funding the research?
Sure Start is organising and funding the research.

10. Contacts for Further Information
You should contact:
Fiona Ford on the "Eating for Pregnancy Help line": 0845-1303646 or 0114 2424084
(Monday – Friday 9am-5pm)

Thank you for reading this.

Appendix V: SUBJECT INFORMATION QUESTIONNAIRE

***Surname*..** ***Code*...............**

***First name*..** ***Postcode*..........**

Height &Weight

What is your height? .... ft ....ins OR ....cm

What is your weight? .... st ....lb OR .... kg

How many weeks pregnant are you? ....weeks

Education

Not yet finished ☐

14 to 20 ☐

21 or over ☐

No formal education ☐

Qualification

Degree or equivalent ☐

Higher education below degree level ☐

GCE'A' level or equivalent ☐

GCSE Grades A-C or equivalent ☐

GCSE Grades D-G or equivalent ☐

Other qualifications ☐

No qualifications ☐

Part time education and qualification

Yes or No ....

If yes what?...

Household Composition

Living alone ☐

Living with partner (no kids) ☐

Living with family (parents, siblings etc) ☐

Living with partner (kids)

Lining alone (kids) ☐

Other (please specify).....................................

Do you have any existing children?

Yes ☐

No ☐

If yes; How old are your children? ....

What was their birth weight? ....

Employment Status

Which of the below describes your employment status?

Economically active

Working → Full-time ☐

Working → Part time ☐

Unemployed ☐

Economically inactive → Looking after home/family

Economically inactive → Other.............

What is your usual occupation? ....

Which of the below describes your partner's employment status?

Economically active

Working → Full-time ☐

Working → Part time ☐

Unemployed ☐

Economically inactive → Looking after home/family

Economically inactive → Other.............

What is his usual occupation? ....

Are you or your partner receiving any of the following benefits?

Working families tax credits ☐

Income support ☐

(Income-related)Job Seekers Allowance ☐

Smoking Behaviour

Non Smoker ☐

Light smoker –fewer than 20 cigarettes per a day ☐

Heavy smoker –20 or more cigarettes per a day ☐

Have you changed how many you smoke since becoming pregnant?

Yes, I gave up during pregnancy ☐

Yes, I have cut down by............cigarettes per day. ☐

No, I have increased my smoking to..........cigarettes per day. ☐

No, I have not changed the number of cigarettes I smoke. ☐

Activity

How physically active is your occupation?

1 Not very active
2 Moderately active
3 Very active
4 Not working

How physically active is your leisure time?

1 Not very active
2 Moderately active
3 Very active

Nutritional Supplements

Did you take vitamins or mineral supplements before you became pregnant?

Yes ☐

No ☐

If yes, for how long? ....

If yes, what kind did you take?		*Which brand?*
Vitamins with Fe	☐	....
Vitamins without Fe	☐	....
Iron	☐	....
Vitamin C	☐	....
Multiminerals	☐	....

Calcium ☐ …………

Folic acid ☐ …………

Other supplements (please describe)……………………………………………

Have you taken a folic acid supplements during your pregnancy?

Yes ☐

No ☐

If yes, as a part of multivitamin or multimineral supplement?

Yes ☐

No ☐

If yes, when did you start taking them?

………………………………………………………………………………………

Who advised you to take them?

………………………………………………………………………………………

Did you buy them or get them from your GP/Midwife?

………………………………………………………………………………………

Was your pregnancy planned?

Yes ☐

No ☐

Was your dietary intake unusual in any way?

Yes ☐

No ☐

If, yes in what way? ………………………………………………………………

Can you cook?

