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Determinants of diet in pregnancy

Development of an explanatory model and application to cross-sectional data from a social-epidemiological birth cohort study

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Abstract

Background:

Diet in pregnancy is crucial for the short and long-term health of mothers and their children. Evidence suggests that it is important to capture diet 'as a whole' rather than 'single' foods and nutrients in order to account for the variety and interaction of different foods and drinks consumed. The complexity of dietary intake can be simplified by representation as dietary patterns or diet quality (including guideline adherence). Findings from different developed countries corroborate that dietary intake in pregnant women is inadequate despite food (theoretically) being abundant. Therefore it is of public health relevance to study the factors that influence diet in pregnancy and that are amenable to change by public health policy or practice.

Aims and objectives:

To assess the complex interplay of determinants of diet in pregnancy and develop an explanatory model based on theoretical and empirical evidence.

Methods:

After an initial scoping of the theoretical and empirical literature, a conceptual framework was developed that identified socio-demographic, individual responses (behavioural/biological) and environmental determinants as key drivers of diet. While empirical literature has largely overlooked pregnancy-related determinants of diet, theoretical literature frames pregnancy as a physiologically, psychologically and sociologically unique period. Pregnancy-related determinants were therefore also included in the framework. The 'fit' of the initial framework was improved based on results from a systematic review and it was then applied to cross-sectional data from the social-epidemiological BaBi birth cohort study (BaBi study). Dietary data was provided by two 24h recalls which recorded >200 foods and drinks consumed but not portion size or frequency. Data on determinants stemmed from the BaBi baseline questionnaire. Univariate and multivariate analyses were performed to assess factors associated with dietary pattern and guideline adherence scores.

Results:

Among BaBi participants nutrition related knowledge was relatively high and the consumption of individual foods and food categories largely reflected recommendations. An exception was the consumption of coffee, sweets and soft drinks and of recommended supplements, but this cannot be definitively assessed given the nature of the data. A health conscious dietary pattern was derived using exploratory factor analysis, but several methodological criteria and factor interpretability indicate that this measure was rather poor. A guideline adherence score was built by summing up the number of recommended foods consumed as best as possible given that only food consumption (yes/no) but not amounts or frequencies were known. Regular physical activity before pregnancy was associated with higher scores on both diet measures. A positive association between scores and maternal age was also observed, albeit only significant for dietary pattern. Pregnancy-related factors anaemia, a rather planned pregnancy, conception duration and nausea were also significantly associated with scores but only with one of the two diet measures, indicating that the scores either measure different latent constructs or that the associations were spurious findings.

Discussion and conclusions:

Dietary intake in pregnancy, at least in some women, appeared in need of improvement. The determinants of diet are complex and go beyond mere motivation or willingness to change behaviour. Both a social and behavioural gradient were identified but evidence on the role of pregnancy-related and environmental determinants is inconclusive at this stage. The conceptual framework could therefore not be refined into a full explanatory model. As the BaBi study is finalising its recruitment, analyses can be repeated using a larger sample size which may allow for a more accurate measurement of the role of determinants of diet. Several recommendations were made for research, practice and policy.

The original contribution to knowledge of this dissertation was designing a framework that can be refined into an explanatory model of determinants of diet in pregnancy and the health consequences for mothers and children.

Preface

This dissertation was submitted for the degree of Doctor of Public Health at Bielefeld University, School of Public Health.

The research herein was conducted as part of the BaBi birth cohort study and supervised by Professor Jacob Spallek (primary supervisor from October 2012) and by Professor Oliver Razum (secondary supervisor from October 2013). This work has been to the best of my knowledge original, unless otherwise referenced.

Chapter 4 briefly outlines findings of a systematic review, the full work has been published in the Journal of Public Health Nutrition this year and interim results have been presented at the Annual Conference of the German Society for Epidemiology in Potsdam in 2015. I was the lead investigator responsible for designing and conducting the search strategy, Dr. Brigitte Borrmann and Dr. Angelique Grosser were involved in screening of articles for inclusion and commenting on the final manuscript, Prof. Dr. Jacob Spallek and Prof. Dr. Oliver Razum were supervisory authors involved in the idea formation and manuscript editing.

The BaBi birth cohort study is funded by the German Mininstry for Research and Education as well as Bielefeld University. The field work described in Chapter 5 was covered by ethical approval and use of the 24 hour Food List (see Appendix 1 – Glossary of terms) was enabled by the German Institute for Human Nutrition Potsdam-Rehbrücke (DIfE). CAPI data (computer assisted interviews of pregnant and postpartum women) were collected by several interviewers employed by the BaBi birth cohort study. 24 hour Food List data were collected by interviewers and me. I entered the data into the DIfE study management system for epidemiology and public health (webbased). Pseudonymised datasets were provided by data managers of both DIfE and the BaBi study which I merged into one dataset before performing all analyses reported in Chapter 5.

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List of abbreviations

24hFL: 24 hour Food List

AHEI-P: Alternate healthy eating index for pregnancy

AIC: Akaike's Informaiton Criterium

ALSPAC: Avon Longitudinal Study of Parents And Children, a birth cohort study conducted by the University of Bristol

BaBi: Gesundheit von Babys und Kindern in Bielefeld, birth cohort study which focuses on health of babies and children in Bielefeld, Germany

BIC: Bayesian Information Criterium

BMI: Body mass index

BMR: Basal metabolic rate

CANDLE: Conditions Affecting Neurocognitive Development and Learning in Early Childhood, birth cohort study

CAPI: Computer assisted personal interview

CFG: Canadian Food Guidelines

CHD: Coronary heart disease

CVD: Cardiovascular disease

df: Degrees of freedom

DGE: Deutsche Gesellschaft für Ernährung e.V., „German Nutrition Society"

DHA: Docosahexaenoic acid

DIPP: Diabetes Prediction and Prevention study

DQI-P: Diet Quality Index for pregnancy

ECCAGE: Brazilian study of food intake and eating behaviour in pregnancy

EFA: Exploratory factor analysis

EnRG: Environmental research framework for weight gain prevention

FAS: Fetal alcohol syndrome

FASD: Fetal alcohol spectrum disorder

FFQ: Food frequency questionnaire

GWG: Gestational weight gain

HEI: Healthy eating index

HSYF: "Healthy Start - Young Family Network" (Gesund ins Leben Netzwerk Junge Familie)

INMA: INfancia y Medio Ambiente Project (Environment and Childhood)

IOM: American Institute of Medicine

KMO: Kaiser-Meyer-Olkin measure of sampling adequacy

LBW: low birth weight, i.e. birth weight of <2,500g

MoBa: Norwegian Mother and Child cohort study

OR: Odds Ratio

PCA: Principal component analysis

PHP: Canadian Perinatal Health Project study

PIN: US Pregnancy, Infection and Nutrition birth cohort study

PUFA: polyunsaturated fatty acids, e.g. as n-3

SES: Socio-economic status

RCT: Randomised controlled trial

SD: Standard deviation

T2DM: Type 2 diabetes mellitus

TEE: Total energy expenditure

WIC: Special Supplemental Nutrition Program for Women, Infants, Children provided to low-income families in the US

PHCHC: Producing Health, Consuming Health Care framework (Evans and Stoddart 1990 and 2003)

1. Introduction

This chapter will introduce the topic of the dissertation, namely the determinants of diet in pregnancy. First of all a background on dietary requirements in pregnancy will be given. Then the main concepts of the work will be introduced: pregnancy, dietary requirements during this period, dietary patterns, dietary quality and the determinants thereof.

In the next chapter, the aims and objectives of the dissertation will be outlines and the public health relevance described (Chapter 2). The third chapter will describe the conceptual framework under which the research will operate. Based on the results of the reviewed literature (Chapter 4), the fit of the conceptual framework will be tested and it will be adapted where necessary and advanced into an explanatory model.

The fifth chapter will describe the empirical part of the dissertation, where the model will be tested using empirical data from the BaBi birth cohort study. Findings from the empirical data analysis will be applied to the theoretical model developed in the fifth chapter ('proof of concept') and if necessary, adjustments will be made to the model.

The dissertation concludes with the final chapter which will discuss findings from both the review of theoretical and empirical literature and the BaBi study analysis and outline recommendations and conclusions.

1.1. Diet during pregnancy

Survival and health depend on food (Ward *et al.*, 2010) – without it we will die within a matter of days (Thomas and Bishop, 2007). The importance of diet (see Appendix 1 – Glossary of terms) becomes even more pronounced during pregnancy, when energy and nutrient intake has to support both the mother and her growing fetus, and accumulate reserves for postnatal lactation (Douglas, 2011). Inadequate nutrition (this includes both deficits and excesses) bears permanent and life-long consequences for the offspring (Robinson, 2013).

Human pregnancies are remarkably energy efficient. Due to a

comparatively long gestation period and relatively small fetus pregnancy poses a rather low nutritional demand on the human body compared to many animal species (British Nutrition Foundation, 2013). Nevertheless, human pregnancy is a time characterised by profound changes (of maternal physiology and psychology, and of fetal nutritional requirements) leading to great maternal adaptation. Reversible hyperphagia, abnormally increased appetite, is perhaps one of the earliest observed changes. Regulation of food intake in pregnancy appears to be driven by hormonal (e.g. progesterone, oxytocin) and neuronal mechanisms (e.g. increased orexigenic neuropeptides and inhibition of anorexigenic neuropeptides) (Douglas, 2011).

On average, women gain 10.0 to 12.5 kg during a singleton pregnancy of which about 4.0 kg are fat (Lennox *et al.*, 2013). The remainder of the weight stems from the fetus, placenta and amniotic fluid as well as growing maternal tissues (uterus and breasts) and increasing levels of blood and extracellular fluid (Expert Consultation on Human Energy Requirements, 2004). During pregnancy, dietary intake must support the growth of all these tissues and fluids. Furthermore, pregnancy increases the basal metabolism raising energy demand. As a women gains weight it becomes harder for her to move her body, leading to an increase in energy need due to higher total energy expenditure (TEE, see Appendix 1) (Butte *et al.*, 2004).

In order to meet the extra nutritional demand, the body utilises a mix of metabolic adaptation, altered absorption and changes in dietary intake (Thomas and Bishop, 2007). If dietary supply is inadequate to meet demands, fetal uptake may deplete maternal stores of nutrients (Thomas and Bishop, 2007) or the development of the fetus may be impaired (Robinson, 2013).

1.1.1. Energy requirements

Energy requirements during pregnancy are closely linked to maternal weight gain which in turn is associated with reproductive outcomes (Forsum, 2004). The energy requirement increases incrementally over the course of pregnancy (Thomas and Bishop, 2007).

The exact amount of energy required, however, is source of debate, and study findings and recommendations for pregnant women vary (Forsum, 2004; Butte *et al.*, 2004).

In Germany, some sources state that energy intake in the final trimester is only about 10 % higher than before pregnancy (Koletzko, 2013; Koletzko *et al.*, 2011). This would be around 200 kcal per day for a woman of average height and activity. The same amount is recommended by the British Manual of Dietetic Practice which is used for training of dietitians and nutrition students (Thomas and Bishop, 2007). Other German sources have recommended an extra 300 kcal (Baerlocher, 1998) per day in the final trimester. The German Nutrition Society (DGE, Deutsche Gesellschaft für Ernährung e.V.) estimates that women with normal pre-pregnancy weight require an additional 70, 250 and 500 kcal per day in the first, second and third trimester, in that order (German Nutrition Society, 2015). These values are based on the joint Food and Agriculture Organization of the United Nations/World Health Organisation/United Nations University Expert Consultation of Human Energy Requirements (Expert Consultation on Human Energy Requirements, 2004).

Butte *et al.* (2004) performed an in-depth nutritional analysis in women from pre-conception to 27 weeks after birth. They used calorimetry (see Appendix 1 – Glossary of terms) and doubly labelled water (see Appendix 1) to measure basal metabolic rate (BMR, see Appendix 1) and total energy expenditure (TEE, see Appendix 1), respectively. Deposition of body protein and fat was also measured as was energy expended on activity. Results showed that women of normal pre-pregnancy BMI needed marginally more energy (compared to pre-conception) in the first trimester, 350 kcal per day in the second and an extra 500 kcal per day in the final trimester (Butte *et al.*, 2004).

The variation in estimates from different experts and sources may arise due to derivation from different populations. Experts agree that energy requirements vary depending on maternal size, physical activity, lifestyle, nutritional status and where she lives (e.g. in a developed or developing country). Recommendations should therefore be population specific (Expert Consultation on Human Energy Requirements, 2004; Butte *et al.*, 2004). Fat retention has also been shown to vary greatly between populations and

appears to influence energy requirements (Forsum, 2004). Fat gain tends to be higher in women who were over- or underweight before pregnancy compared to those of healthy weight (Butte *et al.*, 2004).

Furthermore pre-pregnancy BMI plays an important role on energy requirements. For example, women who are overweight before they become pregnant or who are very sedentary during pregnancy may not need to increase their energy intake by as much (Lennox *et al.*, 2013). Conversely, women who enter a pregnancy being underweight require more energy (Expert Consultation on Human Energy Requirements, 2004). Gestational weight gain (GWG) also has a large effect on energy requirements (Butte *et al.*, 2004).

In summary, energy requirements appear to vary between populations, and international sources differ in their estimation of energy requirements during pregnancy, ranging from as little as an additional 10 % to 500 kcal a day in the final trimester. Experts do however agree that energy requirements increase over the course of pregnancy with highest values being reached in the final trimester.

1.1.2. Nutrient requirements

Macronutrients

The German Nutrition Society DGE estimates that fat deposition increases from 11 % in the first, 47 % in the second to 42 % of fat in the final trimester (German Nutrition Society, 2015). However, no official guideline for fat requirement exists. It is known that n-3 polyunsaturated fatty acids (PUFAs) are important for fetal development, particularly for the nervous system (Thomas and Bishop, 2007). In Germany the network of professionals and institutions called "Healthy Start – Young Family Network" ("Gesund ins Leben – Netzwerk Junge Familie"), which is supported by the Federal Ministry of Food and Agriculture, advices women who do not eat fish regularly to take a docosahexaenoic acid (DHA or n-3, see Appendix 1 – Glossary of terms) supplement of at least 200 mg per day (Koletzko, 2013).

Protein is needed to support the growth of maternal and fetal tissues.

Protein is mainly deposited in the second and third trimester, 20 % and 80 %, respectively (Expert Consultation on Human Energy Requirements, 2004). However, the optimal amount of protein intake for pregnancy is not known (Thomas and Bishop, 2007). A systematic review of 90 studies from developed countries found mean daily protein intake increased over the course of pregnancy from an average of 78 g in the first to 84 g a day in the final trimester (Blumfield *et al.*, 2012a).

The reported mean daily carbohydrate intake was 269 ± 37 g (Blumfield *et al.*, 2012a). Guidelines by the German "Healthy Start – Young Family Network" (HSYF network) do not make specific recommendations regarding carbohydrates, but they recommend that pregnant women consume 'plenty' grain products and potatoes (Koletzko *et al.*, 2011) due to their high content of micronutrients and fibre, and ideally in low-fat preparations (Koletzko *et al.*, 2013).

Overall the HSYF network recommends that pregnant women should *"think for two but not eat for two"* (Koletzko, 2013, p. A 612). With this slogan they try to dispel the popular believe that pregnancy is a time where one must double their food intake (Koletzko, 2013).

Micronutrients

Relative to the increase in energy requirement during pregnancy, the demand for micronutrients increases significantly more because growing tissues (maternal and fetal) must be supported (Grischke, 2004; Rodríguez-Bernal *et al.*, 2013). Particularly important for prevention of fetal malformations are folate/folic acid and iron.

Folate is a water-soluble vitamin that naturally occurs in food. The term folate describes a group of compounds derived from folic acid. Folic acid is the parent molecule but does not occur naturally; it is used in supplements and fortified foods and has higher bioavailability than folate. Both terms are often used interchangeably (Thomas and Bishop, 2007).

Folate coenzymes are crucial for cell-division as they are needed for DNA and RNA synthesis (Thomas and Bishop, 2007) and are involved in other biological mechanisms, such as DNA methylation and thus affect gene

expression (Veeranki *et al.*, 2014). There is strong evidence supporting a causal link between folate insufficiency and occurrence of neural tube defects (e.g. spina bifida) in the offspring, a dose-response relationship has been shown in several studies (Robinson, 2013; Thomas and Bishop, 2007).

Iron is crucial for maternal and fetal red blood cells. During the final trimester the iron needs of the fetus are at its highest level. When iron intake is too low to supply mother and fetus it usually goes to the detriment of the mother, iron deficiency anaemia is thus not uncommon in pregnant women (Thomas and Bishop, 2007).

Studies have shown that adequate iron and folate levels in pregnancy may be difficult to achieve from diet alone (Rodríguez-Bernal *et al.*, 2013; Baerlocher, 1998). The German HSYF network recommendations thus advise women to take 400 µg folate daily from pre-conception until at least the end of the first trimester, but to take iron only when medically indicated, i.e. by a blood test or doctor's exam (Koletzko, 2013; Koletzko *et al.*, 2013).

Another crucial nutrient in pregnancy is iodine. Iodine is needed for the formation of thyroid hormones, regulation of body heat and metabolic rate, protein synthesis and connective tissue integrity. In fetuses and new-borns it is crucial for the formation of the brain and central nervous system (Thomas and Bishop, 2007). There is vast evidence linking low maternal iodine status with impaired cognitive development of the child as well as delays in psychomotor and neurological development (Baerlocher, 1998). Severe iodine deficiency, as evidenced in low-income countries, where iodine deficiencies are common, leads to cretinism, i.e. permanent mental damage of the child (Robinson, 2013). Iodine deficiency is common in Germany (Baerlocher, 1998), the HSYF network thus advised pregnant women to supplement their diets with 100 to 150 µg iodine daily (Koletzko, 2013).

Vitamin D is important for bone synthesis. Deficiency in children leads to rickets and bone malformation, in adults to osteomalacia. There are few dietary sources of vitamin D, most of the supply is synthesised upon UV light irradiation which results in the conversion of 7-dehydrocholesterol into vitamin D (Thomas and Bishop, 2007). Women who cannot meet their

Vitamin D needs through sunlight exposure (e.g. dark skinned women or women with sun exposure of less than 5 to 10 minutes per day) are instructed to take a daily dose of 20 µg Vitamin D (Koletzko, 2013).

There may be medical conditions (e.g. dietary intolerances, allergies) or lifestyle behaviours (e.g. vegetarianism, veganism) necessitating supplementation of additional nutrients or at different doses than those set out in the guidelines by the HSYF network. These cases should be discussed with a medical doctor or dietitian (Koletzko, 2013).

Vitamin A intake, on the other hand, must be restricted rather than increased during pregnancy. Vitamin A is a known teratogen (see Appendix 1 – Glossary of terms), excessive intakes during pregnancy cause several fetal abnormalities (Robinson, 2013).

Food hygiene and harmful substances
Harmful substances such as alcohol and nicotine should be eliminated and diet and food preparation methods amended in order to avoid contamination of or infections from food (Grischke, 2004).

Foodborne illnesses such as infections with listeria monocytogenes, salmonella, toxoplasma gondii or campylobacter can seriously damage the unborn child causing abortions, stillbirth and fetal malformations. However, simple food hygiene guidance and avoidance of certain foods can decrease the risk of contracting these illnesses substantially (Thomas and Bishop, 2007).

HSYF network guidelines recommend that women avoid raw animal products (e.g. eggs, meat, meat products, smoked fish, soft cheeses) and that all fruit and vegetables eaten raw are washed thoroughly before consumption. Cooked and particularly reheated foods must be heated thoroughly before consumption (Koletzko, 2013).

The potentially detrimental effects of alcohol on the developing fetus have been known for decades and about 40 years ago the term fetal alcohol spectrum disorder (FASD) was coined to describe a range of structural abnormalities and disabilities caused by alcohol intake of the mother

(Robinson, 2013). Fetal alcohol syndrome (FAS) describes the most severe form which includes specific facial abnormalities as well as cognitive and behavioural impairment (Vall *et al.*, 2015). Both FAS and FASD are entirely preventable by abstaining from alcohol during pregnancy and are the most common cause of acquired disability in babies (Vall *et al.*, 2015). Alcohol intake may also result in spontaneous abortions in early pregnancy, which is also the time when the fetus is most vulnerable to the detrimental effects of alcohol (Andersen *et al.*, 2012). Due to ethical and methodological difficulties in assessing timing during pregnancy and dosages at which alcohol intake is safe for mother and fetus, it is recommended to *"err on the side of caution"* (Buttriss *et al.*, 2013, p. 239) and abstain from alcohol altogether during the entire pregnancy (Koletzko, 2013; Buttriss *et al.*, 2013). Likewise, Vall et al. (2015), state that *"no evidence of harm does not mean evidence of no harm"* (Vall *et al.*, 2015, p. 927). In Europe, the estimated prevalence of repeated alcohol intake while knowingly pregnant (i.e. after becoming aware of one's pregnancy) ranges from 14.4 % to 30.0 % and the prevalence of FAS is estimated to be 0.2 to 8.2 per 1,000 births in Europe (Landgraf and Heinen, 2016).

Women who smoke during pregnancy gain less weight and their children have higher risk of low birth weight (Thomas and Bishop, 2007). Women should therefore abstain from smoking and also avoid second hand smoke during pregnancy (Koletzko, 2013).

A large British cohort study of nulliparous women assessed micronutrient levels and smoking status of participants using biochemical markers additionally to self-report of smoking. According to the authors, at the time a quarter of all pregnant women in the UK smoked during pregnancy despite anti-smoking interventions. Results showed that pregnant women who smoked had poorer intakes of most micronutrients than their non-smoking counterparts; young smokers were at highest risk of deficiencies (Mathews *et al.*, 2000).

Caffeine is a chemical which increases mental and physical performance. It is known that caffeine crosses the placenta and large caffeine intakes have been implicated in the development of low birth weight infants. However, due to difficulties assessing caffeine intake from many food sources and a general lack of studies, more evidence is needed (Mathews *et al.*, 2000).

Based on a 2001 review, which found that caffeine levels above 200 mg per day may increase risk of fetal growth restriction and possibly miscarriages, the UK lowered the limit from 300 to a maximum of 200 mg per day (Buttriss *et al.*, 2013).

According to German guidelines, caffeinated drinks should only be consumed in moderation (i.e. a maximum of three cups of coffee per day) and caffeinated energy drinks should be avoided altogether (Koletzko, 2013).

1.2. Role of diet for maternal and child health

As outlined, human pregnancy poses a comparatively low nutritional stress to the mother. Nevertheless adequate amounts of energy and micronutrients must be supplied to support the growing maternal and fetal tissues. Inadequacies may result in draining of maternal stores or developmental impairment of the fetus.

1.2.1. Effect of diet in pregnancy on health

Diet and nutrition during pregnancy are crucial for health of the mother and her offspring (Grischke, 2004; James, 2006; Vioque *et al.*, 2013; Rodríguez-Bernal *et al.*, 2013; British Nutrition Foundation, 2013; Koletzko *et al.*, 2012).

Maternal diet has been shown to bear an important influence on fetal growth (Rodríguez-Bernal *et al.*, 2013) and intrauterine growth retardation (James, 2006), and on birth outcomes such as birth defects (Rodríguez-Bernal *et al.*, 2013; Willett, 1994), preterm delivery (Rodríguez-Bernal *et al.*, 2013) and admission to neonatal intensive care (Thompson, 2013).

Additionally, maternal diet affects maternal health, e.g. the risk of pre-eclampsia and gestational diabetes (Rodríguez-Bernal *et al.*, 2013).

Diet also poses an indirect effect on health. Maternal food preferences may be passed on to the offspring as its taste preferences appear to be shaped by flavours present in amniotic fluid and breast milk (James, 2006). Maternal diet may also influence the child's cognitive development (British Nutrition Foundation, 2013) and risk of allergies in later life (Rodríguez-Bernal *et al.*, 2013).

Indirect health effects for the mother may be the result of excessive gestational weight gain and post-partum weight retention, which have both been shown to predispose women to later type 2 diabetes mellitus (T2DM) and obesity (Lawlor and Chaturvedi, 2005). Obesity is a major cause of global morbidity and mortality (Koletzko *et al.*, 2012), and has taken on epidemic proportions making it one of the most dire public health concerns of current times (Lawlor and Chaturvedi, 2005). In 2008 an estimated 297

million women were obese globally and female BMI had increased by 0.5 kg/m² in the previous two decades (Finucane *et al.*, 2011).

Excessive gestational weight gain has been associated with pre-term delivery, higher birth weights, macrosomia and caesarean sections, i.e. it bears health consequences not only for the mother but also her child (Viswanathan *et al.*, 2008).

Furthermore, the indirect health effects of pregnancy diet may go beyond mother and her child. Obesity levels in women of childbearing age are on the rise (Finucane *et al.*, 2011) as are the numbers of women who enter a pregnancy already being overweight or obese (Rasmussen and Yaktine, 2009). In turn, women who are overweight or obese before conception also tend to gain more weight during pregnancy leading to a vicious cycle of excessive weight gain (Rasmussen *et al.*, 2010; Rauh *et al.*, 2014).

1.2.2. Research findings: adequacy of diet in pregnancy

Despite an apparent abundance of food, there is evidence of inadequate dietary intakes of pregnant women living in developed countries; diets not meeting (or exceeding) recommended amounts of energy and macronutrients (Blumfield *et al.*, 2012a) and micronutrients (Hure *et al.*, 2009) have been reported. Micronutrient deficiencies in pregnancy are expected to worsen in high-income countries as diets are become higher in fat and sugar and lower in nutrient density (Gernand *et al.*, 2016).

In a comparison across developed countries, women's dietary intakes did not align with their country-specific recommendations. While energy and fibre intakes were consistently lower than recommended, carbohydrates and PUFAs were low or borderline low, but total fat and saturated fat intakes were commonly exceeding recommended values (Blumfield *et al.*, 2012a). Inadequate dietary intakes during pregnancy have been reported in countries such as Germany (Kirschner, 2013), Spain (Rodríguez-Bernal *et al.*, 2013) and Japan (Okubo *et al.*, 2011b).

In a Canadian study, only 3.5 % of participants consumed the recommended number of servings in each guideline category (Fowler *et al.*, 2012). Similarly, in a New Zealand cohort, only 3 % of women met all

national dietary recommendations (Morton *et al.*, 2014). In an Australian study, only 7 % of pregnant women consumed the recommended number of vegetables (≥5 portions) and 13 % the recommended number of fruits (≥4 portions) (Wen *et al.*, 2010). In a Norwegian birth cohort, 27 % of women exhibited low and 35 % medium adherence to the New Nordic Diet, which had previously been associated with risk of preeclampsia and preterm delivery (Hillesund *et al.*, 2014).

Deficiencies and inadequacies despite (theoretically) wide food availability may have socio-economic causes. For example, studies have associated social deprivation in pregnancy with low blood folate (Vandevijvere et al., 2012; Haggarty *et al.*, 2009) and diets that supply inadequate amounts of protein, vitamins and minerals (Haggarty *et al.*, 2009). In the US, inadequate antioxidant levels were observed in women with lower education levels, who reported food insecurity due to financial constraints and who were African American or Hispanic (Brunst *et al.*, 2014). In the UK, women with greater financial difficulties were found to consume poorer quality diets as indicated by lower intakes of protein, fibre, and several vitamins and mineral (Rogers *et al.*, 1998)

Certain population groups may also be at greater nutritional risk. For example, adolescents, vegetarians, women with special nutritional requirements or intolerances (e.g. lactose intolerant, PKU), carrying twins, and women who smoke, drink alcohol and or use drugs during pregnancy are described as being at risk of nutritional deficiencies (Baerlocher, 1998). Another risk group may be women who enter a pregnancy being overweight or obese (Moran *et al.*, 2013).

1.3.   Role of maternal diet over the life course

It would be difficult writing about the role of diet in pregnancy without outlining the long-term health implications. Therefore a short discourse on the life course perspective will follow.

Evidence corroborates that dietary intake during pregnancy influences the health of the child far beyond birth (British Nutrition Foundation, 2013). There has long been an understanding that maternal nutrition is crucial for the fetus since it depends entirely on maternal supplies for meeting its own nutritional requirements. However, the conclusion that the effects of inadequate nutrient supply in utero can last well into the adult life, has only been reached in the past three decades (McArdle and Gambling, 2013).

1.3.1. Barker hypothesis

Low birth weight (LBW), i.e. weighing less than 2,500 g at birth, is strongly associated with child morbidity (e.g. cerebral palsy, growth deficiency, neurocognitive deficiencies) and mortality (Kramer, 1987). The two main causes of LBW are being born premature and growth retardation in utero. Birth weight is thought to be influenced by many factors including fetal gender, maternal and paternal height, weight and ethnicity. A landmark systematic review of studies from developed countries outlined smoking during pregnancy, poor maternal nutrition and low pre-pregnancy weight as the main causes of LBW (Kramer, 1987).

In the late 1980's David Barker and colleagues identified a link between low birth weight and higher risk of ischaemic heart disease using a follow-up of the so called Hertfordshire historical cohort consisting of men born in the years 1911 to 1930 in six districts in Hertfordshire, England, whose birth weights were recorded (Barker *et al.*, 1989). These findings led on to the formulation of the so called Barker hypothesis which states that low birth weight (as a marker of poor fetal growth) is linked to increased risk of adult disease. It is also referred to as DOHaD (Developmental Origins of Health and Disease) or thrifty phenotype hypothesis.

Using data from a Finnish cohort of men and women born in Helsinki during 1924 to 1944, Barker *et al.* (2002) showed a link between birth weight and

adult coronary heart disease (CHD), T2DM and hypertension incidence. Various studies had previously shown that the effect of LBW was modified by rapid childhood weight gain, i.e. children born small and subsequently gaining a lot of weight during childhood had the greatest risk of developing cardiovascular disease (CVD) and T2DM in later life. This was also reflected in the Helsinki data, where risk of CHD, T2DM and hypertension fell with increasing birth weight but rose with BMI in childhood (Barker *et al.*, 2002).

Due to obvious ethical considerations it is difficult testing the Barker hypothesis in humans. However, some natural experiments exist which allow testing of the hypothesis. One of those is the Dutch famine where the Nazis restricted food availability in western Holland between October 1944 and May 1945. Existing data shows that later health risk differed depending on the age at which people were exposed to food shortage. For example, investigations into breast cancer showed that women who had been exposed before puberty had lower, and women exposed after puberty had higher risk of breast cancer (Uauy and Solomons, 2005).

A recent investigation into the occurrence of T2DM in the Ukraine used the famine which affected parts of the country in 1932/33 as a natural experiment. Prevalence odds ratios (ORs) for those in utero before, during and after the famine were calculated using census data and a national diabetes register. Results demonstrated a clear dose-response relationship, where those conceived during the famine in regions affected by famine had significantly higher ORs than those conceived before or after the famine. Moreover, the ORs were higher in those conceived in areas with extreme compared to severe famine (Lumey *et al.*, 2015).

Further studies found that fetal exposure to famine increased the risk of adulthood hyperglycaemia (Li *et al.*, 2010), hypertension (Li *et al.*, 2011), and T2DM (Lumey *et al.*, 2015), predicted lower educational attainment (Neelsen and Stratmann, 2011), dietary preference for high-fat foods (Lussana *et al.*, 2008) and altered stress response (Reynolds *et al.*, 2007).

The Barker hypothesis operates based on several constructs.

Critical windows

One of the main constructs of the Barker hypothesis is the idea of critical windows of development. This stems from the observation that a child's later health appears to be 'programmed' in so called 'critical windows' during which it is more sensitive to over- or undernutrition (British Nutrition Foundation, 2013). For example, during the first trimester the fetus is most vulnerable to damage from nutritional deficiencies or toxicity (Buttriss *et al.*, 2013). Organs differ in when they are most vulnerable, i.e. the effect that inadequate nutrition will have on organogenesis depends on its timing (McArdle and Gambling, 2013; Buttriss *et al.*, 2013; Koletzko *et al.*, 2012). These effects include changes in the child's organ size or cell type (Buttriss *et al.*, 2013). Organs that have been shown to be affected include the lungs, kidney and liver (Koletzko *et al.*, 2012). While an exposure during critical periods result in permanent damage or disease (or protection thereof), exposures during sensitive periods have a stronger effect than during non-sensitive times but do not act exclusively during those times (Ben-Shlomo and and Kuh, 2002).

With regards to the obesity epidemic, three critical periods have been identified: the perinatal period, infancy and puberty. There is strong evidence that fetal over-nutrition, mainly in the form of glucose, free fatty acids and amino acids, causes changes in the fetus (e.g. metabolic, appetite control, neuroendocrine) which in turn raise its risk of obesity in later life (Lawlor and Chaturvedi, 2005).

Furthermore, a cycle of high pre-pregnancy weight, excessive gestational weight gain and weight retention after pregnancy appear to predispose mothers to overweight and obesity (Lawlor and Chaturvedi, 2005; Rasmussen *et al.*, 2010). Children of overweight and obese mothers have a higher risk of being overweight or obese as adults (Lawlor and Chaturvedi, 2005). Together, this leads to a vicious cycle of *"intergenerational transmission of obesity"* (Thompson, 2013, p. 2).

Epigenetics

Environmental influences may cause changes in DNA methylation profiles leading to changes in gene expression (Koletzko *et al.*, 2012). The study of this is called epigenetics.

Maternal nutrition appears to cause epigenetic changes in stem cell which lead to a change in cells that will be programmed from these stem cells in the future (Buttriss *et al.*, 2013). Research has pointed to so called *"intergenerational effects"* (James, 2006, pp. S8), i.e. maternal changes may affect the phenotype and possibly also the genotype in a way that persists over several generations, even after the *"nutritional insult"* (James, 2006, pp. S8), for example a maternal diet low in protein, is removed.

Developmental plasticity /adaptive programming

Another way in which maternal nutrition may influence fetal health is described by the concept of developmental plasticity. This means that the fetus uses cues by the mother to prepare or adapt for the environment which it will be born into (British Nutrition Foundation, 2013). It is thought that developmental plasticity allows adaption to changing environments by letting one genotype produce different physiological or morphological states depending on environmental cues received during fetal development. This mechanism would be beneficial for survival. An example of this is that children born as a result of ovum donation grow up small if the women receiving the egg is small, even if the donor mother is tall (Barker *et al.*, 2002).

Despite the obvious evolutionary benefits, problems arise when a mismatch occurs between the adaption and the actual environment the child grows up in. Children who experience limited nutrition *in utero* but subsequently grow up in an environment where food is abundant may be more prone to becoming overweight or obese and developing T2DM as their metabolism is simply not fit for food intake beyond what was expected (Buttriss *et al.*, 2013). In relation to childhood obesity this concept has also been referred to as *"mismatch hypothesis"* (Koletzko *et al.*, 2012, p. 374).

Compensatory growth

Compensatory growth may occur in children born small due to uterine undernutrition. They subsequently exhibit high catch-up growth in early childhood. Barker proposed that compensatory growth accelerates cell death and organ degradation and shortening of the telomeres (Barker *et al.*, 2002). Others have referred to this as the *"accelerated postnatal growth hypothesis"* (Koletzko *et al.*, 2012, p. 373).

1.3.2. Life course epidemiology

The Barker hypothesis and related research led on to the postulation of life course epidemiology, which challenged the predominant model of disease causation at the time, the so called adult lifestyle model. As the name suggests, it focused exclusively on exposures during adulthood (Kuh *et al.*, 2003).

Life course epidemiology has been defined as *"the study of long term effects on later health or disease risk of physical or social exposures during gestation, childhood, adolescence, young adulthood and later adult life"* (Kuh *et al.*, 2003, p. 778). It is based on a more holistic approach to health.

The life course framework enables integration of research from different disciplines on health, human development and aging with the aim to clarify the interplay of biological, psychosocial and behavioural processes across the life course or across generations in causing health and disease (Kuh *et al.*, 2003).

Life course models encompass more than just the collection of exposure data from different time points across the life course. They integrate biological and psychosocial pathways and assess the temporal ordering of exposures and the complex relationships between variables with a direct or indirect influence. However, they are methodologically challenging as the interplay of different interrelated exposures over different time points is complex (Ben-Shlomo and and Kuh, 2002). Life course models have been applied to different chronic diseases, such as cancer (Uauy and Solomons, 2005) or perinatal health (Misra, 2006).

Studies across the life course have identified the involvement of maternal

diet in shaping fetal body composition (Blumfield *et al.*, 2012b), offspring blood pressure at 6 months (Aaltonen *et al.*, 2008), bone mass at age 6 years (Heppe *et al.*, 2013) and in adolescence (Yin *et al.*, 2010).

Naturally, factors besides maternal nutrition affect long-term offspring health, among these are social and economic conditions in childhood (Agahi *et al.*, 2014), parental education (Albrecht and Gordon-Larsen, 2014), school and neighbourhood environment (Dundas *et al.*, 2014) and adverse experiences in childhood such as divorce, financial difficulties or violence within the family (Halonen *et al.*, 2014).

1.4. Pregnancy and behaviour and diet change

Pregnancy has been described as a useful time for prevention of child ill health (Baerlocher, 1998; Buttriss *et al.*, 2013) due to the *"extra motivation women tend to have"* (Buttriss *et al.*, 2013, p. 251). Furthermore, life course theory frames pregnancy as a critical period for long-term health and illness of the offspring.

It has als been suggested that pregnancy is a good time for implementing change in dietary habits (Hoffmann *et al.*, 2014) or for maintaining good dietary habits and building knowledge for future dietary intake of oneself and one's family (Anderson, 2001). It is a period in a woman's live where she has *"heightened awareness"* (Gardner *et al.*, 2012, p. 346) of potential threats to her health and that of her child and may thus be more motivated to adapt health-promoting behaviours (Gardner *et al.*, 2012).

Pregnant women have reported being aware of recommended health behaviours, including diet, and reported to be practicing them (Lewallen, 2004). Comparisons of pregnant and non-pregnant women found pregnant women to make a conscious effort to improve their food intake (Anderson *et al.*, 1993) and to increase their fruit consumption and decrease their consumption of alcohol, tobacco and foods associated with health risk such as raw meat, raw fish and ready-made foods (Verbeke and Bourdeaudhuij, 2007). In a retrospective Australian study conducted up to one year after giving birth, women reported they had increased their consumption of fruit and vegetables and had decreased their fast food consumption in pregnancy (Smedley *et al.*, 2013). A prospective assessment (pre-pregnancy, 1st and 3rd trimester), on the other hand, found a notable reduction of alcohol, caffeine and cigarettes consumption but little change in fruit and vegetables consumption in pregnancy (Crozier *et al.*, 2009a).

The description of pregnancy as a time where women are open to nutrition education and lifestyle amendments is somewhat in conflict with the presence of inadequate diets in pregnancy in developed countries (see section 1.2.2).

1.5. Dietary patterns versus single nutrients

Nutritional epidemiology (see Appendix 1 – Glossary of terms) has been described as one of the most important disciplines in the study of human disease aetiology (Trichopoulos and Lagiou, 2001). However, the study of dietary intake is very complex involving *"hundreds of foods and nutrients […] additives and contaminants"* (Trichopoulos and Lagiou, 2001, p. 133). Due to this complexity, dietary intake is methodologically difficult to capture and no gold-standard method for assessing total dietary intake exists to date (Trautwein and Hermann, 2005).

So how can a complex behaviour such as diet be represented and researched in a meaningful way? One solution is the use of global scores describing dietary pattern or dietary quality in order to combine intake data of different foods and nutrients (Willett, 1998).

1.5.1. Dietary patterns

In 1982, Schwerin and colleagues were the first to use dietary patterns to examine the influence of more than *"single nutrients"* (Slattery, 2008, p. 14) on health (Slattery, 2008). This was a result of a growing understanding that single or few nutrients are limited in explaining the influence of diet on health. Foods tend not to be eaten in isolation and the investigation of single nutrients would thus be limited or even misleading, if other present components or nutrients were not considered (Slattery, 2008; Hu *et al.*, 1999).

Furthermore, the single-nutrient approach fails to consider interactions of different nutrients (e.g. iron absorption improved through vitamin C) and nutrients such as potassium and magnesium which are so highly correlated that it becomes difficult to examine their effect separately. A dietary pattern could actually become a confounder when nutrient intakes are associated with certain patterns, as is often the case (Hu *et al.*, 1999).

Finally, as patterns are built on the basis of habitual food consumption, they might represent *"real-world conditions"* (Hu *et al.*, 1999, p. 234) more accurately (Hu *et al.*, 1999). Guidelines expressed as dietary patterns may be more easy to understand for people of low nutrition literacy and as such

offer an effective health promotion strategy (Bowley and Blundell, 2016).

While the aim of dietary patterns, representing complex dietary behaviour in different intake categories or scores, is clear, there are surprisingly few attempts at defining what exactly a dietary pattern is. A lack of universally accepted definition has been noted as far back as 1989 (Oltersdorf *et al.*, 1989).

Patterns have been described as:

*"a **specific constellation** of variables **among or within individuals** that includes many single aspects in one index"* (Oltersdorf *et al.*, 1989, p. 241).

The more recent definition published by the authors of a US Department of Agriculture systematic review into the relationship between dietary patterns and health outcomes appears more in-depth and focuses on consumption frequency and habits (Essery Stoody *et al.*, 2014). They defined dietary patterns as:

*"the **quantities, proportions, variety, or combination** of different foods, drinks, and nutrients (when available) in diets, and the **frequency** with which they are **habitually** consumed"* (Essery Stoody *et al.*, 2014, p. 1).

1.5.2. Diet quality

Similarly, the concept of diet quality, sometimes also referred to as dietary quality, is another relatively new way of describing diet 'as a whole' rather than measuring single nutrients.

The concept of diet quality involves:

*"the assessment of both **quality and variety** of the **entire** diet, enabling examination of associations between whole foods and health status, rather than just nutrients"* (Wirt and Collins, 2009, p. 2473).

The concept also involves the use of a single score:

*"These indices are **more complex explanations** of diet quality than are assessments that use only total energy intake or specific nutrient intake"* (Watts *et al.*, 2007, p. 128).

This means that diet quality can be assessed using composite indices that combine complex behaviour (diet and eating habits) into a single score (Thiele *et al.*, 2004).

Different ways of assessing diet quality exist: scoring adherence to (national) dietary guidelines, rating the diversity of food choice in key food groups (see Appendix 1 – Glossary of terms), or scoring pre-defined food patterns known to protect or impair health (Wirt and Collins, 2009). Diet quality indices often use different foods, or group foods in different categories, and construct their scores differently making comparison across instruments difficult (Thiele *et al.*, 2004).

1.5.3. Similarities of dietary patterns and diet quality

The concepts of dietary patterns and diet quality have both been defined as data reduction methods with the goal of summarising diet in a broader way (Slattery, 2008). Principle component factor analysis is the most commonly used method to study dietary patterns (Northstone *et al.*, 2007), but other multivariate methods have also been used to create scores. Dietary quality is most commonly measured with pre-defined scales or indices (Thiele *et al.*, 2004).

Whichever method is used, the goal is to reduce the wealth of dietary intake data (usually gained from food frequency questionnaires, dietary recalls or weighed food records) into manageable and interpretable groups of foods (see Appendix 1 – Glossary of terms) that tend to be eaten in combination and to relate these to health outcomes.

1.5.4. Ambiguity of terms

The terms dietary pattern and diet quality are sometimes used interchangeably. For example, Poon et al. (2013) refer in their article and title thereof to 'dietary pattern' when they used a dietary quality index to measure it (Poon *et al.*, 2013).

Moreover no 'gold standard' definition of either term currently exists despite an increasing amount of studies using them. While authors are clear on

their wish to combine a complex behaviour into a composite measure (i.e. 'why' an assessment of dietary patterns or dietary quality is necessary), the delineation of what this involves exactly for example in terms of food groups (i.e. 'how' dietary patterns or quality should be assessed) is rather vague.

Perhaps it is this lack of clear definition that has lead authors to use the terms dietary pattern or dietary quality in ways that are not fulfilling the goal of representing complex behaviour in a simple measure. For example, Carmichael *et al.* (2003) developed a diet quality score which involved assessment of the intake of five selected micronutrients and percentage of kilocalories from fat and from sweets (Carmichael *et al.*, 2003). Comparing this to the definition by Wirt *et al.* (2009) it can be argued that the diet quality score does not meet the criteria of assessing 'quality and variety of the entire diet' (see Section 1.5.2.).

Likewise, Fitzsimon *et al.* (2007) aimed to assess dietary patterns during pregnancy and the association with offspring asthma. However, dietary pattern assessment consisted of the average number of servings of three food groups (fruits, vegetables and oily fish) only (Fitzsimon *et al.*, 2007). This does not appear to meet the criteria of assessing more than 'single foods or nutrients' (see Section 1.5.1.) because major food groups such as dairy or grains were omitted.

1.5.5. Early studies of diet 'as a whole' in pregnancy

The use of either concept for describing diet 'as a whole' (as opposed to 'single' foods or nutrients) is useful for the study of diet during pregnancy. As outlined in section 1.5.1., the concept only emerged in the 1980's, and it was a decade before it was applied to pregnant populations making this a relatively new field of research.

One of the first studies using dietary pattern or *"nutrient profiles"* (Wolff and Wolff, 1995, p. 122) to investigate diet of pregnant women was conducted by Wolff and Wolff in 1995, who investigated the effect of maternal dietary patterns on birth weight (Wolff and Wolff, 1995). The authors chose the concept of dietary pattern as opposed to the concept of single nutrients because this had proven a valid method in the field of birth weight research.

In the past, pregnancy weight and gestational weight gain had been used as easily obtainable markers of maternal nutritional status or in the absence of dietary intake data. However, research repeatedly failed to show significant associations between these surrogates and maternal or child health outcomes. Wolff and Wolff therefore used dietary pattern as another easily obtainable marker of complex dietary behaviour which demonstrated a more pronounced and distinctive relationships with birth weight (Wolff and Wolff, 1995).

One of the first records of using dietary quality to assess pregnancy diet was a study by Gardner and Feldstein, who in 1990 assessed diet using the so called "Index for Nutritional Quality" to rate how closely women's diets met intake recommendations of seven key nutrients (Suitor *et al.*, 1990). The first to assess diet quality beyond single key nutrients and rating diet in its entirety in pregnancy were Bodnar *et al.*, who in 2002 as part of the PIN cohort study (Pregnancy, Infection and Nutrition) developed the so called diet quality index for use in pregnancy (DQI-P) (Bodnar and Siega-Riz, 2002).

1.6. Determinants of diet in pregnancy

Determinants have been defined as factors that influence health status (Barnes, 2016) and lead to change in health conditions (Last, 1988). Health outcomes are influenced by a multitude of determinants including medical care, genetics, the environment and individual behaviour (Kindig, 2007). The concept of determinants will be explained in more detail in Chapter 3.

The idea of determinants can also be applied to dietary intake, and considered the factors influencing what foods are eaten. Food choice is influenced by food and non-food factors, the latter include personal taste (preferences and dislikes), as well as biologic, demographic, economic, cultural, social, psychological and physiological factors (Chun *et al.*, 2011).

Since diet and nutrition are important drivers of population health, gaining an insight into their determinants can help understand why some people engage in healthy behaviours while others do not (Brug, 2008). Understanding the drivers of nutrition behaviour can also help nutritionist target their efforts to improve dietary behaviour (Cox and Anderson, 2004).

Determinants of diet are of growing research and political interest, as evidenced by the recent initiation of a European research network on the Determinants of Diet and Physical Activity (DEDIPAC). The DEDIPAC network aims to harmonise the assessment and monitoring of diet and physical activity incorporating their individual, socio-cultural and environmental determinants (Lakerveld *et al.*, 2014).

1.6.1. Types of determinants

Different drivers of eating behaviour have been identified that can be loosely divided into internal and external factors. Internal factors are those relating to a person, such as biological and psychological factors, experiences and social background. External factors are those relating to an individual's environment (which included not only the built environment but social, cultural and political surroundings).

Individual-level determinants include taste preference, nutrition knowledge, attitudes and intentions. They have predominantly been targeted by

nutrition education efforts albeit with limited or short-lived success (Brug, 2008; Lake and Townshend, 2006). A person's socio-economic status also exerts and influence on diet. For example, results from the German Nutrition Survey of 1998, involving a representative sample of 4,030 adults aged 18 to 79 years, identified higher diet quality in those with high income, high education, higher age, and higher physical activity levels (Thiele *et al.*, 2004).

External drivers of nutrition behaviour include the physical as well as the social and cultural environment (Brug, 2008). With a growing understanding that we live in a so called obesogenic environment (Lake and Townshend, 2006; Lawlor and Chaturvedi, 2005), that encompass an abundance of food available throughout the day potentially leading to constant overeating, and the growing recognition that interventions have limited and short-lived success in averting obesity, recent focus of nutrition research (see Appendix 1 – Glossary of terms) has shifted to environmental determinants of diet (Cummins and Macintyre, 2006).

1.6.2. Determinants of diet in pregnancy

As outlined in Section 1.1., energy and nutrient requirements change during pregnancy and changes in food intake are achieved through increased appetite mediated through different neurological and hormonal pathways, as well as physiological adaptations (e.g. improved absorption). Pregnancy is also an important time for behaviour change, including nutrition behaviour (section 1.4).

This means that pregnancy is a unique period in life, with very specific requirements, motivations and needs. This warrants an investigation into the determinants of diet in pregnancy, in particular to test whether:

- pregnancy as a unique period brings about unique determinants
- the influence of known determinant changes during pregnancy

These questions will be explored in the chapters that follow.

1.7. Summary of introduction

This chapter has shown that diet in pregnancy is crucial for the health of mothers and their children. Dietary intake must supply the (short-term) energy and nutrients needs to support the growth of maternal and fetal tissues and may influence long-term health.

Life course epidemiology frames pregnancy as a critical period in which the roots for life long health of the offspring are laid down. Pregnancy has also been identified as a period in life when women are more receptive to health information and behaviour change due to heightened awareness of potential threats to their health and that of their unborn child. Despite the importance of adequate dietary intake and the potentially greater motivation of women, research from developed countries has reported inadequate dietary intakes in pregnancy.

The assessment of diet is methodologically challenging. It is difficult to capture the vast variety of foods and drinks consumed daily, on the other hand assessing only 'single' foods or nutrients in isolation may yield limited, or even biased or confounded, estimates. One potential solution to overcome this conundrum is the aggregation of complex behaviour into simpler dietary patterns or diet quality scores.

Knowledge of dietary intake is important and so is knowledge of the forces that drive it. Ultimately this information could help to assess the population needs and to design more targeted and effective public health interventions.

The next chapters will outline the original contribution to knowledge this dissertation aims to make. The development and testing of a theoretical model of determinants of diet in pregnancy will be outlined. This independent academic work aims to help advance the disciplines of public health and nutrition.

2. Aims, Objectives, Public Health Relevance

2.1.   Research questions

1. Main Question: Which factors determine pregnant women's diet when assessed as dietary pattern or diet quality (including guideline compliance)
   a. in developed countries? [literature review]
   b. in Bielefeld? [empirical analysis]

2. What is the relationship between the identified determinants?
   a. What is known from theoretical and empirical evidence? [literature review, construction of a conceptual framework]
   b. 'Proof of concept' – does the model 'fit' with data from the BaBi-Bielefeld birth cohort study?   [empirical analysis, construction and test of final explanatory model]

The research will take a multiple determinants and life course view.

To answer the research questions, both evidence from theoretical and empirical literature and data from the BaBi-Bielefeld birth cohort study, hereafter only referred to as the "BaBi study" for brevity, will be used.

The following sub-sections of this chapter will detail how the research questions will be answered and why the topic of the dissertation is relevant for public health.

2.2.   Aims and objectives

This dissertation aims to identify determinants of diet in pregnancy and develop an explanatory model of the interplay of different determinants.

In order to achieve the aim of this doctoral thesis, the following objectives will be reached:

1. To review theoretical and empirical literature on determinants of diet in pregnancy.

2. To develop a conceptual framework based on the findings from the literature and

3. To assess determinants of diet in pregnancy in a social epidemiological birth cohort study (BaBi study)

4. To refine the initial conceptual framework into an explanatory model using findings from the literature review and the BaBi study

5. To make recommendations for practitioners and policy makers in Germany

2.3. Public Health Relevance

As outlined in Chapter 1, nutrition in pregnancy shapes the short- and long-term health of mothers and their children. Research findings corroborate that this is also true when diet is assessed 'as a whole' rather than as 'single' foods, food groups or nutrients.

2.3.1. Short- term health

A recent review of the health effects of dietary patterns in pregnancy identified a range of health outcomes in mothers and their offspring. Generally dietary patterns high in fruit, vegetables, legumes and fish were more beneficial for health (Chen *et al.*, 2016). The type of dietary pattern consumed was shown to influence maternal risk of infertility, gestational diabetes mellitus, hypertensive disorders of pregnancy (including gestational hypertension and preeclampsia) and depressive symptoms (Chen *et al.*, 2016). Further studies identified an association with cardio-metabolic markers (Martin *et al.*, 2016), risk of gestational diabetes mellitus (Shin *et al.*, 2015; Tryggvadottir *et al.*, 2015) and excessive gestational weight gain (Silva-del Valle *et al.*, 2013) but the association with postpartum depression was found to be unclear (Okubo *et al.*, 2011a). Some studies found an influence of maternal dietary patterns on gestational blood pressure (Timmermans *et al.*, 2011), while others did not (Eshriqui *et al.*, 2016).

Health consequences affecting the child included impaired fetal growth, preterm birth and risk of asthma (Chen *et al.*, 2016). Studies have also found associations between maternal dietary patterns and risk of premature birth (Englund-Ogge *et al.*, 2014; Hillesund *et al.*, 2014; Mikkelsen *et al.*, 2008; Saunders *et al.*, 2014) and spina bifida (Vujkovic *et al.*, 2009). An energy-rich dietary pattern was associated with greater fetal length (Bouwland-Both *et al.*, 2013) in one study while a pattern rich in processed meat and fat was associated with impaired fetal growth in another (Knudsen *et al.*, 2008).

Similarly, diet quality has also been associated with maternal and child health such as maternal blood triglycerides (Martin *et al.*, 2016), risk of preeclampsia (Rifas-Shiman *et al.*, 2009), postpartum weight retention (van

Ruesten *et al.*, 2014), risk of neural tube defects (Carmichael *et al.*, 2003), fetal growth restrictions (Rodriguez-Bernal *et al.*, 2010) and infant weight and length (Ferland and O'Brien, 2003).

2.3.2. Long- term health

There were fewer studies investigating the long-term health effects of dietary patterns and quality, this may be explained due to both being relatively new constructs, i.e. cohort studies applying either construct have not had long enough a follow-up period to study long-term effects.

Maternal dietary patterns have been associated with bone size and bone mineral density of the offspring aged nine years (Cole *et al.*, 2009) and child behaviour aged 1.5, 3 and 6 years (Steenweg-de Graaff *et al.*, 2014).

Dietary guideline adherence has been associated with lower postpartum weight retention (van Ruesten *et al.*, 2014).

2.3.3. Gaps in research

While it is easy to identify pregnancy as a time where adequate dietary intake should be promoted, it is less easy to pinpoint who is at risk and what determinants should be targeted by health promotion efforts. As the following section will detail, more research into pregnancy diet and the forces driving it is required, particularly in Germany.

Others have noted that studies of the effect of diet in pregnancy on maternal and child health, especially longitudinal studies, have been lacking (Willett, 1998). As have been studies on determinants of dietary behaviour in pregnancy in general (Rifas-Shiman *et al.*, 2009) and on the role of socio-demographic and lifestyle determinants in particular (Northstone *et al.*, 2007).

As outlined in Chapter 1, the study of dietary patterns and diet quality promises greater insights into the relationship between diet and health than the study of 'single nutrients' or 'single foods', it may also be methodologically more adequate as interactions between foods and

nutrients are accounted for and may be more applicable to real world settings.

There is a lack of contemporary data on lifestyle and nutritional habits of pregnant women in Germany (Kirschner, 2013). To my knowledge, no publications of German studies assessing dietary pattern or quality in pregnant women exist, neither have there been studies yet examining the determinants thereof.

The few German studies investigating diet in pregnancy have predominantly focused on 'single' foods/food groups or gestational weight gain (GWG). This may be because diet is complex to assess and in Germany GWG is recorded in the antenatal health care booklet (Mutterpass), i.e. this record can be used in retrospective or cross-sectional studies which are less resource intense than prospective birth cohort studies starting in pregnancy.

The Giessen Wholesome Nutrition Study was a prospective study assessing diet of pregnant 70 women who had been adhering to a predominantly vegetarian diet and a control group of 39 women who routinely ate a Western diet, once per trimester (Koebnick *et al.*, 2001). The predominantly vegetarians and control group consumed similar amounts of fruits, vegetables and grain products but differed in their consumption of meat, fish, potatoes, legumes, soy products and raw foods (Koebnick *et al.*, 2001). Habitual plant based diet consumers had better plasma and red blood cell folate concentrations throughout pregnancy suggesting that a vegetarian diet reduces risk of folate deficiency, provided that vitamin B12 intake is adequate (Koebnick *et al.*, 2001). They also had marginally better magnesium status in pregnancy than their Western diet counterparts (Koebnick *et al.*, 2005). Publications of the Giessen Wholesome Nutrition study focused on single nutrients and foods such as vinegar (Heins *et al;* Koebnick *et al.*, 2004).

Gestational weight gain is often used as an indirect indicator of dietary intake (Wolff and Wolff, 1995). When interpreting the results of studies using GWG it needs to be considered that weight gain is only a proxy for diet, besides food intake it is influenced by a wide range of factors. Among these are physical activity and smoking (Olson *et al.*, 2003), psychological

factors, and physiological factors such as maternal height and age and number of fetuses carried (Rasmussen and Yaktine, 2009).

Current evidence on the influence of diet on GWG points to the role of energy content of the diet. Studies found a significant influence of energy density but not glycaemic load (Deierlein *et al.*, 2008), percentage energy ingested from fat and carbohydrates and intake of milk and sweets (Olafsdottir *et al.*, 2006), energy intake (Rodrigues *et al.*, 2008) and found GWG to be associated with a dietary pattern high in fast food (Uusitalo *et al.*, 2009).

The GeLiS study is a prospective, cluster-randomised, controlled intervention trial in Bavaria investigating the influence of a lifestyle intervention on gestational weight gain (Rauh *et al.*, 2014). Unfortunately the study is ongoing and no results have been published yet. However, results of FeLIPO, the pilot study of GeLis, are available. Over 30 % of the controls and over 15 % of the intervention group were overweight or obese before pregnancy indicating that a considerable number of women in Germany enter a pregnancy with excess bodyweight (Rauh *et al.*, 2013). Diet was assessed using 7-day dietary records collected at three points during pregnancy. Unfortunately, only energy intake was reported, not dietary pattern or quality.

The Berlin study "The influence of migration and acculturation on pregnancy and birth" also examined pre-pregnancy weight gain and GWG but did not assess dietary intake. An analysis of 5,262 women showed that 25.5 % were overweight and 12.8 % obese based on measured pre-pregnancy BMI. Moreover, both overweight and obesity were more prevalent in women born outside Germany, particularly in the Turkish- and Lebanese-born (Reiss *et al.*, 2015).

In a retrospective cross-sectional study in the Munich area, 522 women who had given birth in the previous three days were asked about their dietary supplement use during the pregnancy. Of the study population 54.2 % had a high level of education and 51.3 % were primiparous. A total of 97.1 % reportedly took at least one type of supplement during the course of their pregnancy; folic acid was the most commonly cited. Analysis of the determinants of taking supplements identified a significant positive

association between maternal age and DHA supplements, between education and iron supplements and being German and folic acid supplements. Moreover, smokers were more likely to take folic acid. However, no significant associations for other supplements or with education and parity were found (Becker *et al.*, 2011). While the sample size was relatively large, the majority of participants were highly educated, German, married, non-smoker and had no previous children. The lack of significant association may therefore be due to lack of diversity in the sample which rendered the analysis of sub-groups underpowered. Nevertheless the study points to age, education, ethnicity and smoking status as potential determinants of dietary behaviour in a German population.

The baby-care programme (www.baby-care.de) is a programme aimed at preventing premature births which is provided free of charge through many health insurance companies in Germany. Women taking part in the programme receive a handbook with lifestyle advice and nutrition and cooking information. For a fee, women get the opportunity to fill in a lifestyle and nutrition questionnaire and receive individualised feedback and recommendations. Due to the commercial nature the participants of this programme may not be representative of all German pregnant women, it is plausible that participants would be more affluent and more interested in health and diet. On the upside, it is one of the few current data sources in Germany and includes a large sample size.

Participants (n= 29,815) were asked to categorise themselves into one of six dietary types. Just over half classed themselves as "healthy" (38.5 % "healthy and natural", 12.6 % "healthy and fit"), 24.8 % typified as "fast and cheap" or "fast and easy" while the remaining 24.3 % were predominantly "traditional and good" (21.2 %) or "exclusive and good" (3.1 %). Further analysis identified a positive association between BMI and "fast" and an inverse association with the "healthy" types, i.e. with increasing BMI there were fewer women who classed themselves as "healthy" and more who identified as "fast" eating types. Furthermore low iodine status was seen in 42 %, low iron and folic acid in 70 % and low vitamin D in 95 % of participants (Kirschner, 2013). The publication does not make it clear whether these estimates are based on food intake data or blood tests.

These results show that in Germany a considerable proportion of women enter a pregnancy with excess weight. Low intake of crucial micronutrients was also not uncommon. This indicates a population need for improved dietary intake. With the caveat that diet in these studies was presented as single foods, macronutrients or self-ascribed dietary pattern, a range of factors appeared to influence diet such as socio-demographic characteristics and smoking. In Germany the birth rate has increased by 3.5 % in the last year, if this trend persists then pregnancy diet will become important for more women and children (Statistisches Bundesamt, 2016).

Chapter 4 will outline the results of a systematic review of international literature on determinants of diet 'as a whole' in pregnancy.

2.3.4. Gaps in (the use of) theory

Theory has been described as *"an account of the world which goes beyond what we can see and measure"* (Marshall, 1998, p. 666). Theories are used to organise concepts and understanding of the empirical world systematically (Marshall, 1998). Theoretical epidemiology focuses on the occurrence of health and illness in a population or the prediction of occurrence of diseases and health-related states using mathematical models and theories (Porta *et al.*, 2014).

Use of theories is also important in health (behaviour) promotion (Brug *et al.*, 2005).

Brug *et al.* (2005) outlined five crucial steps in health promotion planning; these should ideally be evidence-based (Brug *et al.*, 2005):

1. Identification of health problem/s that require/s intervention

2. Identification of the behavioural and environmental risk factors

3. Identification of the mediators/determinants of these risk factors

4. Intervention mapping, translation of these determinants into intervention goals, change strategies and methods

5. Implementation and dissemination of the intervention

Theories are particularly important for the third step, as successful interventions depend on the ability to influence particularly the environmental and cognitive determinants of health behaviour including food intake (Brug *et al.*, 2005).

Thus, theories are an important tool of research in general and are used in the fields of epidemiology and health promotion. Are theories used in the field of nutrition?

A general lack of theoretical underpinning of studies investigating social inequalities in food and nutrition has been noted by McIntosh (1996). He

postulates that this may be due to the applied nature of nutritional sciences. For example, while social determinants of diet have been studies, social stratification theory has rarely been applied (McIntosh, 1996). Similarly, Brunner (2000) noted that that up until recently the study of food and nutrition had been primarily of interest to the natural sciences but was mostly ignored by social and cultural sciences, causing the field to lag behind in the development and establishment of sociological theories (Brunner, 2000). This was corroborated by McMillan and Coveney in a 2014 editorial. The authors propose that "failure" of the field of sociology to study food and diet as social practices might partly stem from an ignorance of those funding and those conducting research (McMillan and Coveney, 2014). Beardsworth and Keil (1997) propose that food and eating have not received much attention from sociology because eating is such a mundane activity and food does not receive much attention in food-secure settings such as Western societies which are home to most sociologists (Beardsworth and Keil, 1997).

Much like sociologist, researchers in the field of nutrition, particularly obesity research, have noted a need for change. Obesity interventions focused on the individual have had limited success (Cummins and Macintyre, 2006; Lawlor and Chaturvedi, 2005; Lake and Townshend, 2006). A shift in focus away from the individual, towards the complexity of social and physical context in which people live and make decisions regarding their health, has been advocated (Cummins and Macintyre, 2006; Lake and Townshend, 2006).

However, Oltersdorf (1995) noted that this complexity in itself is problematic. Eating is a banal, everyday activity that everyone is an expert in, thus society has a vast collective experience based on which universal rules of what to eat and what not to eat should have been derived. This in stark contrast with the challenges and uncertainties researchers face when studying the complex interplay of diet, humans and their environment (Oltersdorf, 1995).

Nutrition has been described as a relatively young field of research that is often hindered by using theories that lack strong empirical foundation or that are too focused on the individual, or by using existing theories incorrectly (Brug *et al.*, 2005).

Population dietary interventions have commonly been based on social-psychological theories such as the theory of reasoned action, social cognitive theory or the transtheoretical model that focus on cognitive processes and individual behaviour and as such underestimate, or ignore, the role of the wider social and physical living conditions (Delormier *et al.*, 2009). Psychosocial models are thus increasingly being refined and expanded to include the influence of environmental factors (Raine, 2005). Ball and Thornton (2013) identified as a key research need the use of theoretically grounded determinants and the integration of distal and proximal determinants in understanding the drivers of diet behaviour (Ball and Thornton, 2013).

To summarise, research, particularly on the determinants of diet, would benefit from being built upon a strong theoretical foundation. When studying dietary behaviour, using theories focusing just on individual behaviour and cognitions is probably not sufficient. The work of this dissertation will thus use, and possibly extent existing or develop new, theories.

Miles and Huberman (1994) have stated that *"theory building relies on few general constructs that subsume a mountain of particulars"* (Miles and Huberman, 1994, p. 18). The development of an initial framework, possibly with several iterations to refine it, can help disentangle the particulars (Miles and Huberman, 1994). The next chapter will describe the development of such framework.

2.4. Summary of public health relevance

Diet in pregnancy is crucial for maternal and child health and pregnancy is potentially a good time for initiating behaviour change. Identification of the drivers of diet in pregnancy would allow detection of at risk groups and tailoring of interventions to these groups. However, research into these determinants is lacking.

In Germany there is little evidence on current nutritional status and dietary intakes of women during pregnancy, as studies have predominantly focused on gestational weight gain or 'single' foods or food groups.

A general lack of sound theoretical underpinning in nutrition research has been noted, consequently there is also a need for furthering theoretical knowledge in the topic area.

This dissertation is of public health relevance because:

- diet in pregnancy is important for health of mothers and children, potentially with life-long consequences

- despite an abundance of food in developed countries there is evidence of inadequate diets consumed by (some groups of) pregnant women

- specifically in Germany there is a lack of current data on the diet situation of pregnant women

- knowledge of the determinants of diet in pregnancy would allow identification of at-risk groups and public health efforts to tackle the relevant influencing factors

- improvement of theoretical foundation would advance the discipline of nutrition, and possibly also public health, research

This dissertation aims to contribute to filling these research gaps and advance the theoretical and empirical knowledge.

3. Development of a conceptual framework

Evans and Stoddart (2003) have described the study of determinants of health as very complex. They stated, that *"rather than a simple, linear system of relationships - much less a single causal factor - health depends upon everything, all the time."* (Evans and Stoddart, 2003, p. 374). As the previous chapters have shown, the determinants of diet appear to be similarly complex.

3.1. Aim

This chapter aimed to answer research question 1.a. outlined in Chapter 2. In order to identify relevant determinants and their relationships the literature was reviewed (theoretical and empirical evidence), based on this the conceptual framework was developed.

3.2. What is a conceptual framework?

Smyth (2004) has described a conceptual framework as a tool that provides the scaffolding to research and can be a meaningful starting point of research by allowing reflection about the work itself and its context (Smyth, 2004).

Miles and Huberman (1994) defined a conceptual framework as a product that *"explains, either graphically or in narrative form, the main things to be studied - the key factors, constructs, or variables - and the presumed relationships among them"* (Miles and Huberman, 1994, p. 18). Researchers may start with a fairly crude framework they develop based on their experience, objective and theoretical knowledge. This framework can then become more refined as work progresses. The final framework can help guide data collection and analysis (Miles and Huberman, 1994).

Others have successfully used a conceptual framework as a starting point for exploring relationships between determinants and health outcomes (Bernecki DeJoy and Bittner, 2015), including influences across the life

course (Misra, 2006) and nutritional dimensions in dietary research (Oltersdorf *et al.*, 1989).

In accordance with the definitions by Smyth (2004) and Miles and Huberman (1994), a conceptual framework of determinants of diet 'as a whole' in pregnancy will be developed:

- to use as the starting point and scaffolding structure of this dissertation
- to explain to and familiarise the reader with the key concepts
- to select appropriate variables and decide on an analysis plan

The conceptual framework will provide the structure for disentangling the complex interplay of determinants of diet in pregnancy. As findings become more concrete and the pathways in which diet is determined more tangible, the framework will be refined into an explanatory model.

3.3. What is a model?

Model is a term sometimes used synonymously with theory, but also to describe abstract concepts at a more general level (Marshall, 1998). Models aim to *"simplify phenomena, as an aid to conceptualisation and explanation"* (Marshall, 1998, p. 427). A model is more detailed than a conceptual framework in that it outlines (possible) mechanisms and processes (Shepherd and Raats, 2006). In epidemiology, models are understood as abstract depiction of components of a system or formalised expressions of theories regarding causal pathways (Porta *et al.*, 2014, p. 187). To my knowledge no theoretical model of the determinants of diet in pregnancy exists to date. This dissertation endeavours to fill this important gap in theoretical underpinning by developing an explanatory model (Chapter 5).

3.4. Key concepts and underlying assumptions

This dissertation is based on the following assumptions:

- diet can be adequately measured and reflected as dietary pattern or diet quality (this includes guideline adherence)
- diet is determined by a range of socio-demographic, environmental, individual response (behavioural/biological) and pregnancy-related factors
- the influence of these determinants on diet can be measured
- there is sufficient concordance in the action of determinants across different developed countries that findings can be summarised and displayed in a theoretical model that is applicable to different settings

3.5.   What are determinants?

Research into social determinants of health is an ever growing field spanning several decades' worth of work. Nevertheless, understanding what factors influence health, and perhaps even more importantly, understanding how these determinants can be influenced in order to improve health outcomes, is less clear (Evans and Stoddart, 2003).

Determinants are factors which affect health outcomes in a causal fashion. The terms risk factor and determinant are sometimes used interchangeably, however determinants are thought to be more amenable to intervention, while it is not clear whether risk factors are always causal (Kindig, 2007). Last (1988) defined determinants as *"any factor, whether event, characteristic, or other definable entity, that brings about change in a health condition or other defined characteristic"* (Last, 1988, p. 37). Determinants can be grouped based on their "distance" in scale, level, position, or time to the outcome (Porta *et al.*, 2014). Proximal determinants are those close to the outcome and are also called downstream determinants. Distal determinants, also called upstream determinants, are risk factors that are remote from the outcome which makes the identification of causal pathways difficult (Porta *et al.*, 2014).

3.6.   Diet 'as a whole'

Both dietary patterns and diet quality are constructs for representing complex dietary intake in a condensed way (see section 1.5.).

Dietary patterns may be defined *a posteriori*, i.e. derived from the specific data, or *a priori*, i.e. judging level of adherence to an ideal, pre-specified diet using scales and indices (Trichopoulos and Lagiou, 2001).

Diet quality assessment is based on pre-defined scales often modelled on dietary guidelines or foods known to be detrimental or protective for health (similar to dietary patterns derived *a priori*). Table 1 outlines the similarities and differences between both constructs.

Table 1: Dietary patterns vs. diet quality

	Dietary patterns	Diet quality
Definition	*"the **quantities, proportions, variety, or combination** of different foods, drinks, and nutrients (when available) in diets, and the **frequency** with which they are **habitually consumed**"* (Essery Stoody *et al.*, 2014, p. 1)	*"the assessment of both **quality and variety** of the **entire diet**, enabling examination of associations between whole foods and health status, rather than just nutrients"* (Wirt and Collins, 2009, p. 2473)
Similarities	▪ Focus on 'whole' diet, beyond 'single' foods or nutrients ▪ Variety of diet ▪ Result is a single score or other composite measure ▪ Predominantly investigated as an exposure variable in disease aetiology	
Differences	▪ Either defined *a priori* or derived from data ▪ Data basis is habitual food intake	▪ Always defined *a priori* ▪ Habitual food intake not named explicitly, but implied*

*dietary quality is often used to study diet-disease relationships which are based on habitual intake
Source: author

There is considerable overlap in their definitions and intention to depict diet 'as a whole'. The main differences lie in their methodological derivation.

Another construct is that of dietary intake. It is very complex and difficult to assess exactly (Trautwein and Hermann, 2005; Willett, 1998). Therefore "true" intake may never be completely captured or adequately described, at least with current methods.

In a theoretical visual representation of the interplay of the different concepts it becomes apparent that there is considerable overlap between both dietary patterns and dietary quality and both enable a greater insight into the underlying concept of total diet than 'single' foods or nutrients (Figure 1).
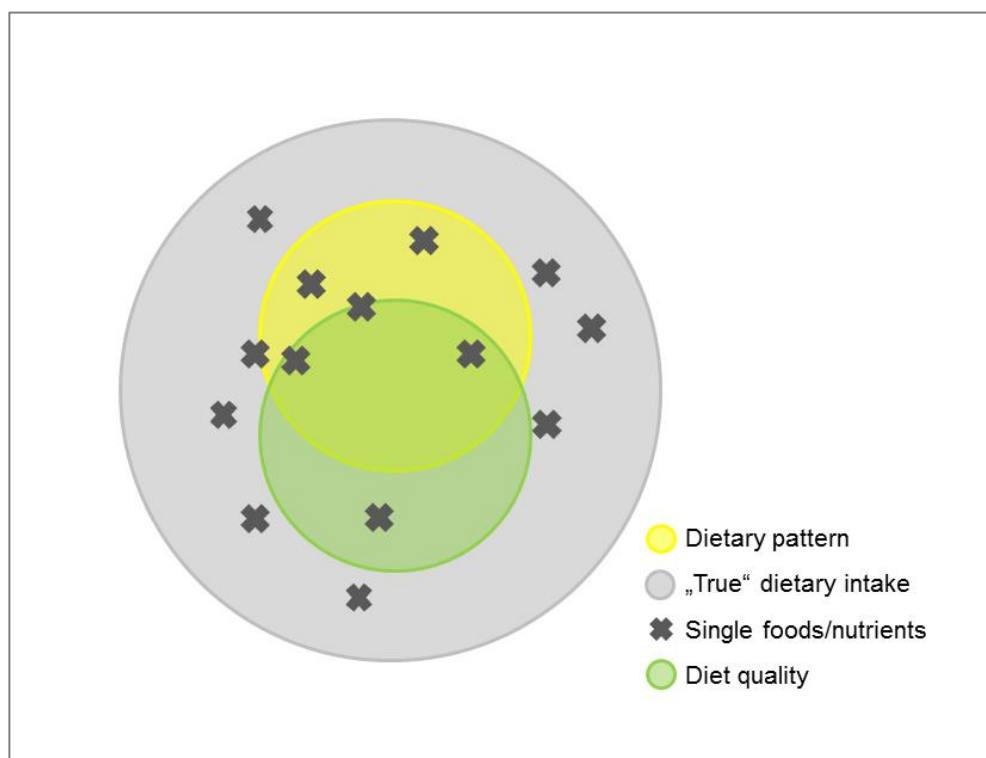
Figure 1: Overlap in dietary concepts
Source: author

Therefore, both dietary patterns and dietary quality will be accepted as valid attempts to capture total dietary intake and will be collectively referred to as 'diet' in this dissertation.

3.7. Determinants of diet

Based on the definition by Last (1988) given in Section 3.4., determinants of diet were defined as factors that brought about change in diet in pregnancy.

As described by Porta *et al.* (2014) in the same section, determinants were categorised according to their 'distance' to the outcome (Porta *et al.*, 2014), which was diet in pregnancy.

An initial scoping of the literature (Doyle and Spallek, 2016) indicated that diet in pregnancy is determined by socio-demographic, lifestyle, pregnancy-related and environmental factors. Diet appeared to align along age, and along a social gradient and a lifestyle gradient whereby those in a stronger social position (e.g. higher income, married) and/or exhibiting health protective behaviours (e.g. taking supplements, physical activity) also adhered to more favourable dietary patterns or had higher diet quality. The influence of environmental and pregnancy-related factors was less commonly researched.

3.7.1. Theories and models

Human nutrition (see Appendix 1 – Glossary of terms) is influenced by a multitude of factors including those related to physiology, personality and culture (Oltersdorf, 1995). Oltersdorf (1995) outlined the different dimensions (humans, diet, time and environment) and elements of analysis involved in nutritional epidemiology (Oltersdorf, 1995). The complex interplay is represented in Figure 2. Since diet in the sense of this dissertation (i.e. measured as dietary patterns or diet quality) is by definition (section 3.5.) a close approximation of 'true' diet based on habitual intake, it was position in-between diet and dietary habits in the model.

To my knowledge no models of determinants of diet 'as a whole' exist. Potential explanations for this are that both concepts are relatively new and have been predominantly used to study disease aetiology, i.e. dietary patterns or quality as determinants of health outcomes, rather than the determinants thereof.
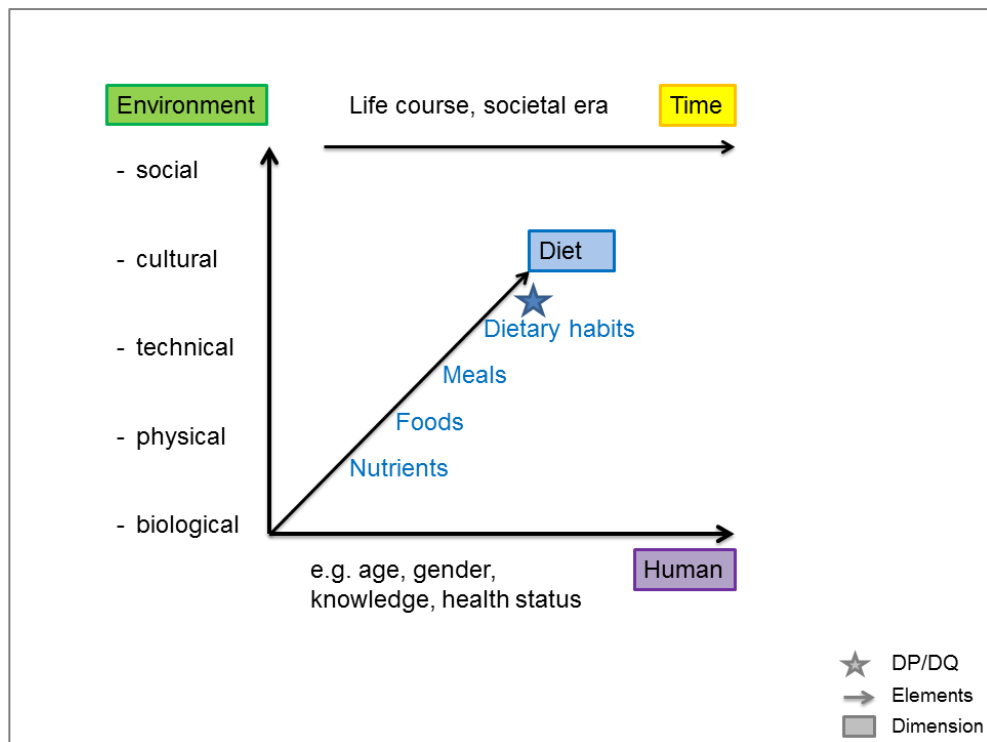
Figure 2: Dimensions of nutritional epidemiology
Adapted from Oltersdorf (1995); DP, dietary pattern, DQ, diet quality

In lieu of models on determinants of diet (measured as patterns or quality), models and frameworks of the determinants of food choice, a related concept, will be explored.

Since the 1990's a considerable number of investigations into the drivers of food choice have been published, they will be examined with the limitation that food choice is positioned at the food level (see Figure 2) and as such is much closer to biological and physical determinants than diet 'as a whole'.

Food choice is a complex behaviour (Shepherd, 1999). The study of food choice is concerned with the foods and drinks people select and consume and the contexts (what, how, when, where and with whom) in which food is eaten (Shepherd and Raats, 2006). Food choice has been described as both a decision process and the outcome thereof (Cox and Anderson, 2004). It appears to be influenced by many factors including, more proximally, cognitive factors such as beliefs and attitudes, and distally by social, economic and cultural factors (Shepherd, 1999).

Furst *et al.* (1996) developed a conceptual framework of determinants and processes involved in *"a single choice event"* (Furst *et al.*, 1996, p. 250).

Figure 3 shows their framework which was developed based on qualitative interviews of adults mainly approached in grocery stores while shopping. Furst *et al.* (1996) propose that food choice behaviour is most distally influenced by experiences across a person's life course that generate specific influences including a person's ideals and resources regarding food choice. In turn, these influences shape a person's personal system in which food choices are made, such as conscious value negotiations, e.g. weighing up the cost, convenience, taste or quality of a particular food item. Most proximally to the single food choice event are personal strategies, which are routine behaviour patterns, such as a preference for branded food or choosing special foods for holidays or occasions (Furst *et al.*, 1996).
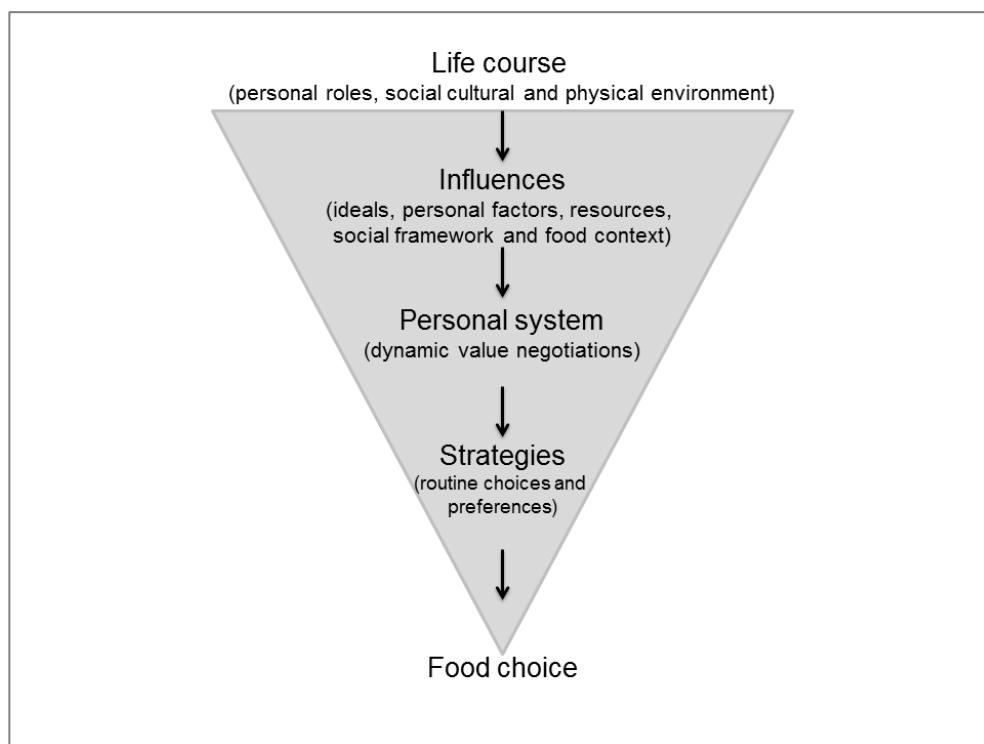
Figure 3: Conceptual model of the food choice process
Adapted from Furst *et al.* (1996)

The conceptual framework by Furst *et al.* (1996) is arguably focused on choice of individual foods in the context of grocery purchasing and as such not directly applicable to the topic of dietary patterns or quality in pregnancy. However, the authors' observations that the study of food

choice is enhanced by considering multiple determinants and particularly the influences of the life course appear abstract enough to also apply when taking the investigation of determinants "a few levels up" to the study of dietary patterns and quality.

Devine (2005) reviewed food choice literature and came to the conclusion that a life course approach to food choice helps explain the links between social and biological pathways that shape nutrition and health (Devine, 2005). She suggests that the life course approach offers three frameworks (Devine, 2005):

- temporal, i.e. food choice develops and transitions over the life time, and timing might be crucial for certain food choices

- social, i.e. the importance of social context of food choice such as the role of social class, race, ethnicity or gender, and the role of changing social context over the life course

- historical, i.e. individual food choices are shaped by the wider historical context such as social, economic, food and health policy trends, and are shaped historically across generations and cohorts

Evans and Stoddart (1990) developed the conceptual 'Producing health, consuming health care' (PHCHC) framework of the patterns of determinants of health (Evans and Stoddart, 1990) shown in Figure 4. Determinants included in the framework were the social environment, physical environment, genetic endowment, individual responses in behaviour and biology and the health care system (Evans and Stoddart, 1990; Evans and Stoddart, 2003).

The framework was developed by an interdisciplinary team at the Canadian Institute for Advanced Research studying health inequalities. The team reviewed a vast amount of literature and developed the PHCHC causal framework with the aim to represent the complexity of the possible determinants of health (Evans and Stoddart, 2003). Previous models had either been overly simplistic in their focus on care and cure provided by the

health care system while ignoring the determinants of health completely, or too simplistic in their consideration of determinants. Those models focused on biological, environmental and lifestyle determinants, which was seen to suggest that people carry most of the responsibility for their own health, having chosen their lifestyle and possibly also the environment in which they live (Evans and Stoddart, 1990).
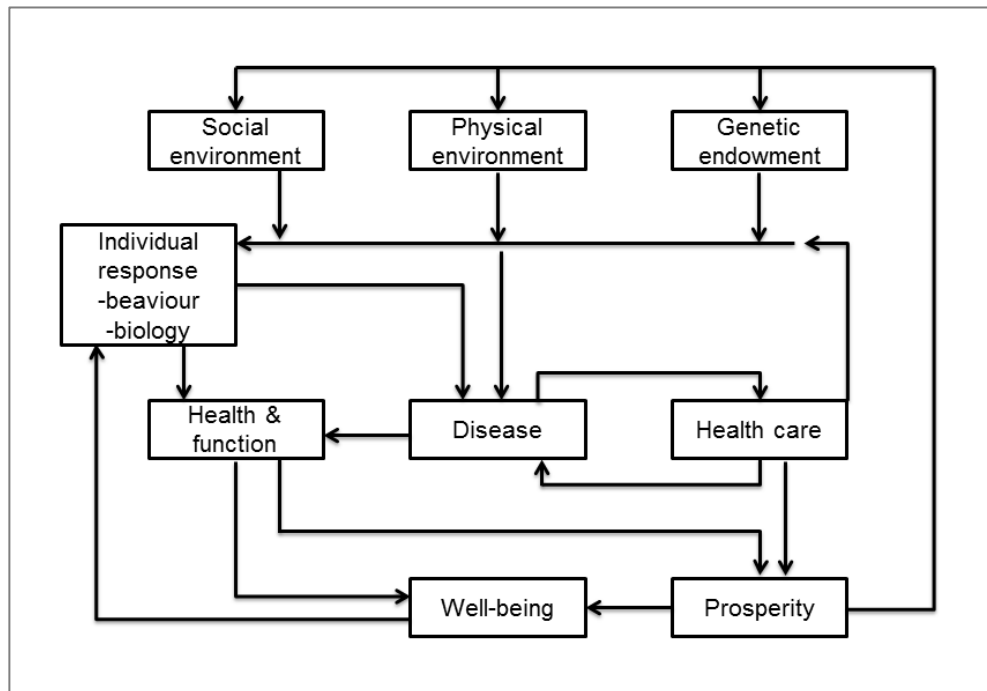
Figure 4: Producing health, consuming health care framework
Adapted from Evans and Stoddart (1990)

The existence of a social gradient in health, i.e. the universal finding across countries and time that morbidity and mortality align along socio-economic status despite advances in medicine and healthcare, lead to the consideration that deeper, underlying influences on health needed to be considered (Evans and Stoddart, 1990).

A unique feature of PHCHC is thus the consideration of individual response in behaviour and biology which advanced some of the features classed under biology or lifestyle in previous models. With this notion the authors aimed to move away from victim blaming and from focusing on education campaigns and interventions which had proven highly ineffective.

An example of a behavioural response is smoking which is influenced by the social environment, e.g. whether smoking is accepted or promoted by one's social group. Examples of a biological response are a lowered immune system in response to stress and the priming effect of infant nutrition on metabolism of dietary fats in later life (Evans and Stoddart, 1990).

By combining both types of responses in one box the authors wanted to overcome the *"free will vs. determinism dichotomy"* (Evans and Stoddart, 2003, p. 374) in health promotion which can lead to victim blaming by just asking people to "chose" healthy lifestyles.

Evans and Stoddart envisioned that sub-frameworks and adaptations for different determinants or population groups would be developed based on their initial framework (Evans and Stoddart, 2003).

Frameworks of determinants of health developed over the past decades share three common features (Evans and Stoddart, 2003), they:

- consider the influence of social, economic, cultural and physical environments in modifying the influence of individual characteristics on health
- acknowledge that health is influenced by many determinants, the interactions of which are highly complex
- focus on the prevention of ill health rather than on treating illness

Thirteen years after the development of the PHCHC framework Evans and Stoddart admitted that their framework was missing the important angle of time and that causal lines should go from the social and physical environment to the genetic box in line with the observation that genes are not stable but their expression can be influenced by the environment (Evans and Stoddart, 2003).

Misra (2006) filled this gap. She adapted the PHCHC framework to the study of perinatal health with consideration of racial inequalities in health. The perinatal health framework considered the determinants of maternal and child health over the life course and the possibility of environmentally induced epigenetic changes (Misra, 2006). The framework is shown in Figure 5, it consists of distal and proximal determinants as well as

processes and maternal and child health outcomes.

Distal determinants are genetic and environmental factors that influence long-term health and well-being. Results from intergenerational studies indicate that genetic factors bear important influences on perinatal health. Environmental determinants are split into the physical environment (e.g. air pollution, housing, crowding) and the social environment (e.g. socio-economic status, education, psychosocial stress). Proximal determinants are individual responses to distal determinants, such as negative health behaviours in response to stress or chronic illness resulting from genetic and environmental causes (Misra, 2006).
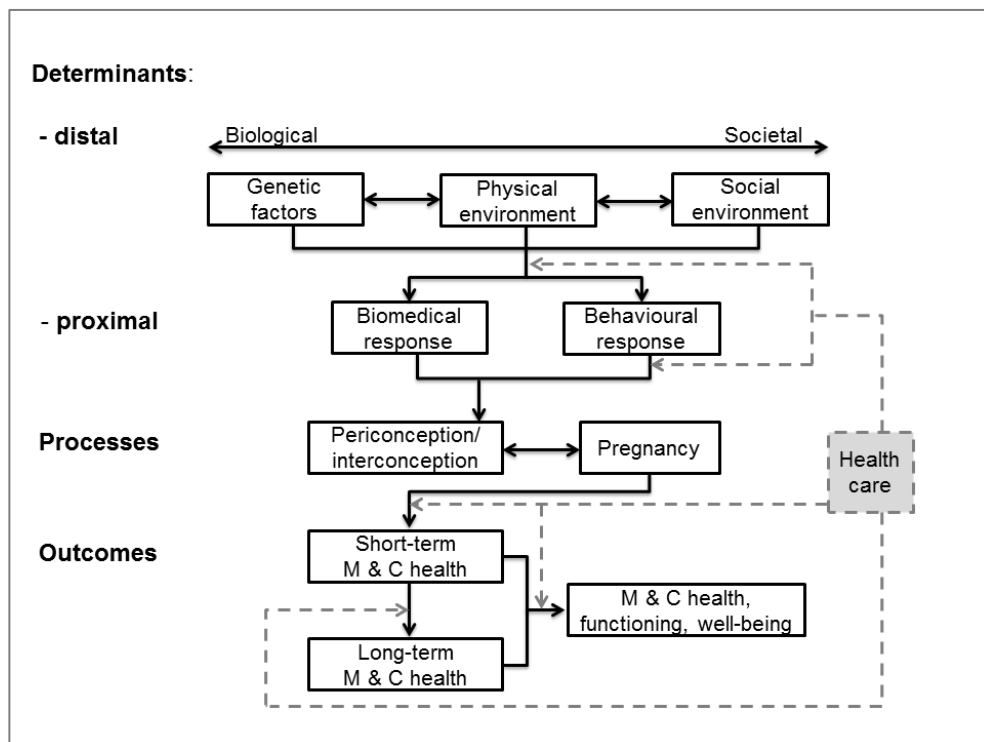
Figure 5: Perinatal health framewok
Adapted from Misra (2006); M & C, maternal and child

3.7.2. Perspectives and dimensions

As dietary intake is highly complex so must be the study of its determinants. Nutritional epidemiology is characterised by a concern with multiple dimensions, particularly those of diet, population, environment and time (Oltersdorf, 1995). With regards to the study of determinants of diet in general, Brug *et al.* (2005) recommended that multiple determinants including individual, social and environmental factors should be integrated (Brug *et al.*, 2005).

Bernecki DeJoy and Bittner (2015) reiterated the importance of multiple determinants specifically in perinatal health (Bernecki DeJoy and Bittner, 2015). They found that lifestyle choices in the perinatal period are particularly influenced by social, cultural, environmental and policy contexts and the integration of multiple determinants can thus lead to enriched understanding and more effective interventions in perinatal health (Bernecki DeJoy and Bittner, 2015).

As described above, Evans and Stoddard (2003) have pointed out, that the interaction of multiple determinants over the life course is crucial for understanding their influence on health, and that research designs should thus include timing and sequence of different determinants where possible (Evans and Stoddart, 2003).

In summary, both the initial scoping literature review and the review of theories and model have indicated the importance of:

- the life course perspective, particularly the role of time, social and historical context

- the consideration of multiple determinants, particularly social, environmental, cultural, responses in behaviour/biology and genetic make-up

This indicated that both a multiple determinants and a life course perspective are important in disentangling the complex role of determinants on health or health behaviour including dietary intake.

3.7.3. Pregnancy-related

The previous sub-section did not identify explicit evidence for the inclusion of pregnancy-related or pregnancy-induced determinants. However the life course perspective has been advocated as has been the consideration of temporality. Under life course theory pregnancy is a critical period (Section 1.3.2.).

The body of sociological literature on pregnancy is rather small (Sutherland, 1997; Hirschauer, 2014). Yet the existing literature gives important insights into the sociological changes a woman may experience additionally to physiological and psychological changes.

Firstly, pregnancy has been described as a sociologically distinct period during which women are under public and medical scrutiny and great social pressure. Societal norms demand that they carry responsibility for the wellbeing of themselves and the unborn child by complying with medical demands (Hirschauer, 2014). Pregnant women also find themselves in a conflict of frames of reference – while they view their pregnancy as a natural process and as integrated into other aspects of their lives and social roles, doctors tend to view it as a medical process and treat it as an isolated event (Graham and Oakley, 2005).

Pregnancy is associated with a changing of social roles. The first pregnancy leads to becomes a mother, beyond this pregnancy can also change a woman's occupational and financial position, living situation, marital status and her personal relationships (Graham and Oakley, 2005). Pregnancy has also been described as a significant event in the life course with significant influence on trajectories and transitions in health attitudes and practices (Devine *et al.*, 2000).

The second insight from theoretical literature is that women's experiences of pregnancy may be shaped by body image changes, particularly in Western societies where body size and shape is closely intertwined with self-image of women (Sutherland, 1997). While for some pregnancy appears to be *"liberating"* (Devine *et al.*, 2000, p. 568) or a welcome *"excuse"* (Anderson, 2001, p. 499) to eat without constraint without being reprimanded by society, others worry about weight and potential weight retention after birth (Anderson, 2001). Both may alter dietary intake.

The preferred body image and how women evaluate physiological changes during pregnancy appears to depend on a woman's social, cultural and ethnic background (Sutherland, 1997).

In an anonymous postal questionnaire distributed in Tokyo (n= 248), 35.5 % of women reported dieting in their current pregnancy. Dieting was predicted by having dieted before pregnancy and by the belief that dieting would lead to a smaller baby (Takimoto *et al.*, 2011). Despite a low prevalence of overweight or obesity (5.6 %) in this population, 91.5 % had clear weight gain targets in mind, and the majority wanted a small baby for smooth delivery (70.0 %) and wished to return to their pre-pregnancy weight (85.9 %). The authors explained that the reported fear of large babies and subsequent operative delivery is in stark contrast to Japan having one of the lowest maternal mortality in the world and birth weights having decreased consistently in the past four decades, such that only 1.0 % of births are macrosomic (Takimoto *et al.*, 2011).

By contrast, in an Australian study 18 % of pregnant participants were overweight and 11 % obese, yet concern with weight gain was lower than in Japan. About half of all participants thought that weight gain was not a concern as long as they ate healthy (53 %) or were physically active (48 %) during pregnancy (Smedley *et al.*, 2013).

An investigation into body image and dieting in pregnant UK women found that body image ideals were relaxed during pregnancy and dietary restraint lower (Davies and Wardle, 1994). The dampening down of weight concerns appears to depend on a woman's pre-pregnancy weight and body image and to be restricted to the time of pregnancy, i.e. concerns often return in the postpartum period (Devine *et al.*, 2000).

In an investigation of the US Pregnancy, Infection, Nutrition (PIN) birth cohort, (n= 1,223) almost half of all participants reported restrained eating before conception (e.g. history of dieting, weight fluctuations, concerns about eating too much); this was associated with inadequate gestational weight gain. Restrained eaters who were underweight before pregnancy gained less than recommended, whereas normal, overweight or obese restrained eaters gained above recommendations (Mumford *et al.*, 2008).

In the British ALSPAC cohort, women with a history of eating disorders, i.e.

bulimia nervosa, anorexia nervosa, or both (n= 414) were compared to women without such history (n= 9,723). Dietary intake was comparable across groups; however women with a history of eating disorder were more likely to adhere to health conscious or vegetarian dietary patterns. They were also almost twice as likely to have caffeine consumptions exceeding the recommended limit for pregnancy, caffeine is a known appetite suppressant used by women with eating disorders (Micali *et al.*, 2012).

Pregnancy is also a physiologically unique period in which the body is undergoing many changes (Rasmussen and Yaktine, 2009). Firstly, pregnancy may assert an influence on dietary intake via physical symptoms; nausea and vomiting are commonly experienced in the first trimester and may cause changes in food avoidance and preferences (Bayley *et al.*, 2002; Latva-Pukkila *et al.*, 2010). Nausea and vomiting in early pregnancy appear to protect from pregnancy loss (Hinkle *et al.*, 2016). The maternal and embryo protection hypothesis suggests the symptoms protect women from ingesting harmful substances and toxins (Sherman and Flaxman, 2002).

In the Norwegian Mother and Child cohort MoBa (n= 21,675), 33 % of women experienced nausea and vomiting in pregnancy, they were younger, less educated and heavier at pregnancy onset and consumed diets higher in energy, mainly due to higher consumption of carbohydrates and soft drinks. A further 39 % of women experiences only nausea and 28 % were without symptoms, they had the lowest total energy intake (Chortatos *et al.*, 2013). Similarly, in a Finnish study women experiencing nausea and vomiting in pregnancy had higher intakes of carbohydrates and shorter pregnancies than women who were symptom free (Latva-Pukkila *et al.*, 2010).

Constipation, cravings and food aversions are also commonly reported by pregnant women and may result in dietary change (Anderson, 2001). Pica, the compulsive ingestions of non-food substances, was reported in 8 % of African Americans in a US study. This may have been the results of micronutrient deficiencies such as iron or a response to stress (Edwards *et al.*, 1994).

Women have also reported change in taste, appetite and meal frequency

upon becoming pregnant (Lim *et al.*, 2008). Cravings for sweet foods and drinks resulted in increased consumption of such foods and appeared to be particularly pronounced in the late second trimester (Belzer *et al.*, 2010). Strong cravings for energy dense foods have been reported as a perceived barrier to improving their diet by pregnant low-income African American women (Groth and Morrison-Beedy, 2013). Experimental studies observed increased consumption of sweet but not salty or non-sweet foods in the second trimester (Bowen, 1992) and changes in salt, sour and bitter preferences in later pregnancy, which may serve to cause the intake of a more varied diet (Duffy *et al.*, 1998). Cravings for sweets have already been reported four decades ago (Hook, 1978), this indicates these cravings are innate, physical responses rather than a response to the current food environments or trends.

In addition to physical symptoms, the mere state of being pregnant was found to change dietary behaviour (Verbeke and Bourdeaudhuij, 2007). For example, different diets were observed in pregnant and non-pregnant women, but these differences could not be attributed to differences in nutrition knowledge; differences may have arisen from different norms and beliefs of what constitutes healthy eating in pregnancy (Anderson *et al.*, 1993).

Findings from the Portuguese Generation XXI cohort showed that food intake changed from preconception to pregnancy, e. g. women consumed more dairy, fats, breads and fruits but less eggs, read meat, fast food and coffee (Pinto *et al.*, 2009).

An Australian study assessing women's health knowledge and behaviour before and during pregnancy retrospectively (n= 100) found that women increased their fruit, vegetable and fibre intake and reduced consumption of fast food (Smedley *et al.*, 2013). Dietary behaviour was more favourable in this study compared to similar Australian studies involving pregnant women, possibly due to participants' higher education level. A sub-section of participants also completed in-depth qualitative interviews. They indicated that doctors are their preferred and most trusted information source but that the information they received from them was largely focused on prevention of food poisoning thus leaving some of their questions unanswered (Smedley *et al.*, 2013).

In a Belgian survey comparing pregnant and non-pregnant women of similar age, education level and parity (n= 278), the groups did not differ in their perception of food safety or the role of food for health but pregnant women more often used dietary supplements, avoided foods for safety reasons (e.g. raw meat or shellfish), avoided alcohol and used food hygiene practices (Verbeke and Bourdeaudhuij, 2007). These results indicate a change in dietary practices in line with guidelines for pregnancy that are focused on food hygiene and risk avoidance.

The effect of the state of pregnancy on dietary intake may depend on women's pre-pregnancy weight. Diet quality was found to decrease over the course of pregnancy in Australian overweight and obese women (Moran *et al.*, 2013).

However findings from pregnant participants of the longitudinal Southampton Women's Survey do not support the idea that being pregnant changes dietary behaviour. Results indicated that dietary patterns changed little from before pregnancy to early and to late pregnancy (Crozier *et al.*, 2009b). This is supported by findings from a US qualitative study on weight and lifestyle orientations. It was found that very few women deviated from their pre-pregnancy trajectory of weight orientation, diet and physical activity, i.e. the level of concern shown during pregnancy usually mirrored that of pre-pregnancy (Devine *et al.*, 2000). This tracking of diet and bodyweight related values and attitudes into pregnancy may explain why some studies have identified diets that remained relatively stable from pre-pregnancy into pregnancy.

Fetal gender may also bear an influence. Women carrying a male fetus were found to consume 10% more energy; this may be due to anabolic testosterone secretion by the male fetus (Tamimi *et al.*, 2003).

Parity was found to influence diet and health during pregnancy. In a Spanish survey (n= 5,087), nulliparae had lower pregnancy and pre-pregnancy weights, reported higher subjective health and consumed more fruit and nuts but less meat and cereals than multiparae (Goni *et al.*, 2014). However nulliparae were younger and more educated and more commonly smoked, drank alcohol or were sedentary. Dietary differences between the two groups may thus stem from differences in socio-economic profile or

health behaviour. In another Spanish study, the INMA cohort, multiparae showed higher diet quality than women in their first pregnancy (Chatzi *et al.*, 2012). Conversely a junk food dietary pattern was more common in multiparae in a New Zealand study (n= 1,714) (Thompson *et al.*, 2010).

Beyond physical symptoms, pregnancy may also act via psychological factors. For example, women appear to be more receptive to behaviour and dietary change during pregnancy. Results from a London-based intervention study show that pregnant women evaluate barriers to healthy eating lower than the general population, which may be due to the proximity of potential health threats (Gardner *et al.*, 2012). This indicates that pregnancy could have a generally health promoting influence.

On the other hand, pregnancy has been described as a potentially stressful period in life where high levels of fatigue, stress and anxiety were associated with higher macronutrient and low micronutrient intake (Hurley *et al.*, 2005). Participants of the Southampton Women's Survey showed marked reduction in smoking, alcohol and caffeine consumption in pregnancy but little increase in fruit and vegetable consumption (Crozier *et al.*, 2009a), this indicates that behaviour change in pregnancy does occur but perhaps nutritional changes are of low priority.

Emotional factors may also be relevant determinants. For example, feelings about motherhood have been shown to influence health behaviour in pregnancy (Kendall *et al.*, 2001).

In the past decade half of all pregnancies in the US were unintended, i.e. were either mistimed (earlier than intended) or unwanted (no child or no further child was desired). Pregnancy intendedness is of public health relevance because unintended pregnancies are associated with poorer maternal and child health (Garbers and Chiasson, 2013).

Unplanned pregnancies were found to more commonly occur in obese women who had higher rates of contraceptive failure and lower rate of contraceptive use (McKeating *et al.*, 2015). Results from the New York PRAMS study (n= 4,161) showed that 7 % of live births were unwanted and the proportion increased with BMI group. After adjusting for socio-demographic confounders, stress and health behaviours in pregnancy, the association remained significant only in women with BMI of 40 kg/m² or

more (Garbers and Chiasson, 2013).

To recapitulate, diet has been described as strongly socially patterned and the use of theoretical foundation has been advocated. Pregnancy has been framed as a socially unique state in which women's roles in society and also their body image may change. It is also a time in life that shows physiological, psychological and emotional changes that may influence diet. Pregnancy will thus be included as determinant of diet in the framework.

3.7.4. Socio-demographic

The way in which food is produced, allocated and consumed closely mirrors underlying social structures (Beardsworth and Keil, 1997). Sociological perspectives can thus help understand the social and cultural contexts shaping population eating patterns (Delormier *et al.*, 2009).

On a more individual level, the process of socialisation shapes diet habits over the life course; for example parents and their parenting style, partners and spouses, children, occupation, nutrition knowledge and time restraints have been shown to form dietary habits (Klotter, 2007). It is thus not surprising that socio-demographic factors are important drivers of dietary intake.

Socio-demographic factors include age, gender, ethnicity, social class, occupation, education, living area, marital status, household composition and housing tenure (Gibney, 2004; Macintyre and Anderson, 1997). Age, gender and social class are particularly influential on dietary intake (Macintyre and Anderson, 1997). Socio-demographic factors are important in nutritional epidemiology; they allow capturing the 'human' dimension (Figure 2) (Oltersdorf, 1995).

Social class is mainly assessed based on income, education and occupation, though housing type and location have also been used in the past (McIntosh, 1996). The association between socio-economic status (SES) and health remains regardless of which definition of SES is used (Müller and Langnäse, 2005).

Under sociological theory, what people eat is influenced both by social

stratification systems such as age, gender and social class and ideologies and meanings constructed by people, for example concepts of what constitutes a healthy food (Delormier *et al.*, 2009). Under Weberian approaches, food can be regarded as a sign of status and group belonging, which is supported by the observation that different food behaviour is exhibited by different social classes and that the type of food one consumes can be used to show (social) group membership (McIntosh, 1996). Bourdieu proposed that those in society with the highest capital (social, economic, cultural) determine what constitutes good taste (food, art, music) and use taste as a means of manifesting their social status (Bourdieu, 1984). Food is thus used as an expression of social distinction, i.e. showing membership of a particular group or social class (Klotter, 2007).

In industrial nations a social gradient in nutritional status can be observed (Müller and Langnäse, 2005). Commonly those in the higher classes consume diets of sufficient quality and quantity to support good health, whereas those in the lower classes do not (McIntosh, 1996; Klotter, 2007).

Darmon and Drewnoswki (2008) identified a social gradient in diet quality based on a review of a large body of epidemiological data and mathematical modelling (Darmon and Drewnowski, 2008). Diets high in whole grains, lean meats, fish and fruit and vegetables (i.e. low energy density foods) have been associated with better health outcomes whereas the opposite was seen for diets high in refined cereals, added sugars and fats (i.e. high energy density and low nutrient density foods). Most of the studies were of observational design, making it difficult to prove a causal link. However the authors found consistent (across populations and using different measures of SES and diet quality) and strong (graded effect that appears to be growing stronger over time) evidence to support a causal link. They thus concluded that SES variables have a causal influence on diet quality and also identified plausible biological, economic and environmental mechanisms. Cheaper foods tend to have greater energy but lower nutrient density; they also tend to have longer shelf lives, offer greater satiety and palatability making them safer options for those on low incomes. In turn, cost of diet increases with diet quality, therefore achieving adequate diet quality can most likely not be achieved on very low incomes

(Darmon and Drewnowski, 2008).

A recent systematic review and meta-analysis of 27 studies comparing prices of different dietary patterns had similar findings to Darmon and Drewnowskis review of diet quality. Rao *et al.* (2013) found that healthier options of various food groups and healthier dietary patterns cost more, on average an additional $ 1.50 per person per day (Rao *et al.*, 2013).

A social gradient in diet can thus, at least in part, be explained by higher cost of healthier foods, dietary patterns or quality. Cost is a significant barrier for people on low-incomes (Rao *et al.*, 2013).

The relationship between income and food expenditure can be explained by Engel's Law. Engel was a German statistician who observed that relative income expenditure on food is largest in poor households. The proportion of income spent on food decreases as income increases (Oltersdorf, 1995; McIntosh, 1996). According to McIntosh (1996), there are few exceptions to Engel's Law (McIntosh, 1996). It therefore follows, that in time of economic constraint food purchases may be one of the first expenditures that people cut down on, possibly resulting in inadequate nutrition. This is supported by recent investigations into household food expenditure in Britain after the economic recession. Household expenditure on food dropped by 8.5 % from 2005-2007 compared to 2010-2012, yet the drop in calories was only 3.6 % indicating that in times of economic restraints households attempt to maintain energy supply by opting for energy denser foods (Griffith *et al.*, November/2013).

Additional to economic theory, poverty and nutrition are also linked in sociological theory. According to Brunner (2000), food is often regarded as a symbol of love and caring and plays an important role in social ties. It has been observed that mothers in poor families tend to supress their own needs in order to provide food that is adequate in quality and quantity to their husband and children (Brunner, 2000). When resources are scarce, people are often faced with a significant conflict: on the one hand it would be relatively easy to scrimp and save on food. On the other hand the integrity of the household and family harmony depends on being able to eat those foods that are deemed acceptable, valuable and desired. This usually results in a trade-off whereby cheaper foods and brands are purchased and

parts of meals are tweaked, rather than change the diet completely to something which is unknown (Brunner, 2000). Bourdieu (1984) observed that the influence of income on food described in Engel's law goes back to the *"opposition between the tastes of luxury (or freedom) and the taste of necessity"* (Bourdieu, 1984, p. 177), these taste preferences are learned in childhood and tend to shape taste in later years (Bourdieu, 1984).

The effects of socio-demographic influences appear to persist in pregnancy. Strong social patterning of dietary pattern adherence has been observed in the ALSPAC cohort (Northstone *et al.*, 2007). A social gradient in fruit and vegetable intake (Murrin *et al.*, 2007) and macronutrient consumption (Larranaga *et al.*, 2013) has been reported in pregnancy. However a regional rather than a social gradient was observed in a comparison of pregnant women in London and Edinburgh in the late 1980's: Londoners had consistently higher intakes of macronutrients and fibre across all social classes (Schofield *et al.*, 1987). The authors concluded that a health conscious middle class or a general trend towards low-energy diets may have obscured the distinct social-class gradient that had been observed in previous studies (Schofield *et al.*, 1987).

In an Australian study of women in their first pregnancy, socio-demographic determinants of food intakes were identified that remained after confounder adjustment (Wen *et al.*, 2010). Positive associations were seen between household income and vegetable, and education and fruit consumption. Older and married or cohabiting women were less likely to consumer fast-food regularly. Lower education and being foreign born were risk factors for high soft drink consumption (Wen *et al.*, 2010).

Women who were older, of higher SES and married or in a *de facto* relationship more likely followed a traditional dietary pattern in a New Zealand cohort (Thompson *et al.*, 2010). Older pregnant women more likely adhered to a Mediterranean dietary pattern in the Rhea and INMA-Mediterranean, but not INMA-Atlantic, cohort (Chatzi *et al.*, 2012). Contrariwise, women who are younger and have low education were shown to have lower intake of antioxidants (Uusitalo *et al.*, 2008) and nutrients (Watson and McDonald, 2009) during pregnancy.

Education and income are closely related. In a Chinese cohort (n= 3,036), a

vegetable rich pattern was associated with better health outcomes. This pattern was more likely consumed by women who were more educated and had higher incomes (He *et al.*, 2015). Education was also a significant predictor of nutrient intake and BMI in pregnant Austrian women (Freisling *et al.*, 2006). Conversely in four Spanish INMA cohort sites, occupation was found to be a more powerful predictor of dietary intake than education (Larranaga *et al.*, 2013). The magnitude of the influence of education, occupation and income on diet in pregnancy may thus differ between countries and settings.

Welfare dependency (Watson and McDonald, 2009) and food insecurity and financial hardship (Brunst *et al.*, 2014) have been associated with poorer nutrient status in pregnancy. Similarly, women reporting difficulty paying for foods exhibited lower intakes of protein, fibre, fruit, vegetables and fish than women without such difficulties (Rogers *et al.*, 1998). It is unclear whether lack of knowledge can partially explain the observed association between income and dietary adequacy. While some US studies have found that low-income women are aware of the role of nutrition in pregnancy and have accurate perceptions of which foods are healthy and unhealthy (Lewallen, 2004) others found misconceptions and mistaken beliefs (Reyes *et al.*, 2013) .

In a Scottish prospective cohort of pregnant women (n= 1,461) deprivation was a significant determinant of the type of diet consumed (Haggarty *et al.*, 2009). The more deprived women reported diets that were lower in protein, fibre and many nutrients compared to the least deprived participants. Deprived women also reported poorer food choices; their diets were high in salt, sugar, fried foods and processed meats. Additionally the most deprived women were most likely to be younger, without a partner and smoke in pregnancy. They also had the poorest birth outcomes indicating a clustering of risk factors (Haggarty *et al.*, 2009).