Yes ☐

No ☐

Who does the cooking at home? (Please describe)………………

How many days in a week do you eat homemade food? ………………

Appendix VI: Overall Index of Multiple Deprivation 2000 Sheffield Wards

Ward Name	Rankling on IMD score out of 8414 England wards	Ranking Percentile - all England Wards	Rank in Sheffield	1991 Townsend Rank	IMD 2000 ranking compared with Townsend
Southey Green	43	1%	1	3	2
Burngreave	60	1%	2	6	4
Manor	76	1%	3	1	-2
Park	98	2%	4	2	-2
Firth Park	129	2%	5	7	2
Castle	198	3%	6	4	-2
Nether Shire	369	5%	7	9	2
Darnall	561	7%	8	11	3
Owlerton	605	8%	9	12	3
Brightside	635	8%	10	13	3
Sharrow	1059	13%	11	5	-6
Norton	1064	13%	12	10	-2
Handsworth	1314	16%	13	16	3
Birley	1766	21%	14	15	1
Netherthorpe	1787	22%	15	8	-7
Heeley	1909	23%	16	14	-2
Intake	2169	26%	17	17	0
Walkley	2587	31%	18	19	1
Mosborough	2800	34%	19	20	1
Hillsborough	3121	38%	20	21	1
Stocksbridge	3140	38%	21	22	1
Chapel Green	3872	47%	22	24	2
South Wortley	3942	47%	23	26	3
Nether Edge	3987	48%	24	18	-6
Dore	4369	52%	25	25	0
Beauchief	5609	67%	26	27	1
Hallam	7309	87%	27	28	1
Broomhill	7953	95%	28	23	-5
Ecclesall	8105	97%	29	29	0

National rank is position out of 8414 electoral wards (smaller number = more deprived)

Percentile is position on scale of 1% (most deprived) to 100% (least deprived)

- Most deprived wards nationally (highest 20%)
- Above average deprivation (21% - 40%)
- Mid-range of wards nationally(41% - 60%)
- Below average deprivation (61% - 80%)
- Least deprived wards nationally (81% - 100%)

Definition: The Index of Multiple Deprivation combines the six separate Domain scores for each ward, having standardised each to a common metric, then using the statistical technique of transformation to a common distribution and finally weighting the domains differentially.

Index of Multiple Deprivation: Summary of individual domains

Income Deprivation — Health Deprivation and Disability

Employment Deprivation — Education, Skills and Training

Housing — Geographical Access to Services

(Under consideration for future - Crime and Social Order, Physical Environment)

Appendix VII: ALSPAC FFQ

A1. How many times nowadays do you eat?

	Never or rarely	Once in 2 weeks	1 - 3 times a week	4 –7 times a week	More than once a day
a) Sausages, Burgers	1	2	3	4	5
b) Pies, Pasties (pork pie, steak/meat pie etc)	1	2	3	4	5
c) Meat (beef, lamb, pork, ham, bacon etc)	1	2	3	4	5
d) Poultry (chicken, turkey etc)	1	2	3	4	5
e) Liver, liver pate, kidney, heart	1	2	3	4	5
f) White fish (cod, haddock, plaice, fish fingers etc)	1	2	3	4	5
g) Other fish (pilchards, sardines, mackerel, tuna, herring, kippers, trout, salmon etc)	1	2	3	4	5
h) Shellfish (prawns, crab, cockles, mussels etc)	1	2	3	4	5
i) Eggs, quiche	1	2	3	4	5
j) Cheese	1	2	3	4	5
k) Pizza	1	2	3	4	5
l) Chips	1	2	3	4	5
m) Roast potatoes (cooked in fat)	1	2	3	4	5
n) Boiled, mashed, jacket potatoes	1	2	3	4	5
o) Rice (boiled)	1	2	3	4	5
p) Pasta (eg spaghetti, Pot Noodles, lasagna)	1	2	3	4	5
q) Crisps	1	2	3	4	5
r) Fried foods (egfried fish, eggs, bacon, chops etc)	1	2	3	4	5

A2. Do you eat the fat on meat?

Yes, all of it	1
Yes, some of it	2
No	3
Never eat meat	4

A3. How many times a week nowadays do you eat:

	Never or rarely	Once in 2 weeks	1 - 3 times a week	4 –7 times a week	More than once a day
a) Baked beans	1	2	3	4	5
b) Peas, sweet corn, broad beans	1	2	3	4	5
c) Cabbage, brussel sprouts, kale and other green leafy vegetables	1	2	3	4	5
d) Other green vegetables (cauliflower, runner beans, leeks etc.)	1	2	3	4	5
e) Carrots	1	2	3	4	5
f) Other root vegetables 1 2 3 4 5 (turnip, swede, parsnip etc.)					
g) Salad (lettuce, tomato, cucumber etc.)	1	2	3	4	5
h) Fresh fruit (apple, pear, banana, orange, bunch of grapes etc.)	1	2	3	4	5
i) Tinned juice (including tomato juice)	1	2	3	4	5
j) Pure juice not in tin	1	2	3	4	5
k) Pudding (e.g. fruit pie, crumble, cheesecake, milk pudding, mousse, gateaux)	1	2	3	4	5
l) Oat cereals (e.g. porridge, Ready Brek, muesli)	1	2	3	4	5
m) Wholegrain or bran cereals (e.g. All Bran, Bran Flakes, Weetabix, Wheatflakes, Fruit & Fibre)	1	2	3	4	5
n) Other cereal (e.g. Cornflakes, Rice Krispies,Special K, Frosties)	1	2	3	4	5
o) Cakes or buns (fruit cake, sponge, teacake, buns, doughnut, flapjack, scone, custard tart, cream cake etc.)	1	2	3	4	5
p) Crispbreads (Ryvita, crackerbread etc.)	1	2	3	4	5

q) Biscuits (digestive, shortcake, Hob Nobs, Rich Tea, Nice, Marie, chocolate biscuits, Penguin, Club, Kit Kat etc.)	1	2	3	4	5
r) Chocolate bars (Mars, Twix, Wispa, Bounty, Creme Egg etc.)	1	2	3	4	5
s) Pulses - dried peas, beans, lentils, chick peas	1	2	3	4	5
t) Nuts, nut roast	1	2	3	4	5
u) Bean Curd (e.g. Tofu, miso)	1	2	3	4	5
v) Tahini	1	2	3	4	5
w) Soya 'Meat', T V P, Vegeburgers	1	2	3	4	5
x) Chocolate (dairy milk or plain, nut, fruit filled etc.)	1	2	3	4	5
y) Sweets (peppermints, boiled sweets, toffees etc.)	1	2	3	4	5

A4. When you have a soft drink, how often do you choose *low calorie or diet* <u>drinks?</u>

Always	1
Sometimes	2
Not at all	3
Don't drink soft drinks	4

A5. How many *pieces of bread, rolls or chappatis* do you eat on a usual day ?

Less than 1	1-2	3-4	5 or more
1	2	3	4

A6. How many times in a month do you eat take-away foods for your main meal?

Never or rarely	1
1 - 2	2
3 - 4	3
5 - 9	4
10 or more	5

A7. What types of bread do you eat most days?

	Yes	No
a) White bread	1	2
b) Brown/granary bread	1	2
c) Wholemeal bread	1	2
d) Chappatis, nan bread	1	2
e) don't usually eat any bread	1	2

A8. What sort of fat do you mainly use:

	(i) On bread or vegetables		(ii) For frying	
	Yes	No	Yes	No
a) Butter, Ghee, Dripping Lard, solid cooking fat	1	2	1	2
b) Hard or soft margarine e.g. Blue Band, Stork, supermarket own brand	1	2	1	2
c) Polyunsaturated margarine e.g. Flora, sunflower, Vitalite	1	2	1	2
d) Low fat spread e.g. Outline Delight, St Ivel, Gold	1	2	1	2
e) Sunflower, soya, corn, olive oil	1	2	1	2
f) Other vegetable oil	1	2	1	2
g) Other (please describe)	1	2	1	2

A9. How many slices of bread (or rolls) spread with fat do you eat each day?