Likewise, diets supplying inadequate amounts of micronutrients were associated with being Hispanic or African American, and levels of food insecurity and education in a sample of US women (Brunst *et al.*, 2014). Household food insecurity was associated with higher rates of prenatal depression (Hromi-Fiedler *et al.*, 2011), poorer mental health (Power *et al.*, 2016) and higher levels of stress and anxiety (Laraia *et al.*, 2015),

indicating that health effects of financial constraints may reach beyond diet in pregnancy.

Age is another determinant of diet in pregnancy. A positive association between age and diet quality scores was observed in a Spanish cohort of pregnant women (Rodriguez-Bernal *et al.*, 2010). The opposite was seen in an Irish cohort where age was inversely associated with fruit and vegetable intake in pregnancy (Murrin *et al.*, 2007). In other studies higher maternal age predicted healthier dietary patterns (Northstone *et al.*, 2007) and diets with higher nutrient density (Mathews *et al.*, 2000).

Age differences in dietary intake do not seem to be a new phenomenon. A study published almost 30 years ago compared diet of pregnant adolescents and older pregnant women. The younger women ate more energy dense diets and more snack foods whereas older pregnant women chose mostly nutrient dense foods. All women had low income and received help from the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC); dietary differences can thus not be easily attributed to socio-economic differences (Endres *et al.*, 1987).

In a Japanese study where concern about weight gain in pregnancy and weight retention thereafter was prevalent, dieting in pregnancy was highest in women under 25 years (Takimoto *et al.*, 2011). It is thus plausible that differences in weight concern lead to different dietary behaviour in younger and older women.

Age dependent food preferences are an alternative explanation. In a Brazilian prospective investigation of diet in pregnancy, older women were more likely to consume a traditional Brazilian dietary pattern, however no significant differences in the consumption of a healthy or processed pattern were seen (Eshriqui *et al.*, 2016). In a Finnish cohort older women more were more likely to consume fish, meat, butter, fruit and vegetables while younger women more likely consumed milk, juice and margarine (Uusitalo *et al.*, 2008). This indicates that older women may eat a greater range of foods; greater diversity could lead to more adequate dietary intake.

Another potential explanation is that older women are more likely to have planned their pregnancy and/or have experienced delays in conceptioon raising motivation to follow dietary advice (Mathews *et al.*, 2000).

To summarise, theoretical knowledge indicates that diet behaviour is influenced by social constructs of what foods are desirable to eat and that food can be used as an expression of social group membership. Much like a social gradient in health, there appears to be a social gradient in diet and cost can be a significant barrier to achieving a healthy diet. Evidence from studies suggests that these observations hold true in pregnancy supporting the inclusion of socio-demographic determinants in the framework.

3.7.5. Environmental

Environmental determinants have been defined as distal and upstream determinants of diet (Hawkes *et al.*, 2006). The influence of the environment on diet is complex as the environment includes many facets beyond the mere physical living surroundings (Raine, 2005).

The study of environmental determinants of diet is a relatively new field in which much still needs to be researched (Ball and Thornton, 2013). Advancing the understanding of the influence of people's living contexts, including policy, environmental and socio-cultural, on eating behaviour is crucial for developing more effective public health interventions (Delormier *et al.*, 2009).

There are different ways of categorising environmental determinants; this dissertation will follow the groupings set out in the environmental research framework for weight gain prevention (EnRG) model (Sleddens *et al.*, 2015), with minor modifications. According to the EnRG model, dietary behaviour is influenced by environmental factors in four domains:

- physical
- social-cultural
- economic/financial and
- political.

In the conceptual framework, the categories of economic/financial and political factors were merged. An additional category, the medical environment, was added because it was hypothesised that pregnant women would have more frequent contact with health care and medical practitioners as part of their antenatal care. These contacts may influence

diet firstly because women may receive nutritional information from practitioners and secondly when a condition such as anaemia or gestational diabetes is diagnosed women may change their dietary intake upon medical advice.

The four sub-categories of environmental determinants used in the conceptual framework will now be discussed.

The physical, or built, environment has been defined as consisting of three elements; the physical design, land use (e.g. residential, commercial or industrial) and transportation systems (Lake and Townshend, 2006). There are different theories how the physical environment can determine dietary intake.

Firstly, the physical environment can influence access to and availability of foods and food outlets (Brug, 2008; Raine, 2005). Socio-economic aspects also appear to play a role. For example, less favourable dietary patterns and higher obesity rates have been observed in low-income and deprived areas, these findings have been replicated in different countries (Cummins and Macintyre, 2006). Choice of supermarkets and grocery stores was found to be better in affluent areas while some low-income areas offer poorer choice or are even so called food deserts (Darmon and Drewnowski, 2008).

The type of food outlets also appears to be crucial determinant of diet. Large supermarkets tend to offer a greater variety of foods at cheaper prices and have consequently been associated with more adequate diets while people who only have access to smaller grocery stores are likely offered a smaller selection of foods at higher prices (Cummins and Macintyre, 2006).

Studies from the US, UK, Australia and Canada indicate that fast food outlets are more prevalent in poorer areas; in turn frequent fast food consumption has been associated with being heavier, even after controlling for socio-economic confounders (Cummins and Macintyre, 2006).

Likewise, a systematic review of 24 studies identified socio-economic, racial and ethnic disparities in neighbourhood food environments. Deprived neighbourhoods and those with large ethnic populations were more likely to

predominantly offer food outlets that promote unhealthy choices (Hilmers *et al.*, 2012).

A Danish cross-sectional study (n= 49,806) of convenience stores, i.e. small stores that generally have a smaller selection of food than supermarkets and offer predominantly convenience and energy-dense foods, found that access to convenience stores determined residents' diet quality. After adjustment for confounders, living within 500m of convenience stores was associated with a higher chance of a very unhealthy diet in non-metropolitan areas; no significant association was found in metropolitan areas (Lind *et al.*, 2016).

Dutch adults of low and high SES reported proximity of fast food outlets and convenience food as barriers to consuming healthy foods (Kamphuis *et al.*, 2007). Schneider and Gruber (2013) conducted an ecological study of fast food outlets in 18 social areas across four districts of Cologne. Results showed that the number of fast food outlet was higher in the more deprived areas (1.19 vs. 0.27 per 1,000 inhabitants) and the average distance to the next fast food outlet was closest in the most disadvantaged areas (177 m) compared to the most affluent areas (511 m) (Schneider and Gruber, 2013). These findings indicate that the type of outlet and proximity are influential on diet; having convenience and fast food outlets nearby is both associated with poorer diets but also neighbourhood disadvantage indicating a clustering of risk factors.

Besides one's neighbourhood, evidence also points to the importance of work place and school food environments (Lake and Townshend, 2006). The home can also be conceptualised as a determinant of diet since it is a place of access to food (Ball and Thornton, 2013).

There are fewer studies involving pregnant women. Some of these have shown that proximity to food outlets may influence dietary quality (Laraia *et al.*, 2004) while others have failed to find a significant association (Nash *et al.*, 2013). Studies investigating the environment more generally (rather than the food environment specifically) have identified differences in diets of pregnant women who lived in rural compared to urban areas (Watts *et al.*, 2007; Tsigga *et al.*, 2011) and different regions of one country (Murrin *et al.*, 2007; Chatzi *et al.*, 2012).

The next category is the socio-cultural environment. What foods are safe, acceptable and desirable to eat is socially and culturally constructed (Caplan, 1996; Klotter, 2007; Bourdieu, 1984). Similarly, the understanding of healthy eating depends on cultural meanings attached to foods and health (Raine, 2005) and cultural acceptability can thus be a barrier to the promotion of healthy foods (Rao *et al.*, 2013).

Cultures and traditions can assert an influence on dietary intake spanning centuries. Klotter (2007) argues that today's diet can be traced back to two major influences. Firstly, a predominantly vegetarian diet with wine, oil and grains as staple foods originating from the ancient Greek and Roman cultures residing in a landscape that was penurious and where meat production was difficult (Mediterranean diet). Secondly, the so called barbaric diet practiced by the Celts and Germanic people who were hunter gatherers and developed a diet based on meat, especially pork, that was under the moral imperative of eating to excess as a sign of strength (Klotter, 2007). Additionally, one's cultural background may become embodied in genetic makeup, for example people descending from pastoralist societies were found to retain the ability to digest lactose beyond childhood, probably because generations of their ancestors were life-long dairy consumers (Freimer *et al.*, 1983). Cultural variation has been seen in aspects of diet such as meal frequency, consumption of meals away from home and types of holiday/celebratory foods (Freimer *et al.*, 1983).

McIntosh (1996) outlined three sociological approaches for explaining the influence of culture on diet and food intake. Firstly, capitalist economies can be regarded as creating a culture of consumerism and maximum consumption of food and other commodities. The second approach sees culture as a resource for dominating other classes and maintaining social order by preserving social status. Finally, culture may influence technology and innovations, agriculture and food production, cooking habits and food choice which in turn influence nutrition and diet (McIntosh, 1996).

Food patterns are acquired and then passed on to future generations via the process of socialisation (McIntosh, 1996). Socialisation occurs primarily within the family unit (Brunner, 2000). The interpersonal environment, i.e. one's family and peers, has been named as a determinant of healthy eating (Raine, 2005).

Further cultural influences on dietary intakes are ethnicity (McIntosh, 1996) and religion (Shatenstein and Ghadirian, 1998). Country of origin, migrant status, acculturation and maintenance of cultural traditions were found to determine diet quality (Darmon and Drewnowski, 2008). Food beliefs and preferences are means to maintain ethnic identity, and adherence to these cultural beliefs may become particularly important in special life stages such as pregnancy and postpartum (Freimer *et al.*, 1983).

Migration can result in cultural and behavioural changes when adapting to a new environment; this process is called acculturation (Sturkenboom *et al.*, 2016). Acculturation can lead to changes in dietary intake (Freimer *et al.*, 1983). A systematic review of 34 studies on the influence of acculturation on Latinos' diet in the US found consistent evidence that dietary fat did not change. However with increasing level of acculturation Latinos consumed less fruit, rice and beans, but more sugar and sugar-sweetened beverages, indicating that diet becomes less healthy in the process of acculturation (Ayala *et al.*, 2008). A similar deterioration of healthy dietary habits has been observed in Europe (Gilbert and Khokhar, 2008). However a Dutch, ethnically diverse cohort study (n= 3,097), found that dietary pattern scores differed significantly between ethnicities but with few exceptions no differences were seen by level of acculturation (age at migration, length of residence, generation status) (Sturkenboom *et al.*, 2016).

Socio-cultural environmental influences have been studied in pregnancy. Ethnic differences have been observed in nutrient (Cohen *et al.*, 2001; Suitor *et al.*, 1990; Brunst *et al.*, 2014) and dietary pattern (Colón-Ramos *et al.*, 2015) consumption. Ethnic differences may not be pronounced in low-income women (Kominiarek, 2014). This might be an indication that income is a stronger influence or that there is very little leeway for adapting diet to cultural preferences when financial means are very limited.

Pregnant Bangladeshi women in Britain were found to have specific food beliefs and practices (Yeasmin and Regmi, 2013). A study of pregnant Mexican immigrant women found that diet did not vary by length of residence in the US but that participants commonly did not achieve recommended fruit and vegetable intake while exceeding recommended intake for saturated fat and cholesterol (Kieffer *et al.*, 2013).

Religion appears to influence diet in pregnancy, e.g. subethnic variations in diet were observed in Asian pregnant women in Britain that were Sikh, Hindu or Moslem (Wharton *et al.*, 1984). Religion may assert an influence through practices, such as Ramadan fasting (Kiziltan *et al.*, 2005) and that dietary rules and beliefs such as traditional Mennonite childbearing beliefs (Kulig *et al.*, 2008).

The third category is the medical environment. As described in Section 3.6.3., sociological theory frames pregnancy as a time where women experience greater social and medical pressure and a changing of social roles. Antenatal care and the resulting medicalisation of oneself, having to undergo many tests and exams such as ultrasounds and urine samples, have been described as inducing distress and anxiety, particularly in women experiencing their first pregnancy (Graham and Oakley, 2005). Women have also reported the medicalisation of pregnancy as a source of pressure and feelings of insecurity (Hirschauer, 2014).

A prospective study of women attending antenatal care in Germany (n= 360) found that two thirds received suspicious or abnormal findings (e.g. malformation, growth retardation) at one point in pregnancy. These findings led to acute worry in 53.2 % of women, yet in over 80 % findings were not substantiated in later tests (Petersen and Jahn, 2008).

Antenatal care is also an important source of health information. For many women it is the first point of receiving oral or written information on diet from a qualified source (Anderson, 2001). Women report that they wish to receive advice on diet and physical activity in pregnancy (Brown and Avery, 2012) and name doctors as their preferred source of information (Smedley *et al.*, 2013). Their needs appear to not always be met as women report that information given on diet was not sufficient (Brown and Avery, 2012), was only given once they exhibited health risks (Smedley *et al.*, 2013) or was overwhelming and difficult to understand (Ferrari *et al.*, 2013).

Women appear to differ in their response to health provider information; while some found advise very motivating (Whitaker *et al.*, 2016a) and report following dietary advice, even if they did not understand it (Ferrari *et al.*, 2013), others described listening to health care advice but ultimately

consuming what was most convenient and appetizing (Groth and Morrison-Beedy, 2013). Health care providers report lack of time, cultural barriers and knowing that a woman has limited financial means for dietary changes as barriers to nutrition counselling (Whitaker *et al.*, 2016a).

Dietary guidelines were also reported as problematic. Providers reported that they lacked knowledge and training on current guidelines (Whitaker *et al.*, 2016a) whereas some women reported frustration and when they received guidance that has changed from previous pregnancies (Ferrari *et al.*, 2013).

Studies found poorer diets in women obtaining public medical care (Murrin *et al.*, 2007; Völgyi *et al.*, 2013). On the one hand side free medical care could simply be a proxy for SES (which has been shown to influence diet), on the other hand it is possible that women receive different care and information in public compared to private health care. In the US, women taking part in the WIC supplementary programme were found to have higher intake of some nutrients than non-participants (Suitor *et al.*, 1990)

The sociological conceptualisation of pregnancy as a medicalised time, along with evidence of greater use of medical care in this period, points to the medical environment as a possible determinant that may be unique to pregnancy.

The final sub-category of environmental determinants consists of the political and economic environment. The observation that food is unequally distributed across the globe, with some starving while others eat more than they need or is good for them, supports a role of wider economic structures in determining diet (Caplan, 1996).

Firstly, as described in Section 3.6.4., cost and financial means are key drivers of diet. It has been shown, that an economic recession by means of decreasing income and financial resources may assert an influence on food expenditure and thus diet. Likewise, deprivation and food insecurity were identified as drivers of dietary intake in pregnancy. Looking beyond the individual or household to the population level, a large body of evidence suggests that economic incentives, e.g. in the form of subsidies on healthy

foods, can be effective means of modifying peoples diets (Ball and Thornton, 2013). For example, vouchers were more effective in changing fruit intake of low-income pregnant women than midwife dietary advice (Burr *et al.*, 2007).

Caplan (1996) observed that studies generally support that poor people do not lack nutrition knowledge but that they use food as a means of showing belonging to society. The wish to be like everyone else can result in spending money on discretionary and holiday foods rather than 'healthy' foods (Caplan, 1996). This indicates that a fairer distribution of resources in society, rather than nutrition knowledge, is an important driver of diet.

Globalisation has shaped what and how we eat. It has been found to contribute to food insecurity through rising food cost, and has reportedly increased risk consciousness and awareness of food quality and quantity of consumers (Ward *et al.*, 2010). Food is now produced (e.g. high in sugar and fat) and consumed (e.g. constant snacking) in ways that are incompatible with human health (Caplan, 1996).

Urbanisation and technical and economic changes have led to a global nutrition transition (Popkin and Gordon-Larsen, 2004). Technical advances have changed the way people work, travel and spend their free time (Popkin *et al.*, 2012). Dating back to the 1960's and 1970's vegetable fats and oils could be produced and sold cheaper making them accessible even for poorer nations and diminishing the classic association between dietary fat content and income (Drewnowski and Popkin, 1997). This means that people are becoming increasingly sedentary and consuming a so called Western diet high in saturated fats, refined carbohydrates and animal source food leading to increasing rates of obesity and chronic diseases (Popkin and Gordon-Larsen, 2004).

Political and economic climate such as conflict, economic recession or high unemployment, may cause people to migrate to another country. People migrating from a low to a high-income country may undergo a rapid dietary transition. Health problems arise when dietary habits from the country of origin are maladaptive, i.e. not suitable for meeting the demands of the new environment (Freimer *et al.*, 1983).

Capitalism has created a culture of consumerism. Consumer culture has been described as a cause of both overeating (McIntosh, 1996) and of distorted body image particularly in women in Western societies (Caplan, 1996).

The political and economic environment is not only likely to influence what people eat, but how knowledge about nutrition is generated and what advice is given by nutritionists and dieticians. Research and education are sometimes placed within food science or animal science departments, which are often highly dependent on funds from the food and agricultural industries (McIntosh, 1996). As McIntosh (1996) states: *"differences in political, economic, and ideological power lead not only to differential access to food but also to differential ability to control the definition of what is 'good to eat'."* (McIntosh, 1996, p. 19).

To recapitulate, the physical environment influences diet by means of access to and availability of food and food outlets. What and how people eat is learned by the process of socialisation and influenced by the wider socio-cultural environment which includes one's ethnicity, religion and personal networks. Pregnancy has been described as a 'medicalised' time in life with frequent contacts with health care provider. Evidence points to antenatal care as being both a source of trusted dietary information and of worry, anxiety and unmet information needs. Finally, the wider political and economic environment influences food production, cost and distribution as well as the generation of nutritional knowledge. Together these findings warrant the inclusion of environmental determinants in the framework.

3.7.6. Individual response

The initial scoping (Doyle and Spallek, 2016) had identified lifestyle determinants, in the further discourse the term individual response will be used instead as proposed by Evans and Stoddart (1990 and 2003) (Evans and Stoddart, 1990; Evans and Stoddart, 2003).

As described in Section 3.6.2., individual responses have been framed as important proximal determinants of health behaviour in both the PHCHC framework (Evans and Stoddart, 1990; Evans and Stoddart, 2003) and perinatal health framework (Misra, 2006).

Others have made similar conceptualisations of the determinants of diet. Hawkes *et al.* (2006) have described dietary behaviour as influenced by the wider environment which interacts with socio-economic and cultural contexts to finally influence individual behaviour and psychology as the most immediate determinants of diet (Hawkes *et al.*, 2006). Hawkes *et al.'s* conceptualisation of individual behaviour and psychology is similar to Evans' and Stoddart's concept of individual response.

The review of individual responses is relevant for the study of dietary intake in pregnancy. Firstly, stress and emotions are known determinants of diet that also exhibit great differences between individuals.

Experimental studies identified individual differences in how people respond to stress and how much of an impact it has on their dietary behaviour. For example, pre-menopausal women undergoing a stress test differed in their emotional and cortisol reactivity to stress. Women with heightened mood (e.g. anger, depression, tension) and cortisol reactivity consumed more calories than women with low reactivity (Epel *et al.*, 2001). Emotional eaters consumed energy dense foods high in fat and sugar after a stress test (Oliver *et al.*, 2000).

Stress also appears to assert a dose-response. Pre-menopausal women were randomly assigned to a low or high-level stress test and offered low and high-fat options of sweet and salty snacks. Women put under high stress consumed more food than those under low stress and showed a preference for sweet and high-fat snacks. Additionally, women who reported consciously restricting their food intake in order to lose weight

(restrained eaters) consumed more fatty snacks than women with low-restraint, irrespective of stress level (Habhab *et al.*, 2009).

These studies indicate that individual responses to stress vary in behaviour (types and amounts of food chosen) and biology (release of stress hormones, physiological reactions like tension), and lead to differential influences on dietary intake.

Individual differences were also observed regarding reaction to food cues, preference for energy content of food and metabolic response to overeating. Schüz *et al.* (2015) identified individual differences in reaction to external (sight, smell, seeing other people eat, advertisement) and internal (mood, rewarding experience) food cues. People with stronger reactivity to food cues tend to snack more, which in turn was associated with higher BMI (Schüz *et al.*, 2015). High fat phenotypes, i.e. people who habitually consume high fat diets, exhibit lower satiety response and a preference for high-fat over low-fat foods, predisposing them to weight gain in an obesogenic environment (Blundell *et al.*, 2005). Individual differences in appetite control were also observed. While some people eat to a constant level of energy, those of high fat phenotype eat to a constant level of food weight, regardless of the fat content, which can lead to passive overconsumption of calories (Cooling and Blundell, 1998).

Bouchard et al. (1990) studied the response to long-term overfeeding in identical twins (Bouchard *et al.*, 1990). Twelve pairs of twins were overfed in a controlled living environment for a period of 100 days. Results showed that body weight increased and body fat distribution changed in all participants, however the amount gained and the local distribution of body fat varied between participants yet showed high resemblance within identical twins, indicating the role of genetic factors (Bouchard *et al.*, 1990).

These findings show that dietary intake, including the preferred flavours or types of food and the amounts eaten, differs between individuals, and that these differences are determined by individual behavioural and biological responses in non-pregnant adults.

Studies have also reported individual responses as determinants of pregnancy diet.

Previous sections have outlined that aspects of pregnancy (e.g. intendedness), one's socio-demographic background (e.g. poverty and food insecurity) and of the medical environment (e.g. antenatal care, medicalisation of pregnancy) can lead to stress and anxiety which in turn impact on women's dietary behaviour. Section 3.6.3. has also outlined that some women amend their health behaviour upon becoming pregnant while others do not. This indicates that the response to being or becoming pregnant differs between individuals.

Women who smoked in pregnancy reported poorer intakes of many nutrients (Haste *et al.*, 1990; Mathews *et al.*, 2000; Trygg *et al.*, 1995), antioxidants (Uusitalo *et al.*, 2008) and fruits (Wen *et al.*, 2011) than their non-smoking counterparts. In the Japanese Osaka Maternal and Child Health study (OMCH), women who smoked in pregnancy more likely followed a wheat products dietary pattern high in rice, bread, sweets and soft drinks (Okubo *et al.*, 2011b). Women adhering to the wheat pattern were also less likely to take supplements indicating a clustering of health risk behaviours. It is possible that smoking is a determinant of dietary intake, for example via changes in taste or appetite, or that smoking is a marker of an underlying determinant such as health consciousness or stress.

Adequate levels of physical activity have been associated with more favourable dietary patterns in pregnancy (Northstone *et al.*, 2007; Cucó *et al.*, 2006). Like smoking, physical activity may have a physiological impact on dietary intake, e.g. via energy requirement, or it may be a marker of an underlying determinant such as health consciousness, body image/interest in weigh management, or how conducive one's environment is to physical activity.

As described in Section 3.6.3., pregnancy can results in changes in body image and eating restraint. A prospective qualitative study interviewing women multiple times across pregnancy and postpartum found that women differed in their behavioural response (dietary practices, physical activity and body weight orientation) to pregnancy (Devine *et al.*, 2000). Women who had been content with their body weight most of their lives were relaxed about weight gain and tended to maintain levels of physical activity and a healthy, varied diet as they had before pregnancy. A similar group

were the so called 'exercisers' who also paid attention to eating and physical activity but tended to exercise more, placed higher importance on being slim, often had a history of eating disorders and were highly educated. The third group were restrained eaters and women who had dieted and struggled with their body weight before pregnancy. They tended to worry about retaining weight after pregnancy. While some relaxed their weight concerns upon the arrival of their child others fought hard to lose the pregnancy weight with exercise and diets. The final group were the 'unhurried'; this group was most relaxed about diet, physical activity and body weight. These women had the lowest education levels, reported eating energy dense sweets and snack foods more often and appeared to be less physically active than the other groups of women (Devine *et al.*, 2000). These findings indicate that education, body image and pre-pregnancy body weight determine individual response to pregnancy and weight gain. Findings also indicate that body image and concern with body weight, exercise and dieting is shaped over the life course and pregnancy can be a critical period for women like the 'exercisers' and 'restrained eaters' described above.

Body weight reflects long-term energy balance, i.e. the energy ingested in relation to energy expanded in everyday life (Prentice and Jebb, 1995; Popkin *et al.*, 2012). Body weight is influenced by genes, and probably much more importantly environment and behaviour, as the rapid increase in obesity was observed despite a relative stable gene pool (Prentice and Jebb, 1995). Bodyweight can thus be conceptualised as a biological (partly genetically determined) and behavioural response (diet and physical activity behaviour).

Pre-pregnancy BMI was inversely associated with intakes of energy, fibre and folate in pregnancy (Derbyshire *et al.*, 2006) and diet quality (Laraia *et al.*, 2007; Rifas-Shiman *et al.*, 2009).

In summary, individual response can be thought of as the 'sum' of all the environmental, socio-demographic and pregnancy-related influences impacting on the individual. Dietary behaviour (change) in pregnancy may thus depend on many factors. For example whether pregnancy is perceived as an important period warranting change, if and what information was received in antenatal care, if that information was comprehensible and

whether one's resources and environment allow for change. Body weight, body image and eating behaviour are shaped over the life course and pregnancy can impact the trajectory. Diet in pregnancy appears to reflect other health risk or protective behaviours displayed before and in pregnancy.

3.8.   Conceptual framework

The conceptual framework is based on the PHCHC framework by Evans and Stoddart (Evans and Stoddart, 1990; Evans and Stoddart, 2003). The authors had envisioned and invited expansion of their framework (Evans and Stoddart, 2003). Misra (2006) showed that the model can be applied to perinatal health under consideration of the life course (Misra, 2006). Furthermore the development of conceptual frameworks that include environmental determinants of diet behaviour has been encouraged (Ball and Thornton, 2013).

Initial scoping outlined a lack of pregnancy-related and environmental factors (Doyle and Spallek, 2016) which should thus be added to establish if and how they are involved.

The framework uses a multiple determinants approach and a life course perspective. As outlined in the first part of this chapter, dietary behaviour and food choice during pregnancy appear to be embedded in a complex web which makes a consideration of multiple determinants and their interplay necessary. Secondly, one of the aims of this dissertation is to outline areas for intervention. Accordingly the approach is used in order to identify more comprehensive and effective starting points for interventions.

The life course approach has been shown to be useful in Misra's perinatal framework, because several influences on maternal health arise long before conception (Misra, 2006). Food preference for example may be shaped by processes of socialisation over the life course (Section 3.6.4.). Pregnancy is also one of several critical periods under life course theory (Chapter 1), thus looking beyond pregnancy may have value for other critical life periods such as infancy as well.

The interactions of different groups of determinants and their interplay over the life course have been named as an important research gaps in the general populations (Lakerveld et al., 2014). This also indicates that there is a need for integrating multiple determinants and life course approaches in the study of determinants of diet in pregnancy.

A graphic display of the conceptual framework (Figure 6) shows that action of socio-demographic and environmental factors is shaped over the life

course leading up to conception. Furthermore individual responses are influenced by socio-demographic and environmental factors across a woman's life course. Pregnancy-related determinants appear after conception and have a unique influence on both diet in pregnancy and individual response.

Pregnancy-related factors were defined as those determinants that relate to pregnancy, or only act during pregnancy, or mediate, or modify the influence of existing determinants during pregnancy. In distance terms pregnancy-related factors were placed closest to diet in pregnancy, since pregnancy is described as a unique period and was thus considered the most immediate influence.

Arrows were included going from pregnancy to the individual response box. This chapter has shown that pregnancy influences health behaviour, e.g. the occurrence of pregnancy related symptoms appears to influence dietary intake and the state of being pregnant may lead to changes in health behaviour including diet. Individual biological responses to pregnancy, such as the potential priming effect of excessive gestational weight gain on later obesity risk (Lawlor and Chaturvedi, 2005) and of gestational diabetes on later risk of T2DM (Salmenhaara *et al.*, 2010) have also been outlined.

Socio-demographic factors were defined as proximal determinants since they may impact diet directly or via effects on individual response or pregnancy, and are thus considerably 'close' to the outcome of interest (diet in pregnancy). In the framework, arrows were drawn from socio-demographic factors to pregnancy as these factors are known to influence health and health outcomes in pregnancy. For example, parity (Bai *et al.*, 2002), maternal age (Nybo Andersen *et al.*, 2000) and a woman's type of occupation (Savitz *et al.*, 1996) are known to influence pregnancy outcomes. As has been described previously, socio-demographic factors also influence individual response, indicated by arrows in the framework going to the individual responses in behaviour and biology box. For example, financial restrained leading to worry about being able to procure enough food was found to cause stress and anxiety in overweight low-income pregnant women. Binge eating and eating calorie dense foods were behaviours they used to remedy the absence of or irregular availability of food (Laraia *et al.*, 2015). Socio-demographic factors were also shown to

influence individual biological responses such as gestational weight gain (Drehmer *et al.*, 2010).

The final category of the framework are environmental factors which are much harder to capture and more distal from diet in pregnancy. Evidence discussed in this chapter has shown that aspects of the environment, such as proximity to and type of food outlets can influence diet in pregnancy directly. The environment can also act indirectly, via its influence on individual responses before and in pregnancy. For example, the wider physical, socio-cultural and political and economic environment were shown to influence what food is acceptable to eat, can be accesses and procured and finally how food is produced and knowledge about what is health or not is generated and provided to consumers.
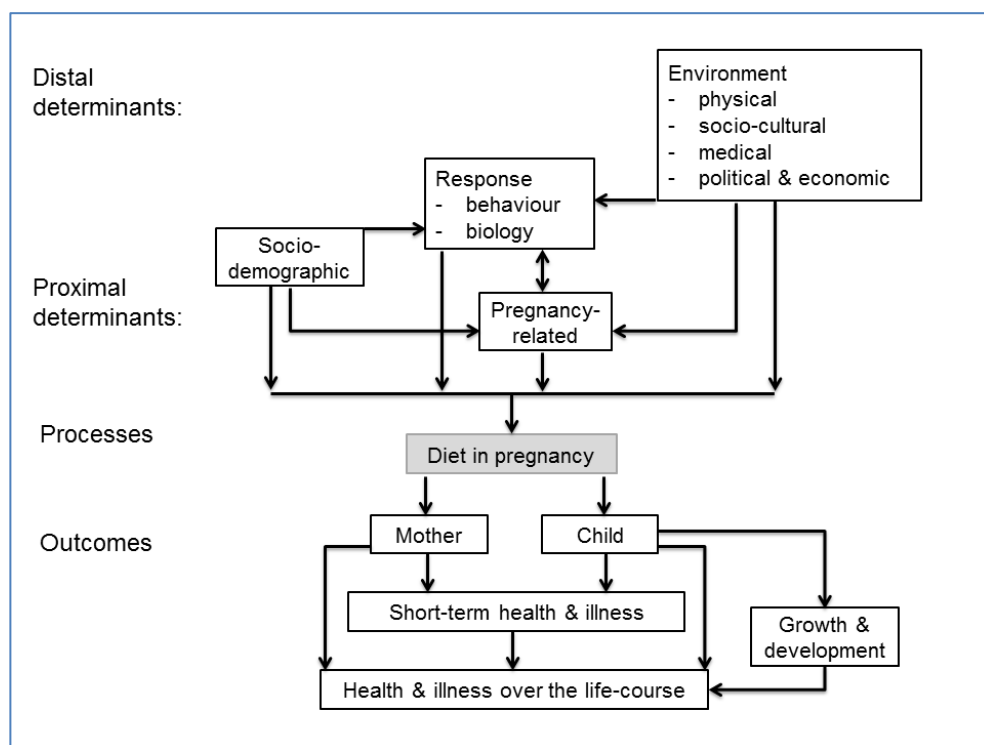
Figure 6: Conceptual multiple-determinants life course framework of diet in pregnancy
Source: author

3.9. Summary of conceptual framework

A conceptual framework can be a meaningful starting point to research by providing structure, e.g. delimiting what is to be studied and what the potential relationships among studied variables are, and by defining the concepts to be studied. When the initial framework becomes more concrete in outlining processes and mechanisms studied it can become an explanatory model.

Diet is a complex behaviour difficult to capture and comprehend. The representation of 'diet as a whole' by dietary patterns or diet quality appears to be a promising new research direction. To understand what influences how women eat in pregnancy a life course perspective and the consideration of multiple determinants are important. But research in this field is lacking especially research using strong theoretical foundation.

The initial review of theoretical and empirical literature identified four important categories of determinants:

- the influence of pregnancy-related factors such as pregnancy discomfort (e.g. nausea and vomiting), pregnancy-related complications and illnesses (e.g. gestational diabetes) or psychological factors have rarely been studied and deserves their own investigation.
- socio-demographic factors are likely the strongest drivers of health and diet in non-pregnant populations and their influence in pregnancy should therefore also be studied.
- environmental determinants of diet are a growing field that appears to fill knowledge gaps where individual factors and behaviours cannot explain the observed dietary behaviours alone, such as in the case of obesity. Studying these drivers may yield additional insights.
- together, pregnancy-related, socio-demographic and environmental influences appear to shape women's individual responses in behaviour and biology. Omission of this category would mean loss of important information

Based on findings from this chapter, a conceptual model was proposed and graphically displayed. The next chapter will outline the result of a systematic literature review which applied the conceptual framework.

4. Systematic review of the literature

In order to test the 'fit' of the conceptual framework and summarise the evidence on determinants of diet in pregnancy, a systematic review was conducted. The full work has been published in Public Health Nutrition (Doyle *et al.*, 2016). This chapter will briefly outline the main findings of our article.

4.1.   Aim

The aim of this chapter was to answer research question 1.a. proposed in Chapter 2 ("which factors determine diet in pregnancy in developed countries?").

4.2.   Methods

The databases PubMed, CINAHL, GreenFILE and the German database MedPilot (now called LIVIVO) were searched in January 2015 and the searches were updated in April 2016. The search combined the terms "determinants", dietary patterns" and "pregnancy", and various synonyms. The search strategy was checked and approved by a librarian and additional hand searches were performed (reference lists of included articles, conference abstracts and key journal table of contents).

Inclusion criteria:

- participants were pregnant or ≤ 8 weeks postpartum at time of diet assessment; not requiring special diets; majority of sample ≥ 18 years
- independent variable: determinants of diet (socio-demographic, environmental, individual response, pregnancy-related)
- dependent variable: dietary pattern, diet quality or guideline adherence
- study design: observational
- languages: English, German
- quality: studies had to report the statistical association between independent and dependent variable(s) graphically or numerically

The likelihood of bias was assessed using adapted Newcastle-Ottawa scales for assessing the quality of non-randomised studies in meta-analyses (Wells *et al.*, 2013).

4.3. Results

A total of 4,368 articles were identified of which 4,238 could be eliminated based on title and abstract alone. The remaining 130 articles were read in full by at least two reviewers. Seventeen publications reporting on twelve different studies were included (Figure 7).
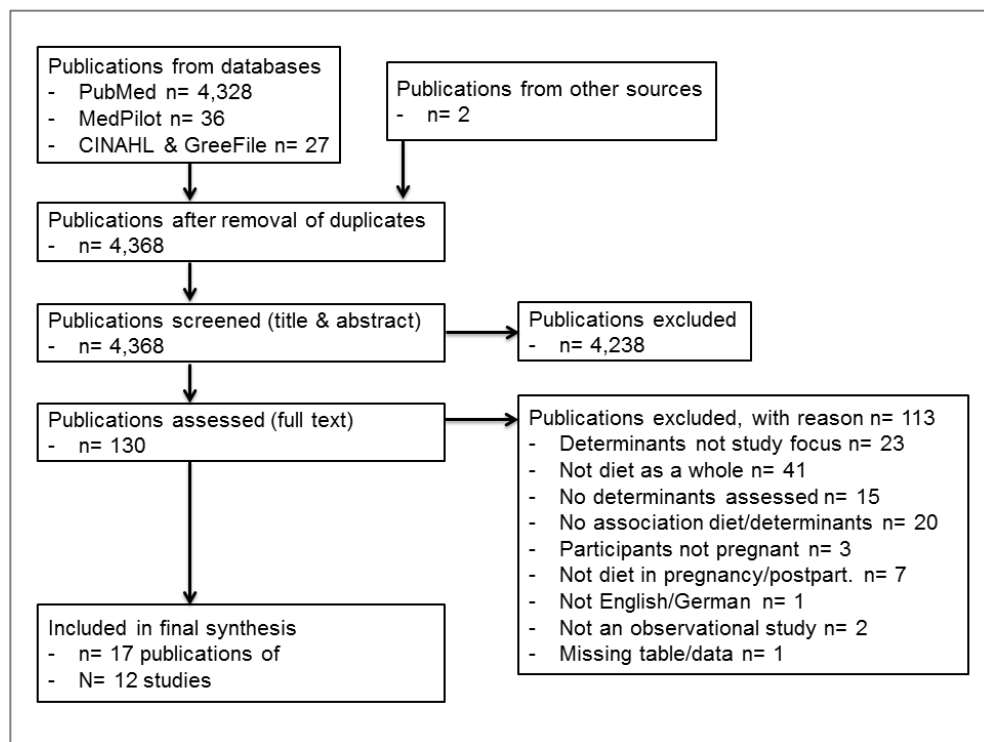
Figure 7: Flow chart
Source: Doyle *et al.* 2016

Most studies were from North America (n= 6) or Europe (n= 5), one was from South America. Eight were cohort studies, though seven of these only reported cross-sectional analyses. Sample sizes ranged from fifty to 12,053. Determinants of diet in pregnancy appears to be a new research topic; most studies (n= 9) were published in the past five years (Table 2).

Table 2: Overview of studies included in the systematic review

ID	Name	Type	Place	Main author (year)	Sample size	Diet assessment	Diet type	NOS (total/ max.)
1	ALSPAC	CH	EU, UK, Avon area	(North stone *et al.*, 2007)	12,053	Self-administered FFQ DPs by PCA with varimax rotation ANOVA and t-tests for univariate associations with DPs Independent associations were determined using the general linear model option Multivariate analyses for adjusted regression coefficients and 95 % confidence intervals	**Health conscious DP:** high loadings for salad, fruit, rice, pasta, oat and bran-based breakfast cereals, fish, pulses, fruit juice and non-white bread **Traditional DP:** high consumption of all types of vegetables, red meat and poultry. **Processed DP:** high intakes of high-fat processed foods, such as meat pies, pizza, burgers, fried foods, chips and baked beans **Confectionary DP:** high intakes of high sugar foods such as chocolate, sweets, biscuits and cakes **Vegetarian DP:** high loadings for meat substitutes, pulses, nuts and herbal teas, high negative loadings for red meat and poultry	6/9
2	CANDLE	CH	NA, USA, Memphis	(Völgyi *et al.*, 2013)	1,155	Interviewer-administered 111-food and beverage items FFQ Interviewers trained and monitored by a registered dietician Exploratory factor analysis with principle component extraction and	**Healthy DP:** high loadings of vegetables, fruits, non-fried fish and chicken, water **Processed DP:** processed meat, fast food items, snacks, sweets and soft drink **US Southern DP:** typical US Southern foods such as eggs, cooked cereals, peaches, corn, fried fish,	4/9

Table 2: continued

ID	Name	Type	Place	Main author (year)	Sample size	Diet assessment	Diet type	NOS (total/ max.)
						varimax rotation	beans, greens, cabbage, sweet potatoes, liver, pig's feet, neck bones oxtails, and tongue, pork, and real fruit juices	
						Median test and Kruskall-Wallis ANOVA used to describe differences in demographics among DPs	Mixed DPs: **Healthy-Processed Healthy-Southern Processed-Southern Mixed**	
3	Not reported	CH	EU, Spain, Reus	(Cucó *et al.*, 2006)*	80	Prospective at different times from preconception to postpartum Exploratory factor analysis (PCA) Associations between lifestyle and socio-demographic variables and DP by fitted multiple linear regressions models	**Sweetened beverages & sugars:** characterised by high intakes of sweetened beverages, sugars, low intakes of fresh fruit, veg, roots and tubers **Vegetables and meat:** high intakes of veg, roots, tubers, red meat, cured cold meats, olive oil, eggs	8/9
4	DIPP	CH	EU, Finland	(Arkkola *et al.*, 2008)	3,730	Retrospective (after birth) by validated FFQ with 181 food items in 52 food groups, designed to reflect Finnish food consumption habits	**Healthy DP:** high loadings of fruit, veg, roots, poultry, rice and pasta, nuts and seeds and low-fat milk **Fast food DP:** high loadings sweets, fast foods, soft drinks, white bread, sausage and processed	5/9

ID	Name	Type	Place	Main author (year)	Sample size	Diet assessment	Diet type	NOS (total/ max.)
						DPs identified by PCA with varimax rotation	meats	
						Multiple linear regression analysis was used to test how age, educational level, smoking during pregnancy, living area and the number of earlier deliveries explained the variance in pattern score	**Traditional bread DP:** high loadings of roots, whole grain breads, high fat cheese and pastry and potatoes	
							Traditional meat DP: high loadings of processed veg, meat, sausage, potatoes and processed meat	
							Low-fat foods DP: high loadings of light soft drinks, wholegrain bread, low-fat milk and margarine	
							Coffee DP: high loadings of coffee, milk in coffee, low-fat pastry and sausages	
							Alcohol & butter DP: high loadings of butter, wine and liquor, beer, negative loadings for fruits, fruit juices and margarine	
5	ECCAGE	CH	SA, Brazil	(Hoffmann et al., 2014)	712	Retrospective (diet during pregnancy)	**Restricted DP:** cookies, whole milk, yogurt, chips, finger foods, soft drinks, ice cream	5/9
						Semi-quantitative, validated, 88-item FFQ	**Varied DP:** grains/cereals/tubers, bread/cakes/cookies, fruits, vegetables, cheese, pizza, mayonnaise, candies	
						DPs identified using cluster analysis	**Common-Brazilian DP:** rice/beans/pasta, French roll, margarine, boneless beef/chicken/eggs,	
						Association between DPs and		

Table 2: continued

ID	Name	Type	Place	Main author (year)	Sample size	Diet assessment	Diet type	NOS (total/ max.)
						sociodemographic variables was analysed using the chi-square test and adjusted standardised residuals	coffee/artificial juices, sugar	
6	PHP	CH	NA, Canada, London	(Fowler et al., 2012)	2,313	Retrospective (past months) By self-administered, semi-quantitative, 106-food item FFQ Compliance with Eating Well with Canada's Food Guide (CFG) recommended serving sizes of food groups. Binomial logistic regression to analyse the association between socio-demographic and lifestyle characteristics with consumption of minimum number of recommended servings of all food groups	**CFG compliance score:** Healthy eating pattern = daily servings of: 8* vegetables & fruits 2* meat & alternatives 7* grain products 3* milk & alternatives	8/9
				(Nash et al., 2013)	2,282	Retrospective (past months) FFQ, 106- food items, validated for use in pregnant women in the cohort Univariate und multivariate linear regressions were performed with the	**Canadian DQI-P score:** Modified version of the DQI-P, adapted for Canadians, based on the 2007 Canada's Food Guide.	7/9

ID	Name	Type	Place	Main author (year)	Sample size	Diet assessment	Diet type	NOS (total/ max.)
						predictor variables on DQ	6 components, intake of:	
						Stepwise procedure was used with automated backwards elimination to create a parsimonious model with variables significant at p< 0.05	Folate, iron, calcium, energy intake from fat	
							Servings of grains and of fruit and veg	
							Total score 70, was converted into %	
						A priori interactions tested between presence of fast-food restaurants and marital status/income		
7	PIN	CH	NA, USA, North Carolina	(Bodnar and Siega-Riz, 2002)	2,063	Retrospective (covering past 3months – entire 2nd trimester)	**DQI-P scores and tertiles:**	6/9
						Self-administered, 120-item modified NCI-Block FFQ	8 components with maximum of 10 points; max. score 80, ≥70 indicates highest DQ; % recommended daily servings for :	
						Student's t-test and ANOVA to compare mean DQI-P scores across socio-demographic characteristics	grains, vegetables, fruits, folate, iron, calcium, kcal from fat, meal pattern score	
							Mean DQI-P score was 55.2 (SD 12.1).	
				(Laraia *et al.*,	918	Retrospective (covering past 3months, usual intake in 2nd	**DQI-P scores and tertiles:**	8/9
							8 components with maximum of 10 points; max.	

ID	Name	Type	Place	Main author (year)	Sample size	Diet assessment	Diet type	NOS (total/ max.)
				2004)		trimester)	score 80, ≥70 indicates highest DQ; % recommended daily servings for :	
						Self-administered, 120-item modified NCI-Block FFQ	grains, vegetables, fruits,	
						ANOVA for mean differences in DQI-P by socio-economic categories	folate, iron, calcium, kcal from fat, meal pattern score	
						Multinomial logistic regression to estimate the effect of food outlets on DQ (crude and adjusted)	Mean DQI-P score was 55.2 (SD 12.1).	
				(Laraia *et al.*, 2007)	2,394	Retrospective (past 3months, entire 2nd TM)	**DQI-P scores and tertiles:**	6/9
						Self-administered, 120-item modified NCI-Block FFQ	8 components with maximum of 10 points; max. score 80, ≥70 indicates highest DQ; % recommended daily servings for :	
						ANOVA with Bonferroni correction for mean differences in DQI-P scores across health behaviour characteristics	grains, vegetables, fruits, folate, iron, calcium, kcal from fat, meal pattern score	
						Multinomial logistic regression to estimate association of pre-gravid BMI with DQ (crude and adjusted)	Mean DQI-P score was 55 (SD 11.6).	

ID	Name	Type	Place	Main author (year)	Sample size	Diet assessment	Diet type	NOS (total/max.)
8	Project Viva	CH	NA, USA	(Rifas-Shiman *et al.*, 2009)	1,777	Two retrospective dietary assessments (in early pregnancy, from last menstrual period until FFQ completion; in 2nd TM referring to previous 3 months) Self-administered, validated, 166-item semi-quantitative FFQ (adapted Willett) Crude and multivariate adjusted linear regression models were used to examine the relationship between maternal characteristics and diet intake	**DQ assessed by AHEI-P score:** Alternate Healthy Eating Index adapted for pregnancy, 9 component, summed up to a maximum score 90: vegetables, fruit, ratio of white to red meat, fibre, trans fats, ratio of polyunsaturated to saturated fat, folate, iron and calcium intake from food In this publication, the "nuts & soy" component was omitted, because women may avoid nuts during pregnancy due to allergy concerns for their offspring Mean AHEI-P score 61 ± (min. 33, max. 89)	7/9
9	Rhea	CH	EU, Greece	(Kritsotakis *et al.*, 2015)	377	Semi-quantitative FFQ, 250-items in 17 groups MD score calculated Spearman's p correlation used to estimate the strength of association between social capital dimensions and MD adherence Linear regression analyses to	**MD DP adherence score:** Maximum 8 points = maximum adherence, based on at least median consumption of beneficial components: vegetables, legumes, fruits and nuts, cereals, fish & seafood, dairy products, and consumption below median of detrimental	5/9

ID	Name	Type	Place	Main author (year)	Sample size	Diet assessment	Diet type	NOS (total/ max.)
						estimate association between social capital and MD score while adjusting for confounders	components: meat, fat: MUFA to SFA ratio.	
10	Not reported	CS	NA, USA, Texas	(Fowles et al., 2011a)	118	Retrospective, three 24 hour dietary recalls Pearson product-moment coefficients for correlations Variables significantly associated with DQ were entered into prediction analysis; a path model was tested	**DQI-P score:** 8 components with maximum of 10 points; max. score 80 ≥70 is highest DQ % recommended daily servings for : grains, vegetables, fruits, folate, iron, calcium, total fat, meal pattern score.	7/10
				(Fowles et al., 2012)	71	Retrospective, three 24 hour dietary recalls Comparative (chi-square test) and correlational analyses	**DQI-P score:** 8 components with maximum of 10 points; max. score 80 ≥70 is highest DQ % recommended daily servings for: grains, vegetables, fruits, folate, iron, calcium, total fat, meal pattern score. Median score was 53.3.	4/10
				(Fowles et	50	Retrospective: three 24 hour dietary recalls conducted over 2 weeks (1st	**DQI-P score:** 8 components with maximum of 10 points; max.	4/10

ID	Name	Type	Place	Main author (year)	Sample size	Diet assessment	Diet type	NOS (total/ max.)
				al., 2011b)		at clinic, 2nd and 3rd via Telephone)	score 80 ≥70 is highest DQ	
						Nutrient and food groups were averaged over the 3 days. Nutrient values were adjusted for energy intake	% recommended daily servings for: grains, vegetables, fruits, folate, iron, calcium, total fat, meal pattern score.	
						Characteristics compared by t-test		
11	Not reported	CS	EU, Greece, Athens	(Tsigga *et al.*, 2011)	100	Retrospective (24 h dietary recalls)	**HEI score:**	5/10
						On three consecutive days: 1st assessment at clinic visit (recruitment), next two days via phone interview by a dietitian.	12 components summing to a maximum score of 100:	
						HEI score calculated from median intake of each participant	Total fruit, whole fruits,	
						Multivariate statistical techniques and logistic regression were used to assess relationship between HEI and characteristics.	total vegetables, dark green and orange vegetables, vegetables and legumes, meat and beans, total grains and whole grains, milk, oils, saturated fat and sodium, kcals from solid fat, alcoholic beverages and added sugars.	
						Simple correspondence analysis (SCA) was conducted in MiniTab between HEI score categories and demographic characteristics	HEI scores above 80 indicate high DQ, scores of 60 to 79.9 indicate average and below 60 low DQ.	
							Mean HEI scores 66.9 (SD 0.6).	

Table 2: continued

ID	Name	Type	Place	Main author (year)	Sample size	Diet assessment	Diet type	NOS (total/ max.)
12	Not reported	CS	NA, USA, North Dakota	(Watts *et al.*, 2007)	5,862	Retrospective FFQ (HSFFQ, adapted from Willett's), validated in that population, 103- items, foods added that were typical for Native Americans in that area DQI-P calculated based on HSFFQ Differences in scores according to socio-demographic characteristics were calculated using t-tests and ANOVA to test for differences	**DQI-P score:** 10 components with maximum of 10 points; max. score 100 % recommended daily servings for grains, vegetables, fruits, folate, iron, calcium, total fat, saturated fat, cholesterol, dietary diversity. Scores >80 indicate a "good" diet, scores of 51 - 80 points indicate a diet that "needs improvement," and scores ≤50 indicate a "poor" diet." Mean DQI-P score 53.9.	5/10

Source: Doyle *et al.* 2016;
CH, cohort study; CS, cross-sectional study; DP, dietary pattern, DQ, diet quality; NA, North America; SA, South America;
*only study assessing diet prospectively

4.3.1. Summary of the available evidence

The most frequently assessed pregnancy-related determinant was parity (Northstone *et al.*, 2007; Völgyi *et al.*, 2013; Arkkola *et al.*, 2008; Fowler *et al.*, 2012; Nash *et al.*, 2013; Bodnar and Siega-Riz, 2002; Laraia *et al.*, 2007; Rifas-Shiman *et al.*, 2009; Kritsotakis *et al.*, 2015; Tsigga *et al.*, 2011), studies also assessed the influence of nausea (Nash *et al.*, 2013) and body image (Northstone *et al.*, 2007).

Socio-demographic determinants were commonly assessed. Most often reported were education (Hoffmann *et al.*, 2014; Rifas-Shiman *et al.*, 2009; Northstone *et al.*, 2007; Völgyi *et al.*, 2013; Cucó *et al.*, 2006; Arkkola *et al.*, 2008; Kritsotakis *et al.*, 2015; Nash *et al.*, 2013; Bodnar and Siega-Riz, 2002; Laraia *et al.*, 2004; Laraia *et al.*, 2007; Fowles *et al.*, 2011a; Fowles *et al.*, 2012; Tsigga *et al.*, 2011; Fowler *et al.*, 2012) and age (Northstone *et al.*, 2007; Völgyi *et al.*, 2013; Cucó *et al.*, 2006; Arkkola *et al.*, 2008; Hoffmann *et al.*, 2014; Bodnar and Siega-Riz, 2002; Laraia *et al.*, 2004; Laraia *et al.*, 2007; Rifas-Shiman *et al.*, 2009; Kritsotakis *et al.*, 2015; Fowles *et al.*, 2011a; Tsigga *et al.*, 2011; Watts *et al.*, 2007).

Other commonly measured socio-demographic determinants were ethnicity/birthplace/nationality (Northstone *et al.*, 2007; Völgyi *et al.*, 2013), (Fowler *et al.*, 2012; Nash *et al.*, 2013; Bodnar and Siega-Riz, 2002; Laraia *et al.*, 2004; Laraia *et al.*, 2007; Rifas-Shiman *et al.*, 2009; Kritsotakis *et al.*, 2015; Fowles *et al.*, 2012; Watts *et al.*, 2007), income/financial difficulty/Medicaid receipt (Northstone *et al.*, 2007; Völgyi *et al.*, 2013; Fowler *et al.*, 2012; Bodnar and Siega-Riz, 2002; Laraia *et al.*, 2004; Laraia *et al.*, 2007; Fowles *et al.*, 2012; Tsigga *et al.*, 2011; Watts *et al.*, 2007) and marital status/partnership/cohabitation (Northstone *et al.*, 2007; Völgyi *et al.*, 2013; Hoffmann *et al.*, 2014; Fowler *et al.*, 2012; Nash *et al.*, 2013; Laraia *et al.*, 2004; Laraia *et al.*, 2007; Kritsotakis *et al.*, 2015; Fowles *et al.*, 2012). Measures of occupation/employment (Northstone *et al.*, 2007; Hoffmann *et al.*, 2014; Fowler *et al.*, 2012) was less commonly evaluated.

Environmental determinants were rarely investigated. Studies assessed the influence of the living environment/place of residence (Arkkola *et al.*, 2008; Kritsotakis *et al.*, 2015; Tsigga *et al.*, 2011; Watts *et al.*, 2007), social environment (support) (Nash *et al.*, 2013; Kritsotakis *et al.*, 2015; Fowles *et al.*, 2011a) and food environment (Nash *et al.*, 2013).

Individual response determinants were the second most frequently investigated category after socio-demographic determinants. Studies reported predominantly on pre-pregnancy body weight/BMI (Northstone *et al.*, 2007; Völgyi *et al.*, 2013; Cucó *et al.*, 2006; Hoffmann *et al.*, 2014; Fowler *et al.*, 2012; Laraia *et al.*, 2007; Rifas-Shiman *et al.*, 2009; Fowles *et al.*, 2012; Fowles *et al.*, 2011b; Tsigga *et al.*, 2011), smoking before (Cucó *et al.*, 2006; Fowles *et al.*, 2012; Watts *et al.*, 2007) and during pregnancy (Northstone *et al.*, 2007; Cucó *et al.*, 2006; Arkkola *et al.*, 2008; Fowler *et al.*, 2012; Laraia *et al.*, 2007; Kritsotakis *et al.*, 2015) and physical activity/exercise before (Kritsotakis *et al.*, 2015) and during pregnancy (Northstone *et al.*, 2007; Cucó *et al.*, 2006; Nash *et al.*, 2013; Laraia *et al.*, 2007, Fowles *et al.*, 2012, 2012, 2012). Less commonly researched were aspects of health behaviour such as supplement use (Fowler *et al.*, 2012; Laraia *et al.*, 2007), alcohol (Fowler *et al.*, 2012) and caffeine (Fowler *et al.*, 2012) consumption in pregnancy.

4.3.2. Pregnancy-related

Parity was associated with dietary pattern score in the ALSPAC and DIPP cohorts (Northstone *et al.*, 2007; Arkkola *et al.*, 2008), and with meeting guidelines (Fowler *et al.*, 2012) and diet quality score (Nash *et al.*, 2013) in the PHP study.

Parity was inversely associated with diet quality In the US cohorts PIN (Bodnar and Siega-Riz, 2002) and Project Viva (Rifas-Shiman *et al.*, 2009) and with Mediterranean diet score in Rhea (Kritsotakis *et al.*, 2015). However another Greek study found that parity did not appear to influence HEI score (Tsigga *et al.*, 2011).

Dieting during pregnancy was inversely associated with the "Confectionary" and positively with the "Traditional" pattern (Northstone *et al.*, 2007).

4.3.3. Socio-demographic determinants

In the ALSPAC cohort, the "Health conscious" pattern was positively associated with education level and age and was more commonly seen in women who were owner-occupier rather than in rented accommodation (Northstone *et al.*, 2007).

As in ALSPAC, in the CANDLE cohort women adhering to the "Healthy" pattern were more likely older, with higher education levels and cohabiting. Additionally, patterns differed depending on ethnicity; the "Processed", "US Southern" and their mixed patterns "Processed-Southern" and "Healthy-Southern" were more commonly consumed by African Americans while Caucasians and women of other ethnicities tended to consume the "Healthy" or "Healthy-Processed" pattern (Völgyi *et al.*, 2013).

In the Spanish cohort assessing dietary patterns across pregnancy (weeks 6, 10, 26 and 38) the "Vegetable and meat" pattern was positively associated with age in weeks 10 and 38 (Cucó *et al.*, 2006).

In the Finnish DIPP study, results from multiple linear regression analysis showed positive associations for age and the "Healthy" and the "Alcohol and butter" patterns but inverse associations for the "Fast food" pattern and the "Traditional meat" pattern. Education was positively associated with the "Healthy", "Low-fat foods" and "Alcohol and butter" patterns (Arkkola *et al.*, 2008).

In the ECCAGE cohort the "Varied" pattern, much like the "Healthy" patterns in studies discussed above, was associated with being older and more educated. It was also associated with living with a partner, being employed and having a higher income (Hoffmann *et al.*, 2014).

Among PHP participants, only 3.5 % of participants met all recommendations and meeting guidelines was not associated with education (Fowler *et al.*, 2012). Using the DQI-P, 56 % were classed as having sufficient diet quality. In the final model, DQI-P score was predicted by being a recent immigrant and being married (Nash *et al.*, 2013).

Three publications from the PIN cohort also found older age, higher education and greater income associated with higher diet quality (Bodnar and Siega-Riz, 2002). Mean DQI-P scores were higher in African-American

women (Bodnar and Siega-Riz, 2002; Laraia *et al.*, 2004).

Another US cohort, Project Viva, assessed diet quality using the Alternate Healthy Eating Index adapted for pregnancy (AHEI-P). In multivariate adjusted models controlling for all maternal characteristics simultaneously, AHEI-P scores were positively associated with age and education. Racial differences in diet quality score largely stemmed from confounding by age and education (Rifas-Shiman *et al.*, 2009).

Mean Mediterranean diet scores were higher in Rhea study participants who were older, more educated, married and Greek nationality (Kritsotakis *et al.*, 2015). In another Greek study, HEI scores did not appear to be influenced by maternal age, education or income (Tsigga *et al.*, 2011).

Age and education were also positively associated with diet quality in low-income, un- and underinsured US women (Fowles *et al.*, 2011a). Another study of low-income US women found no differences in diet quality scores by age or income, but mean scores were lower in Native Americans (unadjusted for confounders) (Watts *et al.*, 2007).

4.3.4. Environmental determinants

Greek women living in urban areas had increased odds of low diet quality (Tsigga *et al.*, 2011). In two North American studies both living within 500 m of fast food restaurants (Nash *et al.*, 2013) and living four miles or more away from supermarkets were associated with lower diet quality (Laraia *et al.*, 2004).

Total social capital and tolerance of diversity scores were positively associated with Mediterranean diet score; social capital via feelings of obligation, reciprocity and self-control may increase motivation to follow a healthy diet (Kritsotakis *et al.*, 2015). Social support from family and friends was positively associated with diet quality (Nash *et al.*, 2013).

4.3.5. Individual response

Women who described themselves "more active" than their peers scored higher on the "Health conscious" pattern (Northstone *et al.*, 2007).

Women who had a normal body weight before pregnancy more likely followed a "Healthy "pattern while overweight and obese more commonly followed the "US-Southern", "Processed" and their mixed patterns (Völgyi *et al.*, 2013). Pre-pregnancy BMI was inversely associated with a "Vegetables and meat" pattern (Cucó *et al.*, 2006) and with diet quality (Laraia *et al.*, 2007; Rifas-Shiman *et al.*, 2009). Conversely, in the ECCAGE study no association was seen between pre-pregnancy BMI and any dietary pattern (Hoffmann *et al.*, 2014). HEI score was negatively associated with BMI in correlational but not regression analysis in a small Greek study (Tsigga *et al.*, 2011).

Smoking in pregnancy was associated with the "Fast foods", "Traditional meat" and "Coffee" patterns (Arkkola *et al.*, 2008). Smoking was positively and physical activity negatively associated with the "Sweetened beverages and sugars" pattern (Cucó *et al.*, 2006). Not smoking and exercising more predicted greater diet quality (Nash *et al.*, 2013) and greater mean Mediterranean diet scores (Kritsotakis *et al.*, 2015). Frequent fast food eaters exhibited lower diet quality (Fowles *et al.*, 2011b).

4.3.6. Additional potentially relevant determinants

Anxiety was linked with the "Confectionary" pattern (Northstone *et al.*, 2007) and inversely associated with diet quality (Nash *et al.*, 2013).

Depression was associated with the "Vegetarian" pattern (Northstone *et al.*, 2007). Diet quality was negatively associated with depression, overall and persistent stress in low-income women with little or no health insurance coverage (Fowles *et al.*, 2011b).

Psychological factors were not represented in the conceptual framework and not included in the search terms; these findings were therefore not derived systematically. Psychological factors could be grouped as individual psychological responses.

4.4.   How studies assessed diet 'as a whole'

This systematic review also enabled observations regarding how diet in pregnancy has been assessed.

The use of diet quality scales, at least during pregnancy, appears to be dominated by North American studies (five of six studies, see Table 2). All tools have been developed in the US (HEI, AHEI, DQI-P) or Canada (CFG compliance). This means that our results on the direction of the association between determinants and diet quality indicators were potentially biased by North American studies; findings should be replicated in different settings. The use of dietary patterns was more evenly spread across countries.

The following observations comprise both the 12 studies included in the narrative synthesis and studies that were identified in the search strategy but did not meet all inclusion criteria and were thus excluded.

Firstly, patterns can differ quite considerably depending on location and culture. Examples of this are the "US southern" pattern identified in the CANDLE study (Völgyi *et al.*, 2013), the "common Brazilian" pattern in the ECCAGE cohort (Hoffmann *et al.*, 2014), the "traditional" and "fusion" pattern found in multi-ethnic New Zealand (Thompson *et al.*, 2010) and the Japanese "rice, fish and vegetable" pattern (Okubo *et al.*, 2011b) which all incorporate regionally or culturally specific foods.

Secondly, dietary patterns do not only vary depending on culture but on geographical region; the Mediterranean pattern for example, which seems to be clearly defined and well researched, appears to differ in its constellation depending on region (Chatzi *et al.*, 2012).

The assessment of dietary patterns can also be challenging as it involves subjective interpretation of which foods contribute mostly to a factor or pattern (Barker *et al.*, 1989). This may be the reason why different patterns are identified arising from the same study's data, as evident in the Generation R study, where two publications identified two and three patterns, respectively (Bouwland-Both *et al.*, 2013; Timmermans *et al.*, 2011). Additionally, not only the derivation of the individual patterns is underlying subjective decisions. The interpretation of which resulting pattern is most or least healthy may also be based on subjective

interpretations. For example, Okubo *et al.* (2011) describe a 'rice, fish and vegetable' pattern as the healthiest one (Okubo *et al.*, 2011b). However, this interpretation may have been influenced by cultural norms, as this pattern also reflects most closely the traditional Japanese diet. The pattern is, however, high in salt which in different contexts may be viewed less favourably.

The total variance explained was highest among the various healthy or health conscious patterns. The "Health conscious" pattern in ALSPAC explained 10.6% of total variance (Northstone *et al.*, 2007), the "Healthy" pattern in the CANDLE cohort explained 5.8% (Völgyi *et al.*, 2013) and the "Healthy" pattern in DIPP explained 7.6% of total variance (Arkkola *et al.*, 2008). Among these cohorts, the variance of all the other patterns was lower; in ALSPAC the "Vegetarian" pattern explained 3.6% (Northstone *et al.*, 2007), in the CANDLE cohort the US Southern pattern explained 4.4% (Völgyi *et al.*, 2013) and in DIPP the "Alcohol and butter" pattern explained only 2.7% of total variance (Arkkola *et al.*, 2008). In the study by Cuco *et al.* (2006), the variance explained by the two patterns ranged between 10 % and 15 % across the different time points (Cucó *et al.*, 2006). This means that among the reviewed studies, the derived dietary patterns commonly only explained a small proportion of the total variance observed among the dietary data.

Diet quality indicators are not without pitfalls either. Participant status can vary greatly depending on the tools and cut-offs used, as seen in the Perinatal Health Project where the proportions of participants classed as having adequate diets varied greatly between the two publications from 3.5 % being classed as guideline compliant using the CFG (Fowler *et al.*, 2012) to 56 % judged as having an adequate DQI-P score (Nash *et al.*, 2013).

4.5.   Discussion

To assess the 'fit' of the conceptual framework, the literature was systematically searched and findings from 17 publications of 12 studies were narratively synthesised.

The lack of studies investigating pregnancy determinants is in contrast with theoretical and empirical literature framing pregnancy as a physiologically and psychologically unique period (Section 3.6.3.). Therefore many research gaps remain such as the influence of pregnancy intendedness, pregnancy ailments and changes in appetite and pregnancy-induced health changes on diet.

Included studies only investigated few pregnancy factors other than parity. Findings on parity were inconsistent. It is possible that this is due to confounding (e.g. age, marital status), or differences between countries for example in resources and support allocated to women in their first and subsequent pregnancies.

Socio-demographic determinants have been most frequently studied. Evidence consistently points to a social gradient whereby women who are older, more educated, with higher incomes or other markers of affluence more likely followed 'healthier' dietary pattern or scored higher on diet quality scales. This confirms that the social gradient observed in the diet of non-pregnant populations (section 3.6.4.) persist in pregnancy. This is in stark contrast to the description of pregnancy as a period of greater motivation for behaviour change and great potential for health promotion (Hoffmann *et al.*, 2014; Gardner *et al.*, 2012; Anderson, 2001). The persistence of the social gradient in pregnancy indicates that either the health promotion potential is not used to its fullest potential, women's motivation is not as great as expected, or, that neither can overcome the wider social forces in play.

Findings regarding ethnicity were less consistent and more research is needed. Evidence from the reviewed studies also indicates that partnership and markers thereof such as cohabitation determine dietary intake.

Environmental determinants of diet are a new and promising field of research (Section 3.6.5.). However this was not reflected in this review as

the impact of the environment was rarely assessed. Further, some facets of the environment that have been conceptualised as relevant in the previous chapter were not assessed at all; the medical and political and economic environment. Others have also noted a lack of studies investigating macro-level environmental determinants (Brug, 2008).

The reviewed studies support social support and social capital as determinants (socio-cultural environment). Evidence regarding the built and food environment stem from few studies with some inconsistencies.

Studies on individual response paint a picture of a 'behavioural' gradient, whereby health promoting behaviour such as adequate physical activity appear linked with higher diet quality or adherence to 'health conscious' types patterns, whereas the opposite was seen for detrimental behaviours such as smoking. Much like the social gradient, the 'clustering' of health risk and protective behaviours observed in different age groups and populations (Spring *et al.*, 2012) appears to persist in pregnancy.

The relationship between pre-pregnancy weight and diet in pregnancy indicates that individual responses affecting body weight including diet and physical activity behaviour, may 'track' into pregnancy. A tracing of dietary pattern from pre-conception into pregnancy has been reported by a prospective analysis of the Southampton Women's survey (Crozier *et al.*, 2009b).

As an unexpected by-product psychological health emerged as a potential new category of determinants for inclusion in the framework. Reviewed studies indicate that depression, stress, and anxiety influence diet during pregnancy. Section 3.7.6. has shown that psychological factors can influence individual responses for example to stress or food cues. Psychological factors will thus be considered to be part of the category of individual responses.

Potential sources of bias were identified in many of the reviewed studies as indicated by their NOS scores. Prominent methodological issues were that sample size calculations were rarely reported and only nine adjusted for confounders (Northstone *et al.,* 2007; Cucó *et al.,* 2006; Arkkola *et al.,* 2008; Hoffmann *et al.*, 2014; Nash *et al.*, 2013; Laraia *et al.*, 2004; Laraia *et al.,* 2007; Rifas-Shiman *et al.*, 2009; Kritsotakis *et al.*, 2015).

The review is limited by only considering observational studies which are methodologically weaker than experimental studies but were the only choice when wanting to identify the drivers of diet when women are free to choose (i.e. in real life settings). Language bias is possible because all included studies were in English. Restriction to high and upper-middle income countries limits the generalisability of findings.

The review benefited from an extensive literature search and quality assessment conducted by multiple reviewers.

The following research needs were identified:

- studies investigating the role of environmental factors and pregnancy itself as a potential unique determinant
- studies using strong methods and statistical techniques to overcome the issues outlined (e.g. subjective decisions in factor analysis and PCA, not adjusting for confounders, lack of sample size calculations)
- prospective studies that allow studying if and how diet patterns or quality changes from pre-conception to pregnancy and across the course of pregnancy

4.6. Summary of systematic review

The literature review supported the multiple determinants life course conceptual framework. However more research is needed on environmental and pregnancy-related determinants in particular and of stronger methodological design in general. The current evidence base is too scant to allow for the complex interplay of determinants to be conclusively disentangled.

The persistence of a social gradient in diet in pregnancy is worrying considering the potential priming effect of inadequate diet for maternal and child health. A lifestyle or behavioural gradient also appear to persist in pregnancy.

Findings of this review identify women who are young, less educated, and less affluent or show health risk behaviours as risk groups for inadequate diet in pregnancy.

5. Empirical analysis: testing framework 'fit'

As outlined in the previous chapters, diet during pregnancy is influenced by many factors that can be grouped into pregnancy-related, socio-demographic, environmental and individual response factors.

Chapter 4 has assessed the 'fit' of the proposed conceptual framework with the wider literature and indicated that psychological factors may also be important determinants. The chapter also outlined the current state of research and identified methods currently used for assessing diet 'as a whole'.

5.1.   Aim

This chapter aims to answer research questions 1.b. ("which factors determine diet in pregnancy in Bielefeld?") and 2.b. ('Proof of concept' – construction and test of final explanatory model with empirical data").

5.2.   Methods

This chapter will analyse cross-sectional data from the BaBi study. Current knowledge on diet in pregnancy in Germany is scarce (Section 2.4.3.). Therefore a brief overview of the diets of BaBi participants will first be given. Then the determinants of diet in BaBi participants will be assessed with the intent to construct the final explanatory model based on these findings.

5.2.1. Study design

The BaBi birth cohort study is a social epidemiological, community based cohort study. The study's focus lies on the influence of socio-economic factors, particularly parental migration background and social status, on the health of children growing up in Bielefeld. The BaBi cohort is the first study of its kind in Germany, due to its in-depth assessment of migration status and inclusion of hard-to-reach groups. The study aims to assess the

development of health inequalities in children from birth until school age. The BaBi study is relevant because health disparities are growing in Germany and because health in early life has a priming effect on later health. The main outcomes assessed are physical and mental/cognitive child development as well as allergies and vaccinations/uptake of screening (Spallek and Razum, 2012).

The BaBi study is set in the city of Bielefeld, which is located in the German federal state of North-Rhine-Westphalia. Bielefeld had just under 334,000 inhabitants at the end of 2015, of these 13.9 % had a foreign nationality and 27.4 % had dual citizenship (i.e. the German and one other nationality) (Stadt Bielefeld, Amt für Demographie und Statistik, 2015).

The BaBi study is funded by the federal ministry of education and research, Germany (Bundesministerium für Bildung und Forschung). Ethical approval had been granted by the ethics committee at the Medical Faculty of the Westfälische Wilhelms-Universität Münster (Ethikkommission der medizinschen Fakultät der Westfälischen Wilhelms-Universität).

5.2.2. Participants

Participating women were recruited during their pregnancy or shortly after birth. Recruitment in pregnancy was conducted with the help of participating gynaecologists, midwives, birth clinics and community contacts (e.g. pharmacies, kindergartens, places where women went for antenatal classes or for social/financial advice in pregnancy), who handed out information material about the study. Interested women could contact the study team by phone or email. Some midwives and gynaecologists also collected expression-of-interest forms for us. On these forms, women could note down their contact details and study staff contacted them to inform them about the study and arrange an interview if interested.

Postpartum women were approached on antenatal wards by trained interviewers. They could either conduct the initial interview there and then or arrange it for a later date. Interviews were conducted from gestational week 14 up to eight weeks after birth. Women had to be residents of Bielefeld during the current pregnancy in order to participate. No

restrictions regarding age, health status or country of origin were made, with the exception of women who did not speak German, English, Turkish or Polish as study interviewers could not speak other languages.

At the time of writing this dissertation (November 2016) recruitment was in its final month and 947 interviews had been conducted and 954 babies had been born.

5.2.3. Data collection

The BaBi study uses a mix of data sources. The baseline assessment focused largely on maternal health and emotional status as well as her living conditions during the pregnancy and previous months. Upon birth, the child became the focus of the study and questions focused mainly on its health and wellbeing.

Computer assisted personal interviews (CAPI) were conducted by trained interviewers in pregnancy (CAPI-pre) or a shortened version up to eight weeks after birth (CAPI-post). The first CAPI took on average one hour. CAPI-pre interviews were conducted at the university, at the women's home or any other public place she wished for, though the university was the most frequent location. CAPI-post interviews were conducted in hospital or an interviewer visited the woman at a later date in her home. Upon birth, the child became the focus of the study and questions focused mainly on its health and wellbeing; fathers or legal guardians had to consent for children's data to be used.

Women who joined the study during pregnancy (CAPI-pre) completed one 24 hour dietary recall at the end of the CAPI interview and a second recall by phone several days later. No dietary recalls were conducted in CAPI-post participants because the previous day was usually spent in hospital, in many cases being in labour or one day postpartum, and was thus deemed not representative of usual dietary intake.

With women's consent, routine health care data were also collected; antenatal health care booklet ("Mutterpass"), perinatal data (standardised hospital statistics, "Perinataldaten") and child health booklets ("Kinder-Untersuchungsheft"). The collection of school entry examination data

("Schuleingangsuntersuchung") is planned for the future. Additionally, demographic and environmental data provided by the city of Bielefeld were collected and are currently being analysed.

Follow-up data is collected by short telephone interview of the mothers (CATI) when children are aged nine to 12 months, 18 to 21 months and 36 to 39 months old.

Sample size calculation was not conducted since the present analysis was explorative and observational.

5.2.4. Dietary assessment methods

The CAPI-pre included questions on nutrition related knowledge and practices (food hygiene, dietary requirements and weight gain recommendations in pregnancy), the use of dietary supplements, dieting, body image and history of eating disorders.

Further dietary data was collected by the so called 24 hour Food List (24hFL) provided by the German Institute of Human Nutrition Potsdam-Rehbrücke (DIfE). The 24hFL consists of 246 food items and enquires whether these were eaten on the previous day (yes/no). Participants were not asked to report portion sizes or consumption frequencies. This makes the instrument quick to conduct and thus keeps participant burden low, making it ideal for large epidemiological studies. The 24hFL was developed to be used in combination with information on standard consumption quantities to assess usual dietary intake (blended approach) (Freese *et al.*, 2014). It has not been validated for use in pregnant populations.

The use of dietary supplements was reported as binary variables (yes/no), or the name of combined multivitamin or mineral supplements could be reported in a commentary field. Such information was recoded as the individual nutrients (see Appendix 3).

In the BaBi study, the 24 hFL was administered twice. The first assessment took place after the initial CAPI-pre, women could choose whether to fill in the questionnaire themselves or have it read out and completed by the interviewer. The second 24 hFL was conducted within two weeks of the first

via phone. Others have successfully used a mix of in-person and telephone 24 hour dietary recalls to estimate dietary patterns in pregnancy (Shin *et al.*, 2015). Dietary recalls were found to perform reasonably well as basis for dietary pattern derivation when compared to five day dietary record (McNaughton *et al.*, 2005).

The phone calls were unannounced with the aim to capture both a week and a weekend day in order to get an overview over typical intake across the entire week. Thus, if the first recall had been conducted on a Monday, i.e. covering intake on a Sunday, the second recall should be conducted on Tuesday to Friday, and vice versa. The advantage of conducting both recalls within a fortnight was that the effects of season and progression of gestation were limited.

An initial assessment of the first 100 conducted diet recalls in the BaBi study showed that the practicability of the 24hFL in a birth cohort was high (Hinz *et al.*, 2014). The assessment took on average five to ten minutes. The first day recall had a 100 % response rate even though it was conducted after the one hour CAPI-pre interview and diet can be a sensitive subject. We attribute this to the fact that women could choose between filling in the questionnaire themselves, and having it read by an interviewer. The second day assessment was completed in 80 % of women; if the second recall was not conducted this was usually because women could not be reached by phone until they had already delivered (Hinz *et al.*, 2014).

5.2.5. Statistical analysis

The present analysis was based on two datasets; 24hFL data provided by DIfE and BaBi data provided by the study's data manager. Both dataset had been reasonably 'clean' when received. As recommended (Kirkwood and Sterne, 2003), data was initially checked by using range checks (numerical variables) and histograms to look for outliers. Dietary data was recoded as indicated in Appendix 2 and Table 3. Some CAPI data was also recoded; age was available as a continuous variable but also recoded into three categories, BMI was coded in accordance with the WHO guidelines (<18.5 kg/m² as underweight, 18.50-24.995 kg/m² as normal, 25-29.99 kg/m²

as overweight, $\geq 30\,kg/m^2$ as obese) (World Health Organization), gestational week at time of interview was coded as trimester (week 1-13 as 1st, week 14-26 as 2nd, week 27-39/40 as 3rd) (Wied, 2003), education was assessed very finely in the CAPI data (allowing for different school forms, e.g. in the former German Democratic Republic) and recoded into the three common school forms in Germany today. Income is a sensitive subject. In anticipation of this, BaBi participants could either report the net household income or indicate a range in which their income was (if they did not feel comfortable reporting the amount). Information from these two variables was combined into income categories as presented in Table 4. Women were also asked if they had some money left at the end of the month that they could save for a rainy day. This variable was used as an indicator or financial situation (strained if saving was not possible, more relaxed if it was) and was particularly useful where participants refused to report either their income amount or range of income. Some CAPI variables were collapsed into fewer categories when individual categories had very few observations, e.g. civil partnership was combined with the category married as both categories were seen as similar enough to be combined.

The main outcome were dietary intake on two days as binary variables (Appendix 2), from these measures, a dietary pattern was derived and the number of HSYF recommendations met were presented as ordinal scores (Table 3).

Statistical analysis comprised five steps:

1. Description of CAPI-pre and CAPI-post participants
   - their pregnancy-related, socio-demographic, environmental and individual response characteristics were described and compared
   - nutrition related knowledge and practices among all participants (CAPI-pre and-post) were described and subgroups explored (age, parity, education, pre-pregnancy weight)
   - determinants of taking folic acid supplements as recommended were explored using logistic regression analysis
   - description of CAPI-pre participants' anthropometric characteristics and correlation with partner's anthropometrics using correlation and regression analysis
2. assessment of data on individual food type across the two assessment days
   - to get an overview over food consumption among participants
   - to assess if assessment day and method (in-person vs. via telephone) was associated with assessment
   - to see whether day one (greater sample size) can be regarded as representative of intake on the second day
3. derivation of dietary patterns using exploratory factor analysis
4. evaluation of compliance with HSYF network guidelines
5. assessment of the association between determinants and diet in pregnancy
   - A dietary pattern score was created for use in bivariate and multivariate analysis of the association between diet and determinants
   - A score was created of the number of HSYFguidelines met; this was used in bivariate analyses and ordered logistic regression of the association between guideline adherence and determinants

The overview of food consumption across assessment was achieved by simply calculating the proportion of respondents who consumed the food on that day.

To assess the association between assessment day (first/second recall, 24hFL) and dietary intake (yes/no), two tests were applied. First, χ^2-tests were run to test whether there was an association between assessment

day and response. The χ²-tests test examines whether there is an association between rows and columns of contingency tables (Kirkwood and Sterne, 2003). It tests the null hypothesis that the proportion of individuals with the characteristic is the same in both (Peacock and Kerry, 2007). The χ²-tests becomes invalid when sample size is small, therefore, in line with recommendations, the Fisher's exact test was used instead when expected cell values are smaller than five (Peacock and Kerry, 2007).

Secondly, it was tested whether there was a consistency in responses between assessment days using McNemar's test. McNemar's test is a type of χ²-tests that assesses the number of discordant pairs and examines whether the discordant responses are different from what would be expected by chance alone (Kirkwood and Sterne, 2003). In this case, discordant pairs were those where a woman reportedly consumed an item one day but not the next and vice versa. McNemar's tests was used to test the null hypothesis that the underlying prevalence, in this case of consumption of a supplement, food, beverage or meal, was the same at two time points, results were given as ratios of proportions (to show the relative change) and p-values (Peacock and Kerry, 2007). McNemar's test is only appropriate, when the total number of discordant pairs is ten or more, otherwise binomial probabilities should be used (Kirkwood and Sterne, 2003), The 'exact McNemar's' test values were reported in all cases (whether discordant pairs were larger than ten or not) as recommended by Peacock and Kerry (Peacock and Kerry, 2007).

Dietary patterns were derived using exploratory factor analysis. Factor analysis helps explore data and underlying dimensions by maximising the information from the original variables in as few derived variables as possible while still yielding meaningful and interpretable results (Gorsuch, 1974). Dietary patterns are commonly derived using factor analyses methods to identify underlying factors (traits) among the correlation matrix of food variables which explain most of the variation among the data (Reedy et al., 2010).

As all dietary data from the 24hFL were binary (0= item not consumed, 1= item was consumed), factor analysis was run off of a tetrachoric correlation

matrix using the 'tetrachoric' command in Stata (Stata Press, 2013). When it is reasonable to assume that the binary variables represent variables which are basically continuous, then tetrachoric correlation coefficients can be calculated as estimates of the Pearson product-moment coefficient (which would have been used had the variables been continuous) (Gorsuch, 1974).

In factor analysis, 'uniqueness' represents the proportion of variance of a variable that is not explained by the common factors, it is the reverse of 'commonality' of a variable, i.e. the amount of its variance that overlaps with the extracted factors (Gorsuch, 1974). When uniqueness is high then factors do not explain the variable well because a high percentage of that variable is explained by things other than the factor, e.g. measurement error. A cut-off of 0.6 is often used to distinguish high (≥0.6) from low (<0.6) values (Stata Press, 2013). Communalities can take values from 0.0, if the variable is completely uncorrelated with any other variable in the matrix, to 1.0, indicating that the variance is perfectly explained by the common factors (Gorsuch, 1974). Negative communality values have no meaning but may occur due to rounding error. Similarly calculations resulting in diagonal elements greater than 1.0 may occur due to rounding errors and are called Heywood cases (Gorsuch, 1974). According to the Stata Multivariate Statistics Reference Manual (2013), Heywood solutions may occur when tests cannot be justified on a formal level, however the tests may still be useful but should be interpreted carefully (Stata Press, 2013).

The original 42 food and beverage variables were combined into 24 groups (Appendix 2). As exploratory factor analysis of these 24 groups performed poorly, a second data export was provided by DIfE (November 2016), which additionally reported the number of different fruits and vegetables consumed was reported and whether consumed dairy products were full-fat or reduced-fat. Furthermore the second data export distinguished between wholegrain and non-wholegrain rice, pasta, bread and other cereals and between fatty/non-fatty fish and between caffeinated/decaffeinated coffee. Exploratory factor analysis was repeated using the second data export. This time factor analysis was run off of a polychoric correlation matrix which allowed the inclusion of ordinal (fruit and vegetable), categorical (dairy full-fat, low-fat, not reported) and binary (all other) variables. The second, 'finer'

data export did not improve dietary pattern derivation but allowed assessment of guideline adherence.

In the second step of diet analysis, adherence to the German guidelines proposed by the HSYF network was assessed (Koletzko *et al.*, 2013; Koletzko *et al.*, 2011). Table 3 represents the individual guidelines and indicates if and how guideline adherence can be assessed using 24hFL data. Others have successfully created guideline adherence scores based on binary variables by summing up the number of recommendations met (Cade *et al.*, 1999). One amendment was made to the HSYF recommendations: the consumption of lean meat was recommended, but as the sample consumed a diet low in meat (as indicated by individual food consumption) meat free alternatives were included (lentils/pulses, eggs and non-fatty fish) as to not disadvantage vegetarians or low-meat consumers in the scoring.

As the analysis of individual foods across assessment days was highly concordant and as the derived dietary pattern were similar in both assessment days it was decided to calculate guideline adherence based on day one recall data only, as this allowed for a larger sample size than restricting analysis to women who had two days' recalls.

HSYF guidelines are based on consumption amounts and frequency (frequently, moderately or sparingly), thus only those foods that were deemed beneficial were scored as it was understood that those foods should ideally be consumed daily, with the caveat that consumption amounts and exact frequency were unknown. The maximum possible guideline adherence score was seven. Higher scores were considered as indicative of greater guideline adherence. No cut-off values were proposed since the assessment, due to lacking knowledge of frequency and portion size was already a rather 'rough estimate' and making a subjective cut was not considered appropriate in such a scenario.

Guideline adherence score was considered an ordinal variable. When the dependent variable is in the form of a score or an ordinal variable, tests based on ranks are appropriate. Therefore non-parametric tests were used in bivariate analyses. The Mann-Whitney U test (equivalent to the Wilcoxon rank sum test) is appropriate when the independent variable has no more

than two categories, otherwise the Kruskal-Wallis test was used (Peacock and Kerry, 2007).

In the final step, determinants of dietary pattern score and of guideline adherence score were assessed in separate multivariate models.

The association between determinants and dietary pattern score was assessed using multiple regression analysis since the pattern score was a continuous variable. Guideline adherence score was assessed in ordinal logistic regression since guideline score was an ordinal variable that could only take on discrete values and because it could not be assumed that the difference between score were equal.

When analysing a complex dataset such as the one in the present dissertation, it has been recommended to stick to an analysis plan and avoid multitude of statistical comparisons which all incur a 5 % chance of spurious findings (Peacock and Kerry, 2007).

When developing a regression model aimed to understand the aetiology of an outcome and identify important exposures, as is the case in this dissertation, the focus should be to *"attach meaning"* (Kirkwood and Sterne, 2003, p. 342) to the variables that are included in the final model. The selection procedure should be based upon the conceptual framework and stepwise methods should be avoided (Kirkwood and Sterne, 2003).

As a rule of thumb it has been proposed to use at least ten times as many observations as exposure variables in regression analyses (Kirkwood and Sterne, 2003), this would mean a maximum of 21 predictor variables (i.e. determinants) since data on 219 first day recalls was available.

To err on the side of caution, it was aimed to include less than the maximum 21 determinants. Preference was given to include those variables for which a lack of research had been identified in the previous chapter, namely pregnancy-related and environmental determinants. Among these, variables that showed very little variability were excluded, namely gestational diabetes treated with diet (pregnancy-related) and most food and living environment variables except for social network (Table 4). Since the role of socio-demographic determinants has been established in existing research (Chapter 4), only a selection of socio-demographic

determinants were entered into the regression model: maternal age, education, household income and perceived migration background.

The first and largest model in both cases (dietary pattern and guideline adherence) included the most important determinants outlined by the systematic review and those for which research was lacking but with strong theoretical foundations. In the second model, determinants not significant in bivariate analyses were omitted. The final and smallest model included only one variable per category of the framework.

Since the dataset was relatively small, analysis was not restricted to subjects with complete data for all included determinant variables. Instead for every analysis all available observations were used and the number of observations was reported in order to allow the reader to discern the presence and extent of missing observations (Peacock and Kerry, 2007). All analyses and graphs were conducted using Stata 13.1 (StataCorp LP, 2013), p-values were presented to two significant figures, where Stata reported p= 0.0000 it was presented as p< 0.0001 and where Stata reported p= 1.000 it was presented as p>0.999. P-values below 0.05 were considered significant (Peacock and Kerry, 2007). Where multiple comparisons were conducted, Bonferroni correction was applied by dividing α by the number of tests conducted (Bland and Altman, 1995).

Table 3: Overview of guideline adherence and combined variables

Component	Recommended amount / frequency	24hFL components	Guideline adherence score (max. score)
Energy and nutrient needs	Slight increase in energy needs over the course of pregnancy; need for vitamins, minerals and trace elements greatly increased – quality of diet and nutrient density important	Not assessed	Cannot be assessed
Meal frequency	Regular meals throughout the day, but exact number of meals depends on individual needs and preferences	1st breakfast, 2nd breakfast, lunch, afternoon snack, dinner, late snack	The overall sum could be assessed but would be difficult to judge as no exact number was recommended
Supplements	• Folic acid: 400 µg/day from preconception to min. end 1st trimester) • Iodine: 100–150 µg/day • Iron: when medically advised 30 mg/day • Vitamin D: 20 µg/day when sun exposure is insufficient • n-3 fatty acid DHA: vegetarians who do not eat oily fish, 200 mg/day	Folic acid, vitamin D, DHA and iron were variables in the 24hFL. Additionally supplements reported in commentary field were re-categorised based on their content of the five recommended supplements (see Appendix 1)	Due to the individualised nature of the recommendations supplements will not be scored but assessed in subgroups
Beverages	At least 1.5L water, preferably unsweetened and low calorie drinks	Low cal. Beverages, soft drinks	Low calorie beverages consumed, yes=1 point

Table 3: continued

Component	Recommended amount / frequency	24hFL components	Guideline adherence score (max. score)
Plenty:			
Fruit and vegetables	5 portions/day	Fruits, vegetables	≥ 5 types of fruits and veg consumed, yes=1 point
Grains and potatoes	With every main meal, preferably wholegrain and low-fat preparations	Carbohydrates	≥1 type of whole-grain carbohydrate consumed, yes 1 point
Moderate:			
Dairy products	Moderate amounts, low-fat dairy products preferably	Dairy	≥1 type of low-fat dairy consumed, yes=1 point
Meat and fish	Meat: preferably lean meat Fish: 2 portions/week, one being oily fish	Red meat, processed meat, poultry, fish	Lean protein= poultry /fish /egg / legumes, yes=1 point; oily fish consumed, yes=1 point
Sparingly:			
Oils and fats	Plant/veg oils: beneficial, regularly Animal/saturated fats: sparingly	Vegetable oil, margarine, butter, other fat	Vegetable oil consumed, yes=1 point
Sweets and snacks	Small quantities only: high energy and low nutrient density foods and snacks	Sweets	Not recommended thus not scored

Source: HSYF guidelines by Koletzko *et al.*, 2013, 24hFL components by DIfE data export, guideline adherence scoring by author

5.3. Results

5.3.1. Description of the study population

Figure 8 shows how the final sample was derived. Data on a total of 219 participants was available, 180 of these conducted a second 24 hour diet recall.
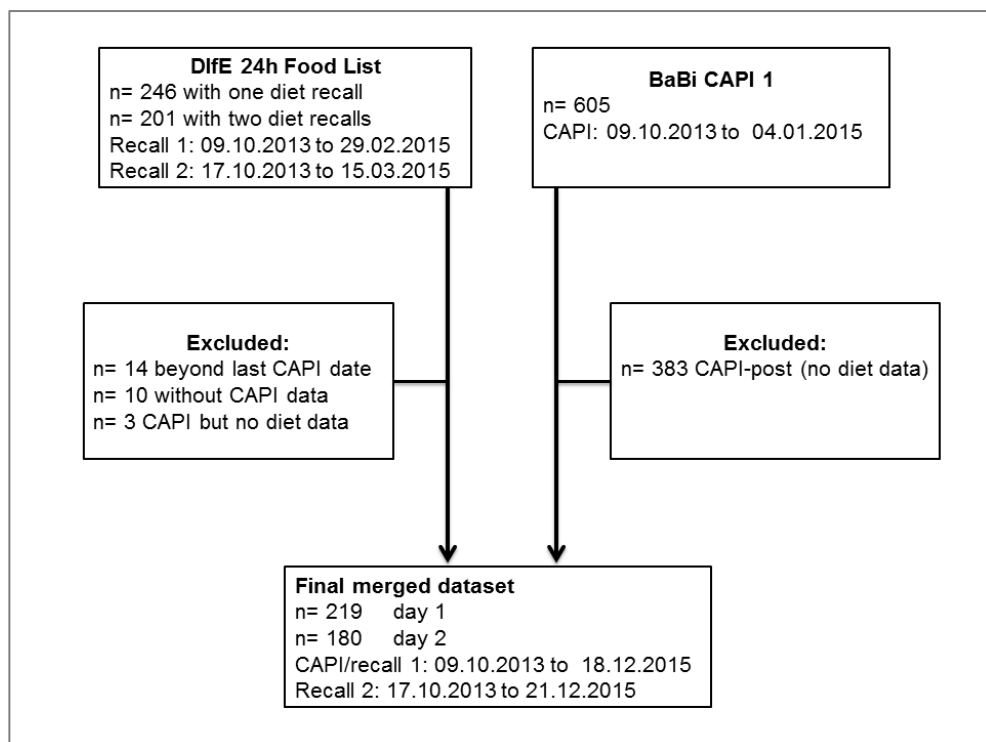
Figure 8: Participant flow chart
Source: author

Between October 2013 and January 2016, 605 women were recruited into the BaBi study. Women either completed the baseline interview in pregnancy (CAPI-pre) or up to eight weeks after birth (CAPI–post). The CAPI dataset included interviews conducted up until the 4th of January 2016, however the most recent CAPI-pre interview was conducted on the 18th of December 2015; the DIfE dataset was consequently restricted to that date. Three women conducted a CAPI-pre interview but refused to do the dietary assessment. For ten participants dietary data was available but

due to a technical issue their observations were missing from the exported CAPI data file. The final sample thus included 219 women with both dietary and CAPI-pre data.

Table 4 shows basic characteristics of women conducting the baseline interview in pregnancy (CAPI-pre) and in postpartum (CAPI-post). Based on the Bonferroni correction, p values of 0.0016 or less were considered as significant. CAPI-pre participants (on whom the further analyses are based) were significantly less likely to report anaemia in the current pregnancy and more likely to report their current pregnancy as "rather planned", indicating that pregnancy intendedness was high. However, when asked how long they were trying to conceive, almost half of CAPI-pre and -post participants reported they were not trying to become pregnant. CAPI-pre women less commonly (not significant) reported having gestational diabetes mellitus that is treated with dietary changes; it is possible that it was diagnosed in some of these women at a time after the interview. Gestational week at date of interview ranged from 12 to 40, the mean was 29.05 weeks (SD 6.93).

Comparison of socio-demographic characteristics showed no significant differences in age; most women were 25 to 34 years old. CAPI-pre women had significantly higher education levels and partners who were more educated. Compared to CAPI-post participants, they had significantly greater net household incomes and more often reported having money left at the end of the month to save (borderline significant). CAPI-pre participants were also significantly more likely to be German and not have a self-ascribed migration background.

CAPI-pre and -post women did not differ with regard to their anthropometric measurements and other individual response variables. No significant differences were observed with regards to environmental determinants either. CAPI-pre participants appeared to have larger social/support networks but this was not significant.

Table 4: Participant characteristics

Characteristic	% (n)		Difference	
	CAPI-pre	CAPI-post	M. d. (95 % CI)	p-value
Pregnancy-related				
Primiparous	42.79 (95/222)	40.47 (155/383)		0.58
Number of previous life births*	n= 117 1.18 (0.61)	n= 222 1.48 (1.05)	0.302 (0.095 to 0.501)	0.0044
Nausea	68.02 (151/222)	65.80 (252/383)		0.58
Vomiting	33.78 (75/222)	33.16 (127/383)		0.88
Cravings	38.01 (84/221)	43.98 (168/382)		0.15
Anaemia	29.95 (65/217)	55.24 (211/382)		**<0.0001**
Pregnancy 'rather planned'	84.62 (187/221)	72.51 (277/382)		**0.001**
Duration attempting to conceive				0.40
• Wasn't trying	46.61 (103/221)	50.13 (188/375)		
• <6 mts.	29.41 (65/221)	31.47 (118/375)		
• 6-11 mts.	14.03 (31/221)	9.87 (37/375)		
• ≥12 mts.	9.95 (22/221)	8.53 (32/375)		
Gestational diabetes treated with diet change	2.25 (5/222)	5.74 (22/383)		0.045
Worry about weight retention	40.27 (89/221)	40.84 (156/382)		0.89

Table 4: continued

Characteristic	% (n)		Difference	
	CAPI-pre	CAPI-post	M. d. (95 % CI)	p-value
Socio-demographic				
Age (years)*	n= 222 31.5 (4.34)	n= 383 31.32 (5.19)	- 0.18 (-0.99 to 0.63)	0.66
Age category				0.33
• < 25yrs.	5.86 (13/222)	8.88 (34/383)		
• 25-34 yrs.	69.82 (155/222)	65.27 (250/383)		
• >35 yrs.	24.32 (54/222)	25.85 (99/383)		
Marital status				0.73
• Unmarried, single	1.36 (3/221)	2.35 (9/383)		
• Unmarried, in partnership	26.70 (59/221)	23.76 (91/383)		
• Married/civil partnership	70.14 (155/221)	71.80 (275/383)		
• Separated/ divorced	1.81 (4/221)	2.09 (8/383)		
Education level				**<0.0001**
• Basic (≤ 9yrs.)	3.62 (8/221)	9.59 (35/365)		
• Middle (=10 yrs.)	12.22 (27/221)	22.47 (82/365)		
• High (≥ 11 yrs.)	84.16 (186/221)	67.95 (248/365)		
Partner's education				**<0.0001**
• Basic (≤ 9yrs.)	6.31 (13/206)	13.39 (45/336)		

Table 4: continued

Characteristic	% (n)		Difference	
	CAPI-pre	CAPI-post	M. d. (95 % CI)	p-value
• Middle (=10 yrs.)	12.62 (26/206)	24.40 (82/336)		
• High (≥ 11 yrs.)	81.07 (167/206)	62.20 (209/336)		
People in household*	n= 221 2.66 (0.89)	n= 378 2.90 (1.11)	0.24 (0.07 to 0.41)	0.0059
Net household income category (€/month)				**0.001**
• < 1,500	8.56 (19/222)	14.88 (57/383)		
• 1,500 to 2,999	26.13 (58/222)	26.37 (101/383)		
• 3,000 to 4,449	35.14 (78/222)	23.50 (90/383)		
• ≥4,500	16.67 (37/222)	12.27 (47/383)		
• Missing	13.51 (30/222)	22.98 (88/383)		
Money left at end of the month to save	75.93 (164/216)	63.71 (237/372)		0.002
Nationality				**<0.0001**
• German	93.21 (206/221)	77.25 (292/378)		
• German and one other	3.17 (7/221)	7.41 (28/378)		
• Not German	3.62 (8/221)	15.34 (58)		
Perceived migration background	14.09 (31/220)	30.91 (115/372)		**<0.0001**

Table 4: continued

Characteristic	% (n)		Difference	
	CAPI-pre	CAPI-post	M. d. (95 % CI)	p-value
Response				
Pre-pregnancy weight (kg)*	n= 217 67.11 (14.90)	n= 364 67.73 (14.87)	0.63 (-1.89 to 3.14)	0.62
Height (m)*	n= 220 168.22 (6.25)	n= 381 167.45 (6.92)	-0.75 (-1.86 to 0.37)	0.19
Pre-pregnancy BMI category				0.43
• Underweight	4.19 (9/215)	3.86 (14/363)		
• Normal	71.63 (154/215)	65.56 (238/363)		
• Overweight	15.35 (33/215)	18.73 (68/363)		
• Obese	8.84 (19/215)	11.85 (43/363)		
Physically active, 3 months before pregnancy	60.18 (133/221)	48.43 (185/382)		0.005
Took folic acid before or during this pregnancy?	84.68 (188/222)	82.72 (316/382)		0.53
Smoked during or 3mts. before this pregnancy	34.44 (31/90)	50.57 (89/176)		0.012

Table 4: continued

Characteristic	% (n)		Difference	
	CAPI-pre	CAPI-post	M. d. (95 % CI)	p-value
Environment				
Number of people I can rely on for help in difficulties				0.011
• Nobody	0.91 (2/220)	1.33 (5/375)		
• 1 to 2	6.36 (14/220)	14.67 (55/375)		
• 3 to 5	40.91 (90/220)	40.00 (150/375)		
• More than 5	51.82 (114/220)	44.00 (165/375)		
Satisfied with food amenities	92.27 (203/220)	95.49 (360/377)		0.102
Satisfied with recreational amenities	96.80 (212/219)	95.44 (356/373)		0.42
Residence as a place for children				0.13
• Satisfied	84.09 (185/220)	81.07 (304/375)		
• Neither / nor	3.64 (8/220)	7.73 (29/375)		
• Dissatisfied	12.27 (27/220)	11.20 (42/375)		
Public transport within 15 min. by food	98.18 (216/220)	98.93 (371/375)		0.44

independent sample t-test for continuous variables; χ^2 and Fisher's exact tests for categorical variables;

*continuous variable reported as mean (SD); M. d., mean difference;

Bonferroni correction: 0.05/31= 0.0016 → p≤0.0016 considered statistically significant

5.3.2. Nutrition knowledge/practices (CAPI-pre and post)

Dietary recall data were only available for CAPI-pre participants but these were a highly select group. Therefore the related concepts of nutrition knowledge and practices were explored for which data on both CAPI-pre and CAPI-post participants were available.

Overall, women were rather knowledgeable about nutrition and weight gain in pregnancy. Almost two thirds (72.3 %, 434/600) of participants said that they received information about diet and nutritional requirements at some stage in their pregnancy. Information receipt differed by parity; 83 % (205/247) of primiparae received information compared to 64.9 % (229/353) of multiparae. Figure 9 shows that among primiparae, information was given more frequently with increasing age, indicating that practitioners may focus on those they perceive at risk or in need or those who demand information.
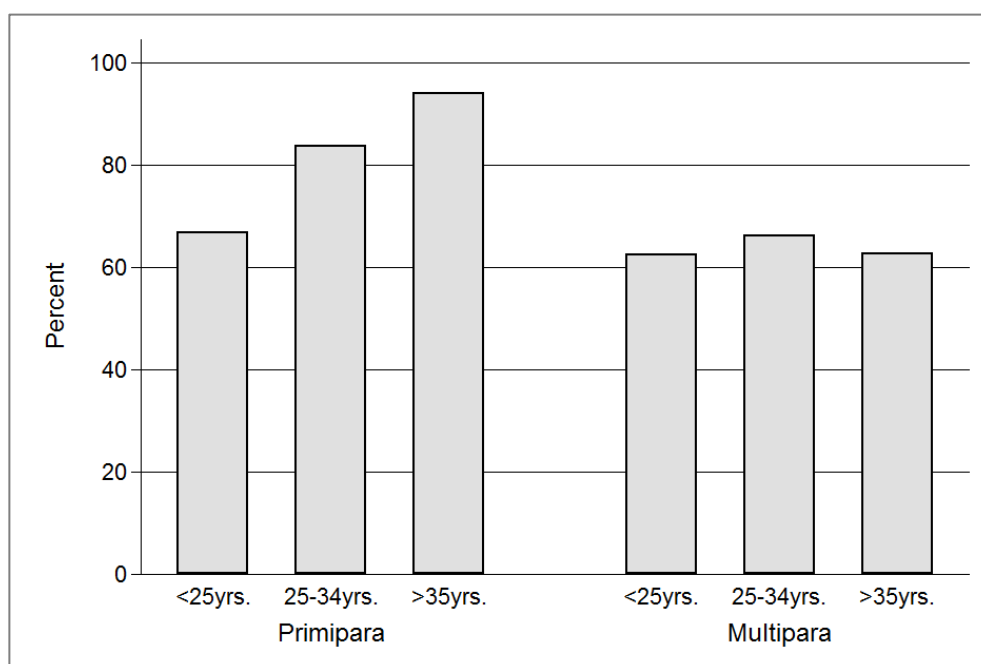
Figure 9: Women who were informed about diet in pregnancy
CAPI-pre CAPI-post participants; n= 600

Whether information was provided did not differ significantly by pre-pregnancy BMI category (χ^2 = 3.29, df= 3, p= 0.35); 78.3 % (18/23) of underweight, 74.0 % (288/389) of normal weight, 68.0 % (68/100) of

overweight and 65.6 % (40/61) of obese women had received information on diet in pregnancy.

To assess nutrition knowledge, participants were asked whether they thought they "knew enough" about diet in pregnancy and about gestational weight gain (subjective knowledge); 91.9 % (550/598) thought they knew enough about diet and 92.2 % (547/593) about gestational weight gain.

To assess their knowledge objectively, women were also presented with two multiple choice questions about energy requirements and weight gain recommendations in pregnancy. Women who chose the correct answers out of the available options were deemed to have sufficient knowledge (objectively). The correct answer for energy requirement was given by 84.0 % (505/601) and for weight gain recommendations by 77.3 % (453/586). Figure 10 indicates that perceived knowledge was higher than objective, and shows that the difference was most pronounced in those with low education level.
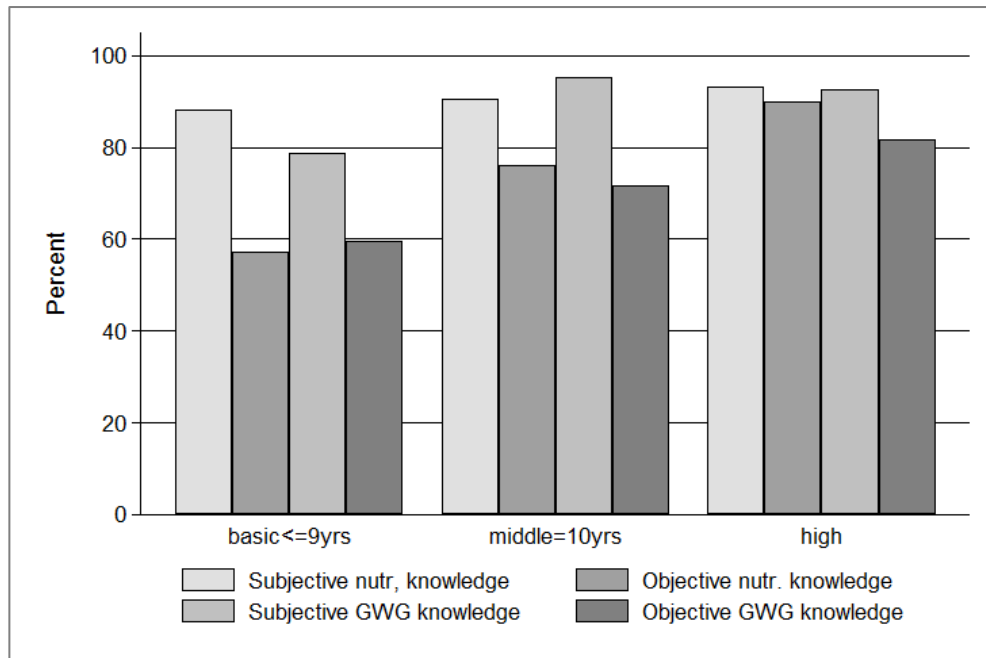
Figure 10: Perceived and objective knowledge by education
CAPI-pre CAPI-post participants (n= 577);
Nutr., nutrition; GWG, gestational weight gain

Women are advised to commence folic acid before conception (Koletzko *et al.*, 2013). To assess whether women followed this recommendation, we asked those who reported taking folic acid supplements at any stage when they commended it. Pre-conceptional folic acid use was reported by 59.4 % (299/503) of women, 37.7 % commenced supplementation in the first trimester (190/503) and 2.8 % (14/503) at an even later stage in their pregnancy. An obvious reason for not starting supplementation before conception is an unplanned pregnancy; 69.7 % (278/399) of women who reported their pregnancy was 'rather planned' commenced folic acid supplementation pre-conceptionally compared to only 20.2 % (21/104) of women whose pregnancy was 'rather unplanned'.

After adjustment, planned pregnancy and education were associated with pre-conceptional folic acid use but maternal age and parity were not (Table 5). Women with highest vs. lowest education had almost five times the odds of starting folic acid supplementation as per recommendation but the confidence interval was wide. Likewise, women with a rather planned pregnancy had higher odds than those without, but again with wide confidence interval.

Table 5: Adjusted odds ratios, pre-conceptional folic acid use

Folic acid, pre-conceptional	Odds ratio*	95 % C.I.	p-value
Maternal education			**0.018**
• basic	1.0		
• middle	3.09	0.89 to 10.76	
• high	4.70	1.43 to 15.39	
Maternal age			0.22
• <25yrs.	1.0		
• 25-34yrs.	2.11	0.85 to 5.23	
• ≥35yrs	1.72	0.65 to 4.57	
Pregnancy rather planned	7.28	4.19 to 12.64	**<0.001**
Primiparous	1.08	0.71 to 1.67	0.69

*each odds ratio is adjusted for all other variables in the table; n= 491

Women were asked whether they were offered "more food" since becoming pregnant as this is a custom reported in some cultures (internal communication, BaBi study). A total of 27.5 % (161/585) replied yes, of these, 77.0 % (124/161) had only the German nationality, 10.56 % (17/161) had dual citizenship and 12.42 % (20/161) had a nationality other than German.

Looking within each group, 25.6 % (124/485) of German women, 48.6 % (17/35) of women with dual citizenship and 30.8 % (20/65) of women with Non-German nationality were offered more food. However, only 27.4 % (45/164) of women who were offered more food reported eating more as a result. This indicates that the impact of being offered more food is low.

5.3.3. CAPI-pre participants

From this point forward only the CAPI-pre participants' data (n= 219) will be described. At the time of the interview, 4 (1.83 %) women were in their first, 72 (32.8 %) in their second and 143 (65.3 %) in their final trimester.

Figure 11 shows the distributions of maternal age, height as well as weight before pregnancy and on the day of the CAPI-pre interview (i.e. weight in pregnancy). Age was normally distributed; the mean age was 31.5 years (SD 4.3, range 19 to 47 years). Maternal height was also approximately normally distributed (mean 168 cm, SD 6.4, range 143 to 183 cm) with one very small outlier; it was verified with the interviewer that this height was correct.

Weight before pregnancy was right skewed (1.83) and kurtosis greater than normal (8.20). Mean pre-pregnancy weight was 67.2 kg (SD 15.0, range 43 to 142 kg). Likewise, weight during pregnancy was right skewed (1.40) with high kurtosis (6.53) (mean 76.5 kg, SD 15.4, range 44.5 to 146 kg) as shown in Figure 11. However, it must be considered that women were at different gestational ages on the interview day, as described above.
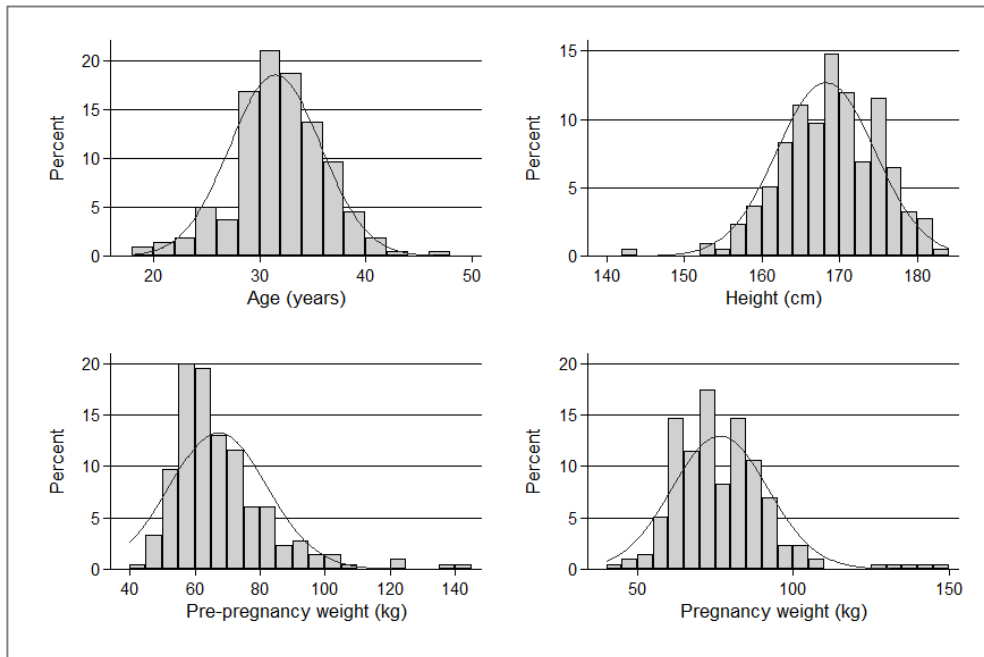
Figure 11: Distribution of age, height and weight before/in pregnancy
Age n= 219, height n= 217, weight before n= 215 and in pregnancy n= 217

Next, the strength of the correlation between mothers' and their partner's height, weight and BMI were estimated using Pearson's correlation coefficient (Table 6).

Maternal pre-pregnancy weight and BMI were was strongly correlated with weight in pregnancy, with measures ranging between 0.83 and 0.94. Interestingly, maternal and paternal anthropometrics were also correlated. Partner's height and weight were correlated with maternal pre-pregnancy weight, BMI and gestational weight, r-values ranged from 0.31 to 0.40. However, linear relationships between partner's height and maternal anthropometric measures were practically non-existent.

Figure 12 shows the reasonably strong correlation between maternal pre-pregnancy and their partner's BMI values.