(include bought sandwiches) ....slices

A10. What type(s) of milk do you use?

	Yes usually	Yes sometimes	No not at all
a) Full fat (silver or gold top)	1	2	3
b) Semi Skimmed (red stripe)	1	2	3
c) Skimmed (blue stripe)	1	2	3

d) Sterilised	1	2	3
e) Dried milk	1	2	3
f) Goat/sheep milk	1	2	3
g) Soya milk	1	2	3
h) Other (please describe)	1	2	3

A11. How often do you have milk:

	Yes usually	**Yes sometimes**	**No not at all**
a) In tea	1	2	3
b) In coffee	1	2	3
c) On breakfast cereal	1	2	3
d) As pudding (custard,rice)	1	2	3
e) To drink on its own	1	2	3
f) As a milky drink (Horlicks, cocoa, all milk coffee)	1	2	3

A12

a) How many cups of tea do you drink in a day? cups (do not include herbal teas)

b) How many spoons of sugar in each cup? spoons

c) How many of the cups of tea you drink each day are decaffeinated? cups

d) How many cups of coffee do you drink in a day? cups

e) How many spoons of sugar in each cup? spoons

f) How many of the cups of coffee you drink each day are decaffeinated? cups

g) How many of the cups of coffee you drink each day are made using real coffee (ie not instant)? cups

h) How many of these are decaffeinated? cups

A13

a) How many drinks of cola do you have **in a week**? drinks
b) How many of these drinks are decaffeinated? drinks

A14

a) Do you drink herbal teas at all?

yes, often	yes, occasionally	no, not at all
1	**2**	**3**

If no, go to A15

If yes,

b) how many cups/mugs of herbal teas have you drunk in the past week? cups/mugs

c) Please list the types of herbal teas you have drunk in the past 3 months:

A15. Do you buy organic foods?

	Yes, usually organic	**Yes, some-times organic**	**No, never organic**
a) Fruit	1	2	3
b) Vegetables	1	2	3
c) Meat	1	2	3
d) Other (please describe)	1	2	3

A16. Apart from herbal teas, are there any other health foods (whether or not <u>bought from a health food shop) that you often eat or drink?</u>

Yes **1** No **2**

If yes, please describe below:

<u>A17 a) Have you been on a diet this pregnancy?</u>

Yes **1** No **2**

If yes, please describe the type of diet:

A17 b) Apart from this pregnancy have you ever gone on a diet to lose weight?

Yes **1** No **2**

If yes,

c) How often?

1-2 **1** 3-5 **2** 6-10 **3** more than 10 times **4**

d) How long do your diets usually last?

under 1 month **1** 1-3 months **2** more than 3 months **3**

A18 a) Are you, or have you ever been a vegetarian?

yes, I am now **1** yes, in past not now **2** no, never **3**

If yes,

b) How many years of your life have you been vegetarian? years (If less than one year put 00)

A19

a) Are you, or have you ever been, a vegan (i.e. do not eat meat, poultry, fish, eggs, butter, milk or cheese)?

yes, I am now **1** not now yes, in past **2** no, never **3**

If yes,

b) How many years of your life have you been vegan?
years (If less than one year put 00)

	Yes, most of the time	**Yes, occasionally**	**No, not at all**
A20 Do you now feel you've put on too much weight?	1	2	3
A21 Do you feel uncomfortable seeing your body in the mirror?	1	2	3
A22 Have you had a strong desire to lose weight at any time during this pregnancy?	1	2	3
A23 Do you feel dissatisfied about your shape?	1	2	3
A24 Have you experienced any loss of control over eating during this pregnancy?	1	2	3
A25 Are you concerned about losing any extra weight you've gained in this pregnancy?	1	2	3

A26. How many days in the past month have you drunk the equivalent of 2 pints of beer, 4 glasses of wine or 4 pub measures of spirit?

everyday	**5**	more than 10 days	**4**
5-10 days	**3**	3-4 days	**2**
1-2 days	**1**	none	**0**

A27. At present how much of the following do you usually drink in a day:

At present	**Weekday**	**Weekend day**
a) Beer or lager (half-pints)		
b) Wine (glasses)		
c) Spirits (pub-measures)		
d) Other alcoholic drinks (pub measures)		

Appendix VIII: Sheffield FFQ

Surname ....
First Name(s) ....
Address ....
....
....
Date of Birth ....