Table 6: Correlations maternal/paternal anthropometric measures

	Maternal height (m)	Pre-pregnancy weight (kg)	Pre-pregnancy BMI (kg/m²)	Pregnancy weight (kg)	Partner's height (m)	Partner's weight (kg)	Partner's BMI (kg/m²)
Maternal height (m)	1.00						
Pre-pregnancy weight (kg)	0.39 **(<0.0001)** n= 213	1.00					
Pre-pregnancy BMI (kg/m²)	0.076 (0.27) n= 211	0.94 **(<0.0001)** n= 213	1.00				
Pregnancy weight (kg)	0.43 **(<0.0001)** n= 217	0.91 **(<0.0001)** n= 213	0.83 **(<0.0001)** n= 211	1.00			
Partner's height (m)	0.19 **(0.0056)** n= 211	0.045 (0.51) n= 208	-0.013 (0.85) n= 206	0.067 (0.33) n= 211	1.00		
Partner's weight (kg)	0.12 (0.097) n= 203	0.35 **(<0.0001)** n= 201	0.34 **(<0.0001)** n= 199	0.32 **(<0.0001)** n= 203	0.43 **(<0.0001)** n= 202	1.00	
Partner's BMI (kg/m²)	0.000 (0.99) n= 201	0.37 **(<0.0001)** n= 199	0.402 **(<0.0001)** n= 197	0.32 **(<0.0001)** n= 201	-0.202 **(0.0040)** n= 202	0.79 **(<0.0001)** n= 202	1.00

Pearson's correlations r, (p-values)

Simple linear regression (n= 213) identified a significant linear relationship between weight before and in pregnancy. For each kg increase in pre-pregnancy weight, pregnancy weight increased by 0.928 kg (95 % CI 0.869 to 0.986), p<0.0001. Pre-pregnancy weight explained 82.5 % of the variance of pregnancy weight.
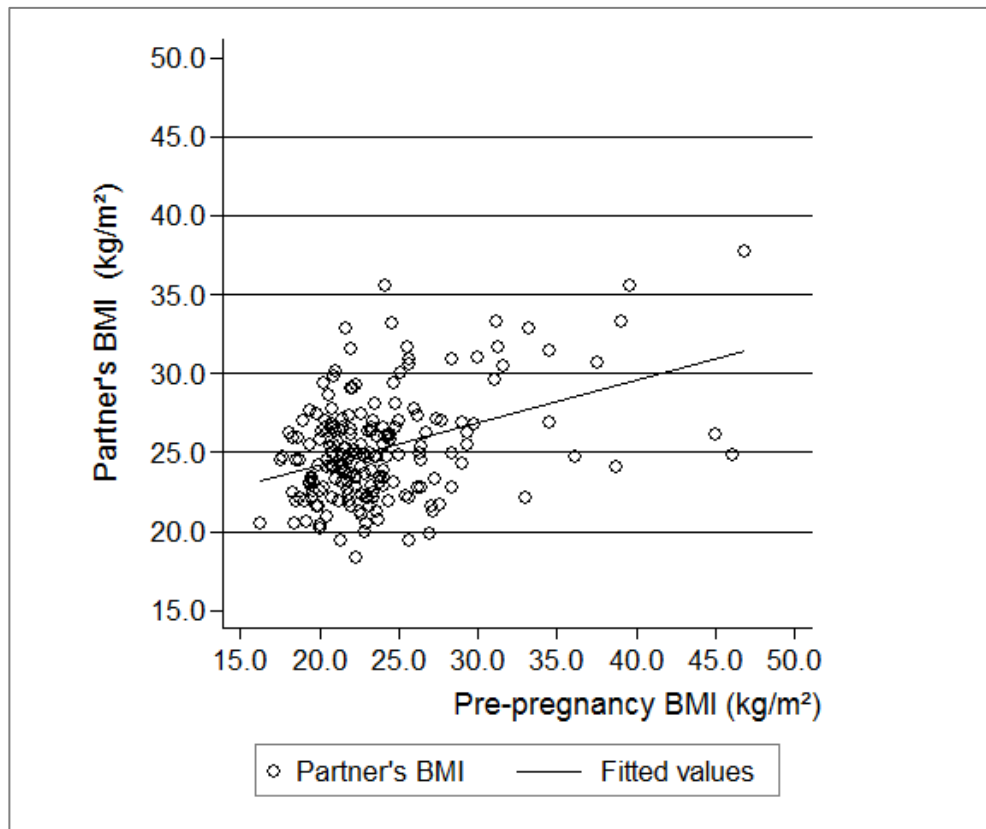
Figure 12: Pre-pregnancy weight and partner's BMI
CAPI-pre participants; n= 197

To assess body image and weight concerns, women were asked how they felt about their current weight, body shape and whether they were worried about being able to lose weight gained after pregnancy. There were no missing values, i.e. answers are based on all 219 participants. Of these, 40.7 % (n= 89) worried about being able to lose pregnancy weight.

Almost one third of women were always (7.8 %, n= 17) or sometimes (22.8 %, n=50) dissatisfied with their body shape, but 10.5 % (n=23) were seldom and 58.9 % (n= 129) never dissatisfied.

Twenty-nine percent of women always (7.3 %, n= 16) or sometimes (21.5 %, n= 47) felt they had gained too much weight; but 63.1 % (n= 138) never and 8.2 % (n= 18) seldom felt so.

Weight loss worry (χ^2 = 0.19, df= 3, p= 0.97) and feeling one has gained too much weight (χ^2 = 10.86, df= 9, p= 0.29) did not differ significantly between pre-pregnancy weight categories. However, body shape dissatisfaction differed significantly (χ^2 = 24.21, df= 9, p= 0.014) (Table 7).

Table 7: Body shape dissatisfaction by BMI

Dissatisfied	Underweight	Normal	Overweight	Obese
• Always	0	8 (5.26)	3 (9.09)	6 (31.58)
• Sometimes	2 (22.22)	30 (19.74)	12 (63.63)	4 (21.05)
• Seldom	2 (22.22)	18 (11.84)	1 (3.03)	1 (5.26)
• Never	5 (55.56)	96 (63.16)	17 (51.52)	8 (42.11)

Fisher's exact tests; n (%)
n= 213, BMI based on pre-pregnancy weight

5.3.4. Dietary behaviour in pregnancy

Diet was assessed on two days in 180 (82.2%) women. The first 24hFL assessment (in person, after the CAPI-pre interview) was approximately evenly spread across weekdays, 47/219 (21.5 %) were conducted on a Monday or Tuesday, 56 (25.6 %) on a Wednesday, and 35 (16 %) and 33 (15 %) on a Thursday or Friday, respectively. The second day assessment (by phone) was predominantly conducted on a Monday (70/180, 38.8 %) in order to facilitate capturing a weekend-day. This proportion should have been higher to match all first day recalls that captured a week-day; but women could not always be reached on the appropriated day. Second day recalls were conducted across all weekdays; 38 (21.1 %) on a Tuesday, 22 (12.2 %) on a Wednesday, 31 (17.2 %) on a Thursday and 19 (10.6 %) on a Friday.

Table 8 shows dietary intake and meal pattern across assessment days. Assessment days did not only differ with regards to day of the week but also in the data collection methods used (in-person or telephone).

To assess whether responses differed across assessment days, i.e. whether an item was more or less likely to be ingested on the first or second assessment day, observations were first treated as unpaired and χ²-test and Fisher's exact tests were run for the categorical (binary) variables. Secondly, the concordance of responses across assessment days was assessed by McNemar's test which treats individual observations as paired.

Assessment day was not significantly associated with most meal or food items, regardless of whether data was treated as un-paired (associations assessed by χ²-test) or paired (concordance by McNemar's test) (Table 8). Based on the Bonferroni correction only p-values of 0.0014 or less were considered significant. Using this value, only the consumption of deli salads differed significantly between assessment days and showed significant inconsistency between individual responses as discordant results were significantly higher than expected by chance alone.

Table 8: Diet characteristics across two assessment days

		Association between day and response [a]			Concordance across days [b]	
		Day 1, n (%)	Day 2, n (%)	p-value	Ratio of proportions (95% CI)	p-value
Meal components	Food intake not 'usual' [c]	44 (20.37)	54 (30.17)	0.025	0.64 (0.44 to 0.93)	0.025
	Breakfast	211 (96.35)	173 (96.11)	0.902	1.00 (0.96 to 1.04)	>0.999
	Second breakfast	50 (22.83)	21 (11.67)	0.004	1.90 (1.26 to 2.87)	0.003
	Lunch	176 (80.37)	150 (83.33)	0.445	0.96 (0.88 to 1.05)	0.461
	Afternoon snack	127 (57.99)	94 (52.22)	0.249	1.11 (0.94 to 1.30)	0.275
	Dinner	206 (94.06)	167 (92.78)	0.604	1.01 (0.96 to 1.06)	0.815
	Late evening snack	33 (15.07)	18 (10.00)	0.131	1.61 (1.00 to 2.60)	0.071
Supplements	Folic acid/folate	147 (67.12)	115 (63.89)	0.498	1.03 (0.96 to 1.12)	0.503
	Iodine	41 (18.72)	42 (23.33)	0.259	0.85 (0.69 to 1.06)	0.238
	Iron	54 (24.66)	47 (26.11)	0.740	0.94 (0.78 to 1.12)	0.629
	Vitamin D	28 (12.79)	27 (15.00)	0.523	0.89 (0.73 to 1.09)	0.453
	DHA/omega 3	22 (10.05)	18 (10.00)	0.988	1.00 (0.73 to 1.36)	>0.999

Table 8: continued

		Association between day and response [a]			Concordance across days [b]	
		Day 1, n (%)	Day 2, n (%)	p-value	Ratio of proportions (95% CI)	p-value
Beverages	Low-calorie	216 (98.63)	180 (100.00)	0.255	0.98 (0.96 to 1.00)	0.25
	Soft drinks	42 (19.18)	31 (17.22)	0.615	1.03 (0.71 to 1.49)	>0.999
	Tea	48 (21.92)	33 (18.33)	0.376	1.24 (0.92 to 1.68)	0.22
	Coffee	105 (47.95)	78 (43.33)	0.358	1.14 (0.99 to 1.31)	0.089
Diet components	Fruit	194 (88.58)	143 (79.44)	0.012	1.10 (1.03 to 1.19)	0.014
	Vegetables	198 (90.41)	153 (85.00)	0.098	1.07 (0.99 to 1.15)	0.08
	Carbohydrates	217 (99.09)	178 (98.89)	>0.999	1.00 (0.98 to 1.02)	>0.999
	Other cereals	111 (50.68)	77 (42.78)	0.115	1.18 (0.99 to 1.40)	0.076
	Dairy products	213 (97.26)	171 (95.00)	0.238	1.02 (0.98 to 1.06)	0.55
	Meat:					
	• Red	37 (16.89)	43 (23.89)	0.083	0.70 (0.48 to 1.02)	0.086
	• Poultry	33 (15.07)	27 (15.00)	0.985	0.96 (0.59 to 1.58)	>0.999

Table 8: continued

	Association between day and response [a]			Concordance across days [b]	
	Day 1, n (%)	Day 2, n (%)	p-value	Ratio of proportions (95% CI)	p-value
• Processed	115 (52.51)	72 (40.00)	0.013	1.22 (1.01 to 1.48)	0.052
Fish	30 (13.70)	19 (10.56)	0.341	1.42 (0.82 to 2.46)	0.27
Legumes	17 (7.76)	15 (8.33)	0.835	0.87 (0.41 to 1.82)	0.85
Nuts	55 (25.11)	38 (21.11)	0.347	1.13 (0.82 to 1.56)	0.54
Eggs	56 (25.57)	44 (24.44)	0.796	1.05 (0.72 to 1.52)	0.91
Oils and fats					
• Vegetable	94 (42.92)	66 (36.67)	0.205	1.20 (0.96 to 1.49)	0.14
• Margarine	47 (21.46)	36 (20.00)	0.720	1.06 (0.84 to 1.32)	0.82
• Butter	126 (57.53)	97 (53.89)	0.466	1.06 (0.93 to 1.21)	0.45
• Other fats	62 (28.31)	54 (30.00)	0.712	0.85 (0.63 to 1.16)	0.37
Sweets and snacks	209 (95.43)	162 (90.00)	0.034	1.05 (1.00 to 1.12)	0.11
Sauces	126 (57.53)	106 (58.89)	0.785	0.94 (0.80 to 1.12)	0.58

Table 8: continued

	Association between day and response [a]			Concordance across days [b]	
	Day 1, n (%)	Day 2, n (%)	p-value	Ratio of proportions (95% CI)	p-value
Soups	12 (5.48)	9 (5.00)	0.831	1.11 (0.45 to 2.73)	>0.999
Deli salads	54 (24.66)	8 (4.44)	**<0.0001**	5.75 (3.01 to 10.97)	**<0.0001**

[a] χ² test and Fisher's exact tests; [b] McNemar's χ²-test,
[c] missing observations n= 216 (day 1) and n= 179 (day 2), all other observations n= 219 (day 1) and n= 180 (day 2)
Bonferroni correction: 0.05/36= 0.0014 → p≤0.0014 considered statistically significant

The majority of women consumed the traditional three main meals: breakfast, lunch and dinner. Just over half had an afternoon snack. Late evening and mid-morning snacks were less commonly consumed.

Folic acid was consumed by over 60% of participants on either day. Folic acid should be used at least until the end of the first trimester (Koletzko *et al.*, 2013). The four participants who were in their first trimester all consumed folic acid on all days recorded. Among women in their second trimester, 76.4 % (55/72) consumed folic acid on the first, and 65.6 % (40/61) on the second assessment day. In the final trimester folic acid use was reported by 61.5 % (88/143) and 62.1 % (72/116) on day one and two, respectively.

Iodine supplementation is recommended throughout pregnancy because it has been estimated that requirements cannot be met by diet and use of iodised salt alone (Koletzko *et al.*, 2013). It is thus disconcerting, that only around 1 in 5 women consumed iodine on either assessment day, particularly considering that this estimate included both iodine taken as single supplement as well as iodine present in multivitamin/-mineral supplements.

Surprisingly, iron consumption was slightly more common than iodine, even though iron supplementation is only recommended upon medical advice (Koletzko *et al.*, 2013). Among women who had anaemia at any stage in the present pregnancy, 53.9 % (35/65) consumed iron supplements on the first and 49.1 % (27/55) on the second day. It is possible that some of the women who did not take iron supplements had had anaemia in the past but did not require supplementation on the assessment day. A small proportion of women without a history of anaemia consumed iron supplements on the first (12.8 %, 19/149) and second (15.7 %, 19/121) day. Iron is present in some multivitamin/-mineral supplements used by participants (see Appendix 3) and may have thus been consumed inadvertently by women without anaemia.

Vitamin D supplementation is recommended for women with dark skin types and/or little exposure to sunlight (Koletzko *et al.*, 2013). As this information is not available in present analysis, it cannot be ascertained whether those women who consumed vitamin D fulfilled these criteria or

whether they took it simply as part of a multivitamin/-mineral preparation (Appendix 3).

Of all supplements recorded, DHA was least commonly consumed. DHA is recommended for women who do not eat oily fish frequently and/or who are vegetarian or vegan (Koletzko *et al.*, 2013). How regularly oily fish was consumed cannot be discerned from the dietary data as it covered two days at most. No participant was vegan, seventeen were vegetarians. Unexpectedly, no vegetarian took DHA supplementation on either assessment day.

In line with recommendations, low-calorie beverages were consumed by almost all women, however soft drinks, which are high in calories, were also consumed by close to 1 in 5 women. Coffee was consumed by close to half of all women. It is recommended that pregnant women limit their caffeine intake (Koletzko *et al.*, 2013). The second, finer, data export from DIfE allowed assessing whether coffee was decaffeinated. However, only 20 women consumed decaffeinated coffee on the first and 11 women on the second day, respectively.

Fruit, processed meats, deli salads and sweets and snacks appeared to be slightly more commonly ingested on the first assessment day but differences between assessment days or discordance within subjects was not significant.

Fruits, vegetables, grains and potatoes ('carbohydrates') were consumed by 80 % of women or more and with reasonable consistency across days and within subjects. Guidelines recommend women consume 'plenty' of fruits, vegetables and grains and potatoes. Consumption of these foods seems in line with guidelines but the consumption quantities are unknown therefore it cannot be discerned whether women consumed plenty or few of those items. The second DIfE data export allowed assessment of the number of different fruits and vegetables consumed. Mean number of fruits consumed was 1.9 (SD 1.4, range 0 to 9) on the first and 1.5 (SD 1.2, range 0 to 5) on the second day. The mean number of vegetables consumed was slightly higher; with a mean of 2.9 (SD 2.2, range 0 to 10) on the first and a mean of 2.5 (SD 1.9, range 0 to 9) on the second day.

HSYF guidelines recommend 'moderate' consumption of dairy products, ideally low-fat types and of lean meat and the consumption of fish twice a week, with one portion being oily fish (Koletzko *et al.*, 2013). With the exception of dairy products, meat, meat products and fish were less frequently consumed than fruits, vegetables and carbohydrates recommended for frequent consumption. However, in the absence of information on consumption size and frequency, it cannot be definitively said whether the protein sources were in fact only consumed moderately. The second DIfE data export allowed assessing whether the recommendations regarding type of recommended protein sources, rather than the frequency of consumption, were adhered to. Low-fat dairy products were consumed by 52 women on the first and 47 on the second day, but in many cases (n= 67 day 1, n= 48, day 2) the fat-content was unknown or not-reported making this a rather rough measurement. Fatty fish was consumed by 15 women on the first and 11 on the second day, but in the absence of dietary intake data beyond the two assessment days it cannot be definitively said that consumption of fatty fish was too infrequent; fatty fish may have been consumed on days not covered by one of the dietary recalls.

Legumes, nuts and eggs are protein sources which were not mentioned specifically in the guidelines but can be considered as the recommended 'meat-free protein sources' suggested by the HSYF Network. Legumes were rarely consumed, but encouragingly nuts and eggs were reported by around a quarter or women. Few participants (n= 17) reported being a vegetarian, but the observation that meat-free protein sources nuts and eggs were more commonly reported than red meat or poultry is an indication that many women, while not completely abstaining from meat, do not eat it daily. This population thus appears to follow the recommendation to eat meat-free protein sources, but again with the caveat that consumption size and frequency are unknown.

Oils, fats and sweets should be consumed sparingly but particularly sweets were an occurrence in most women's diets on both days; but again it cannot be determined whether they were consumed in large or small quantities or portions. Consumption of deli salads varied significantly across assessment days and within participants, however this is likely a

spurious finding considering no other variables differed significantly in the χ^2 or McNemar's test.

5.3.5. Dietary patterns in pregnancy

An exploratory factor analysis of the 24hFL data was conducted on 23 variables with orthogonal (varimax) rotation. As all variables were binary, factor analysis was run off of a tetrachoric correlation matrix using the 'tetrachoric' command in Stata. The variable 'low-calorie beverages' was excluded because there was very low variation in intake, 216 (98.63 %) women consumed low-calorie drinks on the first and all 180 women on the second day.

First, day one data (n= 219) was analysed. The matrix with tetrachoric correlations was found to not be positive semidefinite, it had 4 negative Eigenvalues. A non-positive definite matrix is most likely a sign that there are too many variables but too few cases, or too many highly correlated items in the matrix (Field, 2009). The matrix was adjusted to be positive semidefinite using the 'forcepsd' command, so that the 'factormat' command could perform. The 'forcepsd' command modifies the correlation matrix by setting negative Eigenvalues to zero by reconstructing the correlation matrix to a least-squares positive-semidefinite singular covariance matrix (Stata Press, 2013). After this adjustment, the 'factormat' command could perform and the exploratory factor analysis completed.

At 0.449 the Kaiser-Meyer-Olkin (KMO) measure was below the acceptable limit of 0.5 (Field, 2009). Bartlett's test of sphericity (χ^2 = 362.45, df= 253, p< 0.0001), indicated that correlation was sufficiently large for factor analysis.

The day one analysis identified 10 factors with Eigenvalues above Kaiser's criterion of 1 (Cattell, 1966) and together these 10 factors explained 80.23 % of the variance. To improve interpretation, orthogonal rotation was applied using the 'varimax' command in Stata. Factor loadings of 0.3 or above were considered in interpreting the resulting factors. A scree plot (Figure 13) showed inflexions after the fourth factor, i.e. indicating that the first three factors should be retained (Field, 2009).
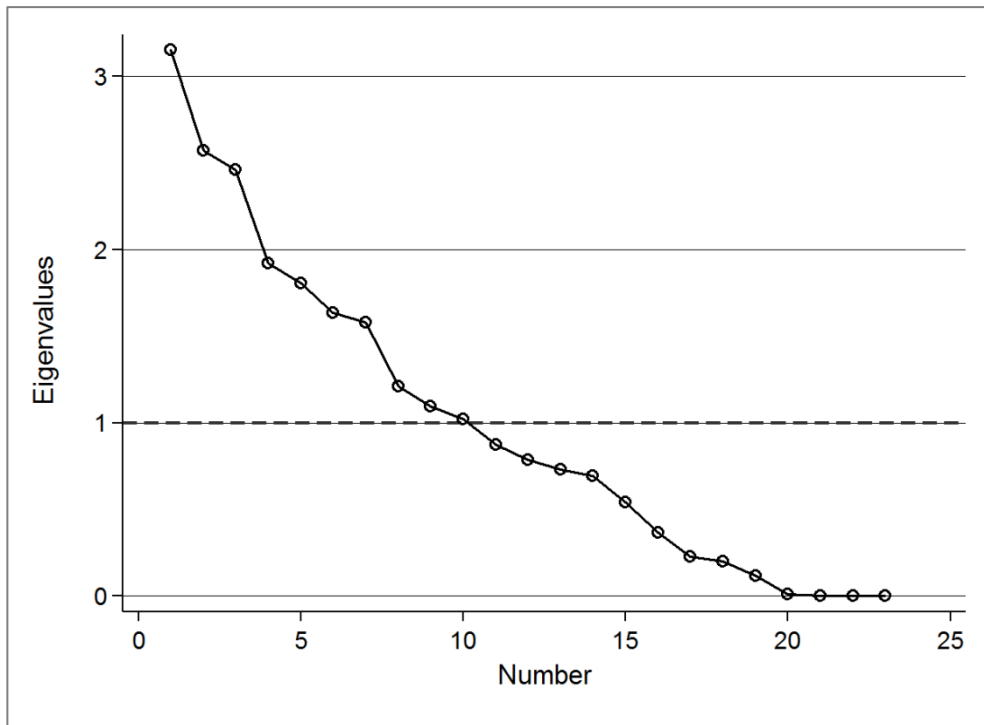
Figure 13: Scree plot of Eigenvalues after EFA, day 1
CAPI-pre participants, first diet recall, n= 219)

In order to assess whether identified patterns were consistent across dietary assessment days, exploratory factor analysis was run again off of the second day data (n= 180). The tetrachoric correlation matrix was not positive semidefinite, it had 5 negative eigenvalues and was adjusted so that the 'factormat' command could run.

The KMO (0.456) was again below the acceptable minimum. Bartlett's test of sphericity (χ^2 =433.89, df= 253, p< 0.0001) again indicated that correlation was sufficiently large for factor analysis. There were 9 factors with an Eigenvalue above 1; together they explained 79.87 % of the total variance. After varimax rotation, the scree plot showed a slight inflexion after the sixth factor and a more pronounced inflection after the 19th factor (Figure 14).

Post-estimation commands were run to check model fit. The 'estat factors' command showed that retention of 14 and 12 factors would be the most appropriate solution yielding the lowest AIC and BIC values for the first and second day data, respectively. Warning messages were issued that all models were Heywood cases in both first and second day recall data.
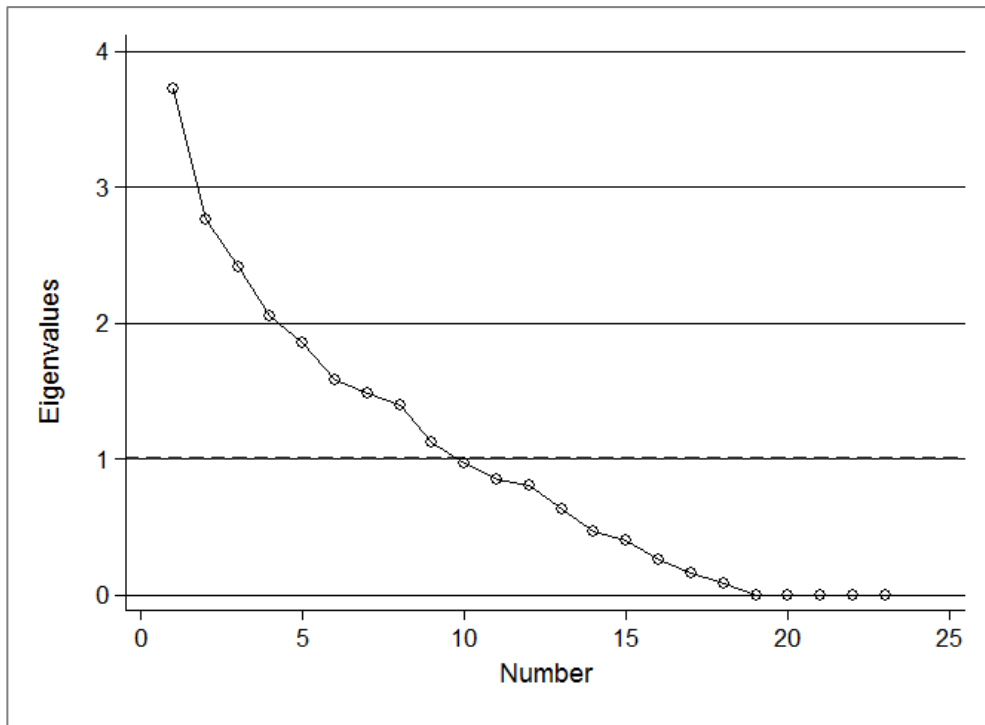
Figure 14: Scree plot of Eigenvalues after EFA, day 2
CAPI-pre participants, second diet recall, n= 180

Rotated factor loadings for the first three factors on both assessment days are presented in Table 9.

Table 9: Factor loadings after varimax rotation, two assessment days

Day	1			2		
KMO	0.449			0.456		
Rotated factor loadings	F 1	F 2	F 3	F 1	F 2	F 3
Vegetables	-0.527		0.601	0.599		0.632
Fruits			0.499			
Carbohydrates	0.869	-0.386		0.741	0.606	
Other cereals	-0.342				-0.314	-0.443
Dairy	0.330	0.628	-0.335	0.699	-0.422	-0.431
Red meat	0.523	0.329		0.427		0.323
Poultry	0.345				-0.505	
Processed meat						
Fish		0.360	0.399	0.386		
Legumes	0.474	0.445	0.362	0.578		-0.402
Vegetable oil			0.501	0.699		
Margarine	0.420	0.450				
Butter		-0.428		0.351		
Other fats	0.339					0.645
Sweets			0.642		-0.489	0.334
Soft drinks	0.539					0.334
Nuts	0.322		0.432	0.597		
Eggs	0.354	-0.351			0.409	
Coffee			0.356	0.421		
Tea			-0.333		0.515	0.302
Sauces					-0.304	0.452
Soups		-0.773		-0.320	0.822	
Deli salad				0.461		
Explained variance of factor (%)	13.70	11.19	10.69	16.19	11.98	10.49

Factor loadings < 0.3 omitted; KMO, Kaise--Meyer-Olkin measure

Factor interpretation is not straightforward. Items with high loading on factor 1 (day 1) were carbohydrates, red meat, legumes, margarine and soft drinks while vegetables showed negative loading. This pattern shares characteristics of the Western diet high in carbohydrates, sugars and animal source foods (Popkin and Gordon-Larsen, 2004) discussed in section 4.3.4., and of the processed dietary pattern in the CANDLE study and fast food pattern in the DIPP study (Table 2). However legumes and nuts do not quite fit, as these are foods recommended as lean protein sources and are part of the healthy dietary pattern seen in the DIPP and ALSPAC studies (Table 2).

Items that loaded high on factor 2 were dairy, legumes, margarine and negative loadings were seen for eggs and soups. As such it can be interpreted as a protein-rich pattern and is similar to the traditional meat pattern that was identified in the DIPP study (Table 2).

Items loading high on the third factor (day 1) were fruits, vegetables, fish, vegetable oil, sweets and nuts, while items loading low were tea and dairy. This factor shares characteristics of health conscious patterns like those identified in the ALSPAC and CANDLE studies. However, the pattern showed high loadings for sweets which are rather a characteristic of confectionary (ALSPAC), processed (CANDLE) and fast food (DIPP) pattern. The first three factors were very dispersed (Figure 15).
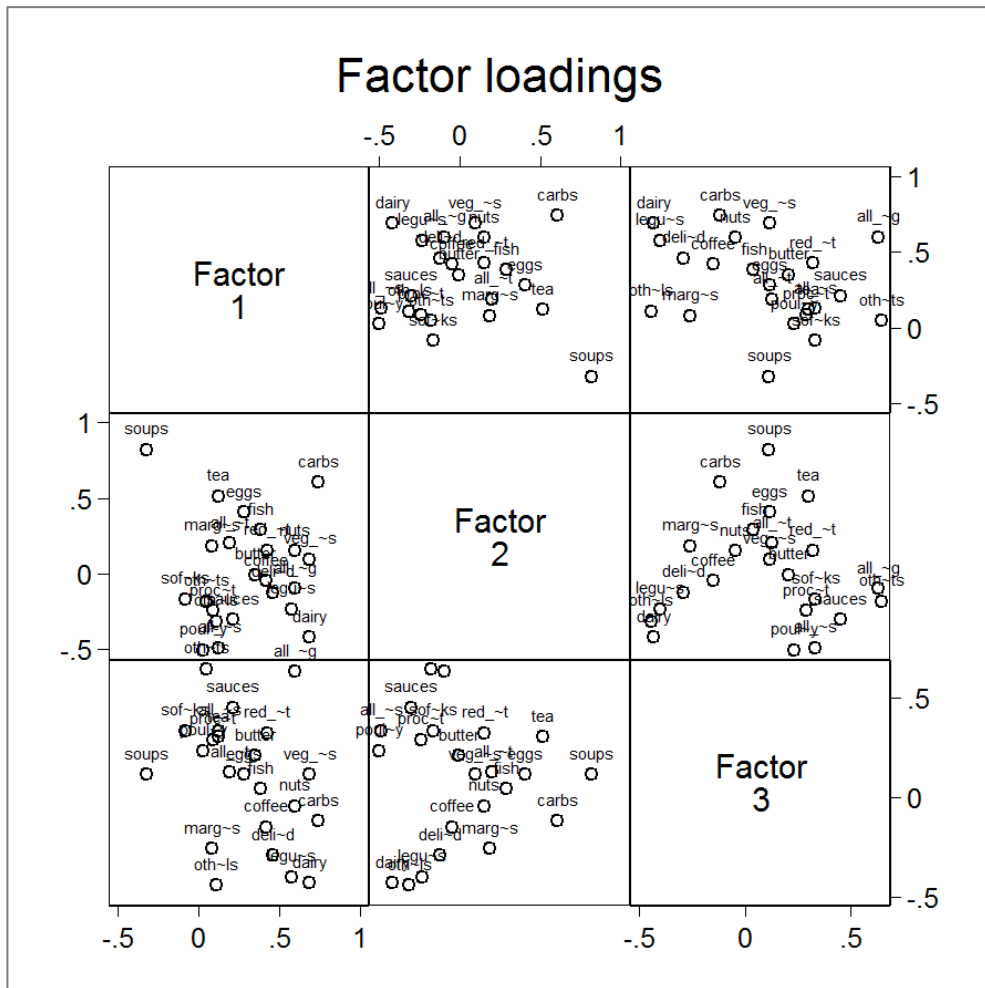
Figure 15: Factor loadings plot of three factors
CAPI-pre participants, first diet recall, n= 219

In the second day data, items loading high on factor 1 were vegetables, carbohydrates, dairy, legumes, vegetable oil and nuts (Table 9). With the exception of the high loading on dairy and carbohydrates, this pattern was similar to the health conscious third pattern seen in the analysis of the first day data.

The second factor showed high loadings for carbohydrates and tea but low loadings for poultry and sweets. This pattern is difficult to interpret; it does not mirror any of the patterns observed in the reviewed studies (Table 2) or on the first day data of the BaBi participants.

Items that loaded high on the final factor were vegetables and other fats and sauces while dairy and legumes showed low loadings. This pattern shared some of the characteristics of the health conscious pattern observed in the first day data, but the loadings for legumes and tea were

the reverse (i.e. previously positive and now negative and vice versa). In addition to sweets, this pattern also loaded high on soft drinks making it difficult to describe this pattern as healthy.

Exploratory factor analyses were repeated using different methods, i.e. principle component analysis (factormat pcf command) and maximum likelihood factoring (factormat ml command), different rotation methods and different numbers of variables, but the results were poorer than those presented here based on KMO value, Scree plot and Kaiser's criterion.

A second data export was provided by DIfE, in which the number of different fruit and vegetables were reported (rather than binary data), dairy products were distinguished into full-fat, low-fat or fat content not reported, and new variables were included for wholegrains, fatty fish and decaffeinated coffee. As the variables in the second export were not all binary anymore, factor analysis was run off of a polychoric correlation matrix thus allowing for categorical and continuous data (UCLA: Statistical Consulting Group, 2016).

The polychoric correlation matrix was not positive semidefinite, it had 5 negative eigenvalues and was adjusted so that the factormat command could run. As with the previous data export, the KMO value (0.451) lay below the acceptable minimum. Bartlett's test of sphericity (χ^2 = 331.79, df= 153, p= 0.000, indicated that correlation was sufficiently large to run factor analysis. A total of 8 factors had an Eigenvalue above 1; together they explained 72.85 % of the total variance. After varimax rotation, the Scree plot showed a slight inflexion after the 14th factor and a more pronounced inflection after the 17th factor (Figure 16).
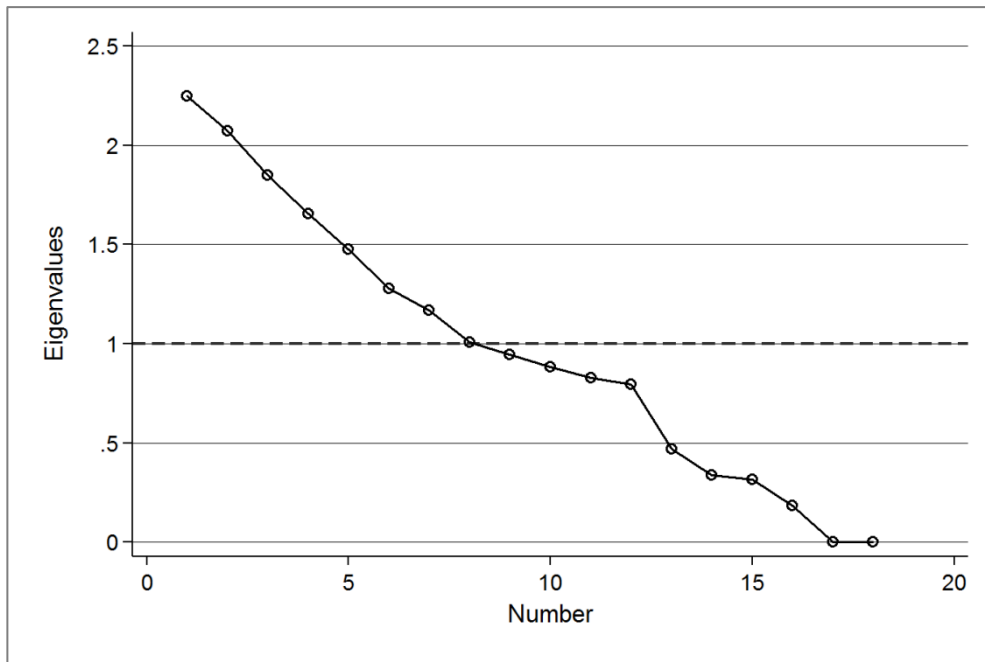
Figure 16: Scree plot of Eigenvalues after EFA, second data export
CAPI-pre participants, first diet recall, n= 219

Post-estimation commands were run to check model fit. The estat factors command showed that retention of 11 factors would be the most appropriate solution yielding the lowest AIC and BIC values. Warning messages were issued that all models were Heywood cases. Stata could not run factor analysis of the second data export second day data due missing values.

As the second data export did not lead to a vast improvement, the decision was made to use the original results presented in Table 9 for further analysis.

In summary, the results of exploratory factor analyses indicate that dietary intake was complex and factor analysis could not provide clarity. The identified patterns only explained between 10 % and 16 % of the total variance among the dietary data. Figure 15 indicates how dispersed the individual foods are; ideally foods should have clustered together indicating the presence of factors.

Therefore the decision was made to use only the third factor of the first day data in further analysis. Based on the foods it loaded highly on and the comparison with similar factors identified in other studies it was named "health conscious pattern". This pattern was the only one that was reflected in the second day data indicating that it was not a spurious finding, and it was the only factor that could be interpreted and fitted in with findings from other studies as indicated by the systematic review in Chapter 4.

The health conscious dietary pattern score was approximately normally distributed (skewness= -0.33, kurtosis= 3.22), the mean score was 0.84 with scores ranging from -0.19 to 1.58. Among participants, 50.2 % (110/219) scored above the mean.

5.3.6. Determinants of dietary patterns in pregnancy

The health conscious pattern score was considered as the outcome variable; higher scores indicated greater adherence to this pattern. The association with pregnancy-related, socio-demographic, environmental and individual response factors was initially assessed in bivariate analyses using one-way analysis of variance (ANOVA); multiple comparisons were performed using Scheffés test. Results are shown in Table 10 and indicate that mean scores varied highly significantly between age groups and significantly between pre-pregnancy weight categories but mean score did not appear to vary significantly by level of parity or education.

Table 10: Health conscious pattern score by maternal characteristics

Category	No.	Mean score	95 % CI	p-value
Maternal age				**<0.0001**
• <25 years	13	0.45	0.24 to 0.67	
• 25 to 34 years	153	0.86	0.80 to 0.91	
• ≥ 35 years	53	0.88	0.80 to 0.96	
Education level				0.38
• Basic	6	0.90	0.51 to 1.29	
• Middle	27	0.76	0.62 to 0.90	
• High	186	0.85	0.80 to 0.89	
Parity				0.44
• Primipara	95	0.86	0.80 to 0.92	
• Multipara	124	0.82	0.76 to 0.89	
Pre-pregnancy BMI category				**0.013**
• Underweight	9	0.54	0.29 to 0.79	
• Normal	152	0.87	0.82 to 0.91	
• Overweight	33	0.84	0.70 to 0.97	
• Obese	19	0.72	0.53 to 0.91	

Results of one-way analysis of variance (ANOVA)
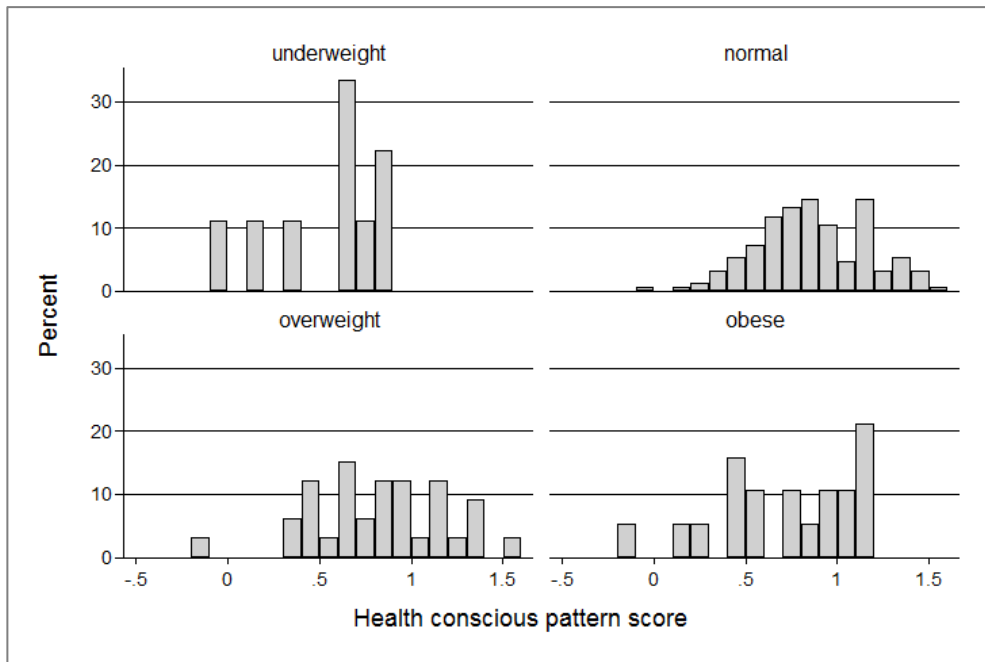
Figure 17: Health conscious pattern adherence score across pre-pregnancy weight categories
CAPI-pre participants, n= 219

Figure 17 indicates that distribution of health conscious dietary pattern adherence score was similar among women who were normal and overweight before pregnancy but was rather asymmetrical in those who were underweight or obese, likely due to the small numbers in the latter category.

Mean adherence score stratified by pre-pregnancy BMI and age categories (Figure 18) appeared to increase with age. Differences between BMI categories were less pronounced.
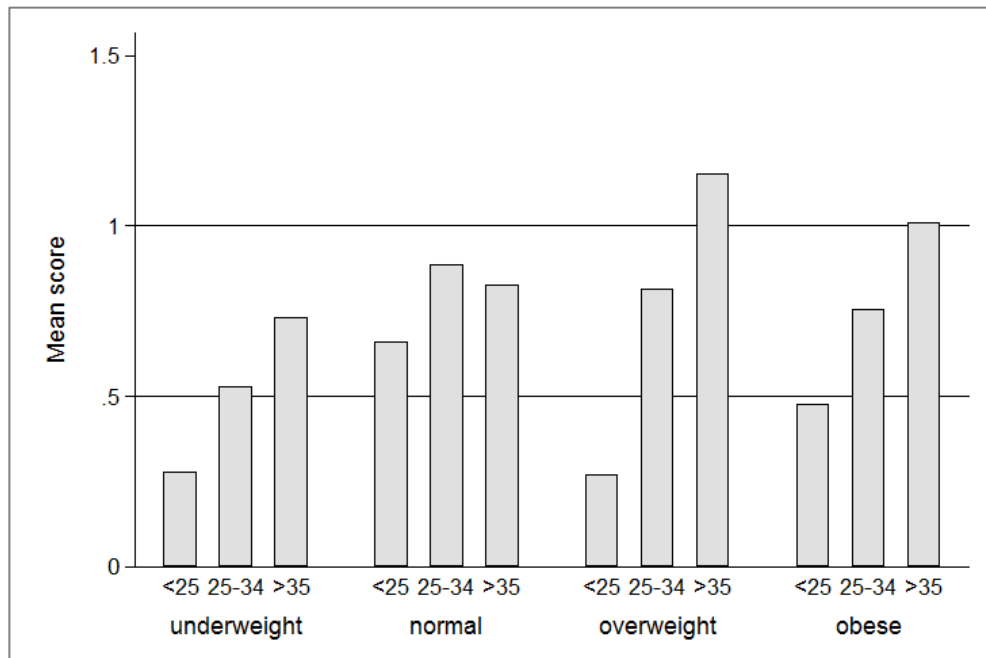
Figure 18: Mean health conscious pattern adherence score across pre-pregnancy weight and age categories
CAPI-pre participants, n= 219

Independent associations with the pattern score were then examined in multiple regression analysis (Table 11).

Table 11: Determinants of health conscious dietary pattern score, multiple regression models

	Model 1			Model 2			Model 3		
	Regression coefficient	95 % C.I.	p-value	Regression coefficient	95 % C.I.	p-value	Regression coefficient	95 % C.I.	p-value
Age category (years)			**0.0008**			**0.002**			**0.0003**
• <25 years	0			0			0		
• 25 to 34 years	0.37	0.15 to 0.59		0.34	0.13 to 0.55		0.37	0.19 to 0.56	
• ≥ 35 years	0.47	0.23 to 0.71		0.42	0.19 to 0.65		0.41	0.21 to 0.61	
Education level			0.12						
• Low	0								
• Middle	-0.30	-0.59 to -0.01							
• High	-0.28	-0.56 to -0.01							

Table 11: continued

	Model 1			Model 2			Model 3		
	Regression coefficient	95 % C.I.	p-value	Regression coefficient	95 % C.I.	p-value	Regression coefficient	95 % C.I.	p-value
Net household income (€/month)			0.41			0.36			
• <1500	0			0					
• 1500 to 2999	0.10	-0.08 to 0.28		0.08	-0.10 to 0.26				
• 3000 to 4499	0.06	-0.11 to 0.24		0.04	-0.14 to 0.22				
• 4500+	-0.004	-0.20 to 0.19		-0.02	-0.21 to 0.18				
• Not reported	-0.03	-0.23 to 0.17		-0.07	-0.27 to 0.13				
Perceived migration background	-0.04	-0.18 to 0.10	0.59	-0.06	-0.20 to 0.80	0.41			
Primipara	0.07	-0.02 to 0.17	0.13						

Table 11: continued

	Model 1			Model 2			Model 3		
	Regression coefficient	95 % C.I.	p-value	Regression coefficient	95 % C.I.	p-value	Regression coefficient	95 % C.I.	p-value
Rather planned pregnancy	0.09	-0.05 to 0.22	0.22	0.06	-0.08 to 0.20	0.40	0.13	0.008 to 0.25	**0.037**
Conception duration			0.21			0.29			
• I wasn't trying	0			0					
• < 6mts.	0.10	-0.02 to 0.21		0.09	-0.02 to 0.21				
• 6 to 12 mts. trying	-0.04	-0.17 to 0.10		-0.02	-0.16 to 0.12				
• 1 year or more	-0.02	-0.18 to 0.15		0.002	-0.16 to 0.16				
Nausea	0.05	-0.06 to 0.16	0.35	0.05	-0.06 to 0.17	0.34			
Vomit	0.02	-0.08 to 0.13	0.66	0.02	-0.09 to 0.13	0.73			

Table 11: continued

	Model 1			Model 2			Model 3		
	Regression coefficient	95 % C.I.	p-value	Regression coefficient	95 % C.I.	p-value	Regression coefficient	95 % C.I.	p-value
Cravings	-0.03	-0.12 to 0.06	0.54	-0.03	-0.12 to 0.06	0.54			
Anaemia	-0.11	-0.21 to -0.02	**0.02**	-0.11	-0.21 to -0.02	**0.02**			
Pre-pregnancy BMI category			0.50			0.69			0.22
• Underweight	-0.17	-0.41 to 0.06		-0.14	-0.38 to 0.09		-0.23	-0.46 to -0.002	
• Normal	0			0			0		
• Overweight	0.02	-0.11 to 0.15		0.005	-0.12 to 0.13		0.012	-0.11 to 0.13	
• Obese	-0.01	-0.18 to 0.17		-0.009	-0.18 to 0.16		-0.05	-0.21 to 0.10	
Regular physical activity 3mts before pregnancy	0.13	0.03 to 0.23	**0.009**	0.13	0.03 to 0.23	**0.01**			

Table 11: continued

	Model 1			Model 2			Model 3		
	Regression coefficient	**95 % C.I.**	**p-value**	**Regression coefficient**	**95 % C.I.**	**p-value**	**Regression coefficient**	**95 % C.I.**	**p-value**
Number of people I can rely on for help			0.27			0.19			0.16
• Nobody	0.002	-0.67 to 0.68		-0.07	-0.74 to 0.59		-0.30	-0.94 to 0.36	
• 1 to 2	0			0			0		
• 3 to 5	-0.03	-0.22 to 0.16		-0.04	-0.23 to 0.15		-0.06	-0.24 to 0.12	
• > 5	-0.11	-0.30 to 0.10		-0.13	-0.32 to 0.74		-0.14	-0.32 to 0.06	
Number of observations	204			204			211		
AIC/BIC	113.98/200.25			115.65/191.96			116.85/150.37		

0= reference category; AIC, Akaike's Informaiton Criterium; BIC, Bayesian Information Criterium

All models were as a whole statistically significant as indicated by their overall p-values. The first (largest) model fitted best based on the AIC value, the third model fitted best based on the BIC value, but the differences were minimal, indicating that all models performed similarly well (Table 11). Based on the R^2 value, the first model explained 28.08 %, the second model 25.33 % and the third model 15.40 % of variance of the health conscious pattern score.

As seen in bivariate analysis, age was significantly associated with mean dietary pattern score in all three models. Mean pattern score increased as age category increased.

Also reflecting results of the bivariate analysis, no significant differences in mean pattern score were seen between the different education levels. Mean pattern score appeared to be lower in women with middle and higher education level which is conflicting all previous literature reviewed.

Net household income did not have a significant overall effect on mean health conscious dietary pattern score. Similar to education level, mean scores appeared to be lower in the higher income groups which is in conflict with studies reviewed (Chapter 4) and the theoretical foundations (Chapter 3) that suggest that healthier diets generally cost more and adequate diets are consequently more commonly achieved by those with higher incomes.

When adjusting for all other variables in the model, women with a perceived migration background appeared to have lower and primiparae higher mean dietary pattern scores, but findings were not significant.

A 'rather planned' pregnancy was associated with higher mean pattern score, albeit only significantly in the final and smallest model that adjusted for age, pre-pregnancy weight and size of the social network. Yet the duration needed to conceive (which is also an indicator of pregnancy intendedness and could indicated heightened health consciousness if duration is long) did not appear to influence pattern score.

Unexpectedly, nausea and vomiting were associated with increased mean health conscious pattern adherence, but this was not significant and the confidence intervals indicate that the true coefficients could be negative,

which would be more in line with the expectation that these pregnancy-related symptoms would impair, rather than improve, diet in pregnancy. As suspected, cravings appeared to decrease pattern adherence score, albeit not significantly.

A further pregnancy-related determinant was anaemia which was hypothesised to be a potential marker of either habitual inadequate dietary intake or a medical diagnosis leading to dietary advice and thus potentially to improved dietary intake. Findings from both model 1 and 2 support the former, i.e. lower dietary pattern scores were seen in women with anaemia.

Pre-pregnancy BMI category was significantly associated with dietary pattern score in bivariate analysis but was not significant in any of the adjusted models. This indicates that the bivariate findings could have been subject to confounding.

In line with findings from the wider literature, women who were regularly physically active before pregnancy had higher adherence to a health conscious pattern as indicated by higher mean scores. The association was significant when mutually adjusting for all factors included in the first and second model.

Social support has been associated with improved diets in the literature. It was thus unexpected that mean guideline pattern scores appeared to decrease as the size of participants' social networks increased. The lack of overall significance and the wide confidence intervals within each category indicate that there was no clear association between social network and dietary pattern adherence. This may be an indication of a true lack of association or of a complex, non-linear relationship.

5.3.7. Guideline adherence in pregnancy

The German HSYF guidelines (Table 3) cannot fully be represented by the dietary data since the guidelines are focused on amounts eaten, i.e. foods are grouped into those that women should consume abundantly, moderately or sparingly. Derivation of the scores has been explained in the methods section (5.2.4.).

Table 12: Overview of guideline adherence score

Component	Maximum score	n (%) meeting recommendation
Low-calorie beverage	1	216 (98.6)
≥5 fruit and vegetables	1	110 (50.2)
Wholegrain carbohydrates	1	93 (42.5)
Low-fat dairy	1	52 (30.1)
Lean protein sources	1	89 (40.6)
Oily fish or DHA supplement	1	36 (16.4)
Vegetable oil	1	94 (42.9)
Total guideline score	**7**	**2 (0.91)**

CAPI-pre participants, first day diet recall, n= 219

Table 12 shows the individual guidelines upon which the total guideline adherence score is based. Most women consumed low-calorie beverages and half of them consumed at least five different types of fruit and vegetables. Fewer achieved the guidelines for wholegrains, low-fat dairy and lean protein sources. Assessment of the individual foods consumed (Table 8) has shown that meat consumption was low among the participants. It is thus possible that women who did not consume lean protein sources have consumed soya or other meat substitutes which were not captured in the score, or they may have consumed red or processed meat instead. Consumption of oily fish or a DHA supplement was the recommendation most seldom met in this sample.
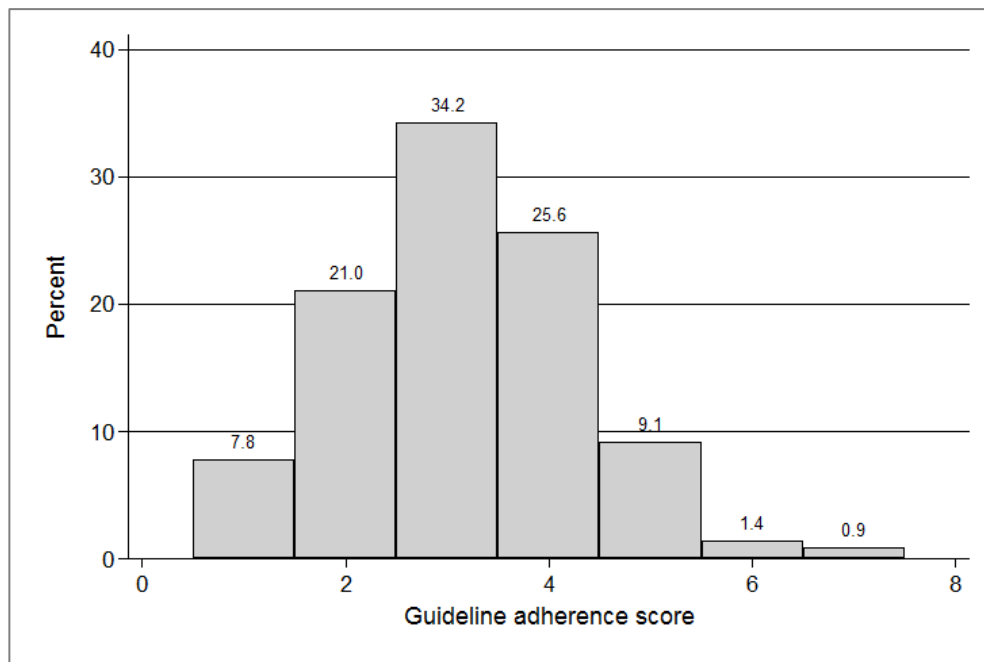
Figure 19: Distribution of guideline adherence score
CAPI-pre participants, first diet recall, n= 219

Guideline adherence score ranged from 1 to 7 (Figure 19). Women most commonly achieved two to four points. When diving the score into quartiles, 40.0 % (81/219) of women scored above the median of 3.

Overall, guideline adherence score was approximately normally distributed (skewness= 0.3, kurtosis= 3.2), this was supported by non-significant Shapiro-Wilk W test for normal data and Skewness and kurtosis normality test. However, score was an ordinal rather than continuous variable, in this case the use of non-parametric tests is recommended (Peacock and Kerry, 2007).

5.3.8. Determinants of guideline adherence

The literature identified age and education as the strongest determinants of diet in pregnancy. Parity and pre-pregnancy weight were important pregnancy-related and individual response factors, respectively. The median guideline adherence score differed significantly between age, education and pre-pregnancy BMI categories, but not between primiparae and multiparae (Table 13).

Table 13: Guideline adherence score by maternal characteristics

Category	No.	Median score	Interquartile range	p-value
Maternal age				**0.031**
• <25 years	13	2	2 to 3	
• 25 to 34 years	153	3	2 to 4	
• ≥ 35 years	53	3	2 to 4	
Education level				**0.046**
• Basic	6	2	1 to 3	
• Middle	27	3	3 to 4	
• High	186	3	2 to 4	
Parity				0.93
• Primipara	95	3	3 to 4	
• Multipara	124	3	2 to 4	
Pre-pregnancy BMI category				**0.022**
• Underweight	9	2	2 to 3	
• Normal	152	3	2 to 4	
• Overweight	33	3	2 to 4	
• Obese	19	3	2 to 3	

CAPI-pre participants, first diet recall, n= 219;
Mann-Whitney U Test (equivalent to Wilcoxon rank sum test) where independent variables ≤2 categories, otherwise Kruskal-Wallis test

Figure 20 shows the median guideline adherence score across weight and age categories. Median score appeared to increase with age in all but the overweight. Women who were underweight before pregnancy appeared to have the lowest median scores; this may be an indication that they ate less overall, resulting in lower scores, or might be an artefact because this was a small group.
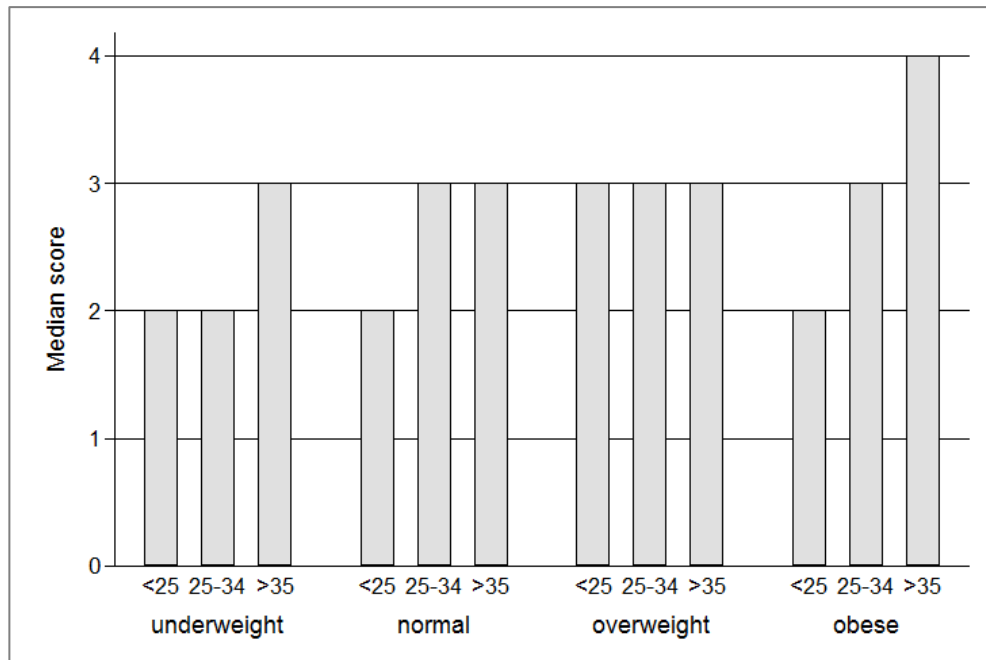
Figure 20: Median guideline adherence score by pre-pregnancy weight and age
CAPI-pre participants, first diet recall, n= 219

Three models were fitted using ordered logistic regression (Table 14). The first model included the most relevant determinants identified in the systematic review (maternal age, education, household income, parity, pre-pregnancy weight and physical activity and social network), as well as determinants that have been identified as important in the conceptual framework (migration background, pregnancy intendedness measured by 'rather planned' pregnancy and conception duration, nausea, vomiting and cravings as physical symptoms of pregnancy, anaemia as a potential marker of both poor diet and a condition potentially leading to diet consultation/advice).

In the second model, parity was omitted because it was not significant in bivariate analysis (Table 14).

The third model was the smallest, it only included one variable for each category of the framework that was deemed most important based on the reviewed evidence: age (socio-demographic), pregnancy "planned-ness" (pregnancy-related), pre-pregnancy weight category (individual response) and social network (social environment).

Table 14: Determinants of guideline adherence score, ordered logistic regression models

	Model 1			Model 2			Model 3		
	Odds ratio	95 % C.I.	p-value	Odds ratio	95 % C.I.	p-value	Odds ratio	95 % C.I.	p-value
Age category (years)			0.20			0.13			0.051
• <25 years	1			1			1		
• 25 to 34 years	2.07	0.54 to 7.87		2.14	0.57 to 8.10		3.44	1.17 to 10.15	
• ≥ 35 years	3.37	0.77 to 14.79		3.63	0.86 to 15.32		4.26	1.31 to 13.78	
Education level			0.25			0.23			
• Low	1			1					
• Middle	4.05	0.59 to 27.86		4.16	0.61 to 28.46				
• High	2.34	0.36 to 15.10		2.36	0.37 to 15.20				

Table 14: continued

	Model 1			Model 2			Model 3		
	Odds ratio	95 % C.I.	p-value	Odds ratio	95 % C.I.	p-value	Odds ratio	95 % C.I.	p-value
Net household income (€/month)			0.18			0.19			
• <1500	1			1					
• 1500 to 2999	0.60	0.20 to 1.80		0.63	0.21 to 1.85				
• 3000 to 4499	0.53	0.19 to 1.51		0.55	0.19 to 1.54				
• 4500+	0.93	0.29 to 2.96		0.93	0.29 to 2.97				
• Not reported	0.30	0.09 to 0.99		0.32	0.10 to 1.02				
Perceived migration background	0.74	0.31 to 1.76	0.50	0.76	0.32 to 1.79	0.53			
Primipara	0.88	0.49 to 1.57	0.63						

Table 14: continued

	Model 1			Model 2			Model 3		
	Odds ratio	95 % C.I.	p-value	Odds ratio	95 % C.I.	p-value	Odds ratio	95 % C.I.	p-value
Rather planned pregnancy	3.47	1.41 to 8.56	**0.007**	3.47	1.40 to 8.55	**0.007**	4.45	2. 09 to 9.47	**<0.0001**
Conception duration			**0.002**			**0.0014**			
• I wasn't trying	1			1					
• < 6mts.	2.52	1.26 to 5.10		2.50	1.25 to 5.02				
• 6 to 12 mts. trying	0.83	0.36 to 1.91		0.80	0.35 to 1.85				
• 1 year or more	0.42	0.16 to 1.14		0.41	0.15 to 1.09				
Nausea	0.49	0.25 to 0.97	**0.041**	0.50	0.25 to 0.98	**0.044**			
Vomit	1.63	0.84 to 3.16	0.15	1.62	0.84 to 3.13	0.15			

Table 14: continued

	Model 1			Model 2			Model 3		
	Odds ratio	95 % C.I.	p-value	Odds ratio	95 % C.I.	p-value	Odds ratio	95 % C.I.	p-value
Cravings	0.85	0.49 to 1.47	0.56	0.86	0.49 to 1.49	0.58			
Anaemia	0.69	0.38 to 1.24	0.22	0.70	0.39 to 1.25	0.23			
Pre-pregnancy BMI category			0.14			0.13			0.22
• Underweight	0.25	0.06 to 1.01		0.25	0.06 to 1.00		0.24	0.06 to 0.91	
• Normal	1			1			1		
• Overweight	0.68	0.30 to 1.53		0.69	0.31 to 1.55		0.90	0.45 to 1.81	
• Obese	1.50	0.55 to 4.08		1.54	0.57 to 4.16		0.86	0.36 to 2.05	
Regular physical activity 3mts before pregnancy	3.23	1.78 to 5.88	**<0.0001**	3.22	1.77 to 5.85	**<0.0001**			

Table 14: continued

	Model 1			Model 2			Model 3		
	Odds ratio	95 % C.I.	p-value	Odds ratio	95 % C.I.	p-value	Odds ratio	95 % C.I.	p-value
Number of people I can rely on for help			0.39			0.37			0.39
• Nobody	0.54	0.02 to 20.50		0.53	0.01 to 20.34		1.03	0.04 to 26.29	
• 1 to 2	1			1			1		
• 3 to 5	0.36	0.11 to 1.12		0.35	0.11 to 1.15		0.41	0.14 to 1.19	
• > 5	0.44	0.14 to 1.43		0.43	0.13 to 1.40		0.51	0.18 to 1.45	
Number of observations	204			204			211		
AIC/BIC	632.59/735.46			630.79/730.33			659.73/710.01		

1= reference category; AIC, Akaike's Informaiton Criterium; BIC, Bayesian Information Criterium

All three models were as a whole statistically significant as indicated by their p-value of the likelihood ratio χ^2 test. The second model fitted best based on the AIC while the third model fitted best based on the BIC value, but the differences were small indicating that the fit was comparable among all three models.

The proportional odds ratio of high guideline adherence score was higher in the older age categories, albeit only significant in the third and smallest model, which could indicate the presence of confounding in the third model or of overfitting in the first two models.

Unlike in bivariate analysis, education was not significant in multiple regression analysis, which indicates the presence of confounding or overfitting. The odds of high score appeared lowest in the most educated women, which is in conflict with all previous literature reviewed. The confidence intervals and p-value were large indicating that this could be a spurious finding.

The chance of having a high guideline adherence score did not appear to differ depending on women's household income, perceived migration background or parity.

Women who had a rather planned pregnancy had 3.4 to 4.4 times the odds of achieving a high guideline adherence score compared to those who had a rather unplanned pregnancy, given that all other variables in the model were held constant. Similarly, the duration needed to conceive emerge as a significant determinant; women who needed less than 6 months to conceive had twice the odds of achieving high scores compared to those who were not trying to conceive. Longer conception duration had been hypothesised to lead to more worry and health concern resulting in greater adherence to guidelines. Instead, the odds of high guideline adherence appeared to be lower in the groups with longer conception duration. This may be an indication of reverse causality, i.e. habitually consuming a low-quality diet may impair ability to conceive. Since the confidence intervals are large and crossing 1.0, the observation may have occurred by chance.

The chance of exhibiting high guideline adherence was lower in women who reported nausea, but other pregnancy-related symptoms (cravings, and vomiting) did not appear to be associated with guideline adherence

score. Anaemia had been included in the model because it was hypothesised that it could either be a marker of habitual inadequate dietary intake or of a medical diagnosis leading to dietary advice and thus potentially leading to improved dietary intake. Both models in which anaemia was included did not support that it was a determinant of guideline adherence.

Pre-pregnancy BMI category was significantly associated with guideline adherence score in bivariate analysis, but not in the three models indicating that the bivariate relationship could have been due to confounding.

As established in the literature, women who were physically activity before pregnancy more likely scored high on the guideline adherence scale.

It was unexpected, that the odds of achieving a high guideline adherence score were lower in those with the greatest number of people to rely on, albeit not significant in any model. The literature has associated social support with better, rather than poorer, diet in pregnancy. It is possible that the number of people one can rely on is too crude a measure of social support and it is the quality, rather than quantity of support from others that counts. The lack of significance and the direction of the association should thus be interpreted with caution and may be a spurious finding.

5.4. Summary of empirical analysis

This chapter has shown that BaBi study participants were largely informed and knowledgeable about diet in pregnancy, but information provision in antenatal care and correct knowledge of the nutrition and weight gain recommendation differed in subgroups of women. Pre-conceptual folic acid use is recommended in Germany. It is important for practitioners to know that the chance of this is lower among less educated women and those whose pregnancy was rather unplanned. The latter issue cannot easily be overcome. However, women with lower education could potentially benefit from taking the time in antenatal care and beforehand to explain guidelines regarding pre-conceptional folic acid use, diet and weight gain.

CAPI-pre participants' anthropometric measures were approximately normally distributed and correlated with partners' measures. Research had indicated that body image ideals may be relaxed during pregnancy, findings from the CAPI-pre participants showed that 40% worried about not being able to lose pregnancy weight and close to 10 % were constantly dissatisfied with their body shape and size in pregnancy.

Dietary intake (CAPI-pre) was largely in line with recommendations for pregnancy except for a low proportion reporting intake of iodine, of DHA supplements/oily fish and potentially high proportion with daily consumption of soft drinks and sweets, which cannot be conclusively assessed with binary consumption data. A health conscious dietary pattern score and a HSYF guideline adherence score were derived; both should be interpreted with caution given that it was only known whether items were consumed but not consumption size or frequency. Despite some methodological shortcomings, the association with a range of socio-demographic, pregnancy-related, individual response factors and one environmental marker could be assessed. In line with findings from the systematic review, diet appeared to be more health conscious or in greater agreement with guidelines in older women and those who were regularly physically active before pregnancy. It was unexpected that education and household income were not associated with diet; this may be a reflection of a homogeneous sample rather than a lack of association. The relationship between several pregnancy-related factors and dietary pattern/guideline score differed and should be investigated in later BaBi analyses with a greater sample.

6. Discussion

Diet in pregnancy is important for short and long-term maternal and child health. Under life course theory, pregnancy is a critical period that shapes health trajectories of mothers and their offspring. Dietary intake is very complex and therefore difficult to measure. The relatively new concepts of dietary patterns and diet quality (including guideline adherence) aim to simplify the complexity by representing diet as a scores or patterns defined *a priori* or derived from dietary intake data (*a posteriori*); both concepts have been associated with maternal and child outcomes.

Research indicates that even in developed countries, where food is (theoretically) abundant, 'healthy' dietary patterns or high quality diets are not consumed by all pregnant women. It is thus of public health relevance to study the factors that determine the type of diet women consume in pregnancy in order to identify at-risk groups and relevant starting points for public health policies and programmes. Theoretical and empirical literature describes the determinants of diet as multi-facetted and complex, yet the relatively young scientific discipline of nutrition has been slow to study these determinants and has been particularly weak in using theories that reach beyond individual cognitive and behavioural factors.

This dissertation aimed to identify the determinants of diet in pregnancy in developed settings. In order to achieve the aim and answer the research questions a conceptual framework was developed based on theoretical and empirical evidence. Its fit was tested using a systematic review (Chapter 4 – research question 1.a: determinants of diet in developed countries). The framework was then applied to empirical data from the BaBi study (Chapter 5 – research question 1.b: determinants of diet among BaBi participants).

The second research question aimed to assess the relationship among the determinants by refining the 'coarse' conceptual framework into a 'finer' explanatory model that could disentangle the interplay of the different determinants. The review of the literature (Chapters 3 and 4 – research question 2.a: evidence from the literature) as well as application to BaBi data (Chapter 5 – research question 2.b: proof of concept/construction and test of final explanatory model) only allowed to partially answer the second

research question. The explanatory model remains to be adapted further. This may be possible with later analyses using the final, then larger, BaBi sample, or with data from other studies.

6.1. Determinants of diet in pregnancy – evidence from developed countries

The systematic review of observational studies from developed countries (Chapter 4) showed that socio-demographic and individual response determinants were most commonly studied but the categories of pregnancy-related and environmental determinants were lagging behind. The reviewed studies identified both a social and a 'behavioural' gradient, i.e. women of higher social status (e.g. higher education, income, and social class) and who exhibited other health protective behaviours (e.g. regular physical activity, not smoking, or using recommended supplements) also displayed more adequate dietary patterns or greater diet quality. Women who are young, less educated, and less affluent or show health risk behaviours were identified as risk groups for inadequate diet in pregnancy (Doyle *et al.*, 2016). Psychological determinants emerged as a new group of determinants that should be added to the conceptual framework (Doyle *et al.*, 2016).

The concept of dietary quality was mainly applied in studies from North America, meaning that findings on the determinants of dietary quality in pregnancy may not necessarily apply across to other continents. Dietary patterns appear context specific, i.e. they vary in their components and in their interpretation depending on country or region (Doyle *et al.*, 2016).

Among reviewed studies, 'healthy' or 'health conscious' dietary patterns commonly explained the highest total variance of all patterns identified (Section 4.4.), evidence on the existence of healthy patterns thus appears consistent. However, at 15% or less the explained total variance should still be considered low and indicates that factor analysis could not fully explain underlying dimensions in the data.

6.2. Determinants of diet in pregnancy – evidence from empirical analysis

Analysis of dietary intake of CAPI-pre participants showed that the consumption of individual foods and food groups was largely in line with recommendations and there was a high degree of concordance of dietary behaviour across the two assessment days. The consumption of sweets and snacks, of sugary beverages and of some supplements appeared to deviate from recommendations.

A health conscious dietary pattern score was derived *a posteriori* and a guideline adherence score was developed *a priori*. Both scores were associated with maternal age and regular physical activity before pregnancy. The association with pregnancy-related determinants differed between the two scores. Only one environmental determinant, a marker of social support network, was included but not associated with either score.

Diet assessment was only available for CAPI-pre participants. As these were a highly selective group of women, nutrition related concepts were explored using all BaBi participants (CAPI-pre and CAPI-post), which allowed for a larger and more diverse sample. Findings indicate that a large proportion receive nutrition related information in antenatal care and perceive themselves to have adequate knowledge. However, information provision and objectively measured knowledge differed depending on women's parity, age and education level.

The analysis also allowed important observations regarding dietary assessment in pregnancy and identified areas for further research as well as recommendations for research, practice and policy.

6.2.1. Nutrition knowledge and practices

Dietary recalls were only conducted by CAPI-pre participants. However, a range of questions on nutrition knowledge and practices were included in the baseline interview by both CAPI-pre and CAPI-post participants allowing for a larger and more heterogeneous sample.

Overall, knowledge of diet in pregnancy and recommended weight gain

was high. Encouragingly, the majority of women reported having received nutrition and weight gain advice in pregnancy. This is consistent with some studies (Whitaker *et al.*, 2016a; Lewallen, 2004) but in conflict with a recent systematic review of studies from developed countries which found that pregnant women were not receiving adequate nutrition advice (Lucas *et al.*, 2014). It is likely that information provision differs between setting (e.g. countries, type of antenatal care provided or local guidelines).

Among BaBi-participants, whether information was supplied in antenatal care appeared to differ depending on women's characteristics. Primiparae more commonly received information about diet in pregnancy than women who already had children. Over 90 % of primiparae aged 35 or older received information, but the proportion was lower in the younger age groups. This is an indication that among participants, practitioners have offered information predominantly to at-risk groups like older primiparae and those they presume have not received such information before (i.e. in a previous pregnancy). It is also possible that information was provided more commonly to those who have demanded information.

Differences in antenatal nutrition information provision have also been observed in other studies. Differences have been reported between women of different parity, race, education level, perceived health status, pre-pregnancy BMI (Whitaker *et al.*, 2016b), income level and using different types of antenatal care centre (Fowles, 2002). Furthermore, pregnant women have reported that the advice they received about gestational diet and weight gain was too short and not personalised enough (Brown and Avery, 2012; Ferrari *et al.*, 2013) and was only provided when medical complications occurred (Smedley *et al.*, 2013). A systematic review of qualitative and quantitative studies also reported that participants in included studies commonly found diet information in antenatal care was overwhelming or provided too late, i.e. after the first trimester (Lucas *et al.*, 2014).

Antenatal care providers reiterate this by citing time constraints and worry that the topic may be sensitive or not well understood by their patient (e.g. due to low education level, language or cultural barriers) as obstacles to providing nutrition and weight gain advice (Whitaker *et al.*, 2016a). Providers also reported being hesitant of discussing diet and weight gain

with overweight and obese women for fear of offending they reported waiting until the woman initiated a conversation about weight gain and otherwise only gave vague or very general information (Stengel *et al.*, 2012).

However, language or cultural barriers were unlikely barriers in this group as most participants were German. Information provision did not differ between the pre-pregnancy weight groups either. This is in line with other research (Brown and Avery, 2012) and also indicates that 'fear of offending' was not an issue for BaBi participants' providers. It should be further investigated whether time limits are a barrier to providing information about diet and weight gain to pregnant women in Germany. This is particularly relevant given that women cite brief and incomprehensible information as barriers to implementing advice (Lucas *et al.*, 2014). The quality of the consultation has been found to also be important; when women perceive nutrition and weight gain advice to be unhelpful they are less likely to follow it (Whitaker *et al.*, 2016a), whereas receipt of meaningful and detailed advice was associated with women intending to follow the advice given (Whitaker *et al.*, 2016b).

To assess whether information was not just received but also understood, subjective and objective knowledge was assessed among BaBi participants. Based on reviewed literature, it was anticipated that knowledge would vary depending on women's characteristics (e.g. education level) and setting (e.g. information provision in antenatal care) (Fowles, 2002). The comparison of subjective and objective knowledge of gestational nutrition and weight gain showed that women of low and middle education tended to overestimate their knowledge level. This could become problematic if nutrition information was offered but declined as a woman does not perceive herself in need of more information. However, the findings could be spurious since the proportion of women with low and middle education level was rather small.

Findings from the empirical analysis fit with other German studies. Qualitative interviews with women in their final trimester in Munich showed that knowledge of gestational weight gain and of diet in pregnancy was limited. Even women who considered themselves knowledgeable about nutrition described practices which were in conflict with recommendations

(Nehring *et al.*, 2015). A potential explanation may lie with the provision of antenatal care in Germany. Differences in the use of prenatal care, particularly by maternal social and educational status, have been observed in Germany, despite this service generally being free and accessible to all (Simoes *et al.*, 2009). It is therefore possible that BaBi participants with greater objective knowledge had also used different or more sources of antenatal care such as a gynaecologist, a midwife and antenatal classes. It is also plausible that women with higher education are more able to 'fill in the gaps' left in antenatal care by researching relevant information, e.g. using the internet or books. Providers reportedly find it easier to counsel women on nutrition and weight gain who have higher education levels and express an interest in these topics (Whitaker *et al.*, 2016a). Nehring *et al.* (2015) identified four types of women in their qualitative analysis; informed women who do not put knowledge into practice, women with strict guideline adherence, women following their feeling/what their body tells them and women who were mostly indifferent (Nehring *et al.*, 2015). This indicates that in Germany, factors beyond knowledge and information influence whether women follow dietary guidance.

Using the combined CAPI-pre and CAPI-post sample it was also assessed whether women commenced folic acid before conception as per recommendation (Koletzko *et al.*, 2013). Adjusted odds ratios indicated that maternal education and a 'rather planned' pregnancy (as a marker of pregnancy intendedness) predicted pre-conceptional folic acid use but parity and maternal age did not. Others have identified high maternal education but also age (Nilsen *et al.*, 2016; Oliver *et al.*, 2014), as well as pregnancy intendedness and primiparity (Nilsen *et al.*, 2016) as strong determinants of using folic acid pre-conceptionally. Similarly, multiparity (Manniën *et al.*, 2014), not having a partner (Manniën *et al.*, 2014) (which could be regarded as a marker of an unintended pregnancy), unplanned pregnancy, nausea and forgetting to take them (Lucas *et al.*, 2014) were reported as determinants of not using folic acid pre-conceptionally.

The baseline interview also indicated that a custom of being offered more food when pregnant was more common in women who had dual citizenship or were foreign nationals. This is an indication that the cultural environment may be a relevant determinant of diet in pregnancy in Germany.

6.2.2. Diet among CAPI-pre participants only

In the second step of analysis, dietary recall data of only the 219 CAPI-pre participants was assessed. Among those, age and height were normally distributed but weight before and in pregnancy showed some outliers who weighed 140 kg or more. Based on BMI before pregnancy, 15 % were overweight and 8 % obese. This is comparable to current estimates for Germany where 15 % and 6 % of women aged 18 to 29 years were deemed overweight and obese, respectively (Robert Koch-Institut (RKI), 2012). Comparison with other studies shows that the prevalence among BaBi participants is lower than observed in the Berlin Perinatal study where 25.5 % where overweight and 12.8 % obese (Reiss *et al.*, 2015). The observed difference can be explain by almost 50 % of participants in Berlin having had a migration background compared to 7 % based on nationality and 14 % based on perception in BaBi, and immigrants from certain countries having a higher prevalence of overweight and obesity than the autochthonous population (Reiss *et al.*, 2015). The BaBi prevalence is comparable to estimates from a Bavarian intervention study with similar participant structure, where prevalence in the control and intervention group and averaged to 15 % overweight and 8.5 % obese (Rauh *et al.*, 2013).

Pre-pregnancy weight has been framed as an individual response that may shape diet in pregnancy (Section 3.7.6.). It has been observed that people in a relationship shape each other's diets (Klotter, 2007) and food choice (Shepherd, 1999). Non-pregnant adults have identified spouse's or partner's health behaviour as a very important influence on their own diet (Kamphuis *et al.*, 2007), and pregnant women have identified their family as an important source of support and information (Lewallen, 2004). Maternal and paternal (meaning their current partner's) anthropometric measurements were therefore assessed in correlational analysis. Body weight in pregnancy was strongly correlated with weight and BMI before pregnancy. This reiterates the importance of achieving a healthy weight before conception (Rasmussen *et al.*, 2010) and also indicates that weight before pregnancy could be a useful marker for practitioners to identify women at risk of inappropriate weight gain and potentially of inadequate diet. Despite the caveat that weight gain is a crude and indirect marker of diet (as has been described in section 2.4.3.), pre-pregnancy BMI has been associated with nutrient intake in the first trimester (Derbyshire *et al.*, 2006)

and poorer nutritional blood biomarkers in pregnancy (Tomedi *et al.*, 2013).

The correlation with partner's anthropometrics was understandably weaker but still significant and positive. The observed r-value of 0.4 for correlation of partners' BMI was stronger than values of r= 0.1 to 0.2 observed in the literature (Jeffery and Rick, 2002). Correlation of spouses' BMI has been explained using the social obligation hypothesis, i.e. people in relationships sharing meals and eating more regularly and potentially more energy dense, and the marriage market hypothesis, i.e. those who are 'off the market' no longer having to restrict their diet intake or maintaining a slim figure (Averett *et al.*, 2008). A prospective investigation using direct measures of height and weight (rather than self-report) found that both cross-sectional BMIs and changes over a two-year period were positively correlated among spouses; this observation could be partially attributed to shared environmental factors (Jeffery and Rick, 2002). BMI was also found to be correlated among unmarried but cohabiting couples (Burke *et al.*, 2004). An Australian cohort observing participants from age 9 to 25 years showed that important transitions in life such as leaving the parental home, cohabiting with a partner and becoming a parent were associated with changes in diet and physical activity behaviour and weight status (Burke *et al.*, 2004). Other prospective investigations have also identified both the shared household environment and the transition to cohabitation/marriage as predictors of obesity (The and Gordon-Larsen, 2009).

The observed correlation of anthropometric measures may thus be an indication that both a shared environment and important life transitions shape body composition and weight related behaviours of both partners. The correlation results are limited by measures being based on self-report. Self-reported measures tend to underestimate weight and BMI and overestimate height compared to objective measures (Connor Gorber *et al.*, 2007). It is likely that report of partner's anthropometrics is even less accurate than of one's own height and weight. A further limitation is that it is unknown whether BaBi-participants had been cohabiting before pregnancy and how long they have been doing so. Nevertheless, these results warrant further investigation into the relationship between partners' anthropometrics and the both shared (household) environmental factors and the important life transitions (romantic relationships, cohabitation, marriage and

pregnancy/child birth) as potential determinants of dietary behaviour of pregnant women and potentially their partners as well.

Body image has been described as the perception and attitude of one's body (Mehta *et al.*, 2011) and has been framed as an individual response (section 3.7.6.) that may change during pregnancy (section 3.7.3.). It was thus assessed as a potential determinant. Being able to lose the weight gained in pregnancy was a concern for 40 % of participants. Dissatisfaction with one's body weight or thinking one has gained too much weight were constant concerns for 7 % and 8% of women, respectively. This proportion is comparable to 10 % of women who exhibited a high level weight and shape concern in the ALSPAC cohort (Northstone *et al.*, 2007). High levels of concern about weight and shape have been associated with not intending to breastfeed (Barnes *et al.*, 1997) and of inadequate weight gain in pregnancy (Mehta *et al.*, 2011), thus appear relevant for maternal and child health. Others have indicated that relaxation of body image ideals, rather than dissatisfaction, is also problematic for maternal and child health due to its association with excessive gestational weight gain (Mehta *et al.*, 2011). The long-term health implications (for mother and child) of body image should thus be assessed in follow-up analyses of the BaBi study. It is important for antenatal care providers to know that body image issues may not resolve during pregnancy, an observation reiterated by others (Davies and Wardle, 1994). Others have also urged health care providers to be sensitised to history of dieting history and body image (Takimoto *et al.*, 2011) and signs of eating disorders (Broussard, 2012) in pregnancy and in the postpartum period (Rocco *et al.*, 2005).

The second part of the analysis of CAPI-pre participants focused on the 24hFL data. Assessment of dietary intake showed that meal pattern, supplement use and consumption of individual foods were largely concordant across assessment days indicating a high level of consistency of how and what women ate. There were practically no differences in food consumption between assessment days and method (in-person or via the telephone). Where differences were observed, these appear to be a reflection of changes between weekdays and the weekend. Reporting non-usual food intake and a second breakfast varied considerably across days and between subjects, this is consistent with sleeping longer and eating

later and differently on a Sunday which is not uncommon among adults. There was some variation, albeit not significant, of fruit, processed meats, deli salads and sweets and snacks across first and second day recall. These may be discretionary foods more likely consumed on weekends, foods subject to greater social desirability bias influencing the report depending on the method used, or spurious findings.

Measured on the level of individual foods and food groups, women's diets appeared to be largely consistent with recommendations for diet in pregnancy.

Folic acid was the most commonly reported supplement and most importantly was used by all women in their first trimester as recommended, but this was a small group. At 67 % (first day) the proportion taking folic acid was lower than the proportion of 87 % reported for Germany in the EuroPrevall birth cohort (Oliver *et al.*, 2014). However, in the EuroPrevall study, women were asked if they had taken supplements *"during pregnancy"* (Oliver *et al.*, 2014, p. 2409); consequently the proportion would also include women who had only taken folic acid at the beginning of their pregnancy or who took them only every other day. EuroPrevall participants were also interviewed in their final trimester or up to four weeks after birth; the reported figure may have therefore affected by recall bias.

The use of the remaining four recommended supplements appeared to be less consistent with the HSYF guidelines. Iodine should have been consumed by all women on both assessment days but the proportion doing so was low. The finding fits in with the wider literature which has described mild gestational iodine deficiency as endemic in Europe (Gernand *et al.*, 2016). The iodine status of pregnant women in Germany should be further researched, as women are unlikely to meet iodine demands by diet alone (Koletzko *et al.*, 2013). Iron, vitamin D and DHA are only recommended for certain groups or stages of pregnancy, this made it difficult to ascertain whether they were used as recommended.

A quarter of women took iron supplements; in line with recommendations, the use appeared to be associated with a diagnosis of anaemia. Low iron status in pregnancy has been observed in developed countries such as New Zealand (Watson and McDonald, 2009), Spain (Rodríguez-Bernal *et*

al., 2013) or Finland (Erkkola *et al.*, 1998). BaBi participants infrequently consumed meat, a rich source of iron, which may have put them at risk of low iron status and deficiency.

At 13 % (first day), Vitamin D supplement use was considerably higher than the proportion of 1.3 % reported for Germany in the EuroPrevall cohort (Oliver *et al.*, 2014). This is reassuring as pregnant women have been named as an at-risk group for low vitamin D status and requirements are unlikely to be met by diet alone (Oliver *et al.*, 2014).

Eleven percent of CAPI-pre participants reported the use of a DHA supplement on the first recall day, in the EuroPrevall cohort the proportion using 'fish oils' in Germany was 17 %, but again this was at any stage in the pregnancy (Oliver *et al.*, 2014). It is potentially problematic that against recommendation, no vegetarian used a DHA supplement, particularly given that vegetarians are prone to having low DHA levels (Davis and Kris-Etherton, 2003). However, the observation is based on only a small subgroup of women.

The small proportion of participants (vegetarians and non-vegetarians) reporting consumption of DHA supplements or oily fish on either assessment day fits in with the literature. Inadequate DHA intake from food and supplements has been observed in a sample of highly educated pregnant Canadian women (Denomme *et al.*, 2005). A qualitative study of pregnant American women identified misinformation as a reason for low fish consumption; worry about mercury toxicity was named as a reason for fish avoidance (Bloomingdale *et al.*, 2010). In fact, the German HSYF guidelines also recommend the avoidance of *"carnivorous fish types like tuna and swordfish, which are at the end of the maritime food chain and may exhibit a high amount of toxic or harmful substances"* (Koletzko *et al.*, 2013, p. 314). National recommendations have been shown to influence food avoidance in pregnancy, in Germany 'shellfish' was named most frequently as a food group avoided in pregnancy (Oliver *et al.*, 2014). It is plausible that information regarding fish consumption, DHA and toxicity could have been misunderstood by BaBi participants, particularly if there were differences in (the quality of) nutrition information provision as the assessment of nutrition knowledge indicated. It should be investigated further how information regarding DHA, (oily) fish and potential toxicity is

communicated to and understood by pregnant women in Germany. If BaBi findings indeed reflect an issue faced by the wider population, messages should be refined and vegetarians, particularly those who do not consume rich dietary sources of DHA (eggs and fish/seafood) should be targeted, as they are an at risk group for inadequate DHA intake and poor conversion of α-linolenic acid (from plant sources, see Appendix 1) to DHA (Davis and Kris-Etherton, 2003). However, these findings need to be interpreted with caution because they are based on a small number of women and on only two assessment days; it is possible that women used DHA supplements or ate (oily) fish on days that were not recorded.

In line with recommendations, low-calorie beverages were widely consumed. However, close to 20 % consumed soft drinks and 90 % consumed sweets and snacks which are items only recommended to be consumed sparingly. The consumption of sugar-sweetened beverages has risen globally, possibly in response to powerful advertisement and their increasing availability (Caballero, 2015); the frequent consumption among participants may thus be a reflection of a wider global trend.

On the other hand, it may be a reflection of changes in taste preferences. Pregnancy has been associated with increased cravings for sweet foods and drinks (Belzer *et al.*, 2010) and an increased consumption of soft drinks and sweets in pregnancy compared to pre-pregnancy has been observed (Crozier *et al.*, 2009b). This has been attributed to the alleviation of symptoms of nausea and vomiting (Chortatos *et al.*, 2013). In qualitative interviews, pregnant Canadian women reported physical symptoms, cultural norms and lifestyle adjustments as reasons for an increased sugar intake (Graham *et al.*, 2013). A Norwegian study observed small but significant decreased in the consumption of sugar-sweetened beverages, yet 6 % still consumed them daily in early pregnancy (Skreden *et al.*, 2015). In contrast, in the Southampton Women's Survey soft drink consumption increased in the final trimester (Crozier *et al.*, 2009a), and in an Australian study 21 % of pregnant women consumed soft drinks daily (Wen *et al.*, 2013). Consumption of sugary drinks in pregnancy in Germany should be further investigated, ideally under consideration of portion size and consumption frequency, because high consumption of energy dense but nutrient poor sugary drinks and snacks has been associated with excessive

gestational weight gain and postpartum weight retention (Bortoletto Martins and D'Aquino Benicio, 2011).

Coffee was consumed by over 40 % of participants and appeared to not be decaffeinated in many cases. This corroborates with other studies that found women decreased their consumption but many did not fully abstain from drinking coffee (Skreden *et al.*, 2015). Results of the Southampton Women's Survey indicate that 16 % of women exceeded recommended caffeine intake in early and 19 % in late pregnancy (Crozier *et al.*, 2009b). In the absence of knowledge of consumption frequency and portion size it is difficult to assess whether intake of sweets, snacks and coffee was problematic among CAPI-pre participants, but it warrants a more detailed investigation.

The health conscious dietary pattern explained 10.7 % of total variance which was comparable to similar patterns derived in other birth cohort studies, as described in Section 4.4. However, the derivation of said pattern using exploratory factor analysis did not work as well as expected based on the review of the literature where the method has been commonly employed. It is possible, that others have experienced similar problems applying factor analysis but did not discuss these in the publications or did not publish their work in the first place.

Dietary pattern derivation has been noted to be complex and methodologically challenging (Hodge and Bassett, 2016; Essery Stoody *et al.*, 2014). The root of the problem may lie in four areas: the analysis methods, the type of data, the sample size or its characteristics.

Firstly, exploratory factor analysis requires several subjective decisions to be made by the researcher which can yield misleading results (Fabrigar *et al.*, 1999; Osborne and Costello, 2009). It has been shown that choice of rotation and factor loading cut-offs can influence the interpretability of dietary pattern derived from exploratory factor analysis (Castro *et al.*, 2015). Particularly use of factor loading cut-offs below 0.2 was shown result in models lacking acceptable fit (Castro *et al.*, 2015), yet studies have used such low cut-offs (Hu *et al.*, 1999; Arkkola *et al.*, 2008). Spurious factors may emerge if variables are included that are irrelevant to the construct one is aiming to measure and true common factors may not be identified or be

concealed (Fabrigar *et al.*, 1999). To overcome these potential issues, exploratory factor analysis was repeated with fewer variables and different rotation methods, and the recommended factor loading threshold of 0.3 was used. None of this improved the results. Based on the Kaiser criterion and on the post-estimation commands around ten factors should have been retained, which meant very little data reduction.

The second potential problem was the type of data. The dietary data was binary and therefore very simple. Information on size and frequency consumed was not available. In their systematic review of dietary patterns and health outcomes, Essery Stoody *et al.* (2014) observed that dietary patterns did not differ so much in the types of food consumed but in the amount and frequency with which these foods were consumed (Essery Stoody *et al.*, 2014). Moreover, tetrachoric correlations, which are necessary when data is binary, commonly lead to problems. They are based on the (often inappropriate) assumption that the underlying variables are normally distributed and can lead to inflated coefficients, which is why some have recommended not using factor analysis with binary variables at all (Gorsuch, 1974). Using the second data export with a 'finer' variable structure and polychoric correlation matrix did not improve results. This is another indication that the type of data, i.e. the absence of information on the amounts eaten, was problematic. Some have advocated the use of principal component analysis, which aims to reduce data rather than identify latent constructs, and is less prone to Heywood cases (Fabrigar *et al.*, 1999). Heywood cases had been observed in the present analysis, they are commonly an indication of a poorly fitting model or a model violating assumptions of the common factor model (Fabrigar *et al.*, 1999). The analysis was thus repeated using the 'pcf' (principal component factor) option, but neither the KMO measure nor the interpretability of the dietary patterns was improved. Previous research has indicated that different dietary assessment methods (food frequency questionnaires, dietary recalls and food dairies), and different analysis methods (factor analysis, cluster analysis and index analysis) yield similar results (Reedy *et al.*, 2010). This suggests the presence of 'real' dietary patterns that can be identified regardless of method, an observation reiterated by others (Bowley and Blundell, 2016; Essery Stoody *et al.*, 2014; Sanchez-Villegas *et al.*, 2010; Reedy *et al.*, 2010). Consequently, it is unlikely that the present analysis

did not identify dietary patterns because they do not exist. The results of the systematic review detailed in Chapter 4 also showed that dietary patterns have been identified in pregnant women using a variety of methods. However, valid as the concept of dietary pattern may be, assessing it adequately in pregnant women is very difficult and many advances have yet to be made to the field, such as the use of dietary assessment methods validated for the population and the appropriate interpretation of patterns derived *a posteriori* (Sanchez-Villegas *et al.*, 2010).

Thirdly, there is evidence to suggest the sample size was challenging. Factor analysis performs better with larger samples (Yong and Pearce, 2013; Gorsuch, 1974). Different 'rules of thumb' regarding sample size have been noted in the literature. Using a sample of at least 100 observations, and ratios of five to 10 participants per measured variable (Fabrigar *et al.*, 1999), or a sample of at least 100 to 200 observations and ratios of participants to variables anywhere between 2:1 to 20:1 have been suggested (Guadagnoli and Velicer, 1988). The required sample size appears to also be influenced by the extent of the factor loadings; for factors with factor loadings of 0.4 or less, as was the case for many food items in the present analysis, sample sizes of 300 to 400 are recommended (Guadagnoli and Velicer, 1988).

Lastly, comparison of CAPI-pre and -post participants showed that the former, who provided dietary data, were a highly selective group. A likely reason why the analysis did not perform well is thus the lack of variability among the sample. Very homogeneous samples should be avoided in factor analysis (Fabrigar *et al.*, 1999; Gorsuch, 1974). The problem has likely been amplified by the nature of the data, which was too 'coarse' to identify difference among a highly homogeneous sample, at that with a small sample size.

As the dietary pattern score was derived with some level of uncertainty due to methodological shortcomings outlined above, guideline adherence was also evaluated. A second data export provided by DIfE allowed determining in more detail whether guidelines were followed. Adherence to the HSYF network guidelines for diet in pregnancy was assessed by simply scoring the number of recommendations met.

Similarly to the dietary pattern score, the guideline adherence score needs to be interpreted with caution. The guidelines are based on consumption amounts and frequency, i.e. foods to consume plenty, moderately or rarely. The scoring that was based on mostly binary data was therefore derived with imprecision. Fruit and vegetable consumption was available as the number of different items consumed but again without knowledge of portion size or consumption frequency. The fruit and vegetable variables consequently present the variety of items consumed rather than the actual total intake amount.

Neither the 24hFL nor the guideline adherence score have been validated for use in pregnant populations. When constructing diet quality scales *a priori*, as in the present analysis, the use of validated instruments and careful choice of included components of the score have been recommended (Sanchez-Villegas *et al.*, 2010). The decision on the relative contribution to the overall score and the categorisation of foods into groups have also been named as key issues in developing diet quality scores (Waijers *et al.*, 2007).

The guideline adherence score in the present analysis was consequently impaired by lack of validation, by inclusion of those components that could be assessed based on the 24hFL rather than components chosen based on theoretical considerations and potentially impaired by using a pre-defined categorisation of food and awarding one point for each guideline met rather than given greater scores to guidelines considered more 'important'.

6.2.3. Determinants of diet in pregnancy

The final step of the empirical analysis was the assessment of the association between determinants and diet, measured as dietary pattern and guideline adherence, among CAPI-pre participants. For the aforementioned reasons these results should be interpreted carefully due to the outlined issues in deriving dietary pattern and guideline adherence scores.

The health conscious dietary pattern and HSYF guideline adherence

scores appear to capture slightly different constructs as 50% of women scored above the mean pattern score but 40% scored above the median of the guideline adherence score. This reflects findings that arose from the systematic review (section 4.4.) which showed that applying different methods to the same study sample can result in different patterns or different categorisation of participants. Despite potentially assessing slightly different latent constructs, there were similarities though in the determinants of the health conscious dietary pattern and of the guideline adherence score.

The systematic review has found consistent evidence for a positive association between maternal age and a 'healthier' diet. Among CAPI-pre participants, both pattern score and the chance of high guideline adherence increased with age, albeit non-significant in the first two guideline adherence models and only borderline significant in the final model.

Surprisingly, no association with maternal education was found. This may indicate a true absence of association in this population or be a result of too little variation of education level among the sample. It was also unexpected that household income was not associated with either of the two scores (dietary pattern/guideline adherence). It is possible that sample size and homogeneity have masked a true effect. Others have attributed a lack of association between guideline adherence in pregnancy and education and household income to the applied food groupings giving limited information on diet quality (Morton *et al.*, 2014). The absence of association in the present analysis may therefore indicate that neither the dietary pattern nor the guideline adherence score were adequate to capture the 'finer' nuances of differences in dietary consumption attributable to education and household income.

Last among the socio-demographic factors reviewed was migration background. A perceived migration background was associated with lower pattern score and lower chance of high guideline adherence but this was not significant in any model. Again, this might indicate a true absence of association or reflect of lack of variability among the sample. Migration background was assessed rather coarsely, i.e. based on perception. Future analyses of the BaBi study using the final and larger sample should re-investigate the influence of migration background on diet. BaBi data allows

assessing different aspect of migration background such as acculturation, dominant cultural identification and duration of living in Germany.

Findings of the category of pregnancy-related determinants (parity, pregnancy intent, conception duration, nausea, vomiting, cravings and anaemia) differed considerably between the two diet scores applied.

The association between parity and dietary pattern and guideline adherence was inconclusive. The systematic review had also identified conflicting evidence; in some studies parity was inversely associated with diet adequacy whereas the association was positive in others. It is equally plausible that greater parity would mean greater knowledge and experience of how to achieve a diet that is high in quality or follows a healthy pattern, or that greater parity would mean lower resources for diet. A qualitative investigation from Munich identified women who already had children as rather relaxed about their pregnancy (Nehring *et al.*, 2015). This feeling of placidity may also translate into a more relaxed approach to dietary behaviour. Nulliparae and multiparae reportedly differ with regard to nutrient intake, dietary habits, socio-demographic factors and health behaviour (Goni *et al.*, 2014). It is therefore possible that observed associations between parity and diet (Bodnar and Siega-Riz, 2002; Rifas-Shiman *et al.*, 2009; Morton *et al.*, 2014; Fowler *et al.*, 2012) are complex or even confounded by underlying socio-demographic or behavioural factors. Another potential explanation for differences between primi- and multiparous BaBi participants could be nutrition knowledge or information receipt. As previously discussed, diet information appeared to be more commonly provided to primiparae. Interestingly, parity was positively associated with health conscious pattern adherence but inversely with guideline adherence score (non-significant in any of the models). Findings from the present empirical analysis can thus not help illuminate if and how exactly parity relates to dietary behaviour.

Among CAPI-pre participants, nausea was associated with lower guideline adherence but vomiting and cravings did not emerge as determinants of dietary pattern or guideline adherence. This could indicate the absence of a true association. On the other hand, it could indicate that these symptoms, which frequently occur at the beginning of pregnancy, were not relevant determinants among the study participants, who were largely in the later

trimesters. Anaemia was associated with lower dietary pattern and guideline adherence score, albeit only significant in the former. This finding was novel; it should thus be replicated by further studies to ensure it was not a spurious finding. Since the analysis was cross-sectional in nature, reverse causality cannot be excluded, i.e. it is possible that anaemia is a result of habitually poor diet rather than a determinant thereof.

Pregnancy intendedness has been identified as a potential determinant based on theoretical evidence but no studies investigating its influence on diet were identified in the systematic review, leaving a research gap. Having a rather planned pregnancy, as an indicator of the intendedness and desirability of the current pregnancy, was associated with greater odds of high guideline adherence score. It is possible, particularly among a highly educated sample such as in the present analysis, that women who wish to become pregnant gather information on diet in anticipation of becoming pregnant. This putative relationship is supported by the significant association with conception duration. However, it was unexpected that trying to conceive for 6 months or longer was associated with lower odds of achieving guidelines. The reverse had been postulated, i.e. that as conception takes longer women would become more anxious and thus attentive to health behaviour including diet (Section 3.7.3.). Similarly to the findings on anaemia, the association may be spurious or a sign of reverse causality, i.e. habitually poor dietary intake also leading to poorer fertility.

As the final pregnancy-related factor included in the models, nausea was associated with dietary pattern score (not significant) and lower chance of high guideline adherence (significant). This finding fits in with the wider literature that suggests that nausea can lead to avoidance of certain foods and a preference for sweet foods and soft drinks (Bayley *et al.*, 2002; Chortatos *et al.*, 2013; Hook, 1978; Latva-Pukkila *et al.*, 2010).

Being regularly active before pregnancy was positively associated with both dietary pattern and guideline adherence score. This is in agreement with findings from the systematic review that identified a 'lifestyle gradient' whereby health protective behaviours before and during pregnancy were associated with greater dietary adequacy in pregnancy. In German pregnant women, physical activity behaviour was found to persist into

pregnancy, i.e. those who were physically active before pregnancy continued to do so while those who were previously inactive were unlikely to take up exercise or physical activity (Nehring *et al.*, 2015).

Pre-pregnancy weight was associated with diet in the systematic review, but not all studies found a significant association. Findings from the BaBi study found strong correlation between pre-pregnancy weigh (as a marker of long term energy balance) and weight in pregnancy, indicating that diet and physical activity behaviours track into pregnancy. The models however failed to find an association between pre-pregnancy weight and dietary pattern or guideline adherence in pregnancy. Again, this could mean a true lack of association or be a reflection of a small and homogeneous sample.

6.3. Relationship of the identified determinants

Research question 2 aimed to disentangle the relationship among the identified determinants of diet 'as a whole' in pregnancy.

The combined results from the theoretical literature (Chapter 3), the systematic review (Chapter 4) and empirical analysis (Chapter 5) show that women vary in their dietary intake in pregnancy. Even among the highly selective CAPI-pre participants differences in the adequacy of diet could be seen. Fifty percent of participants scored above the mean health conscious dietary pattern adherence and 40 % above the median HSYF guideline adherences scales. This reiterates the findings by reviewed studies that inadequate diets in pregnancy exist even in contexts with a (theoretical) wide availability of food. Due to the potential priming effects on maternal and child health, diet in pregnancy is of public health relevance. Dietary intake in pregnancy, at least in some population groups, was found to be in need of improvement in other developed countries (Section 1.2.2.), this appears to hold true for the German context as well.

Findings from the review of theory (Chapter 3), of other studies (Chapter 4) and results of the empirical analyses (Chapter 5) have also shown that both diet in pregnancy and its determinants are complex. This is in stark contrast to the rather simplistic view of pregnancy as a time of 'heightened awareness' of one's health and 'greater willing' to change behaviour including diet (Section 1.4.). Rather than mere willingness, diet appears to be determined by wider external forces (socio-demographic attributes, pregnancy-related, individual response and environmental factors).

Pregnancy related determinants were conceptualised as the most proximal determinants of diet in pregnancy (Section 3.7.3.), but they were infrequently assessed in the reviewed studies (Chapter 4). The empirical analysis could not help disentangle the role of parity and pregnancy-related symptoms such as nausea. The analysis did, however, show that markers of pregnancy intendedness (i.e. a rather planned pregnancy and conception duration) were associated with dietary pattern and guideline adherence scores.

Women with a rather planned pregnancy more likely commenced folic acid at the time recommended.

This indicates that pregnancy intendedness is important in shaping diet and nutrition behaviour in pregnancy.

These findings should first of all be replicated in other studies, to ensure that they were not spurious findings or the result of a homogeneous study sample. If pregnancy intendedness is consistently identified as a determinant of diet, future research should disentangle its actions. For example, it is possible that an intended pregnancy results in greater motivation for behaviour change, much like the conceptualisation of pregnancy as a time of 'heightened awareness' (Section 1.4.), outlined above. On the other hand it is also possible that intended pregnancies are planned pregnancies and that women who plan their pregnancies also assert a control over other aspects of their life, including diet. In that case pregnancy intendedness would be a marker of underlying psychological factors.

To summarise the evidence on pregnancy-related determinants, this dissertation has shown that much more needs to be learned about their role. Thus far it can be said that pregnancy intendedness appears to exert an influence. The conception of pregnancy as a time of 'heightened awareness' and of 'willingness to change' may apply to those with an intended pregnancy. However, it has been estimated that about half of all pregnancies are unplanned (Anderson, 2001) which would have obvious implications on whether pregnancy would result in heightened motivation or rather stress and worry.

The exploration of socio-demographic determinants identified a clear social gradient in the reviewed literature (Chapter 4). This social gradient in diet was not fully replicated in the empirical analysis, but this is likely a result of a highly homogeneous sample. The analysis of the more heterogeneous total BaBi sample (CAPI-pre and CAPI-post participants) showed that the more educated women had greater subjective knowledge of diet and weight gain recommendations and were more likely to use folic acid pre-conceptionally. This can be viewed as an indication that education plays a role in nutrition knowledge and nutrition related behaviours. It is possible that education would have emerged as a determinant of dietary pattern or guideline adherence score, had the sample been more diverse.

The empirical analysis replicated findings from other studies regarding maternal age; older women exhibited greater scores on both the health conscious dietary pattern and HSYF guideline adherence scale. The association between age and diet in pregnancy, albeit consistent, is not inherently understandable though. It should be further investigated why diet changes were seen between different age groups and whether these are truly due to age or whether the association was confounded. On the one hand, the process of ageing may truly improve diet, for example due to the formation of adult dietary patterns, as suggested by Verbeke and Bourdehuij (Verbeke and Bourdeaudhuij, 2007). On the other hand, older BaBi participants were found to more commonly receive nutrition information in antenatal care, particularly if they were in their first pregnancy, indicating that the association may be confounded by differences in care or underlying social structures of older compared to younger women.

To summarise the evidence on socio-demographic determinants, the persistence of a social gradient into pregnancy indicates that the description of pregnancy as a time of heightened awareness and openness to behaviour change is overly simplistic, at least for sub-groups of women. The wider drivers of dietary behaviour do not just 'magically' vanish upon becoming pregnant, therefore ensuring adequate diets in pregnancy for all women means creating structures to support this rather than relying on motivation and willingness to change. Others have also stated that the expectation of pregnancy as a time of heightened awareness of health and openness to behaviour change was not reflected in the behaviour of many women (Kominiarek, 2014).

Individual responses have been described as the 'sum' of all the environmental, socio-demographic and pregnancy-related influences impacting on the individual (Section 3.7.6.). It was argued that body weight, body image and eating behaviour are shaped over the life course and that pregnancy could potentially affect or change a woman's trajectory depending on personal factors and the environment. Results of the reviewed studies (Chapter 4) had shown that health trajectories appear to be stable. Behavioural responses (e.g. physical activity, weight maintenance) appeared to 'track' into pregnancy, which means that those

exhibiting health protective behaviours before pregnancy were also more likely to adhere to a high quality or health conscious diet in pregnancy. The empirical analysis (Chapter 5) found physical activity before pregnancy was associated with both dietary pattern and guideline adherence in pregnancy reiterating the observed 'tracking' of behavioural response. Pre-pregnancy BMI was not associated with either diet score in pregnancy but was correlated with partner's BMI indicating the presence of shared environmental or social factors in shaping body weight. Both the observed tracking of behaviour and the role of shared environment with a partner indicated the importance of pre-conceptional health and behaviour. This in turn indicates that the promotion of maternal and child health may be more effective if it began before conception.

To recapitulate the findings regarding the individual response determinants, their action needs to be researched and disentangled further. So far it can be said that health behaviour before pregnancy appears to persist on the same trajectory and the persistence on a more or less healthy trajectory appears to also be reflected in dietary behaviour in pregnancy. This indicates that health promotion should begin before conception.

The final and most distal category of determinants was the group of environmental factors. The systematic review had identified a lack of studies assessing environmental determinant of diet in pregnancy. The empirical analysis could not fill this research gap. The analysis results were inconclusive regarding the role of a woman's social network as a marker of the social environment.

However, the analysis of BaBi data indicated that there may be differences in information provision in antenatal care which could be a marker of differences in the medical environment which may in turn shape nutrition knowledge and potentially influence diet behaviour in pregnancy. The observed correlation between participants' and their partners' BMIs may also be an indication of shared environmental factors.

To recapitulate, while there is theoretical evidence to suggest the influence of environmental determinants (Section 3.7.5.), but very little is currently known about the actual influence of the physical, socio-cultural, medical and political/economic environment on diet in pregnancy. Future research

should assess if and how the different facets of the environment influence diet in pregnancy. This knowledge could help identify structural changes that need to be made in order to realise adequate diet in pregnancy for all women.

Despite not being able to definitively 'refine' the explanatory model (research question 2.b.) based on the evidence gathered by this dissertation, the conceptual framework, coarse as it may be, can be regarded as a first step in disentangling the complex interplay of determinants of diet in pregnancy. Future BaBi-study analyses, or other studies, may lead to the envisioned finalised model.

The conceptual framework has added knowledge to the field by combining angles previously not used when assessing diet in pregnancy; a life course view, the inclusion of multiple determinants and the use of theoretical foundation. This is novel in that the study of diet has largely focused on individual cognitive or psychological influences and the field of nutrition in general has been weak in using theoretical foundation.

However, while the framework has taken a life course *view*, the empirical analysis could not actually apply this as it was based on cross-sectional data. Future analyses of the BaBi-study can use follow-up data to assess the influence on child health and development. This dissertation has also not fully used the potential for analysing environmental influences on diet in pregnancy. Wider contextual data based on official city statistics are currently analysed and may allow assessing the influence of food outlets near women's place of residence, for example.

In order to study the dynamics of food choice, it has been recommended to study dietary behaviour and the contexts in which food choices are made across time and also consider wider social and policy changes (Devine, 2005). It would therefore be ideal if future studies assess diet prospectively across important stages of the life course, including pregnancy. With current methods this would likely be a very complex undertaking with a high participant burden. It remains to be seen if advances in dietary assessment methods make a life-course diet study a possibility.

6.4.   Strengths and limitations

The comparison of CAPI-pre and CAPI-post participants identified significant differences in pregnancy-related and socio-demographic characteristics. Dietary data were only available for CAPI-pre participants who were clearly of higher social status as indicated by education and income and were also a distinct group with regards to parity and migration background. They also had larger support networks and fared better in some health and health behaviour aspects.

This is a clear selection bias which likely arose from the recruitment procedure. Women who joined the study during their pregnancy were recruited via gynaecologists and midwives and wider advertisement (distribution of flyers and poster in places commonly frequented by pregnant women like pharmacies and antenatal classes). CAPI-pre participants were thus likely individuals who read information material handed to them, who have an interest in health and are open to part-taking in studies. The latter may be a reflection of greater social consciousness, i.e. feeling an obligation to part-take for the greater good of society; it may also be a reflection of a lower barrier to research and higher education, i.e. participants may have personal experience of conducting research or feel a personal tie to Bielefeld University due to being staff, student or alumni.

Women who joined the study after birth had commonly heard about the study through the avenues described above, but only chose to participate once approached by study staff. This may be because issues that made them hesitant about participating could be resolved in personal communication or because once their baby was born their interest in, and possibly reasons for (e.g. if the child was born with health issues), taking part in the study changed.

Others found that women who volunteer to partake in birth cohorts (i.e. self-selecting) tend to be older, better educated, nulliparous, less likely to smoke in pregnancy and more likely to take folic acid (Pizzi *et al.*, 2012; Nilsen *et al.*, 2009). Results from the BaBi study mirror this observed bias of self-selection. This can be seen as an indication that selection bias is a common issue in longitudinal studies for which there is no easy solution. It has been noted that participation in prospective birth cohort studies can be

enhanced by giving detailed verbal information on study aims (Clarisse *et al.*, 2007). This explains why the response improved when BaBi staff approached women directly; however this was only feasible on postnatal wards which then rendered the dietary recall inappropriate.

Another limitation was the dietary instrument which captured diet rather 'coarsely'. The absence of consumption frequency and amount makes it difficult to discern whether guidelines were followed as these are worded in terms of consumption frequency (i.e. consume plenty, moderately or sparingly).

Additionally, the instrument has not been validated for use in pregnant women. Ideally a 'gold standard' method of dietary assessment, such as food diaries, should have been used in a sub-sample of the study participants (Willett, 1998). This could have been used to validate both the use of the 24hFL in pregnant women and the appropriateness of the guideline adherence scoring. The absence of information on consumption amounts also impaired the guideline adherence scoring. It is possible that women who ate less because they are smaller and accordingly have a lower BMR also scored lower on the guideline adherence scale. Another limitation is a 'blind spot' in the guideline score. Only the consumption of foods recommended to eat was scored. It is however possible that women with very high overall food consumption ate both recommended 'to eat' and 'not to eat' foods. However, this was not reflected in the scoring. Both issues could have been overcome if information on consumption amounts had been known as analyses could have then been adjusted for total energy intake to account for differences in body size and physical activity among participants (Willett, 1998; Nelson and Bingham, 1997; Waijers *et al.*, 2007). Energy intake data could have also been used to identify individuals with unrealistically low intakes, this is recommended for example when the sample includes overweight or obese individuals who are known to under-report their dietary intakes (Willett, 1998; Nelson and Bingham, 1997).

On the other hand, the 24hFL had one major advantage as it was fast and easy to conduct (Freese *et al.*, 2014) and acceptability by participants was high (Hinz *et al.*, 2014). This makes it an ideal instrument for use in large epidemiological studies such as the BaBi cohort. The use of scores to

assess guideline adherence has been described as an appropriate method (Waijers *et al.*, 2007). The methodological challenges experienced when applying factor analysis have already been described, given the nature of the data it was however the best currently available method for pattern derivation.

Timing was another limitation of the dietary assessment. It was conducted at very different times in pregnancy. However, prospective analyses indicate that dietary remain relatively constant over the course of pregnancy (Cucó *et al.*, 2006; Crozier *et al.*, 2009b; McGowan and McAuliffe, 2013), indicating that interpersonal variation in gestational week/trimester do not impair the ability to study diet in pregnancy. Intrapersonal variations were kept to a minimum by aiming to conduct both recalls within two weeks.