Code........................
Date of Survey............
Questionnaire No.........
Group Code................
Survey Number...........

The following questions are about the foods you USUALLY eat. Please indicate the number of days per week that you eat each item on average. Ring the answer as in these examples:

If you rarely or NEVER eat the food, ring	**1**
If you eat the food once a fortnight, ring	**2**
If you eat the food 1-3times/week, ring	**3**
If you eat the food 4-7timess/week, ring	**4**
If you eat the food more than once a day, ring	**5**

Frequency

How many times a week nowadays do you eat:

1. Sausages, Burgers	1 2 3 4 5
2. Pies, pastries (pork pie, steak/meat pie etc)	1 2 3 4 5
3. Meat (beef, lamb, pork, ham, bacon etc)	1 2 3 4 5
4. Poultry (chicken, turkey etc)	1 2 3 4 5
5. White fish (cod, haddock, plaice, fish fingers etc)	1 2 3 4 5
6. Other fish (sardines, macherel, tuna, herring, kippers, trout, salmon)	1 2 3 4 5
7. Shellfish (prawns, crab, cockles, mussels etc)	1 2 3 4 5
8. Eggs	1 2 3 4 5
9. Quiche	1 2 3 4 5
10. Cheese	1 2 3 4 5
11. Pizza	1 2 3 4 5
12. Chips, oven, homemade, fries	1 2 3 4 5
13. Chips(fish &chips)	1 2 3 4 5
14. Roast potatoes (cooked in fat)	1 2 3 4 5

If you rarely or NEVER eat the food, ring 1
If you eat the food once a fortnight, ring 2
If you eat the food 1-3times/week, ring 3
If you eat the food 4-7timess/week, ring 4
If you eat the food more than once a day, ring 5