The current analysis is also limited by being cross-sectional in nature. Therefore, only associations between determinants and diet could be discussed. In some unexpected observations such as the association between anaemia and lower dietary pattern score, the possibility of reverse causality cannot be disputed. In order to assess whether relationships are causal, prospective data would be more powerful. The previous section (6.3.) has outlined how the 'ideal' study of determinants of diet 'as a whole' in pregnancy under a life course perspective should be conducted.

Despite these pitfalls, the present analysis described diet and related (e.g. body image, nutrition knowledge) characteristics of pregnant women in Bielefeld and identified that some of the determinants of the conceptual framework appeared relevant in this population. As the BaBi study is currently finalising baseline data collection, it is possible to re-analyse dietary data using a larger sample and a finer distinction of dietary data and thus overcoming some issues encountered in this dissertation. Based on such analyses the final explanatory model can be refined, e.g. moderators, modifiers and confounders can be identified and the finer interplay of determinants disentangled.

The BaBi study benefits from a prospective design which also allows for testing the 'lower part' of the conceptual framework, i.e. the future health implication for mother and child of diet consumed in pregnancy.

6.5. Recommendations for research, practice and policy

The wider reviewed literature indicates that the determinants of diet 'as a whole' in pregnancy is a new research area that is also relevant for public health. Dietary pattern and quality appear to be valid constructs that can be identified to some degree of precision using current methods available. However, the literature reviewed also showed that the field is hindered by a lack of clear definitions which means that the terms are sometimes used ambiguously and even interchangeably. The first recommendation for research is therefore the development and distribution of clear definitions of both dietary patterns and dietary quality, or of a combination of both concepts considering the similarities and overlap in both constructs (see Section 3.6. and Table 1).

A further hindrance is current methodology. Dietary patterns are commonly derived using exploratory factor analysis and principle component analysis which are both criticised for being based on subjective decisions and interpretation by the researcher (Section 6.2.1.). The use of diet quality indices appears more reliable at first sight, but they are derived *a posteriori.* As such they are based on either findings from studies investigating 'single' foods or nutrients (with the disadvantages outlined previously such obscuring synergetic effects or confounding from other foods) or on *a priori* methods such as dietary pattern which then again are impaired by the current methodological issues outline.

These methodological difficulties are not isolated to the study of dietary patterns and quality, but rather a reflection of an overarching issue experienced by nutrition research. Measuring diet is a difficult undertaking (Willett, 1998; Margetts and Nelson, 1997; Hodge and Bassett, 2016). In a recent editorial, Hodge and Basset (2016) concluded that dietary patterns seem to be here to stay, but they urged readers, to *"keep in mind that creating dietary patterns does not overcome the inherent weaknesses in dietary data"* (Hodge and Bassett, 2016, p. 193). This holds true for interpretation of this dissertation as well.

Encouragingly, nutritional epidemiology has reacted to the issues faced when trying to capture diet in its totality. New approaches for deriving dietary patterns have been developed such as exploratory structural

equation modelling (Castro *et al.*, 2015), simplified factor analyses approaches (Schulze *et al.*, 2003) and latent class modelling (Sotres-Alvarez *et al.*, 2013) and are currently being applied. It remains to be seen whether future studies of dietary patterns will move away from factor and principal component analysis and use new methods and approaches and whether these result in improved ability to capture the latent construct of diet 'as a whole'.

This dissertation has shown that diet is strongly socially patterned and that diet in pregnancy is no exception to this. More research into the social determinants of diet, and how to improve restrictions for those in lower social positions, should thus be conducted. Oltersdorf envisioned the development of a discipline of *"social epidemiology of eating behaviour"* (Oltersdorf, 1995, p. 315) as far back as 1995 (Oltersdorf, 1995). The need for a greater consideration of social determinants of dietary patterns has recently been voiced (Bowley and Blundell, 2016).

In summary, the constructs of dietary pattern and quality to capture the underlying concept of diet 'as a whole' appear valid and theoretically sound but practically very difficult to implement given current methods. The recommendations for research are thus to develop clear and unanimous definitions of each concept, or a combination of both, and sound methods of assessment. Furthermore the study of determinants of diet in pregnancy, particularly under consideration of social determinants, is recommended.

Findings of this dissertation also allow drawing recommendations for practice. Results from the systematic review and empirical analysis have identified women who are younger and exhibiting health risk behaviours (or a lack of health protective behaviours) before and in pregnancy as at-risk group for diets in pregnancy that do not comply with guidelines or do not follow a 'healthy' dietary pattern. Pregnancy-related and environmental determinants also appear to influence dietary behaviour. Training and professional development of gynaecologists, midwifes and providers of antenatal classes should be adapted accordingly.

These practitioners should become sensitised to the importance of diet in pregnancy. The misconception that diets consumed by pregnant women are necessarily 'adequate' in countries with wide availability of food should

be cleared and the complex determinants of diet and the groups of women who appear to be at-risk should be taught.

Younger women have been clearly identified as an at-risk group based on results from the empirical analysis and wider literature. The association between diet in pregnancy and other health behaviours should be used to reframe the conception of pregnancy as a time of heightened awareness. For health care practitioners and providers of antenatal care the messages should be refined that other health behaviours appear to mirror diet in pregnancy and may thus be a useful marker. It would be overly simplistic to assume that information provision *alone*, especially if it is brief and incomprehensible as outlined by studies in the field, can suffice to yield change in diet behaviour, particularly if health protective behaviours were not practiced before. But receiving information in a manner that is comprehensible and in an adequate time frame (e.g. early enough in pregnancy and given enough time to process information and ask questions) appears a necessary *prerequisite* to understanding the requirements and guidelines of diet in pregnancy. Practitioners and care providers should be sensitised to this. Furthermore, practitioners should be proactive when discussing guidelines for diet and supplement use, rather than reactive (i.e. waiting for women to give cues that they are interested in the topic).

Additionally, recommendations regarding nutrition communication, education and programmes can be made. Findings of this dissertation have shown that the conception of pregnancy as a time of 'heightened awareness' and 'openness' to health promotion and behaviour change appears to be overly simplistic for many women. Nutrition communication as well as nutrition education campaigns and programmes must consider this reality (rather than work against it by having unrealistic expectations that motivation and awareness will suffice for behaviour change) and be adapted accordingly. The HSYF guidelines and the websites and information materials connected to the HSYF initiative, as an example of current nutrition education and programmes in Germany, could also be improved. Firstly, clear guidelines for diet in pregnancy should be provided. The currently used HSYF guidelines may be difficult to understand because recommendations are worded as consumption frequencies (e.g. consume

plenty, consume moderately) which may be difficult to understand without giving examples of what is meant by those frequencies. The individual messages may also be difficult to understand, for example the conflicting messages regarding fish consumption (i.e. oily fish vs. mercury toxicity) should be cleared up. Additionally, the HSYF guidelines could be improved in terms of cultural appropriateness. Germany is a country with a high proportion of people with a migration background and is also a common destination of migration (Spallek and Razum, 2012; Razum *et al.*, 2008). This dissertation has identified cultural (including religious) determinants of dietary behaviour in pregnancy (Section 3.7.5.). For example, cultural groups may differ in their preferred starchy staple foods (e.g. potatoes, rice, pasta), preferred meal patterns and cooking methods and in religious practices such as fasting, food preparation (e.g. kosher cooking) and food avoidance (e.g. halal food in Islam) (Thomas and Bishop, 2007). As one example, HSFY recommend particularly the consumption of potatoes and whole grains as carbohydrate sources. These may not be appealing to all cultural groups; the recommendations should therefore give examples of various carbohydrate sources. Other multicultural societies, such as the United Kingdom, have incorporate examples of foods consumed by other cultures into their guidelines and information materials, for example rice, noodles, maize, millet, oats, sweet potatoes, yams and cornmeal are named (National Health Service, 2015; Food Standards Agency, 2002). German guidelines should be adapted in a similar manner.

Finally, policy needs can be identified based on the findings of this dissertation. Diets that are not compatible with recommendations have been observed in pregnant women even in developed countries where food is abundant. Mere availability of food therefore does not appear to be enough to ensure adequate consumption. As outlined in Chapter 3, there are many 'upstream' determinants of diet such as the physical environment (e.g. access to and type of food outlets), socio-cultural environment (e.g. what is desirable, acceptable and safe to eat), medical environment (e.g. type of antenatal care received) and political and economic environment (e.g. how food is produced and distributed and the generation of nutrition knowledge). Upstream determinants are difficult to identify and change (Hawkes *et al.*, 2006), and identifying solutions, policy and otherwise, probably warrants its own review of evidence.

However, some recommendations can already be made based on the present dissertation. Firstly, antenatal care in Germany could be organised in a way that allows a clear discussion of recommendations regarding diet and weight gain in pregnancy. Time constraints were identified as commonly expressed reasons for lack of, or inadequacy of, provision of nutrition related information. Therefore, antenatal care should be re-organised in a way that nutrition advice is mandatory and provided in an adequate time frame for women to ask questions and clarify information. Whether and how this could really be implemented in the context of the German health care system is beyond the scope of this dissertation but could be reviewed in future work.

The use of food taxation and subsidies are also currently discussed as means to improve diet at the population level (Temple, 2016). As pregnant women are by far not the only population group exhibiting inadequate dietary intake, actions at the government level may target many population groups. Improving diets of young women for example, may have a positive 'knock on' effect once they reach reproductive age and the foundations for healthy habits have already been laid down.

Tackling the wider drivers of diet in pregnancy is a complex undertaking warranting more research before more detailed recommendations can be made. Based on current discourse, the use of a systematic search for solutions (Popkin, 2011) and strategic approach to nutrition (Temple, 2016, 2016) have been identified as promising starting points.

6.6. Conclusion

Diet in pregnancy shapes the health trajectories of mothers and their infants. Pregnancy is commonly described as a period where behaviour change, including dietary behaviour, can easily be implemented due to greater motivation, awareness and willingness to change. However, this dissertation has shown that this conceptualisation is overly simplistic. Both diet and its determinants are very complex and mere willingness appears to be unlikely to be sufficient to overcome the wider structures determining diet in pregnancy.

This dissertation has shown both a social and behavioural gradient of diet in pregnancy, i.e. women who are less affluent or exhibit health risk behaviours, appear less likely to exhibit adequate diets in pregnancy. Younger and less educated women were also identified as an at-risk group. The role of environmental and pregnancy-related determinants needs to be regarded as inconclusive at this stage.

As a first step in disentangling the complex interplay of determinants of diet in pregnancy, a conceptual framework was proposed. Improvements for the field, such as the development of clear definitions of dietary patterns and diet quality, improved methods for assessing dietary intake and the use of longitudinal/life course studies were recommended. As improvements and advances are made, the finer interplay can be disentangled and developed into a full explanatory model.

Based on this work it was recommended to improve dietary guidelines and communication thereof in Germany and to develop systemic and strategic policies to act on the complex determinants of diet in pregnancy. As the field of research advances, clearer and more detailed policy recommendations can be drawn.

7. References

Aaltonen, J., Ojala, T., Laitinen, K., Piirainen, T.J., Poussa, T.A. and Isolauri, E. (2008), "Evidence of infant blood pressure programming by maternal nutrition during pregnancy: a prospective randomized controlled intervention study", *The Journal of Pediatrics*, Vol. 152 No. 1, p. 79-84, 84.e1-2.

Agahi, N., Shaw, B.A. and Fors, S. (2014), "Social and economic conditions in childhood and the progression of functional health problems from midlife into old age", *Journal of Epidemiology & Community Health*, Vol. 68 No. 8, pp. 734–740.

Albrecht, S.S. and Gordon-Larsen, P. (2014), "Socioeconomic gradients in body mass index (BMI) in US immigrants during the transition to adulthood: examining the roles of parental education and intergenerational educational mobility", *Journal of Epidemiology & Community Health*.

Andersen, A.-M.N., Andersen, P.K., Olsen, J., Gronbaek, M. and Strandberg-Larsen, K. (2012), "Moderate alcohol intake during pregnancy and risk of fetal death", *International Journal of Epidemiology*, Vol. 41 No. 2, pp. 405–413.

Anderson, A.S. (2001), "Pregnancy as a time for dietary change?", *Proceedings of the Nutrition Society*, Vol. 60 No. 04, pp. 497–504.

Anderson, A.S., Campbell, D. and Shepherd, R. (1993), "Nutrition knowledge, attitude to healthier eating and dietary intake in pregnant compared to non-pregnant women", *Journal of Human Nutrition and Dietetics*, Vol. 6 No. 4, pp. 335–353.

Arkkola, T., Uusitalo, U., Kronberg-Kippila, C., Mannisto, S., Virtanen, M., Kenward, M.G., Veijola, R., Knip, M., Ovaskainen, M.-L. and Virtanen, S.M. (2008), "Seven distinct dietary patterns identified among pregnant Finnish women—associations with nutrient intake and sociodemographic factors", *Public Health Nutrition*, Vol. 11 No. 2, pp. 176–182.

Averett, S.L., Sikora, A. and Argys, L.M. (2008), "For better or worse: relationship status and body mass index", *Economics & Human Biology*, Vol. 6 No. 3, pp. 330–349.

Ayala, G.X., Baquero, B. and Klinger, S. (2008), "A systematic review of the relationship between acculturation and diet among Latinos in the United States: implications for future research", *Journal of the American Dietetic Association*, Vol. 108 No. 8, pp. 1330–1344.

Baerlocher, K. (1998), "Prävention beim Kind durch Ernährung der Schwangeren und Stillenden?", *Monatsschrift Kinderheilkunde*, Vol. 146 No. S1, pp. S73-S87.

Bai, J., Wong, F.W., Bauman, A. and Mohsin, M. (2002), "Parity and pregnancy outcomes", *American Journal of Obstetrics and Gynaecology*, Vol. 186 No. 2, pp. 274–278.

Ball, K. and Thornton, L. (2013), "Food environments: measuring, mapping, monitoring and modifying", *Public Health Nutrition*, Vol. 16 No. 7, pp. 1147–1150.

Barker, D.J., Eriksson, J.G., Forsén, T. and Osmond, C. (2002), "Fetal origins of adult disease: strength of effects and biological basis", *International Journal of Epidemiology*, Vol. 31 No. 6, pp. 1235–1239.

Barker, D.J., Winter, P.D., Osmond, C., Margetts, B. and Simmonds, S.J. (1989), "Weight in infancy and death from ischaemic heart disease", *The Lancet*, Vol. 2 No. 8663, pp. 577–580.

Barnes, J., Stein, A., Smith, T. and Pollock, J.I. (1997), "Extreme attitudes to body shape, social and psychological factors and a reluctance to breast feed. ALSPAC Study Team. Avon Longitudinal Study of Pregnancy and Childhood", *Journal of the Royal Society of Medicine*, Vol. 90 No. 10, pp. 551–559.

Barnes, R. (2016), "Health Impact Assessment (HIA). Glossary of terms used", available at: http://www.who.int/hia/about/glos/en/ (accessed 8 December 2016).

Bayley, T.M., Dye, L., Jones, S., DeBono, M. and Hill, A.J. (2002), "Food cravings and aversions during pregnancy: relationships with nausea and vomiting", *Appetite*, Vol. 38 No. 1, pp. 45–51.

Beardsworth, A. and Keil, T. (1997), *Sociology on the menu: An invitation to the study of food and society*, Routledge, London, New York.

Becker, S., Schmid, D., Amann-Gassner, U. and Hauner, H. (2011), "Verwendung von Nährstoffsupplementen vor und während der Schwangerschaft", *Ernährungs - Umschau*, Vol. 1 No. 11, pp. 36–41.

Belzer, L.M., Smulian, J.C., Lu, S.-E. and Tepper, B.J. (2010), "Food cravings and intake of sweet foods in healthy pregnancy and mild gestational diabetes mellitus. A prospective study", *Appetite*, Vol. 55 No. 3, pp. 609–615.

Ben-Shlomo, Y. and and Kuh, D. (2002), "A life course approach to chronic disease epidemiology: conceptual models, empirical challenges and interdisciplinary perspectives", *International Journal of Epidemiology*, Vol. 31 No. 2, pp. 285–293.

Bernecki DeJoy, S. and Bittner, K. (2015), "Obesity stigma as a determinant of poor birth outcomes in women with high BMI: a conceptual framework", *Maternal and Child Health Journal*, Vol. 19 No. 4, pp. 693–699.

Bland, J.M. and Altman, D.G. (1995), "Multiple significance tests: the Bonferroni method", *The BMJ*, Vol. 310, p. 170.

Bloomingdale, A., Guthrie, L.B., Price, S., Wright, R.O., Platek, D., Haines, J. and Oken, E. (2010), "A qualitative study of fish consumption during pregnancy", *The American Journal of Clinical Nutrition*, Vol. 92 No. 5, pp. 1234–1240.

Blumfield, M.L., Hure, A.J., Macdonald-Wicks, L., Smith, R. and Collins, C.E. (2012a), "Systematic review and meta-analysis of energy and macronutrient intakes during pregnancy in developed countries", *Nutrition Reviews*, Vol. 70 No. 6, pp. 322–336.

Blumfield, M.L., Hure, A.J., MacDonald-Wicks, L.K., Smith, R., Simpson, S.J., Giles, W.B., Raubenheimer, D. and Collins, C.E. (2012b), "Dietary balance during pregnancy is associated with fetal adiposity and fat distribution", *The AmericanJournal of Clinical Nutrition*, Vol. 96 No. 5, pp. 1032–1041.

Blundell, J.E., Stubbs, R.J., Golding, C., Croden, F., Alam, R., Whybrow, S., Le Noury, J. and Lawton, C.L. (2005), "Resistance and susceptibility to weight gain: individual variability in response to a high-fat diet", *Physiology & Behavior*, Vol. 86 No. 5, pp. 614–622.

Bodnar, L.M. and Siega-Riz, A.M. (2002), "A Diet Quality Index for Pregnancy detects variation in diet and differences by sociodemographic factors", *Public Health Nutrition*, Vol. 5 No. 6, pp. 801–809.

Bortoletto Martins, A.P. and D'Aquino Benicio, M.H. (2011), "Influence of dietary intake during gestation on postpartum weight retention", *Revista de saude publica*, Vol. 45 No. 5, pp. 870–877.

Bouchard, C., Tremblay, A., Després, J.-P., Nadeau, A., Lupien, P.J., Thériault, G., Dussault, J., Moorjani, S., Pinault, S. and Fournier, G. (1990), "The Response to Long-Term Overfeeding in Identical Twins", *The New England Journal of Medicine*, Vol. 322 No. 21, pp. 1477–1482.

Bourdieu, P. (1984), *Distinction: A social critique of the judgement of taste*, Harvard University Press, Cambridge, Mass.

Bouwland-Both, M.I., Steegers-Theunissen, R P M, Vujkovic, M., Lesaffre, E M E H, Mook-Kanamori, D.O., Hofman, A., Lindemans, J., Russcher, H., Jaddoe, V W V and Steegers, E A P (2013), "A periconceptional energy-rich dietary pattern is associated with early fetal growth: the Generation R study", *BJOG*, Vol. 120 No. 4, pp. 435–445.

Bowen, D.J. (1992), "Taste and food preference changes across the course of pregnancy", *Appetite*, Vol. 19 No. 3, pp. 233–242.

Bowley, C.I. and Blundell, L.L. (2016), "Dietary patterns and sociodemographic factors: considerations for nutrition research", *Public Health Nutrition*, pp. 1–2.

British Nutrition Foundation (Ed.) (2013), *Nutrition and development: Short and long term consequences for health*, Report of a British Nutrition Foundation Taskforce, Wiley-Blackwell, Chichester.

Broussard, B. (2012), "Psychological and behavioral traits associated with eating disorders and pregnancy: a pilot study", *Journal of Midwifery & Women's Health*, Vol. 57 No. 1, pp. 61–66.

Brown, A. and Avery, A. (2012), "Healthy weight management during pregnancy: what advice and information is being provided", *Journal of Human Nutrition and Dietetics*, Vol. 25 No. 4, pp. 378–387.

Brug, J. (2008), "Determinants of healthy eating: motivation, abilities and environmental opportunities", *Family Practice*, 25 Suppl 1, p. i50-5.

Brug, J., Oenema, A. and Ferreira, I. (2005), "Theory, evidence and Intervention Mapping to improve behavior nutrition and physical activity interventions. Debate", *International Journal of Behavioral Nutrition and Physical Activity*, Vol. 2 No. 1, p. 2.

Brunner, K.-M. (2000), "Soziologie der Ernährung und des Essens - die Formierung eines Forschungsfeldes", *Soziologische Revue*, Vol. 23 No. 2.

Brunst, K.J., Wright, R.O., DiGioia, K., Enlow, M.B., Fernandez, H., Wright, R.J. and Kannan, S. (2014), "Racial/ethnic and sociodemographic factors associated with micronutrient intakes and inadequacies among pregnant women in an urban US population", *Public Health Nutrition*, Vol. 17 No. 9, pp. 1–11.

Burke, V., Beilin, L.J., Dunbar, D. and Kevan, M. (2004), "Changes in health-related behaviours and cardiovascular risk factors in young adults: associations with living with a partner", *Preventive Medicine*, Vol. 39 No. 4, pp. 722–730.

Burr, M.L., Trembeth, J., Jones, K.B., Geen, J., Lynch, L.A. and Roberts, Z.E.S. (2007), "The effects of dietary advice and vouchers on the intake of fruit and fruit juice by pregnant women in a deprived area: a controlled trial", *Public Health Nutrition*, Vol. 10 No. 6, pp. 559–565.

Butte, N.F., Wong, W.W., Treuth, M.S., Ellis, K.J. and O'Brian Smith, E. (2004), "Am Energy requirements during pregnancy based on total energy expenditure and energy deposition", *The American Journal of Clinical Nutrition*, Vol. 79, pp. 1078–1087.

Buttriss, J.L., Stanner, S.A. and Sanders, T.A. (2013), "Putting the Science into Practice: Public Health Implications", in British Nutrition Foundation (Ed.), *Nutrition and development: Short and long term consequences for health*, Report of a British Nutrition Foundation Taskforce, Wiley-Blackwell, Chichester, pp. 216–255.

Caballero, B. (2015), "Focus on sugar-sweetened beverages", *Public Health Nutrition*, Vol. 18 No. 7, pp. 1143–1144.

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*, Vol. 2 No. 04.

Caplan, P. (1996), "Why do people eat what they do? Approaches to food and diet from a social science perspective", *Clinical Child Psychology and Psychiatry*, Vol. 1 No. (2), pp. 213–227.

Carmichael, S.L., Shaw, G.M., Selvin, S. and Schaffer, D.M. (2003), "Diet quality and risk of neural tube defects", *Medical Hypotheses*, Vol. 60 No. 3, pp. 351–355.

Castro, M.A.d., Baltar, V.T., Selem, Soraya Sant'Ana de Castro, Marchioni, D.M.L. and Fisberg, R.M. (2015), "Empirically derived dietary patterns. Interpretability and construct validity according to different factor rotation methods", *Cadernos de Saúde Pública*, Vol. 31 No. 2, pp. 298–310.

Cattell, R.B. (1966), "The Meaning and Strategic Use of Factor Analysis. Chapter 6", in Cattell, R.B. (Ed.), *Handbook of Multivariate Experimental Psychology*, Rand McNally & Company, Chicago, pp. 174–243.

Chatzi, L., Mendez, M., Garcia, R., Roumeliotaki, T., Ibarluzea, J., Tardon, A., Amiano, P., Lertxundi, A., Iniguez, C., Vioque, J., Kogevinas, M. and Sunyer, J. (2012), "Mediterranean diet adherence during pregnancy and fetal growth: INMA (Spain) and RHEA (Greece) mother-child cohort studies", *The British Journal of Nutrition*, Vol. 107 No. 1, pp. 135–145.

Chen, X., Zhao, D., Mao, X., Xia, Y., Baker, P.N. and Zhang, H. (2016), "Maternal Dietary Patterns and Pregnancy Outcome", *Nutrients*, Vol. 8 No. 6.

Chortatos, A., Haugen, M., Iversen, P.O., Vikanes, A., Magnus, P. and Veierod, M.B. (2013), "Nausea and vomiting in pregnancy: associations with maternal gestational diet and lifestyle factors in the Norwegian Mother and Child Cohort Study", *British Journal of Obstetrics and Gynaecology*, Vol. 120 No. 13, pp. 1642–1653.

Chun, J.K., Lim, S.W. and Cho, W.I. (2011), "Effect of Pregnancy and Consciousness Factors on Food-Related Behavior", in Preedy, V.R., Watson, R.R. and Martin, C.R. (Eds.), *Handbook of behavior, food and nutrition*, Springer, New York, NY [u.a.], pp. 1985–2007.

Clarisse, B., Nikasinovic, L., Poinsard, R., Just, J. and Momas, I. (2007), "The Paris prospective birth cohort study: which design and who participates?", *European Journal of Epidemiology*, Vol. 22 No. 3, pp. 203–210.

Cohen, G.R., Curet, L.B., Levine, R.J., Ewell, M.G., Morris, C.D., Catalano, P.M., Clokey, D. and Klebanoff, M.A. (2001), "Ethnicity, nutrition, and birth outcomes in nulliparous women", *American Journal of Obstetrics and Gynecology*, Vol. 185 No. 3, pp. 660–667.

Cole, Z.A., Gale, C.R., Javaid, M.K., Robinson, S.M., Law, C., Boucher, B.J., Crozier, S.R., Godfrey, K.M., Dennison, E.M. and Cooper, C. (2009), "Maternal dietary patterns during pregnancy and childhood bone mass: a longitudinal study", *Journal of Bone and Mineral Research*, Vol. 24 No. 4, pp. 663–668.

Colón-Ramos, U., Racette, S., Ganiban, J., Nguyen, T., Kocak, M., Carroll, K., Völgyi, E. and Tylavsky, F. (2015), "Association between Dietary Patterns during Pregnancy and Birth Size Measures in a Diverse Population in Southern US", *Nutrients*, Vol. 7 No. 2, pp. 1318–1332.

Connor Gorber, S., Tremblay, M., Moher, D. and Gorber, B. (2007), "A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review", *Obesity Reviews*, Vol. 8 No. 4, pp. 307–326.

Cooling, J. and Blundell, J. (1998), "Are high-fat and low-fat consumers distinct phenotypes? Differences in the subjective and behavioural response to energy and nutrient challenges", *European Journal of Clinical Nutrition*, Vol. 52 No. 3, pp. 193–201.

Cox, D.N. and Anderson, A.S. (2004), "Food Choice", in Gibney, M.J. (Ed.), *Public Health Nutrition*, *Nutrition Society textbook series*, Blackwell Science, Oxford, UK, Ames, Iowa, pp. 144–166.

Crozier, S.R., Robinson, S.M., Borland, S.E., Godfrey, K.M., Cooper, C. and Inskip, H.M. (2009a), "Do women change their health behaviours in pregnancy? Findings from the Southampton Women's Survey", *Paediatric and Perinatal Epidemiology*, Vol. 23 No. 5, pp. 446–453.

Crozier, S.R., Robinson, S.M., Godfrey, K.M., Cooper, C. and Inskip, H.M. (2009b), "Women's dietary patterns change little from before to during pregnancy", *The Journal of Nutrition*, Vol. 139 No. 10, pp. 1956–1963.

Cucó, G., Fernández-Ballart, J., Sala, J., Viladrich, C., Iranzo, R., Vila, J. and Arija, V. (2006), "Dietary patterns and associated lifestyles in preconception, pregnancy and postpartum", *European Journal of Clinical Nutrition*, Vol. 60 No. 3, pp. 364–371.

Cummins, S. and Macintyre, S. (2006), "Food environments and obesity— neighbourhood or nation?", *International Journal of Epidemiology*, Vol. 35 No. 1, pp. 100–104.

Darmon, N. and Drewnowski, A. (2008), "Does social class predict diet quality?", *The American journal of Clinical Nutrition*, Vol. 87 No. 5, pp. 1107–1117.

Davies, K. and Wardle, J. (1994), "Body image and dieting in pregnancy", *Journal of Psychosomatic Research*, Vol. 38 No. 8, pp. 787–799.

Davis, B.C. and Kris-Etherton, P.M. (2003), "Achieving optimal essential fatty acid status in vegetarians: current knowledge and practical implications", *The American Journal of Clinical Nutrition*, Vol. 78 No. 3 Suppl, pp. 640S–646.

Deierlein, A.L., Siega-Riz, A.M. and Herring, A. (2008), "Dietary energy density but not glycemic load is associated with gestational weight gain", *The American Journal of Clinical Nutrition*, Vol. 88 No. 3, pp. 693–699.

Delormier, T., Frohlich, K.L. and Potvin, L. (2009), "Food and eating as social practice—understanding eating patterns as social phenomena and implications for public health", *Sociology of Health &Iillness*, Vol. 31 No. 2, pp. 215–228.

Denomme, J., Stark, K.D. and Holub, B.J. (2005), "Directly quantitated dietary (n-3) fatty acid intakes of pregnant Canadian women are lower than current dietary recommendations", *The Journal of Nutrition*, Vol. 135 No. 2, pp. 206–211.

Derbyshire, E., Davies, J., Costarelli, V. and Dettmar, P. (2006), "Prepregnancy body mass index and dietary intake in the first trimester of pregnancy", *Journal of Human Nutrition and Dietetics*, Vol. 19 No. 4, pp. 267–273.

Devine, C.M. (2005), "A life course perspective: understanding food choices in time, social location, and history", *Journal of Nutrition Education and Behavior*, Vol. 37 No. 3, pp. 121–128.

Devine, C.M., Bove, C.F. and Olson, C.M. (2000), "Continuity and change in women's weight orientations and lifestyle practices through pregnancy and the postpartum period. The influence of life course trajectories and transitional events", *Social Science & Medicine*, Vol. 50 No. 4, pp. 567–582.

Douglas, A.J. (2011), "Neuroendocrine Mechanisms of Change in Food Intake During Pregnancy", in Preedy, V.R., Watson, R.R. and Martin, C.R. (Eds.), *Handbook of Behavior, Food and Nutrition*, Springer, New York, NY [u.a.], pp. 1969–1983.

Doyle, I.-M., Borrmann, B., Grosser, A., Razum, O. and Spallek, J. (2016), "Determinants of dietary patterns and diet quality during pregnancy: a systematic review with narrative synthesis", *Public Health Nutrition*, pp. 1–20.

Doyle, I.-M. and Spallek, J. (2016), "Determinants of dietary behaviour during pregnancy", *Public Health Forum*, Vol. 24 No. 3.

Drehmer, M., Camey, S., Schmidt, M.I., Olinto, M.T.A., Giacomello, A., Buss, C., Melere, C., Hoffmann, J., Manzolli, P., Soares, R.M., Ozcariz, S. and Nunes, M.A.A. (2010), "Socioeconomic, demographic and nutritional factors associated with maternal weight gain in general practices in Southern Brazil", *Cadernos de Saúde Pública*, Vol. 26 No. 5, pp. 1024–1034.

Drewnowski, A. and Popkin, B.M. (1997), "The Nutrition Transition. New Trends in the Global Diet", *Nutrition Reviews*, Vol. 55 No. 2, pp. 31–43.

Duffy, V.B., Bartoshuk, L.M., Striegel-Moore, R. and Rodin, J. (1998), "Taste changes across pregnancy", *Annals of the New York Academy of Sciences*, Vol. 855, pp. 805–809.

Dundas, R., Leyland, A.H. and Macintyre, S. (2014), "Early-Life School, Neighborhood, and Family Influences on Adult Health: A Multilevel Cross-Classified Analysis of the Aberdeen Children of the 1950s Study", *American Journal of Epidemiology*, Vol. 180 No. 2, pp. 197–207.

Edwards, C.H., Johnson, A.A., Knight, E.M., Oyemade, U.J., Cole, O.J., Westney, O.E., Jones, S., Laryea, H. and Westney, L.S. (1994), "Pica in an urban environment", *The Journal of Nutrition*, Vol. 124 No. 6 Suppl, pp. 954S–962.

Endres, J., Dunning, S., Poon, S.W., Welch, P. and Duncan, H. (1987), "Older pregnant women and adolescents: nutrition data after enrollment in WIC", *Journal of the American Dietetic Association*, Vol. 87 No. 8, p. 1011-6, 1019.

Englund-Ogge, L., Brantsaeter, A.L., Sengpiel, V., Haugen, M., Birgisdottir, B.E., Myhre, R., Meltzer, H.M. and Jacobsson, B. (2014), "Maternal dietary patterns and preterm delivery: results from large prospective cohort study", *BMJ*, Vol. 348 No. mar04 3, pp. g1446.

Epel, E., Lapidus, R., McEwen, B. and Brownell, K. (2001), "Stress may add bite to appetite in women: a laboratory study of stress-induced cortisol and eating behavior", *Psychoneuroendocrinology*, Vol. 26 No. 1, pp. 37–49.

Erkkola, M., Karppinen, M., Jarvinen, A., Knip, M. and Virtanen, S.M. (1998), "Folate, vitamin D, and iron intakes are low among pregnant Finnish women", *European Journal of Clinical Nutrition*, Vol. 52 No. 10, pp. 742–748.

Eshriqui, I., Vilela, A.A.F., Rebelo, F., Farias, D.R., Castro, M.B.T. and Kac, G. (2016), "Gestational dietary patterns are not associated with blood pressure changes during pregnancy and early postpartum in a Brazilian prospective cohort", *European Journal of Nutrition*, Vol. 55 No. 1, pp. 21–32.

Essery Stoody, E., Spahn, J.M., McGrane, M.M., MacNeil, P.C., Fungwe, T.V., Altman, J.M., Lyon, J., Obbagy, J.E. and Wong, Y.P. (2014), *A Series of Systematic Reviews on the Relationship Between Dietary Patterns and Health Outcomes*, Alexandria, VA.

Evans, R.G. and Stoddart, G.L. (1990), "Producing health, consuming health care", *Social Science and Medicine*, Vol. 31 No. 12, pp. 1347–1363.

Evans, R.G. and Stoddart, G.L. (2003), "Consuming Research, Producing Policy?", *American Journal of Public Health*, Vol. 93 No. 3, pp. 371–379.

Expert Consultation on Human Energy Requirements (2004), *Human energy requirements: Report of a joint FAO/WHO/UNU expert consultation Rome, 17 - 24 October 2001, FAO food and nutrition technical report series*, Vol. 1, United Nations Univ, Rome.

Fabrigar, L.R., Wegener, D.T., MacCallum, R.C. and Strahan, E.J. (1999), "Evaluating the use of exploratory factor analysis in psychological research", *Psychological Methods*, Vol. 4 No. 3, pp. 272–299.

Ferland, S. and O'Brien, H.T. (2003), "Maternal dietary intake and pregnancy outcome", *The Journal of Reproductive Medicine*, Vol. 48 No. 2, pp. 86–94.

Ferrari, R.M., Siega-Riz, A.M., Evenson, K.R., Moos, M.-K. and Carrier, K.S. (2013), "A qualitative study of women's perceptions of provider advice about diet and physical activity during pregnancy", *Patient Education and Counseling*, Vol. 91 No. 3, pp. 372–377.

Field, A.P. (2009), *Discovering statistics using SPSS: (and sex and drugs and rock 'n' roll), Introducing statistical methods,* 3rd ed., SAGE Publications, Los Angeles [i.e. Thousand Oaks, Calif.], London.

Finucane, M.M., Stevens, G.A., Cowan, M.J., Danaei, G., Lin, J.K., Paciorek, C.J., Singh, G.M., Gutierrez, H.R., Lu, Y., Bahalim, A.N., Farzadfar, F., Riley, L.M. and Ezzati, M. (2011), "National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9·1 million participants", *The Lancet*, Vol. 377 No. 9765, pp. 557–567.

Fitzsimon, N., Fallon, U., O'Mahony, D., Loftus, B.G., Bury, G., Murphy, A.W. and Kelleher, C.C. (2007), "Mothers' dietary patterns during pregnancy and risk of asthma symptoms in children at 3 years", *Irish Medical Journal*, Vol. 100 No. 8, pp. suppl 27–32.

Food Standards Agency (2002), *Healthy eating: Eating while you are pregnant*.

Forsum, E. (2004), "Energy requirements during pregnancy: old questions and new findings", *The American Journal of Clinical Nutrition*, Vol. 79 No. 6, pp. 933–934.

Fowler, J.K., Evers, S.E. and Campbell, M.K. (2012), "Inadequate dietary intakes among pregnant women", *Canadian journal of dietetic practice and research a publication of Dietitians of Canada*, Vol. 73 No. 2, pp. 72–77.

Fowles, E.R. (2002), "Comparing pregnant women's nutritional knowledge to their actual dietary intake", *MCN. The American journal of Maternal Child Nursing*, Vol. 27 No. 3, pp. 171–177.

Fowles, E.R., Bryant, M., Kim, S., Walker, L.O., Ruiz, R.J., Timmerman, G.M. and Brown, A. (2011a), "Predictors of Dietary Quality in Low-Income Pregnant Women", *Nursing Research*, Vol. 60 No. 5, pp. 286–294.

Fowles, E.R., Stang, J., Bryant, M. and Kim, S. (2012), "Stress, depression, social support, and eating habits reduce diet quality in the first trimester in low-income women: a pilot study", *Journal of the Academy of Nutrition and Dietetics*, Vol. 112 No. 10, pp. 1619–1625.

Fowles, E.R., Timmerman, G.M., Bryant, M. and Kim, S. (2011b), "Eating at fast-food restaurants and dietary quality in low-income pregnant women", *Western Journal of Nursing Research*, Vol. 33 No. 5, pp. 630–651.

Freese, J., Feller, S., Harttig, U., Kleiser, C., Linseisen, J., Fischer, B., Leitzmann, M.F., Six-Merker, J., Michels, K.B., Nimptsch, K., Steinbrecher, A., Pischon, T., Heuer, T., Hoffmann, I., Jacobs, G., Boeing, H. and Nöthlings, U. (2014), "Development and evaluation of a short 24-h food list as part of a blended dietary assessment strategy in large-scale cohort studies", *European Journal of Clinical Nutrition*, Vol. 68 No. 3, pp. 324–329.

Freimer, N., Echenberg, D. and Kretchmer, N. (1983), "Cultural variation. - nutritional and clinical implications", *The Western Journal of Medicine*, Vol. 139 No. 6, pp. 928–933.

Freisling, H., Elmadfa, I. and Gall, I. (2006), "The effect of socioeconomic status on dietary intake, physical activity and Body Mass Index in Austrian pregnant women", *Journal of Human Nutrition and Dietetics*, Vol. 19 No. 6, pp. 437–445.

Furst, T., Connors, M., Bisogni, C.A., Sobal, J. and Falk, L.W. (1996), "Food choice: a conceptual model of the process", *Appetite*, Vol. 26 No. 3, pp. 247–265.

Garbers, S. and Chiasson, M.A. (2013), "Class III Obesity and Unwanted Pregnancy Among Women with Live Births in New York City, 2004–2007", *Maternal and Child Health Journal*, Vol. 17 No. 8, pp. 1459–1467.

Gardner, B., Croker, H., Barr, S., Briley, A., Poston, L. and Wardle, J. (2012), "Psychological predictors of dietary intentions in pregnancy", *Journal of Human Nutrition and Dietetics*, Vol. 25 No. 4, pp. 345–353.

German Nutrition Society (DGE) (2015), "New Reference Values for Energy Intake", *Annals of Nutrition & Metabolism*, Vol. 66 No. 4, pp. 219–223.

Gernand, A.D., Schulze, K.J., Stewart, C.P., West, K.P., JR and Christian, P. (2016), "Micronutrient deficiencies in pregnancy worldwide: health effects and prevention", *Nature Reviews. Endocrinology*, Vol. 12 No. 5, pp. 274–289.

Gibney, M.J. (Ed.) (2004), *Public health nutrition, Nutrition Society textbook series*, Blackwell Science, Oxford, UK, Ames, Iowa.

Gilbert, P.A. and Khokhar, S. (2008), "Changing dietary habits of ethnic groups in Europe and implications for health", *Nutrition Reviews*, Vol. 66 No. 4, pp. 203–215.

Goni, L., Cuervo, M., Santiago, S., Zazpe, I. and Martinez, J.A. (2014), "Parity implications for anthropometrical variables, lifestyle behaviors and dietary habits in pregnant women", *Anales del sistema sanitario de Navarra*, Vol. 37 No. 3, pp. 349–362.

Gorsuch, R.L. (1974), *Factor analysis, Saunders books in psychology*, Saunders, Philadelphia.

Graham, H. and Oakley, A. (2005), "Competing ideologies of reproduction. Medical and maternal perspectives on pregnancy", in Scambler, G. (Ed.), *Medical sociology: Major themes in health and social welfare*, Volume 3: Coping with illness, *Major themes in health and social welfare*, Routledge, London, New York, pp. 110–126.

Graham, J.E., Mayan, M., McCargar, L.J and Bell, R.C. (2013), "Making compromises: a qualitative study of sugar consumption behaviors during pregnancy", *Journal of Nutrition Education and Behavior*, Vol. 45 No. 6, pp. 578–585.

Griffith, R., O'Connell, M. and Smith, K. (November/2013), *Food expenditure and nutrional quality over the Great Recession: IFS Briefing Note BN143*.

Grischke, E.-M. (2004), "Empfehlungen zur Ernährung in der Schwangerschaft", *Ernährung & Medizin*, Vol. 19 No. 4, pp. 165–168.

Groth, S.W. and Morrison-Beedy, D. (2013), "Low-income, pregnant, African American women's views on physical activity and diet", *Journal of midwifery & women's health*, Vol. 58 No. 2, pp. 195–202.

Guadagnoli, E. and Velicer, W.F. (1988), "Relation to sample size to the stability of component patterns", *Psychological Bulletin*, Vol. 103 No. 2, pp. 265–275.

Habhab, S., Sheldon, J.P. and Loeb, R.C. (2009), "The relationship between stress, dietary restraint, and food preferences in women", *Appetite*, Vol. 52 No. 2, pp. 437–444.

Haggarty, P., Campbell, D.M., Duthie, S., Andrews, K., Hoad, G., Piyathilake, C. and McNeill, G. (2009), "Diet and deprivation in pregnancy", *The British Journal of Nutrition*, Vol. 102 No. 10, pp. 1487–1497.

Halonen, J.I., Vahtera, J., Kivimaki, M., Pentti, J., Kawachi, I. and Subramanian, S.V. (2014), "Adverse experiences in childhood, adulthood neighbourhood disadvantage and health behaviours", *Journal of Epidemiology & Community Health*, Vol. 68 No. 8, pp. 741–746.

Haste, F.M., Brooke, O.G., Anderson, H.R., Bland, J.M., Shaw, A., Griffin, J. and Peacock, J.L. (1990), "Nutrient intakes during pregnancy: observations on the influence of smoking and social class", *The American Journal of Clinical Nutrition*, Vol. 51 No. 1, pp. 29–36.

Hawkes, C., Asfaw, A., Bauman, A., Bull, F., Eckhardt, C., Leroy, J. and Smith, M. (2006), *Evidence on the determinants of dietary patterns, nutrition and physical activity, and the interventions to maintain or to modify them: A systematic review*, London.

He, J.-R., Yuan, M.-Y., Chen, N.-N., Lu, J.-H., Hu, C.-Y., Mai, W.-B., Zhang, R.-F., Pan, Y.-H., Qiu, L., Wu, Y.-F., Xiao, W.-Q., Liu, Y., Xia, H.-M. and Qiu, X. (2015), "Maternal dietary patterns and gestational diabetes mellitus. A large prospective cohort study in China", *British Journal of Nutrition*, Vol. 113 No. 08, pp. 1292–1300.

Heins, U., Koebnick, C. and Leitzmann, C., "Vinegar drink to improve iron-status during pregnancy. Poster for the 10th International Symposium on Trace Elements in Man and Animal, Evian, France 1999", available at: http://www.uni-giessen.de/fbz/fb09/institute/ernaehrungswissenschaft/prof/nutr-ecol/veroeff/voeff-epid/vinegar-drink.

Heppe, D.H.M., Medina-Gomez, C., Hofman, A., Franco, O.H., Rivadeneira, F. and Jaddoe, Vincent W V (2013), "Maternal first-trimester diet and childhood bone mass: the Generation R Study", *The American journal of clinical nutrition*, Vol. 98 No. 1, pp. 224–232.

Hillesund, E.R., Overby, N.C., Engel, S.M., Klungsoyr, K., Harmon, Q.E., Haugen, M. and Bere, E. (2014), "Associations of adherence to the New Nordic Diet with risk of preeclampsia and preterm delivery in the Norwegian Mother and Child Cohort Study (MoBa)", *European Journal of Epidemiology*, Vol. 29 No. 10, pp. 753–765.

Hilmers, A., Hilmers, D.C. and Dave, J. (2012), "Neighborhood disparities in access to healthy foods and their effects on environmental justice", *American Journal of Public Health*, Vol. 102 No. 9, pp. 1644–1654.

Hinkle, S.N., Mumford, S.L., Grantz, K.L., Silver, R.M., Mitchell, E.M., Sjaarda, L.A., Radin, R.G., Perkins, N.J., Galai, N. and Schisterman, E.F. (2016), "Association of Nausea and Vomiting During Pregnancy With Pregnancy Loss: A Secondary Analysis of a Randomized Clinical Trial", *JAMA internal medicine*.

Hinz, I.-M., Grosser, A.M., Baumbach, A., Höller, C., Schmitz, J., Razum, O., Freese, J., Nöthlings, U., Boeing, H. and Spallek, J. (2014), "Anwendbarkeit der 24-h Food List in der sozialepidemiologischen BaBi Geburtskohorte", paper presented at Epidemiologie als Schlüssel für Prävention und bessere Versorgung, 17.09.2014-20.09.2014, Ulm.

Hirschauer, S. (2014), *Soziologie der Schwangerschaft: Exploration pränataler Sozialität, Qualitative Soziologie*, Vol. 19, Lucius et Lucius, Stuttgart.

Hodge, A. and Bassett, J. (2016), "What can we learn from dietary pattern analysis?", *Public Health Nutrition*, Vol. 19 No. 2, pp. 191–194.

Hoffmann, J.F., Nunes, M.A., Schmidt, M.I., Olinto, M.T., Melere, C., Ozcariz, S.G., Buss, C., Drehmer, M., Manzolli, P., Soares, R.M., Pinheiro, A.P. and Camey, S. (2014), "Dietary patterns during pregnancy and the association with sociodemographic characteristics among women attending general practices in southern Brazil: the ECCAGe Study", *Cad Saude Publica*, Vol. 30 No. (4), pp. 970–980.

Hook, E.B. (1978), "Dietary cravings and aversions during pregnancy", *The American Journal of Clinical Nutrition*, Vol. 31 No. 8, pp. 1355–1362.

Hromi-Fiedler, A., Bermudez-Millan, A., Segura-Perez, S. and Perez-Escamilla, R. (2011), "Household food insecurity is associated with depressive symptoms among low-income pregnant Latinas", *Maternal & child nutrition*, Vol. 7 No. 4, pp. 421–430.

Hu, F.B., Rimm, E., Smith-Warner, S.A., Feskanich, D., Stampfer, M.J., Ascherio, A., Sampson, L. and Willet, W.C. (1999), "Reproducibility and validity of dietary patterns assessed with a food-frequency questionnaire", *American Journal of Clinical Nutrition*, Vol. 69, pp. 243–249.

Hure, A., Young, A., Smith, R. and Collins, C. (2009), "Diet and pregnancy status in Australian women", *Public Health Nutrition*, Vol. 12 No. 6, pp. 853–861.

Hurley, K.M., Caulfield, L.E., Sacco, L.M., Costigan, K.A. and Dipietro, J.A. (2005), "Psychosocial influences in dietary patterns during pregnancy", *Journal of the American Dietetic Association*, Vol. 105 No. 6, pp. 963–966.

James, P. (2006), "Marabou 2005: Nutrition and Human Development", *Nutrition Reviews*, Vol. 64, pp. S1-S11.

Jeffery, R.W. and Rick, A.M. (2002), "Cross-sectional and longitudinal associations between body mass index and marriage-related factors", *Obesity Research*, Vol. 10 No. 8, pp. 809–815.

Kamphuis, C.B.M., van Lenthe, F.J., Giskes, K., Brug, J. and Mackenbach, J.P. (2007), "Perceived environmental determinants of physical activity and fruit and vegetable consumption among high and low socioeconomic groups in the Netherlands", *Health & place*, Vol. 13 No. 2, pp. 493–503.

Kendall, A., Olson, C.M. and Frongillo, E A Jr (2001), "Evaluation of psychosocial measures for understanding weight-related behaviors in pregnant women", *Annals of Behavioral Medicine*, Vol. 23 No. 1, pp. 50–58.

Kieffer, E.C., Welmerink, D.B., Sinco, B.R., Welch, K.B., Schumann, C.Y. and Uhley, V. (2013), "Periconception diet does not vary by duration of US residence for Mexican immigrant women", *Journal of the Academy of Nutrition and Dietetics*, Vol. 113 No. 5, pp. 652–658.

Kindig, D.A. (2007), "Understanding population health terminology", *The Milbank quarterly*, Vol. 85 No. 1, pp. 139–161.

Kirkwood, B.R. and Sterne, J.A.C. (2003), *Essential medical statistics,* 2nd ed., Blackwell Science, Malden, Mass.

Kirschner, W. (2013), "Ernährung als Thema in der Schwangerenvorsorge", *Der Gynäkologe*, Vol. 46 No. 5, pp. 313–319.

Kiziltan, G., Karabudak, E., Tuncay, G., Avsar, F., Tuncay, P., Mungan, O. and Meral, P. (2005), "Dietary intake and nutritional status of Turkish pregnant women during Ramadan", *Saudi medical journal*, Vol. 26 No. 11, pp. 1782–1787.

Klotter, C. (2007), *Einführung Ernährungspsychologie: Mit 5 Tabellen, UTB,* 2860 Psychologie, Haushalts- und Ernährungswissenschaften, Reinhardt, München [u.a.].

Knudsen, V.K., Orozova-Bekkevold, I.M., Mikkelsen, T.B., Wolff, S. and Olsen, S.F. (2008), "Major dietary patterns in pregnancy and fetal growth", *European Journal of Clinical Nutrition*, Vol. 62 No. 4, pp. 463–470.

Koebnick, C., Heins, U.A., Hoffmann, I., Dagnelie, P.C. and Leitzmann, C. (2001), "Folate status during pregnancy in women is improved by long-term high vegetable intake compared with the average western diet", *The Journal of Nutrition*, Vol. 131 No. 3, pp. 733–739.

Koebnick, C., Hoffmann, I., Dagnelie, P.C., Heins, U.A., Wickramasinghe, S.N., Ratnayaka, I.D., Gruendel, S., Lindemans, J. and Leitzmann, C. (2004), "Long-term ovo-lacto vegetarian diet impairs vitamin B-12 status in pregnant women", *The Journal of Nutrition*, Vol. 134 No. 12, pp. 3319–3326.

Koebnick, C., Leitzmann, R., Garcia, A.L., Heins, U.A., Heuer, T., Golf, S., Katz, N., Hoffmann, I. and Leitzmann, C. (2005), "Long-term effect of a plant-based diet on magnesium status during pregnancy", *European Journal of Clinical Nutrition*, Vol. 59 No. 2, pp. 219–225.

Koletzko, B. (2013), "Ernährung in der Schwangerschaft. Für das Leben des Kindes prägend", *Deutsches Ärzteblatt*, Vol. 110 No. 13, pp. A612-A613.

Koletzko, B., Bauer, C.P., Bung, P., Cremer, M., Flothkotter, M., Hellmers, C., Kersting, M., Krawinkel, M., Przyrembel, H., Rasenack, R., Schafer, T., Vetter, K., Wahn, U., Weissenborn, A. and Wockel, A. (2013), "German national consensus recommendations on nutrition and lifestyle in pregnancy by the 'Healthy Start - Young Family Network'", *Annals of Nutrition & Metabolism*, Vol. 63 No. 4, pp. 311–322.

Koletzko, B., Bauer, C.-P., Hellmers, C., Kersting, M., Krawinkel, M., Przyrembel, H., Schäfer, T., Vetter, K., Wahn, U., Weißenborn, A., Wöckel, A., Bung, P., Rasenack, R., Cremer, M., Albrecht, V., Pahne, A., Potz, A. and Weiser, G. (2011), *Ernährung in der Schwangerschaft: Handlungsempfehlungen KOMPAKT*, Im Auftrag des bundesweiten Netzwerks „Gesund ins Leben – Netzwerk Junge Familie", Bonn.

Koletzko, B., Brands, B., Poston, L., Godfrey, K. and Demmelmair, H. (2012), "Early nutrition programming of long-term health", *The Proceedings of the Nutrition Society*, Vol. 71 No. 3, pp. 371–378.

Kominiarek, M.A. (2014), "A survey of health behaviors in minority women in pregnancy: the influence of body mass index", *Women's Health Issues*, Vol. 24 No. 3, p. e291-5.

Kramer, M.S. (1987), "Determinants of low birth weight: methodological assessment and meta-analysis", *Bulletin of the World Health Organization*, Vol. 65 No. 5, pp. 663–737.

Kritsotakis, G., Chatzi, L., Vassilaki, M., Georgiou, V., Kogevinas, M., Philalithis, A.E. and Koutis, A. (2015), "Social capital, tolerance of diversity and adherence to Mediterranean diet: the Rhea Mother-Child Cohort in Crete, Greece", *Public Health Nutrition*, Vol. 18 No. 7, pp. 1300–1307.

Kuh, D., Ben-Shlomo, Y., Lynch, J., Hallqvist, J. and Power, C. (2003), "Life course epidemiology", *Journal of Epidemiology & Community Health*, Vol. 57 No. 10, pp. 778–783.

Kulig, J.C., Wall, M., Hill, S. and Babcock, R. (2008), "Childbearing beliefs among Low-German-speaking Mennonite women", *International Nursing Review*, Vol. 55 No. 4, pp. 420–426.

Lake, A. and Townshend, T. (2006), "Obesogenic environments: exploring the built and food environments", *The journal of the Royal Society for the Promotion of Health*, Vol. 126 No. 6, pp. 262–267.

Lakerveld, J., van der Ploeg, Hidde P, Kroeze, W., Ahrens, W., Allais, O., Andersen, L.F., Cardon, G., Capranica, L., Chastin, S., Donnelly, A., Ekelund, U., Finglas, P., Flechtner-Mors, M., Hebestreit, A., Hendriksen, I., Kubiak, T., Lanza, M., Loyen, A., MacDonncha, C., Mazzocchi, M., Monsivais, P., Murphy, M., Nöthlings, U., O'Gorman, D.J., Renner, B., Roos, G., Schuit, A.J., Schulze, M., Steinacker, J., Stronks, K., Volkert, D., Van't Veer, P., Lien, N., Bourdeaudhuij, I. de and Brug, J. (2014), "Towards the integration and development of a cross-European research network and infrastructure: the DEterminants of DIet and Physical ACtivity (DEDIPAC) Knowledge Hub", *The International Journal of Behavioral Nutrition and Physical Activity*, Vol. 11, p. 143.

Landgraf, M. and Heinen, F. (2016), *S3-Leitlinie Diagnostik des Fetalen Alkoholsyndroms: Kurzfassung*, AWMF-Registernr.: 022-025.

Laraia, B., Vinikoor-Imler, L.C. and Siega-Riz, A.M. (2015), "Food insecurity during pregnancy leads to stress, disordered eating, and greater postpartum weight among overweight women", *Obesity (Silver Spring, Md.)*, Vol. 23 No. 6, pp. 1303–1311.

Laraia, B.A., Am Siega-Riz, Kaufman, J.S. and Jones, S.J. (2004), "Proximity of supermarkets is positively associated with diet quality index for pregnancy", *Preventive Medicine*, Vol. 39 No. 5, pp. 869–875.

Laraia, B.A., Bodnar, L.M. and Siega-Riz, A.M. (2007), "Pregravid body mass index is negatively associated with diet quality during pregnancy", *Public Health Nutrition*, Vol. 10 No. 9, pp. 920–926.

Larranaga, I., Santa-Marina, L., Begiristain, H., Machon, M., Vrijheid, M., Casas, M., Tardon, A., Fernandez-Somoano, A., Llop, S., Rodriguez-Bernal, C.L. and Fernandez, M.F. (2013), "Socio-economic inequalities in health, habits and self-care during pregnancy in Spain", *Maternal and Child Health Journal*, Vol. 17 No. 7, pp. 1315–1324.

Last, J.M. (1988), *A dictionary of epidemiology: second edition*, Oxford University Press, New York.

Latva-Pukkila, U., Isolauri, E. and Laitinen, K. (2010), "Dietary and clinical impacts of nausea and vomiting during pregnancy", *Journal of Human Nutrition and Dietetics*, Vol. 23 No. 1, pp. 69–77.

Lawlor, D.A. and Chaturvedi, N. (2005), "Treatment and prevention of obesity—are there critical periods for intervention?", *International Journal of Epidemiology*, Vol. 35 No. 1, pp. 3–9.

Lennox, A.M., Buttriss, J.L. and Gibson-Moore, H.J. (2013), "Maternal Nutrition and Infant Feeding. Current Practice and Recommendations", in British Nutrition Foundation (Ed.), *Nutrition and development: Short and long term consequences for health*, Report of a British Nutrition Foundation Taskforce, Wiley-Blackwell, Chichester, pp. 28–73.

Lewallen, L.P. (2004), "Healthy behaviors and sources of health information among low-income pregnant women", *Public Health Nursing (Boston, Mass.)*, Vol. 21 No. 3, pp. 200–206.

Li, Y., He, Y., Qi, L., Jaddoe, V.W., Feskens, Edith J M, Yang, X., Ma, G. and Hu, F.B. (2010), "Exposure to the Chinese famine in early life and the risk of hyperglycemia and type 2 diabetes in adulthood", *Diabetes*, Vol. 59 No. 10, pp. 2400–2406.

Li, Y., Jaddoe, V.W., Qi, L., He, Y., Lai, J., Wang, J., Zhang, J., Hu, Y., Ding, E.L., Yang, X., Hu, F.B. and Ma, G. (2011), "Exposure to the Chinese famine in early life and the risk of hypertension in adulthood", *Journal of Hypertension*, Vol. 29 No. 6, pp. 1085–1092.

Lim, S.W., Chun, J.K. and Cho, W.I. (2008), "Effect of pregnancy on food consumption and consciousness factors associated with food satisfaction", *Appetite*, Vol. 50 No. 2-3, pp. 519–528.

Lind, P.L., Jensen, P.V., Glumer, C. and Toft, U. (2016), "The association between accessibility of local convenience stores and unhealthy diet", *European Journal of Public Health*, Vol. 26 No. 4, pp. 634–639.

Lucas, C., Charlton, K.E. and Yeatman, H. (2014), "Nutrition advice during pregnancy: do women receive it and can health professionals provide it?", *Maternal and Child Health Journal*, Vol. 18 No. 10, pp. 2465–2478.

Lumey, L.H., Khalangot, M.D. and Vaiserman, A.M. (2015), "Association between type 2 diabetes and prenatal exposure to the Ukraine famine of 1932–33: a retrospective cohort study // Association between type 2 diabetes and prenatal exposure to the Ukraine famine of 1932–33. A retrospective cohort study", *The Lancet Diabetes & Endocrinology*, Vol. 3 No. 10, pp. 787–794.

Lussana, F., Painter, R.C., Ocke, M.C., Buller, H.R., Bossuyt, P.M. and Roseboom, T.J. (2008), "Prenatal exposure to the Dutch famine is associated with a preference for fatty foods and a more atherogenic lipid profile", *The American Journal of Clinical Nutrition*, Vol. 88 No. 6, pp. 1648–1652.

Macintyre, S. and Anderson, A. (1997), "Socio-demographic and psycho-social variables", in Margetts, B.M. and Nelson, M. (Eds.), *Design concepts in nutritional epidemiology*, 2nd ed., Oxford Univ. Press, Oxford [u.a.], pp. 273–288.

Manniën, J., Jonge, A. de, Cornel, M.C., Spelten, E. and Hutton, E.K. (2014), "Factors associated with not using folic acid supplements preconceptionally", *Public Health Nutrition*, Vol. 17 No. 10, pp. 2344–2350.

Margetts, B.M. and Nelson, M. (Eds.) (1997), *Design concepts in nutritional epidemiology,* 2nd ed., Oxford Univ. Press, Oxford [u.a.].

Marshall, G. (1998), *A dictionary of sociology, Oxford paperback reference,* 2nd ed., Oxford University Press, New York.

Martin, C.L., Siega-Riz, A.M., Sotres-Alvarez, D., Robinson, W.R., Daniels, J.L., Perrin, E.M. and Stuebe, A.M. (2016), "Maternal Dietary Patterns are Associated with Lower Levels of Cardiometabolic Markers during Pregnancy", *Paediatric and Perinatal Epidemiology*, Vol. 30 No. 3, pp. 246–255.

Mathews, F., Yudkin, P., Smith, R.F. and Neil, A. (2000), "Nutrient intakes during pregnancy: the influence of smoking status and age", *Journal of Epidemiology and Community Health*, Vol. 54 No. 1, pp. 17–23.

McArdle, H.J. and Gambling, L. (2013), "Mechanisms and Pathways of Critical Windows of Development", in British Nutrition Foundation (Ed.), *Nutrition and development: Short and long term consequences for health*, Report of a British Nutrition Foundation Taskforce, Wiley-Blackwell, Chichester, pp. 75–85.

McGowan, C.A. and McAuliffe, F.M. (2013), "Maternal dietary patterns and associated nutrient intakes during each trimester of pregnancy", *Public Health Nutrition*, Vol. 16 No. 01, pp. 97–107.

McIntosh, W.A. (1996), *Sociologies of food and nutrition, The language of science*, Plenum Press, New York.

McKeating, A., O'Higgins, A., Turner, C., McMahon, L., Sheehan, S.R. and Turner, M.J. (2015), "The relationship between unplanned pregnancy and maternal body mass index 2009-2012", *The European Journal of Contraception & Reproductive Health Care*, Vol. 20 No. 6, pp. 409–418.

McMillan, J. and Coveney, J. (2014), "Editorial. What took you so long? Sociology's recent foray into food", *Health Sociology Review*, Vol. 19 No. 3, pp. 282–284.

McNaughton, S.A., Mishra, G.D., Bramwell, G., Paul, A.A. and Wadsworth, M.E.J. (2005), "Comparability of dietary patterns assessed by multiple dietary assessment methods: results from the 1946 British Birth Cohort", *European Journal of Clinical Nutrition*, Vol. 59 No. 3, pp. 341–352.

Mehta, U.J., Siega-Riz, A.M. and Herring, A.H. (2011), "Effect of body image on pregnancy weight gain", *Maternal and Child Health Journal*, Vol. 15 No. 3, pp. 324–332.

Micali, N., Northstone, K., Emmett, P., Naumann, U. and Treasure, J.L. (2012), "Nutritional intake and dietary patterns in pregnancy: a longitudinal study of women with lifetime eating disorders", *British Journal of Nutrition*, Vol. 108 No. 11, pp. 2093–2099.

Mikkelsen, T.B., Osterdal, M.L., Knudsen, V.K., Haugen, M., Meltzer, H.M., Bakketeig, L. and Olsen, S.F. (2008), "Association between a Mediterranean-type diet and risk of preterm birth among Danish women: a prospective cohort study", *Acta obstetricia et gynecologica Scandinavica*, Vol. 87 No. 3, pp. 325–330.

Miles, M.B. and Huberman, A.M. (1994), *Qualitative data analysis: An expanded sourcebook,* 2nd ed., SAGE Publications, Thousand Oaks.

Misra, D.P. (2006), "Racial Disparities in Perinatal Health: A Multiple Determinants Perinatal Framework with a Lifespan Approach", *Harvard Health Policy Review*, Vol. 7 No. 1, pp. 72–90.

Moran, L.J., Sui, Z., Cramp, C.S. and Dodd, J.M. (2013), "A decrease in diet quality occurs during pregnancy in overweight and obese women which is maintained post-partum", *International Journal of Obesity (2005)*, Vol. 37 No. 5, pp. 704–711.

Morton, S.M.B., Grant, C.C., Wall, C.R., Atatoan Carr, P.E., Bandara, D.K., Schmidt, J.M., Ivory, V., Inskip, H.M. and Camargo, C.A., JR (2014), "Adherence to nutritional guidelines in pregnancy: evidence from the Growing Up in New Zealand birth cohort study", *Public Health Nutrition*, Vol. 17 No. 9, pp. 1919–1929.

Müller, M.J. and Langnäse, K. (2005), "Einfluss sozialer Faktoren auf Gesundheit, Lebensstil und Ernährung", in Müller, M.J. (Ed.), *Gesundheit und Ernährung - Public Health Nutrition*, *UTB*, Ulmer, Stuttgart, pp. 143–154.

Mumford, S.L., Siega-Riz, A.M., Herring, A. and Evenson, K.R. (2008), "Dietary restraint and gestational weight gain", *Journal of the American Dietetic Association*, Vol. 108 No. 10, pp. 1646–1653.

Murrin, C., Fallon, U.B., Hannon, F., Nolan, G., O'Mahony, D., Crowley, D., Bury, G., Daly, S., Morrison, J.J., Murphy, A.W. and Kelleher, C.C. (2007), "Dietary habits of pregnant women in Ireland", *Irish Medical Journal*, Vol. 100 No. 8, p. suppl 12-5.

Nash, D.M., Gilliland, J.A., Evers, S.E., Wilk, P. and Campbell, M.K. (2013), "Determinants of diet quality in pregnancy: sociodemographic, pregnancy-specific, and food environment influences", *Journal of Nutrition Education and Behavior*, Vol. 45 No. 6, pp. 627–634.

National Health Service (2015), "Pregnancy and baby. Have a healthy start in pregnancy", available at: http://www.nhs.uk/conditions/pregnancy-and-baby/pages/healthy-pregnancy-diet.aspx (accessed 4 December 2016).

Neelsen, S. and Stratmann, T. (2011), "Effects of prenatal and early life malnutrition: evidence from the Greek famine", *Journal of Health Economics*, Vol. 30 No. 3, pp. 479–488.

Nehring, I., Feurig, S., Roebl-Matthieu, M., Schiessl, B. and Kries, R.V. (2015), "Sichtweisen schwangerer Frauen zu ihrem Ernahrungs- und Bewegungsverhalten: eine Beratungsgrundlage zur Vermeidung exzessiver Gewichtszunahme", *Gesundheitswesen*.

Nelson, M. and Bingham, S.A. (1997), "Assessment of food composition and nutrient intake", in Margetts, B.M. and Nelson, M. (Eds.), *Design concepts in nutritional epidemiology*, 2nd ed., Oxford Univ. Press, Oxford [u.a.], pp. 123–169.

Nilsen, R.M., Leoncini, E., Gastaldi, P., Allegri, V., Agostino, R., Faravelli, F., Ferrazzoli, F., Finale, E., Ghirri, P., Scarano, G. and Mastroiacovo, P. (2016), "Prevalence and determinants of preconception folic acid use: an Italian multicenter survey", *Italian Journal of Pediatrics*, Vol. 42 No. 1, p. 65.

Nilsen, R.M., Vollset, S.E., Gjessing, H.K., Skjaerven, R., Melve, K.K., Schreuder, P., Alsaker, E.R., Haug, K., Daltveit, A.K. and Magnus, P. (2009), "Self-selection and bias in a large prospective pregnancy cohort in Norway", *Paediatric and Perinatal Epidemiology*, Vol. 23 No. 6, pp. 597–608.

Northstone, K., Emmett, P. and Rogers, I. (2007), "Dietary patterns in pregnancy and associations with socio-demographic and lifestyle factors", *European Journal of Clinical Nutrition*, Vol. 62 No. 4, pp. 471–479.

Nybo Andersen, A.-M., Wohlfahrt, J., Christens, P., Olsen, J. and Melbye, M. (2000), "Maternal age and fetal loss. Population based register linkage study", *BMJ*, Vol. 320 No. 7251, pp. 1708–1712.

Okubo, H., Miyake, Y., Sasaki, S., Tanaka, K., Murakami, K. and Hirota, Y. (2011a), "Dietary patterns during pregnancy and the risk of postpartum depression in Japan: the Osaka Maternal and Child Health Study", *The British journal of nutrition*, Vol. 105 No. 8, pp. 1251–1257.

Okubo, H., Miyake, Y., Sasaki, S., Tanaka, K., Murakami, K. and Hirota, Y. (2011b), "Nutritional adequacy of three dietary patterns defined by cluster analysis in 997 pregnant Japanese women: the Osaka Maternal and Child Health Study", *Public Health Nutrition*, Vol. 14 No. 4, pp. 611–621.

Olafsdottir, A.S., Skuladottir, G.V., Thorsdottir, I., Hauksson, A. and Steingrimsdottir, L. (2006), "Maternal diet in early and late pregnancy in relation to weight gain", *InternationalJjournal of Obesity (2005)*, Vol. 30 No. 3, pp. 492–499.

Oliver, E.M., Grimshaw, K.E.C., Schoemaker, A.A., Keil, T., McBride, D., Sprikkelman, A.B., Ragnarsdottir, H.S., Trendelenburg, V., Emmanouil, E., Reche, M., Fiocchi, A., Fiandor, A., Stanczyk-Przyluska, A., Wilczynski, J., Busacca, M., Sigurdardottir, S.T., Dubakiene, R., Rudzeviciene, O., Vlaxos, G.D., Beyer, K. and Roberts, G. (2014), "Dietary habits and supplement use in relation to national pregnancy recommendations: data from the EuroPrevall birth cohort", *Maternal and Child Health Journal*, Vol. 18 No. 10, pp. 2408–2425.

Oliver, G., Wardle, J. and Gibson, E.L. (2000), "Stress and food choice: a laboratory study", *Psychosomatic medicine*, Vol. 62 No. 6, pp. 853–865.

Olson, C.M., Strawderman, M.S., Hinton, P.S. and Pearson, T.A. (2003), "Gestational weight gain and postpartum behaviors associated with weight change from early pregnancy to 1 y postpartum", *International Journal of Obesity and Related Metabolic Disorders*, Vol. 27 No. 1, pp. 117–127.

Oltersdorf, U. (1995), *Ernährungsepidemiologie: Mensch, Ernährung, Umwelt*, E. Ulmer, Stuttgart (Hohenheim).

Oltersdorf, U., Boeing, H., Hendrichs, A. and Bodenstedt, A.A. (1989), "Strategies for analyzing nutritional data for epidemiological purposes — Conceptual framework", *Zeitschrift für Ernährungswissenschaft*, Vol. 28 No. 3, pp. 240–259.

Osborne, J.W. and Costello, A.B. (2009), "Best practice in exploratory factor analysis:. four recommendations for getting the most out of your analysis", *Pan-Pacific Management Review*, Vol. 12 No. 2, pp. 131–146.

Peacock, J. and Kerry, S.M. (2007), *Presenting medical statistics: From proposal to publication a step-by-step guide, Oxford medical publications*, Oxford University Press, Oxford, New York.

Petersen, J. and Jahn, A. (2008), "Suspicious findings in antenatal care and their implications from the mothers' perspective: a prospective study in Germany", *Birth (Berkeley, Calif.)*, Vol. 35 No. 1, pp. 41–49.

Pinto, E., Barros, H. and dos Santos Silva, Isabel (2009), "Dietary intake and nutritional adequacy prior to conception and during pregnancy: a follow-up study in the north of Portugal", *Public Health Nutrition*, Vol. 12 No. 7, pp. 922–931.

Pizzi, C., Stavola, B.L. de, Pearce, N., Lazzarato, F., Ghiotti, P., Merletti, F. and Richiardi, L. (2012), "Selection bias and patterns of confounding in cohort studies: the case of the NINFEA web-based birth cohort", *Journal of Epidemiology and Community Health*, Vol. 66 No. 11, pp. 976–981.

Poon, A.K., Yeung, E., Boghossian, N., Albert, P.S. and Zhang, C. (2013), "Maternal Dietary Patterns during Third Trimester in Association with Birthweight Characteristics and Early Infant Growth", *Scientifica*, Vol. 2013 No. 7028, pp. 1–7.

Popkin, B.M. (2011), "Contemporary nutritional transition: determinants of diet and its impact on body composition", *The Proceedings of the Nutrition Society*, Vol. 70 No. 1, pp. 82–91.

Popkin, B.M., Adair, L.S. and Ng, S.W. (2012), "Global nutrition transition and the pandemic of obesity in developing countries", *Nutrition Reviews*, Vol. 70 No. 1, pp. 3–21.

Popkin, B.M. and Gordon-Larsen, P. (2004), "The nutrition transition: worldwide obesity dynamics and their determinants", *International Journal of Obesity and Related Metabolic Disorders*, 28 Suppl 3, p. S2-9.

Porta, M.S., Greenland, S., Hernán, M., Silva, I.d.S. and Last, J.M. (2014), *A dictionary of epidemiology,* Six edition, Oxford University Press, Oxford.

Power, M., Uphoff, E., Kelly, B. and Pickett, K.E. (2016), "Food insecurity and mental health. An analysis of routine primary care data of pregnant women in the Born in Bradford cohort", *Journal of Epidemiology and Community Health*, pp. jech-2016-207799.

Prentice, A.M. and Jebb, S.A. (1995), "Obesity in Britain: gluttony or sloth?", *BMJ (Clinical research ed.)*, Vol. 311 No. 7002, pp. 437–439.

Raine, K.D. (2005), "Determinants of healthy eating in Canada. An overview and synthesis", *Canadian Journal of Public Health*, Vol. 96 No. Supplement 3, pp. S8-S14.

Rao, M., Afshin, A., Singh, G. and Mozaffarian, D. (2013), "Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis", *BMJ open*, Vol. 3 No. 12, pp. e004277.

Rasmussen, K.M., Abrams, B., Bodnar, L.M., Butte, N.F., Catalano, P.M. and Maria Siega-Riz, A. (2010), "Recommendations for weight gain during pregnancy in the context of the obesity epidemic", *Obstetrics and Gynecology*, Vol. 116 No. 5, pp. 1191–1195.

Rasmussen, K.M. and Yaktine, A.L. (2009), *Weight gain during pregnancy: Reexamining the guidelines*, National Academies Press, Washington, D.C.

Rauh, K., Gabriel, E., Kerschbaum, E., Schuster, T., Kries, R. von, Amann-Gassner, U. and Hauner, H. (2013), "Safety and efficacy of a lifestyle intervention for pregnant women to prevent excessive maternal weight gain: a cluster-randomized controlled trial", *BMC pregnancy and childbirth*, Vol. 13, p. 151.

Rauh, K., Kunath, J., Rosenfeld, E., Kick, L., Ulm, K. and Hauner, H. (2014), "Healthy living in pregnancy: a cluster-randomized controlled trial to prevent excessive gestational weight gain - rationale and design of the GeliS study", *BMC pregnancy and childbirth*, Vol. 14, p. 119.

Razum, O., Zeeb, H., Meesemann, U., Schenk, L., Bredehorst, M., Brzoska, P., Dercks, T., Glodny, S., Menkhaus, B., Salman, R., Saß, A.-C. and Ulrich, R. (2008), *Migration und Gesundheit: Schwerpunktbericht der Gesundheitsberichterstattung des Bundes*.

Reedy, J., Wirfalt, E., Flood, A., Mitrou, P.N., Krebs-Smith, S.M., Kipnis, V., Midthune, D., Leitzmann, M., Hollenbeck, A., Schatzkin, A. and Subar, A.F. (2010), "Comparing 3 dietary pattern methods—cluster analysis, factor analysis, and index analysis—With colorectal cancer risk: The NIH-AARP Diet and Health Study", *American Journal of Epidemiology*, Vol. 171 No. 4, pp. 479–487.

Reiss, K., Breckenkamp, J., Borde, T., Brenne, S., David, M. and Razum, O. (2015), "Contribution of overweight and obesity to adverse pregnancy outcomes among immigrant and non-immigrant women in Berlin, Germany", *European Journal of Public Health*, Vol. 25 No. 5, pp. 839–844.

Reyes, N.R., Klotz, A.A. and Herring, S.J. (2013), "A qualitative study of motivators and barriers to healthy eating in pregnancy for low-income, overweight, African-American mothers", *Journal of the Academy of Nutrition and Dietetics*, Vol. 113 No. 9, pp. 1175–1181.

Reynolds, R.M., Godfrey, K.M., Barker, M., Osmond, C. and Phillips, David I W (2007), "Stress responsiveness in adult life: influence of mother's diet in late pregnancy", *The Journal of Clinical Endocrinology and Metabolism*, Vol. 92 No. 6, pp. 2208–2210.

Rifas-Shiman, S.L., Rich-Edwards, J.W., Kleinman, K.P., Oken, E. and Gillman, M.W. (2009), "Dietary quality during pregnancy varies by maternal characteristics in Project Viva: a US cohort", *Journal of the American Dietetic Association*, Vol. 109 No. 6, pp. 1004–1011.

Robert Koch-Institut (RKI) (2012), "Einflussfaktoren auf die Gesundheit: Übergewicht und Adipositas. GEDA 2010 Faktenblätter", available at: http://www.rki.de/DE/Content/Gesundheitsmonitoring/Gesundheitsberic hterstattung/GBEDownloadsB/Geda2010/uebergewicht_adipositas.pdf?__blob=publicationFile (accessed 7 January 2013).

Robinson, S. (2013), "Introduction to Early Life and Later Disease", in British Nutrition Foundation (Ed.), *Nutrition and development: Short and long term consequences for health*, Report of a British Nutrition Foundation Taskforce, Wiley-Blackwell, Chichester, pp. 1–12.

Rocco, P.L., Orbitello, B., Perini, L., Pera, V., Ciano, R.P. and Balestrieri, M. (2005), "Effects of pregnancy on eating attitudes and disorders: a prospective study", *Journal of Psychosomatic Research*, Vol. 59 No. 3, pp. 175–179.

Rodrigues, P.L., Lacerda, Elisa Maria de Aquino, Schlussel, M.M., Spyrides, Maria Helena Constantino and Kac, G. (2008), "Determinants of weight gain in pregnant women attending a public prenatal care facility in Rio de Janeiro, Brazil: a prospective study, 2005-2007", *Cadernos de saude publica*, 24 Suppl 2, p. S272-84.

Rodriguez-Bernal, C.L., Rebagliato, M., Iniguez, C., Vioque, J., Navarrete-Munoz, E.M., Murcia, M., Bolumar, F., Marco, A. and Ballester, F. (2010), "Diet quality in early pregnancy and its effects on fetal growth outcomes: the Infancia y Medio Ambiente (Childhood and Environment) Mother and Child Cohort Study in Spain", *The American Journal of Clinical Nutrition*, Vol. 91 No. 6, pp. 1659–1666.

Rodríguez-Bernal, C.L., Ramón, R., Quiles, J., Murcia, M., Navarrete-Muñoz, E.M., Vioque, J., Ballester, F. and Rebagliato, M. (2013), "Dietary intake in pregnant women in a Spanish Mediterranean area: as good as it is supposed to be?", *Public Health Nutrition*, Vol. 16 No. 08, pp. 1379–1389.

Rogers, I., Emmett, P., Baker, D. and Golding, J. (1998), "Financial difficulties, smoking habits, composition of the diet and birthweight 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*, Vol. 52 No. 4, pp. 251–260.

Salmenhaara, M., Uusitalo, L., Uusitalo, U., Kronberg-Kippila, C., Sinkko, H., Ahonen, S., Veijola, R., Knip, M., Kaila, M. and Virtanen, S.M. (2010), "Diet and weight gain characteristics of pregnant women with gestational diabetes", *European Journal of Clinical Nutrition*, Vol. 64 No. 12, pp. 1433–1440.

Sanchez-Villegas, A., Brito, N., Doreste-Alonso, J., Nissensohn, M., Henriquez, P., Hermoso, M., Berti, C. and Serra Majem, L. (2010), "Methodological aspects of the study of dietary patterns during pregnancy and maternal and infant health outcomes. A systematic review", *Maternal & child nutrition*, 6 Suppl 2, pp. 100–111.

Saunders, L., Guldner, L., Costet, N., Kadhel, P., Rouget, F., Monfort, C., Thome, J.-P., Multigner, L. and Cordier, S. (2014), "Effect of a Mediterranean diet during pregnancy on fetal growth and preterm delivery: results from a French Caribbean Mother-Child Cohort Study (TIMOUN)", *Paediatric and Perinatal Epidemiology*, Vol. 28 No. 3, pp. 235–244.

Savitz, D.A., Olshan, A.F. and Gallagher, K. (1996), "Maternal Occupation and Pregnancy Outcome", *Epidemiology*, Vol. 7 No. 3, pp. 269–274.

Schneider, S. and Gruber, J. (2013), "Neighbourhood deprivation and outlet density for tobacco, alcohol and fast food: first hints of obesogenic and addictive environments in Germany", *Public Health Nutrition*, Vol. 16 No. 7, pp. 1168–1177.

Schofield, C., Wheeler, E. and Stewart, J. (1987), "The diets of pregnant and post-pregnant women in different social groups in London and Edinburgh: energy, protein, fat and fibre", *The British Journal of Nutrition*, Vol. 58 No. 3, pp. 369–381.

Schulze, M.B., Hoffmann, K., Kroke, A. and Boeing, H. (2003), "An approach to construct simplified measures of dietary patterns from exploratory factor analysis", *The British Journal of Nutrition*, Vol. 89 No. 3, pp. 409–419.

Schüz, B., Schüz, N. and Ferguson, S.G. (2015), "It's the power of food: individual differences in food cue responsiveness and snacking in everyday life", *The International Journal of Behavioral Nutrition and Physical Activity*, Vol. 12 No. 149, pp. 1–8.

Shatenstein, B. and Ghadirian, P. (1998), "Influences on diet, health behaviours and their outcome in select ethnocultural and religious groups", *Nutrition*, Vol. 14 No. 2, pp. 223–230.

Shepherd, R. (1999), "Social determinants of food choice", *Proceedings of the Nutrition Society*, Vol. 58 No. 04, pp. 807–812.

Shepherd, R. and Raats, M. (2006), *The psychology of food choice, Frontiers in nutritional science*, Vol. 3, CABI, Wallingford.

Sherman, P.W. and Flaxman, S.M. (2002), "Nausea and vomiting of pregnancy in an evolutionary perspective", *American Journal of Obstetrics and Gynecology*, Vol. 186 No. 5 Suppl Understanding, p. S190-7.

Shin, D., Lee, K. and Song, W. (2015), "Dietary Patterns during Pregnancy Are Associated with Risk of Gestational Diabetes Mellitus", *Nutrients*, Vol. 7 No. 11, pp. 9369–9382.

Silva-del Valle, M., Sanchez-Villegas, A. and Serra-Majem, L. (2013), "Association between the adherence to the Mediterranean diet and overweight and obesity in pregnant women in Gran Canaria", *Nutricion hospitalaria*, Vol. 28 No. 3, pp. 654–659.

Simoes, E., Kunz, S. and Schmahl, F. (2009), "Inanspruchnahmegradienten in der Schwangerenvorsorge fordern zur Weiterentwicklung des Praventionskonzepts auf", *Gesundheitswesen;* Vol. 71 No. 7, pp. 385–390.

Skreden, M., Bere, E., Sagedal, L.R., Vistad, I. and Overby, N.C. (2015), "Changes in beverage consumption from pre-pregnancy to early pregnancy in the Norwegian Fit for Delivery study", *Public Health Nutrition*, Vol. 18 No. 7, pp. 1187–1196.

Slattery, M.L. (2008), "Defining dietary consumption: is the sum greater than its parts?1", *American Journal of Clinical Nutrition*, No. 88, pp. 14–15.

Sleddens, E.F.C., Kroeze, W., Kohl, L.F.M., Bolten, L.M., Velema, E., Kaspers, P., Kremers, S.P.J. and Brug, J. (2015), "Correlates of dietary behavior in adults: an umbrella review", *Nutrition Reviews*, Vol. 73 No. 8, pp. 477–499.

Smedley, J., Jancey, J.M., Dhaliwal, S., Zhao, Y., Monteiro, S.M. and Howat, P. (2013), "Women's reported health behaviours before and during pregnancy. A retrospective study", *Health Education Journal*, Vol. 73 No. 1, pp. 28–40.

Smyth, R. (2004), "Exploring the usefulness of a conceptual framework as a research tool:. A researcher's reflection", *Issues in Educational Research*, Vol. 14 No. 2, pp. 167–180.

Sotres-Alvarez, D., Herring, A.H. and Siega-Riz, A.-M. (2013), "Latent transition models to study women's changing of dietary patterns from pregnancy to 1 year postpartum", *American Journal of Epidemiology*, Vol. 177 No. 8, pp. 852–861.

Spallek, J. and Razum, O. (2012), "Gesundheitschancen. Frühzeitige Weichenstelllung", *Deutsches Ärzteblatt*, Vol. 109 No. 46, pp. A2298-A2301.

Spring, B., Moller, A.C. and Coons, M.J. (2012), "Multiple health behaviours: overview and implications", *Journal of Public Health (Oxford, England)*, 34 Suppl 1, p. i3-10.

Stadt Bielefeld, Amt für Demographie und Statistik (2015), *Statistische Kurzinformation Bielefeld: Bevölkerung in den Stadtbezirken*, Stichtag: 31.12.2015.

Stata Press (2013), *Stata Multivariate Statistics: Reference Manual*, Release 13, College Station, Texas.

StataCorp LP (2013), *Stata Statistical Software: Release 13*, StataCorp, College Station, Texas.

Statistisches Bundesamt (2016), *Mehr Krankenhausentbindungen 2015 bei niedrigerer Kaiserschnittrate: Pressemitteilung 355/16*.

Steenweg-de Graaff, J., Tiemeier, H., Steegers-Theunissen, Régine, P. M., Hofman, A., Jaddoe, Vincent, W. V., Verhulst, Frank, C. and Roza, Sabine, J. (2014), "Maternal dietary patterns during pregnancy and child internalising and externalising problems. The Generation R Study", *Clinical Nutrition*, Vol. 33 No. 1, pp. 115–121.

Stengel, M.R., Kraschnewski, J.L., Hwang, S.W., Kjerulff, K.H. and Chuang, C.H. (2012), ""What my doctor didn't tell me": examining health care provider advice to overweight and obese pregnant women on gestational weight gain and physical activity", *Women's Health Issues*, Vol. 22 No. 6, p. e535-40.

Sturkenboom, S.M., Dekker, L.H., Lamkaddem, M., Schaap, L.A., de Vries, Jeanne H M, Stronks, K. and Nicolaou, M. (2016), "Acculturation and dietary patterns among residents of Surinamese origin in the Netherlands: the HELIUS dietary pattern study", *Public Health Nutrition*, Vol. 19 No. 4, pp. 682–692.

Suitor, C.W., Gardner, J.D. and Feldstein, M.L. (1990), "Characteristics of diet among a culturally diverse group of low-income pregnant women", *Journal of the American Dietetic Association*, Vol. 90 No. 4, pp. 543–549.

Sutherland, S.M. (1997), "Pregnancy: A Social Construction", Thesis for the degree Master of Arts, Department of Sociology, Lakehead University, Thunder Bay, Ontario, 1997.

Takimoto, H., Mitsuishi, C. and Kato, N. (2011), "Attitudes toward pregnancy related changes and self-judged dieting behavior", *Asia Pacific Journal of Clinical Nutrition*, Vol. 20 No. 2, pp. 212–219.

Tamimi, R.M., Lagiou, P., Mucci, L.A., Hsieh, C.-C., Adami, H.-O. and Trichopoulos, D. (2003), "Average energy intake among pregnant women carrying a boy compared with a girl", *BMJ (Clinical research ed.)*, Vol. 326 No. 7401, pp. 1245–1246.

Temple, N.J. (2016), "Strategic nutrition: a vision for the twenty-first century", *Public Health Nutrition*, Vol. 19 No. 1, pp. 164–175.

The, N.S. and Gordon-Larsen, P. (2009), "Entry into romantic partnership is associated with obesity", *Obesity (Silver Spring, Md.)*, Vol. 17 No. 7, pp. 1441–1447.

Thiele, S., Mensink, G.B.M. and Beitz, R. (2004), "Determinants of diet quality", *Public Health Nutrition*, Vol. 7 No. 01.

Thomas, B. and Bishop, J. (2007), *Manual of dietetic practice,* 4th ed., Blackwell Pub., Oxford, Ames, Iowa.

Thompson, A.L. (2013), "Intergenerational impact of maternal obesity and postnatal feeding practices on pediatric obesity", *Nutrition Reviews*, 71 Suppl 1, p. S55-61.

Thompson, J.M.D., Wall, C., Becroft, D.M.O., Robinson, E., Wild, C.J. and Mitchell, E.A. (2010), "Maternal dietary patterns in pregnancy and the association with small-for-gestational-age infants", *The British Journal of Nutrition*, Vol. 103 No. 11, pp. 1665–1673.

Timmermans, S., Steegers-Theunissen, Regine P M, Vujkovic, M., Bakker, R., den Breeijen, H., Raat, H., Russcher, H., Lindemans, J., Hofman, A., Jaddoe, Vincent W V and Steegers, Eric A P (2011), "Major dietary patterns and blood pressure patterns during pregnancy: the Generation R Study", *American Journal of Obstetrics and Gynecology*, Vol. 205 No. 4, p. 337.e1-12.

Tomedi, L.E., Chang, C.-C.H., Newby, P.K., Evans, R.W., Luther, J.F., Wisner, K.L. and Bodnar, L.M. (2013), "Pre-pregnancy obesity and maternal nutritional biomarker status during pregnancy: a factor analysis", *Public Health Nutrition*, Vol. 16 No. 8, pp. 1414–1418.

Trautwein, E.A. and Hermann, S. (2005), "Grundlagen der Ernährungsepidemiologie", in Müller, M.J. (Ed.), *Gesundheit und Ernährung - Public Health Nutrition*, *UTB*, Ulmer, Stuttgart, pp. 40–49.

Trichopoulos, D. and Lagiou, P. (2001), "Dietary patterns and mortality", *British Journal of Nutrition*, Vol. 85 No. 02, p. 133.

Trygg, K., Lund-Larsen, K., Sandstad, B., Hoffman, H.J., Jacobsen, G. and Bakketeig, L.S. (1995), "Do pregnant smokers eat differently from pregnant non-smokers?", *Paediatric and Perinatal Epidemiology*, Vol. 9 No. 3, pp. 307–319.

Tryggvadottir, E.A., Medek, H., Birgisdottir, B.E., Geirsson, R.T. and Gunnarsdottir, I. (2015), "Association between healthy maternal dietary pattern and risk for gestational diabetes mellitus", *European Journal of Clinical Nutrition*, Vol. 70 No. 2, pp. 237–242.

Tsigga, M., Filis, V., Hatzopoulou, K., Kotzamanidis, C. and Grammatikopoulou, M.G. (2011), "Healthy Eating Index during pregnancy according to pre-gravid and gravid weight status", *Public Health Nutrition*, Vol. 14 No. 2, pp. 290–296.

Uauy, R. and Solomons, N. (2005), "Diet, nutrition, and the life-course approach to cancer prevention", *The Journal of Nutrition*, Vol. 135 No. 12 Suppl, p. 2934S-2945S.

UCLA: Statistical Consulting Group (2016), "Stata FAQ. How can I perform a factor analysis with categorical (or categorical and continuous) variables?", available at: http://www.ats.ucla.edu/stat/stata/faq/efa_categorical.htm (accessed 12 November 2016).

Uusitalo, L., Uusitalo, U., Ovaskainen, M.-L., Niinisto, S., Kronberg-Kippila, C., Marjamaki, L., Ahonen, S., Kenward, M.G., Knip, M., Veijola, R. and Virtanen, S.M. (2008), "Sociodemographic and lifestyle characteristics are associated with antioxidant intake and the consumption of their dietary sources during pregnancy", *Public Health Nutrition*, Vol. 11 No. 12, pp. 1379–1388.

Uusitalo, U., Arkkola, T., Ovaskainen, M.-L., Kronberg-Kippila, C., Kenward, M.G., Veijola, R., Simell, O., Knip, M. and Virtanen, S.M. (2009), "Unhealthy dietary patterns are associated with weight gain during pregnancy among Finnish women", *Public Health Nutrition*, Vol. 12 No. 12, pp. 2392–2399.

Vall, O., Salat-Batlle, J. and Garcia-Algar, O. (2015), "Alcohol consumption during pregnancy and adverse neurodevelopmental outcomes", *Journal of epidemiology and community health*, Vol. 69 No. 10, pp. 927–929.

van Ruesten, A. von, Brantsaeter, A.L., Haugen, M., Meltzer, H.M., Mehlig, K., Winkvist, A. and Lissner, L. (2014), "Adherence of pregnant women to Nordic dietary guidelines in relation to postpartum weight retention: results from the Norwegian Mother and Child Cohort Study", *BMC Public Health*, Vol. 14, p. 75.

Veeranki, S.P., Gebretsadik, T., Dorris, S.L., Mitchel, E.F., Hartert, T.V., Cooper, W.O., Tylavsky, F.A., Dupont, W., Hartman, T.J. and Carroll, K.N. (2014), "Association of Folic Acid Supplementation During Pregnancy and Infant Bronchiolitis", *American Journal of Epidemiology*, Vol. 179 No. 8, pp. 938–946.

Verbeke, W. and Bourdeaudhuij, I. de (2007), "Dietary behaviour of pregnant versus non-pregnant women", *Appetite*, Vol. 48 No. 1, pp. 78–86.

Vioque, J., Navarrete-Muñoz, E.-M., Gimenez-Monzó, D., García-de-la-Hera, M., Granado, F., Young, I.S., Ramón, R., Ballester, F., Murcia, M., Rebagliato, M. and Iñiguez, C. (2013), "Reproducibility and validity of a food frequency questionnaire among pregnant women in a Mediterranean area", *Nutrition Journal*, Vol. 12, pp. 1–9.

Viswanathan, M., Siega-Riz, A.M., Moos, M.K., Deierlein, A., Mumford, S., Knaack, J., Thieda, P., Lux, L.J. and Lohr, K.N. (2008), "Outcomes of maternal weight gain", *Evidence report/technology assessment*, No. 168, pp. 1–223.

Völgyi, E., Carroll, K.N., Hare, M.E., Ringwald-Smith, K., Piyathilake, C., Yoo, W. and Tylavsky, F.A. (2013), "Dietary patterns in pregnancy and effects on nutrient intake in the Mid-South: the Conditions Affecting Neurocognitive Development and Learning in Early Childhood (CANDLE) study", *Nutrients*, Vol. 5 No. 5, pp. 1511–1530.

Vujkovic, M., Steegers, E.A., Looman, C.W., Ocke, M.C., van der Spek, P J and Steegers-Theunissen, R.P. (2009), "The maternal Mediterranean dietary pattern is associated with a reduced risk of spina bifida in the offspring", *British Journal of Obstetrics and Gynaecology*, Vol. 116 No. 3, pp. 408–415.

Waijers, P.M.C.M., Feskens, E.J.M. and Ocke, M.C. (2007), "A critical review of predefined diet quality scores", *The British Journal of Nutrition*, Vol. 97 No. 2, pp. 219–231.

Ward, P., Coveney, J. and Henderson, J. (2010), "Editorial: A sociology of food and eating: Why now?", *Journal of Sociology*, Vol. 46 No. 4, pp. 347–351.

Watson, P.E. and McDonald, B.W. (2009), "Major influences on nutrient intake in pregnant New Zealand women", *Maternal and Child Health Journal*, Vol. 13 No. 5, pp. 695–706.

Watts, V., Rockett, H., Baer, H., Leppert, J. and Colditz, G. (2007), "Assessing Diet Quality in a Population of Low-Income Pregnant Women:. A Comparison between Native Americans and Whites", *Maternal and Child Health Journal*, Vol. 11 No. 2, pp. 127–136.

Wells, G., Shea, B., O'Connel, D., Peterson, J., Welch, V., Losos, M. and Tugwell, P. (2013), "The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses", available at: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp.

Wen, L.M., Flood, V.M., Simpson, J.M., Rissel, C. and Baur, L.A. (2010), "Dietary behaviours during pregnancy: findings from first-time mothers in southwest Sydney, Australia", *The International Journal of Behavioral Nutrition and Physical Activity*, Vol. 7, p. 13.

Wen, L.M., Rissel, C., Simpson, J.M., Lee, E. and Baur, L.A. (2011), "Maternal smoking, weight status and dietary behaviours during pregnancy: findings from first-time mothers in south-west Sydney, Australia", *The Australian & New Zealand journal of obstetrics & gynaecology*, Vol. 51 No. 1, pp. 31–37.

Wen, L.M., Simpson, J.M., Rissel, C. and Baur, L.A. (2013), "Maternal "junk food" diet during pregnancy as a predictor of high birthweight: findings from the healthy beginnings trial", *Birth (Berkeley, Calif.)*, Vol. 40 No. 1, pp. 46–51.

Wharton, P.A., Eaton, P.M. and Wharton, B.A. (1984), "Subethnic variation in the diets of Moslem, Sikh and Hindu pregnant women at Sorrento Maternity Hospital, Birmingham", *The British Journal of Nutrition*, Vol. 52 No. 3, pp. 469–476.

Whitaker, K.M., Wilcox, S., Liu, J., Blair, S.N. and Pate, R.R. (2016a), "Patient and Provider Perceptions of Weight Gain, Physical Activity, and Nutrition Counseling during Pregnancy: A Qualitative Study", *Women's Health Issues*, Vol. 26 No. 1, pp. 116–122.

Whitaker, K.M., Wilcox, S., Liu, J., Blair, S.N. and Pate, R.R. (2016b), "Provider Advice and Women's Intentions to Meet Weight Gain, Physical Activity, and Nutrition Guidelines During Pregnancy", *Maternal and Child Health Journal*, Vol. 20 No. 11, pp. 2309–2317.

Wied, S. (2003), *Pschyrembel Wörterbuch Pflege: [Pflegetechniken, Pflegehilfsmittel, Pflegewissenschaft, Pflegemanagement, Psychologie, Recht]*, de Gruyter, Berlin [u.a.].

Willett, W. (1998), *Nutritional epidemiology, Monographs in epidemiology and biostatistics*, Vol. 30, 2nd ed., Oxford Univ. Press, New York [u.a.].

Willett, W.C. (1994), "Diet and health: what should we eat?", *Science (New York, N.Y.)*, Vol. 264 No. 5158, pp. 532–537.

Wirt, A. and Collins, C.E. (2009), "Diet quality—what is it and does it matter?", *Public Health Nutrition*, Vol. 12 No. 12, pp. 2473–2492.

Wolff, C.B. and Wolff, H.K. (1995), "Maternal Eating Patterns and Birth Weight of Mexican American Infants", *Nutrition and Health*, Vol. 10 No. 2, pp. 121–134.

World Health Organization, *Obesity: Preventing and managing the global epidemic report of a WHO consultation, WHO technical report series*, Vol. 894, World Health Organization, Geneva.

Yeasmin, S.F. and Regmi, K. (2013), "A qualitative study on the food habits and related beliefs of pregnant British Bangladeshis", *Health Care for Women International*, Vol. 34 No. 5, pp. 395–415.

Yin, J., Dwyer, T., Riley, M., Cochrane, J. and Jones, G. (2010), "The association between maternal diet during pregnancy and bone mass of the children at age 16", *European Journal of Clinical Nutrition*, Vol. 64 No. 2, pp. 131–137.

Yong, A.G. and Pearce, S. (2013), "A Beginner's Guide to Factor Analysis:Focusing on Exploratory Factor Analysis", *Tutorials in Quantitative Methods for Psychology*, Vol. 9 No. 2, pp. 79–94.

8. Appendices

Appendix 1: Glossary of terms

Basal metabolic rate (BMR): is the minimum energy expenditure per unit of time of humans (or endothermic animals) at rest. BMR can be estimated from body weight using age- and gender-based equations such as the Schofield equation.

Calorimetry: measure of energy expenditure of a person. In direct calorimetry the heat produced by a subject in a special chamber is measured. In indirect calorimetry energy expenditure is measured indirectly via the ratio of oxygen to carbon dioxide (respiratory quotient).

Diet: is the sum of all foods consumed by a person, animal or organism. Diets often differ between groups of people. While diets can vary with time (e.g. seasons, special occasions and holidays, weekends) they usually display underlying patterns and there are foods that are regularly eaten, i.e. there is an element of typicality.

Doubly labelled water method: 'gold standard' method to assess energy expenditure that is used to validate dietary assessment methods. Subjects take an oral dose of $^2H_2$ ^{18}O and then donate several urine, blood or saliva samples over time. Based on the elimination time of deuterium and oxygen-18 from the body, carbon dioxide production can be calculated, from which energy expenditure can be derived. Additionally, the doubly labelled water methods can be used as a measure of total body water, from this body composition can be calculated.

Food groups: Diets are made up of different food groups based on similarities in biological or nutrient characteristics or the function they have in meals or daily food patterns. Perhaps the most well-known food groupings are those used in the food guide pyramid: plant based foods (fruits, vegetables, starchy grains and pulses), animal based foods (meat, fish, dairy products and eggs), oils and fats, and finally beverages.

Food frequency questionnaire: method for assessing dietary intake that is relatively easy to conduct and thus useful in large

epidemiological studies. Average long-term diet (e.g. over weeks, months or years) is usually assessed by listing foods and then asking respondents to report the how often those were eaten. Sometimes additional questions are included such as consumption quantity (portion size) and composition (e.g. fat content, cooking method).

Food list: when a comprehensive dietary assessment is not feasible or is not the focus of the study, a brief food list can be applied which usually records consumption of select foods (or nutrients) that were usually selected based on prior knowledge or research hypotheses (e.g. specific disease risk) or as a brief screening tool to identify certain individuals (e.g. at risk groups, to categorise participants as high, medium or low consumers).

Nutrition: describes the nutrients provided by food. Nutrients can be divided into macronutrients (carbohydrates, fat, protein and alcohol), which are the main energy sources, and micronutrients (vitamins, minerals and trace elements). Human nutrition describes the process employed by cells, tissues, organs and the whole body to obtain and use substances needed for structural and functional integrity.

Nutritional epidemiology: is the scientific basis of the field of public health nutrition. It generates knowledge based upon which public health decisions are to be made. Nutritional epidemiological research aims to find and explain the best possible scientific evidence regarding the role of nutrition in health and illness. This is achieved by describing the distribution and size of nutrition-related diseases in a population, by elucidating disease aetiology and by providing necessary information to manage and plan prevention, control and treatment of diseases.

Omega-3 fatty acids: long-chain, polyunsaturated plant (α-linolenic acid) and marine based (eicosapentaenoic acid and docosahexaenoic acid) fatty acids that are important for human metabolism.

Public health nutrition: is a field focused on the promotion of health through nutrition and the prevention of diet-related illnesses among

at the population level.

Teratogen: harmful substances (e.g. chemical, medications, infections) acting *in utero* and producing malformations and abnormalities.

Total energy expenditure: has been partitioned into the components resting metabolic rate (the largest proportion, energy required to sustain live, at rest), thermogenic effect of food (energy required to digest and metabolise food), physical activity (energy expended during activity and movement), and adaptive thermogenesis (capacity to conserve or expand energy in response to food intake and temperature extremes).

The following resources were used to produce this glossary:

Margetts, B.M. and Nelson, M. (Eds.), *Design concepts in nutritional epidemiology*, 2nd ed., Oxford Univ. Press, Oxford [u.a.].

Oltersdorf, U. (1995), *Ernährungsepidemiologie: Mensch, Ernährung, Umwelt*, E. Ulmer, Stuttgart (Hohenheim).

Porta, M.S., Greenland, S., Hernán, M., Silva, I.d.S. and Last, J.M. (2014), *A dictionary of epidemiology,* Six edition, Oxford University Press, Oxford.

Willett, W. (1998), *Nutritional epidemiology, Monographs in epidemiology and biostatistics*, Vol. 30, 2nd ed., Oxford Univ. Press, New York [u.a.].

Appendix 2: Overview of food groups

Food group (DIfE)		Food items (DIfE)	Recoding used in BaBi study
1	Potatoes	Potatoes, fried potatoes, filled potatoes, mashed potatoes, potato dumplings, fried potato patty, French fries, other potato products	Carbohydrates = consumed FG 1 or 13 or 14
2	Leafy vegetables	Lettuce, mixed salad, spinach	Vegetables = consumed FG 2 or 3 or 4 or 5 or 6
3	Fruiting vegetables	Aubergine, avocado, pickled gherkin, pepper, cucumber, tomato, zucchini	
4	Root vegetables	Turnip cabbage, carrot (raw or cooked)	
5	Cabbages	Cauliflower, broccoli, curly kale (green cabbage), Brussel sprouts, red cabbage, white cabbage, sauerkraut	
6	Other vegetables	Vegetable mix, mushrooms, other cooked vegetables, asparagus, other raw vegetables, garlic (raw/cooked), onion (raw/cooked)	
7	Legumes	Pulses (e.g. peas, chickpeas, lentils, beans)	Legumes = consumed FG 7
8	Fruits	Pineapple, apple, orange, apricot, banana, pear, strawberry, pomegranate, blueberry, raspberry, cherry, kiwi, mandarin, melon, mirabelle, nectarine, fresh fruit salad, peach, plum, physalis, gooseberry, grape, fresh fig, other fresh fruit	Fruits = consumed FG 8 or 10
9	Nuts	Seeds (e.g. sunflower, pumpkin), linseeds, nuts (fresh/roasted/salted, including almonds, peanuts, pistachio), other seeds, trail mix	Nuts = consumed FG 9
10	Other fruits	Stewed fruits, canned fruits, olives, red fruit compote, dried fruits	

Food group (DIfE)		Food items (DIfE)	Recoding used in BaBi study
11	Milk and dairy products	Buttermilk, crème fraiche, fruit yogurt, flavoured yogurt, natural yogurt, quark/curd cheese (plain, flavoured, with herbs), milk, milkshake, cocoa, kefir, condensed milk in tea/coffee, mousse au chocolat, custard, tiramisu, cream, sour cream, soured milk	Dairy = consumed FG 11 or 12
12	Cheese	Feta, cream cheese, cottage cheese, mozzarella, curdled milk cheese (e.g. Harzer cheese), sliced cheese, hard cheese (e.g. Gouda, Emmentaler, Parmesan), soft cheese (e.g. Camembert, Brie)	
13	Pasta, rice	Groats (German "Grütze"), pearl barley, cereal grist (German "Getreideschrot"), pasta (white/wholegrain), rice, other cereals	
14	Bread	Croissant, sweet bun (German "Splitterbrötchen"), bread/breadroll from spelt, rye, wholegrain, wholemeal, wheat, or other grain, baguette, other bread	
15	Other cereals	Cornflakes, rice krispies, puffed rice, oats and other cereals, muesli, cereal grist and other cereals, savoury snacks (e.g. crackers, saltines, crisps)	Other cereals = consumed FG 15
16	Red meat	Minced meat, gyros, veal, lamb, beef goulash, beef roulade, meat skewer, roast pork, pork goulash, other beef, other pork, game, rabbit	Red Meat = consumed FG 16
17	Poultry	Chicken and turkey strips, other poultry	Poultry = consumed FG 17
18	Processed meat	Black pudding/blood sausage, bratwurst/fried sausage, boiled sausage (Frankfurter, Wiener, Bockwurst, Knackwurst), Cabanossi, pork sausage, poultry sausage, meat ball, cooked ham, "Leberkäse", "Fleischkäse", liver sausage/pate, "Mettwurst", collared pork ("Presssack"), raw/smoked ham, salami, ham, other meat products, other sausages, meat in gelantine, Bavarian veal sausage ("Weißwurst")	Processed meat = consumed FG 18

Food group (DIfE)		Food items (DIfE)	Recoding used in BaBi study
19	Offals	Liver, other organ meat	Excluded in further analysis because not consumed
20	Fish	Eel, fried herring, kipper, fish fingers, trout, herring, cod, shellfish, mussels, salmon, mackerel, pickled herring, rolled marinated herring ("Rollmops"), redfish, frozen fish meal ("Schlemmerfilet"), Pollack, other fish, sprat, tuna, squid	Fish = consumed FG 20
21	Eggs	Boiled egg, other egg dish, fried egg, omelette, scrambled egg	Eggs = consumed FG 21
22	Vegetable oils	Safflower oil, linseed oil, olive oil, rapeseed oil, sunflower oil, grapeseed oil, wheat germ oil, other vegetable oils	Veg. oil = consumed FG 22
23	Margarines	Margarine, reduced fat spread	Margarine = consumed FG 23
24	Butter	Butter	Butter = consumed FG 24
25	Other fats	Lard, bacon, other fats, "I don't know what cooking fat was used"	Other fat = consumed FG 25
26	Sugar	Honey, jam, preserves, honey/sugar in coffee/tea, chocolate/nougat spread, praline, chocolate bar, other chocolate or sweets with chocolate, other sweets, other deserts, other sweets without chocolate, ice cream, sugar beet molasses	Sweets and snacks = consumed FG 26 or 27
27	Cake, cookies	Pancake, baked goods with yeast, cookies/cakes with/without chocolate, cheesecake, fruit flan, cream cake/tart, sponge cake, other cake, waffles	
28	Fruit and vegetable juice	Apple juice, grapefruit juice, elderflower juice, multivitamin juice, orange juice, other fruit juice, other vegetable juice, tomato juice, grape juice	Low cal. Beverage = FG 28 or 32

Food group (DIfE)		Food items (DIfE)	Recoding used in BaBi study
29	Soft drinks	Cola, diet cola, lemonade, diet lemonade	Soft drinks = consumed FG 29
30	Coffee	Cappuccino, café latte, coffee with/without caffeine, espresso	Coffee = consumed FG 30
31	Tea	Green tea, black tea, other hot drinks	Tea = consumed FG 31
32	Other non-alcoholic drinks	Fruit tea/infusion, herbal tea, alcohol-free beer, malt beer, mineral water, tab water, other cold drinks	
33	Wine	Rose/red/white/sparkling wine, prosecco	Excluded in further analysis because consumed by ≤1%
34	Beer	Bier, wheat beer, ale, stout, bock beer	Excluded in further analysis because not consumed
35	Spirits	Spirits, e.g. brandy, whiskey, vodka, schnapps, rum	Excluded in further analysis because not consumed
36	Other alcoholic beverages	Mulled wine, liqueur (e.g. amaretto, cream liqueur, Genever), mixed drinks (e.g. cocktails and other alcoholic mixed beverages), shandy (beer mixed with lemonade), wine spritzer, other alcoholic beverages	Excluded in further analysis because not consumed
37	Sauces	Bolognese sauce, mince sauce, cocktail dressing/sauce, oil-vinegar dressing, oil-vinegar-herb dressing, French dressing, yogurt dressing, mayonnaise, remoulade/tartar sauce, "I don't know", other sauces with meat or fish/with cooked vegetables/with rice, potatoes, pasta or other side dishes, tomato ketchup, curry sauce, tomato sauce, other sauces	Sauces = consumed FG 37

Food group (DIfE)		Food items (DIfE)	Recoding used in BaBi study
38	Soups	Crème soups (e.g. pumpkin/asparagus/broccoli), cold sweet/fruit soup, clear soups (e.g. vegetable/noodle), other soups	Soups = consumed FG 38
39	Miscellaneous	Vinegar, cereal fried patty ("Getreidebratling"), vegetable fried patty, artificial sweetener in coffee/ tea, vegetable spread, vegetable paste, mustard, soy milk, soy sauce, tofu, filled puff patry	Excluded in further analysis because it contained too many different foods (difficult to interpret)
40	Delicatessen salad	Egg salad, meat salad (sausage and meat in mayonnaise sauce), herring salad, pickled herring salad, potato salad, other spreads	Deli salad = consumed FG 40
41	Mixed dish with meat	Doner kebab, meat stew, lasagne with meat, pizza, toasted baguette	Excluded in further analysis because it contained too many different foods (difficult to interpret)
42	Mixed dish with vegetables	Vegetable stew, roasted vegetables, vegetable casserole	Excluded in further analysis because it contained too many different foods (difficult to interpret)

Source: DIfE/German Institute of Human Nutrition; provided in German, translated into English by author;
FG, food group

Appendix 3: Supplements used

Name	Producer	Folate	Iodine	Iron	Vitamin D	DHA	Source
Folio	Steripharm	Yes	Yes	No	No	No	http://www.steripharm.de/produkte/folio-folio-jodfrei/produktinformation-folio-folio-jodfrei.html
Folio forte	Steripharm	Yes	Yes	No	No	No	http://www.steripharm.de/produkte/folio-forte-folio-forte-jodfrei/produktinformation-folio-forte-folio-forte-jodfrei.html
Femibion	Merck	Yes	Yes	No	Yes	No	https://www.femibion.com/content/dam/merck/health-care/biopharma/Femibion/General%20Assets/PDF/Femibion%201/Femibion1_DEU.pdf---schwangerschaft.html
Femibion 2	Merck	Yes	Yes	No	Yes	Yes	https://www.femibion.com/content/dam/merck/health-care/biopharma/Femibion/General%20Assets/PDF/Femibion%202/Femibion2_DEU.pdf
Centrum materna	Nestle Nutrition GmbH	Yes	Yes	No	Yes	No	http://www.pharmacheck.de/kurzbeschreibung/centrum-maternadha-03365073.html
DM Mama A-Z	DM Das gesunde Plus	Yes	Yes	Yes	Yes	No	https://www.dm.de/das-gesunde-plus-a-z-mama-tabletten-p4010355082336.html
Elevit Gynvital	Bayer	Yes	Yes	Yes	Yes	Yes	https://www.elevit.de/elevit-gynvital.php
Gynvital Gravida	Bayer	Yes	Yes	No	Yes	Yes	http://www.gynvital.de/produkte/zusammensetzung/
Ferrosanol	Ferro Sanol	No	No	Yes	No	No	http://www.eisenmangel.de/
Kräuterblut	Floradix	No	No	Yes	No	No	http://www.floradix.de/home.html

Recoded information from the commentary field "other supplements" in 24 hour Food List

Danksagung

Eidesstattliche Versicherung

Hiermit versichere ich, dass ich die Dissertation selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe. Alle Ausführungen, die anderen Schriften wörtlich oder sinnesgemäß entnommen wurden, sind kenntlich gemacht.

Bielefeld, den 09.12.2016 _____

Eidesstattliche Erklärung

Hiermit erkläre ich, dass ich bisher keine weiteren Promotionsversuche unternommen habe. Die hier vorliegende Dissertation wurde an keiner anderen Fakultät in der gegenwärtigen oder einer ähnlichen Fassung eingereicht.

Bielefeld, den 09.12.2016 _____