15. Boiled, mashed, jacket potatoes 1 2 3 4 5

16. Rice (boiled) 1 2 3 4 5

17. Pasta (pot noodles, tinned spaghetti, lasagne) 1 2 3 4 5

18. Crisps 1 2 3 4 5

19. Do you eat the fat on the meat?

1. Yes, all of it
2. Yes, some of it
3. No
4. Never eat meat

20. Mushy peas, fish and chips 1 2 3 4 5

21. Baked beans 1 2 3 4 5

22. Peas, sweet corn, broad beans 1 2 3 4 5

23. Cabbage, brussel sprouts, kale and other green leafy vegetables 1 2 3 4 5

24. Other green vegetables (cauliflower,) runner beans, leeks etc 1 2 3 4 5

25. Other root vegetables (turnip, swede, parsnip etc) 1 2 3 4 5

26. Carrots, tinned carrots 1 2 3 4 5

27. Salad (lettuce, tomato, cucumber etc) 1 2 3 4 5

28. Squash 1 2 3 4 5

29. Fresh fruit (apple, pear, banana, orange, bunch of grapes etc) 1 2 3 4 5

30. Fruit juice 1 2 3 4 5

31. Pudding (e.g. fruit pie, crumble, cheese,) cake, milk pudding, mousse, gateaux) 1 2 3 4 5

32. Oat cereals (e.g. porridge, ready brek, muesli) 1 2 3 4 5

33. Wholegrain or bran cereals (e.g. All brans, Bran flakes, Weetabix, Fruit & Fibre) 1 2 3 4 5

34. Other cereals (e.g. cornflakes, rice krispies, Special K, frosties) 1 2 3 4 5

35. Cakes or buns (fruit cake, sponge, teacake, buns, doughnut, scone, custard tart, cream cake) 1 2 3 4 5

36. Biscuits (digestive, shortcake, hob nobs, penguin, chocolate, rich tea, kit kat) 1 2 3 4 5

37. Chocolate bars (mars, twix, wispa, bounty, creme eggs etc) 1 2 3 4 5

38. Quorn 1 2 3 4 5

39. Soya meat, veggie burgers, 1 2 3 4 5

40. Chocolate (dairy milk or plain, nut, fruit filled etc) 1 2 3 4 5

41. Sweets (peppermints, boiled sweets, toffees etc) 1 2 3 4 5

Bread, Fat and Milk

42. When you have a soft drink, how often do you choose low calorie or diet drinks?

1. Always
2. Sometimes
3. Not at all
4. Do not drink soft drinks

43. What type of bread do you eat most days?

1. White bread
2. Brown/granary bread
3. Wholemeal bread
4. Chappatis, naan bread
5. Do not usually eat any bread

How many slices of bread do you eat on a usual day??

1. Less than 1
2. 1-2
3. 3-4
4. 5 or more

44. How many days in a month do you eat take-away foods for your main meal?

1. Never or rarely
2. 1-2
3. 3-4
4. 5-9

5. 10 or more

45. What sort of fat do you mainly use on bread or vegetables?

1. Butter, Ghee, Lard, Solid cooking fat
2. Hard or soft margarine e.g. Blue Band, Stork
3. Polyunsaturated margarine e.g. Flora, Sunflower
4. Low fat spread e.g. Outline, Delight, St Ivel Gold
5. Sunflower, Soya, Corn, Olive oil
6. Other

How many slices of bread spread with fat per day?

..................**slices**
.... **grams**

46. What sort of fat do you mainly use for frying?

1. Butter, Ghee, Lard, Solid cooking fat
2. Hard or soft margarine e.g. Blue Band, Stork
3. Polyunsaturated margarine e.g Flora, Sunflower
4. Low fat spread e.g Outline, delight,St Ivel Gold
5. Sunflower, Soya, Corn, Olive oil
6. Other

47. What type(s) of milk do you use?

1. Full fat	1 2 3 4 5
2. Semmi-skimmed	1 2 3 4 5
3. Skimmed	1 2 3 4 5
4. Sterilised	1 2 3 4 5
5. Dried milk	1 2 3 4 5
6. Goat milk	1 2 3 4 5
7. Sheep milk	1 2 3 4 5
8. Soya milk	1 2 3 4 5
9. Do not drink milk	

How often do you have milk?

1. In tea	1 2 3 4 5
2. In coffee	1 2 3 4 5
3. On breakfast cereals	1 2 3 4 5
4. As a pudding (custard, rice)	1 2 3 4 5
5. To drink on its own	1 2 3 4 5
6. As a milky drink	1 2 3 4 5

Drinks

49. How many cups of tea do you drink in a day? .... Cups
50. How many spoons of sugar in each cup? .... Spoons

51. How many cups of coffee do you drink in a day?.................. Cups
52. How many spoons of sugar in each cup? .... Spoons

53. How many drinks of cola do you have in a week?

.... Glasses

54. Do you drink herbal teas at all? Yes / No

55. How many cups of herbal teas have you drunk in the past week?

.... Cups

56. Do you buy organic foods? Yes / No

57. What type of organic foods?

1. Fruits
2. Vegetables
3. Meat

58. Have you been on a diet during this pregnancy?

1. Yes
2. No

59. Apart from this pregnancy, have you ever gone on a diet to loose weight? Yes / No

60. How often?

1. 1-2
2. 3-5
3. 6-10
4. More than 10 times

61. Have you ever been vegetarian or vegan?

1. Yes
2. No

62. In a typical week, how much of the following do you usually drink in a day

Beer or lager	1 2 3 4 5
Amount per occasion	.... Half-pints
Wine	1 2 3 4 5
Amount per occasion	.... Glasses
Spirits	1 2 3 4 5
Amount per occasion	.... measures